Plate Product Lifetimes And The Environment 2017
Conferene Proceedings

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Publication date
2017

Document Version
Final published version

Citation (APA)
Bakker, C., & Mugge, R. (Eds.) (2017). *Plate Product Lifetimes And The Environment 2017: Conferene Proceedings*. (Research in Design Series; Vol. 9). IOS Press.

PLATE

Product Lifetimes And The Environment

Conference Proceedings | 8-10 November, 2017 | Delft, NL

Edited by:
Conny Bakker
Ruth Mugge

Published by:
IOS Press BV

TU Delft

PLATE 2017 Conference Proceedings

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ISBN 978-1-61499-819-8 (print)
ISBN 978-1-61499-820-4 (online)

Publisher
IOS Press BV
Nieuwe Hemweg 6b
1013 BG Amsterdam
The Netherlands
tel: +31-20-688 3355
fax: +31-20-687 0019
email: info@iospress.nl
www.iospress.nl

PRINTED IN THE NETHERLANDS

Editorial

Product lifetimes are of critical importance in the debate on circular economy, resource efficiency, waste reduction, and low carbon strategies for sustainability. Consequently, the environmental, economic, and social challenges related to product lifetimes are gaining interest among academics of different disciplines, original equipment manufacturers (OEMs) and other companies, government bodies, and policy stakeholders. To successfully tackle the challenges related to product lifetimes, it is important to tackle the topic from multiple perspectives and thus to share knowledge and expertise of different disciplines, such as design, business management, economics, marketing, consumer behaviour, sociology, anthropology, and politics.

The Product Lifetime and the Environment (PLATE) conference originated from the desire to bring together academic researchers, industry, and policy stakeholders working in the field of sustainability in order to benefit from each other's knowledge and further advance the field. In November 2017, the 2nd PLATE conference was held at the faculty of Industrial Design Engineering of the Delft University of Technology in the Netherlands. We are delighted to hereby present the conference proceedings of this exceptional three-days event. The 2nd PLATE conference included 88 conference papers, 4 key note presentations, 10 workshops, and a PhD-only session.

Specifically, the papers correspond to the following seven conference themes:

1. Design for product longevity
2. The role of product lifetimes in resource efficiency
3. Product lifetimes optimization
4. Cultural perspectives on the throwaway society
5. Business opportunities, economic implications and marketing strategies
6. Consumer influences on product lifetimes, including repair and reuse
7. Policy, regulation and legislation.

One hundred and forty-five proposals for papers were submitted to the organisers in the form of abstracts. Following a peer review process, 88 papers were finally accepted for publication in the proceedings. We were impressed by the quality of the papers and are grateful to include contributions from researchers from many disciplines and 24 countries across five continents.

As editors of these proceedings, we are pleased to put together this collection of interesting papers on the topic of product lifetimes in the context of sustainability. We are confident that the proceedings will contribute to the academic knowledge in this field as well as advance the debate on this important topic.

Conny Bakker and Ruth Mugge (Editors)

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PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Consumers' attitudes towards product care: an exploratory study of motivators, ability factors and triggers

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Keywords
Circular economy
Product longevity
Consumer behaviour
Behaviour change

Abstract
To contribute to a more sustainable way of consumption, products should stay usable as long as possible. Therefore, it is necessary to take care of products. Product care should be understood as any action that helps prolonging the lifetime of a product, such as maintenance, repair etc. These product care activities can be conducted by the consumer or by a service. Our interview study helps to understand consumers' current product care behaviour towards products of different categories. Our study is based on Fogg's behaviour model, which states that motivation, ability and triggers have to be present at the same time to lead to certain behaviour. We were able to identify different motivators (e.g. pleasure, price, functionality), ability factors (e.g. tools, time and effort) and triggers (e.g. appearance triggers, social triggers) for product care. Based upon the findings of this study, strategies that enhance product care are suggested and relevant aspects for future research are proposed.

The need for product care in the Circular Economy

One of the basic principles of the Circular Economy (CE) is the aim to keep products in use for a longer period of time. A consequent step to prolong the use of a product is to avoid its replacement. To avoid product replacement, the following design principles have been proposed: design for reliability & robustness, design for upgradeability, design for variability, design for product attachment, and design for repair & maintenance (Van Nes & Cramer, 2005).

Although there is a general interest among consumers in topics such as sustainability and longevity of products, it is still difficult or even impossible for consumers to repair many consumer durables such as a coffeemaker or a laptop, as this is often prevented by means of product design (Bakker et al., 2014). The website ifixit.com is based on the belief that "people should be able to use their stuff how they want to, for as long as they possibly can" (Wiens, 2015, p. 124). It offers repair manuals as well as a repairability scorecard to assess the possibility of self-repair for products (Flipsen et al., 2016). Due to the mismatch between consumers' interest and the difficulty to repair and maintain everyday products, we assume that a big potential for designers and companies to shift towards a CE lies in focusing on the design for repair & maintenance principle.

Thus far, the focus of implementing this design principle has been on the product and to change its design in such a way that repair is feasible and easy (e.g. Cooper, 1994; Van Nes & Cramer, 2005; Vezzoli & Manzini, 2008). However, the design for repair & maintenance principle can only have an impact on the CE when the consumer has the ability and the self-confidence that he/she is able to repair and maintain the product by himself/herself. Even if he/she has gained this self-confidence, the consumer also requires the relevant motivation. One source of motivation is the experience of a strong attachment towards a product (Mugge, 2007; Page, 2014). But in a CE, consumers also need to take care of everyday products with a moderate or low attachment level.

The following study contributes to this field by investigating consumers' perspective on product care. We identify reasons why consumers either do or do not take care of their products. Based on the study's insights on the factors that stimulate or reduce consumers' care activities, companies can adjust their product design, services, and communication in such a way that these care activities are more likely to be executed.

Fogg's behaviour model

In this study, we used the behaviour model by Fogg (2009). This model has been developed to design persuasive technologies. As our aim is to persuade consumers to take care of their products, the transfer to the design of consumer durables seemed appropriate. The model claims that behaviour generally results from the concurrence of three factors: motivation (if people want to do it), ability (if people can do it) and triggers (a stimulus that provokes them to do it). Only if these three factors occur at the same time, a certain behaviour will take place.

Study on product care behaviour

Method

To identify currently existing motivators, ability factors, and triggers for product care, in-depth interviews were conducted with 15 people at their homes. To cover a broad range of different products that are relevant in people's everyday life, we defined six product categories that were discussed in each interview: 1) household appliances & tools, 2) consumer electronics & communication devices, 3) means of transport, 4) furniture & interior design items, clothes, 5) shoes & fashion accessories, and 6) sport equipment, accessories for hobbies & leisure. For each category, the participant was asked to name a product that he/she takes care of, for example, because he/she devotes effort and/or attention to it, so it remains usable for a longer period of time. Depending on the answer, further questions included the reason and the process of taking care as well as possible problems to do so. Subsequently, we asked participants to specify a product that he/she does not devote effort and/or time to, even if that means that he/she cannot use it for an extensive period of time. Again, reasons and barriers for this behaviour were requested.

Interviews lasted around 25 minutes on average. All 15 interviews were audio recorded. After a verbatim transcription of the interview recordings, a qualitative content analysis was conducted, making use of the software f4/f5 (see www.audiotranskription.de). The coding process started by a full coding of two interviews by the main researcher, which resulted in 97 codes. The three factors of the Fogg behaviour model – motivation, ability, and triggers – served as a basis for this coding, but it became clear that more codes and subcodes would be needed to cover all relevant aspects. Thus, after a discussion among the three members of the research team, more relevant codes were added. This led to a coding scheme of 154 codes, which was then applied to all interview transcripts. During a further coding session, two researchers refined and merged these codes, resulting in (sub)codes related to the three factors from Fogg's behaviour model – motivation, ability, triggers – as well as codes related to product care behaviour in a more general way.

Findings

We gained insights into different care activities, such as careful handling or the usage of adequate accessories for the products. Participants also showed different levels of care intensity, ranging from no care activities at all to regular care activities that are often based on affective reasons.

An analysis based on Fogg's behaviour model allowed us to identify motivators, ability factors, and triggers. These factors determine if consumers take care of their products. As motivators, we identified:

1. *pleasure:* If fun and positive experiences are connected to the product, consumers will more likely take care of it.

2. *aesthetics:* This factor is especially important for very appealing products. As people want these products to stay nice, they will invest time and/or money in their appearance.

3. *functionality:* If a product offers features that are valued by the consumer, he/she will more likely take care of that product.

4. *price:* A high price leads to consumers expecting a high quality of the product. Therefore, they are more willing to take care for expensive products. On the other hand, they will not repair a product if its spare parts or the required service are at a very high price.

5. *intrinsic motivation:* Many participants in our study reported that they are interested in sustainable consumption. They do not want to waste resources and materials, so they have a general motivation to keep products as long as possible.

6. *rebellion against brand policy:* When a company tries to prohibit consumers from repairing their products, for example, by using special joining techniques, this can result in a rebellious reaction from the consumer. He/she is then motivated to avoid the company's repair service and takes care on his/her own.

7. *irreplaceability:* An emotional attachment towards the product often leads to consumers taking care of it.

8. *fit with the participant's identity:* If consumers think that a product represents their values or lifestyle well, they are more willing to take care of that product.

9. *shared ownership:* Sometimes products are owned by several people, especially family members. This often leads to a decreasing feeling of responsibility for this product, resulting in less care activities.

We recognised that the ability to take care of a product depends on the following four factors:

1. *perceived knowledge and skills:* Participants think they do not have the relevant knowledge or skills to take care of their products. This is especially relevant for electronic devices.

2. *time and effort:* Some participants mentioned that they do not have the time to take care of products. Others stated that the required effort is too high.

3. *tools:* A lack of required tools for repair or maintenance also leads to a decreasing ability for product care.

4. *general repairability:* Sometimes participants doubted if the product could be repaired in general.

Relevant triggers – stimuli that provoke a behaviour by enhancing either motivation or ability or by working as a signal – for product care are:

1. *appearance triggers:* When a product does not look nice anymore, consumers are more motivated to take care of it.

2. *time triggers:* After a certain amount of time has passed, consumers' motivation increases. This is especially relevant for regular care activities, such as the annual check of a car.

3. *social triggers:* Other people, such as family members, can increase the motivation to take care of a product, for example, by commenting on the care activities. On the other side, negative comments might decrease the motivation to take care.

4. *previous care experiences:* If previously conducted care activities went well, consumers are more likely to take care again. On the contrary, negative experiences often lead to avoidance of future care activities.

5. *challenge-based approach:* Some participants regard care activities as a personal challenge they want to meet. This leads to an increased level of motivation. These people are also willing to enhance their knowledge and skills to succeed, so this is the only trigger that does not only increase motivation, but also ability.

Implications for designers and future research

Based on our findings, we propose several strategies to enhance consumers' product care activities: First, motivation has to be considered when designing for product care, as people will not change their product care behaviour without being motivated to do so, so there should always be a reason for consumers to take care. There is a big potential for companies regarding the product-related motivators pleasure, functionality, and aesthetics. One promising approach to increase these motivators is the design principle Slow Design. Slow Design encourages the user to spend more time on the meaningful parts of the interaction rather than on the interactions in general and demands a more compelling involvement of the consumer (Fuad-Luke, 2002; Grosse-Hering et al., 2013). Product care could therefore be encouraged in two ways: On the one hand, Slow Design will keep the product usable for a longer period of time and it can contribute to more appealing aesthetics, thereby enhancing consumers' motivation to take care. On the other hand, the underlying activities also lead to a stronger bond between consumer and product, which results in the consumer's wish to extend the product's lifetime. Additionally, our study shows that features, such as a good service, were mentioned as determinants for the purchase decision. Generally, it is important to explain to the consumer that the product is not only of high quality, but that its lifetime can be extended by the consumer himself/herself easily. This results in the acceptance of a higher price at the time of purchase, which in turn enhances the motivation to take care of the product.

To enhance people's ability to repair a product, free video tutorials or better instructions, which would lead to more advanced skills and knowledge on how to take care of the products could be implemented. Repair & maintenance workshops could also address this problem and additionally solve the problem of missing tools. Companies could also offer accompanying services that help consumers with their problems. These strategies could be intensified by specific design and business model approaches, such as design for disassembly, a service for spare parts (see e.g. Mashhadi et al., 2016) and the usage of standard tools.

The observed gap between attitude – a high interest in sustainability and longevity of products – and action – a general low level of product care – is likely caused by the absence of triggers. In many situations, triggers that provoke immediate care activities are missing. Consequently, even though the participants were motivated and had the ability to carry out the care activities, the absence of a relevant trigger will prevent consumers to conduct product care activities.

Companies can trigger their consumers by either focusing on external or internal triggers. Time triggers range from relatively simple measures, such as a reminder for an annual check-up, to more complex ones, such as a signal that is integrated in the product and attracts attention after a certain time of usage. Appearance triggers can be realised by designing the surface of the product in such a way that it changes over time. Then, a look at the product can trigger the consumer to conduct a product care activity. If a product emanates its care state in some way so that it is also visible for other people, it could work as a social trigger. People may then be encouraged to take care of their product, because of social pressure. By focusing on the experience of the product care activity and turning it into a positive experience and a desirable outcome, it is more likely that people will take care also in the future, as stated by the previous care activities trigger. A challenge-based approach could be realised by an accompanying service, which allows consumers to compete in their care activities, but also on a much more individual level by daring the consumer to take care by a demanding, but at the same time not too difficult care activity.

In future studies, triggers as well as the communication of product care-related features of a product or a service should be further investigated. The decision between taking care of a product in person versus using a service needs more research attention to understand in which conditions the focus should be on either product features or on a service. As the circular economy is a global approach, the influence of different cultural backgrounds could also be explored.

Conclusion

The aim of our study was to gain an understanding of current product care behaviour and to identify existing motivators, ability factors, and triggers for product care. To be able to design products that can really change consumers' behaviour in terms of product care, we used Fogg's behaviour model. The findings show that companies can use different strategies to enhance consumers' care behaviour.

As Fogg's model claims that motivation, ability, and triggers have to be present at the same time to provoke a behaviour change, it will be necessary to not only target the product design itself, but also corresponding services, such as tutorials or reminders for an annual check-up. Only by taking consumers' motivation, ability as well as relevant triggers into account, companies can encourage consumers to perform product care activities and thereby extend products' lifetimes.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-5

Developing a quantitative research method on planned obsolescence in architecture

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Keywords
Planned obsolescence
Building lifetimes
Demolitions
Urban transformation
Tarlabaşı Renewal Project

Abstract
Planned obsolescence, a developed theory to maintain the continuity of production by consuming, manifests itself in a large number of products since its first emergence. Through the use of substandard materials, the short-lived products ensure rapidity and continuity in consumption. Additionally, the newer and different options awaken desire of consumers to change their 'obsolete' products. Thus, planned obsolescence becomes both a trigger and a consequence of the consumer society. In contrast to broad discussions on the scheduled lifespan of the products in economics and industrial design, a very small number of studies focus on the building lifetimes. Indeed, planned obsolescence is also a problem of architecture but surely has been carried within a different process and approach than with industrial products. The initial aim of this study is to point out the existence of planned obsolescence in architecture by exposing the ambiguity behind the determination of building demolitions (in other words consciously defined 'expiration dates'). In the framework of the paper, an ongoing urban transformation project in İstanbul: Tarlabaşı Renewal project is examined as a case study. By doing so, the crucial variables that have effects on economic existences of the buildings are underlined in the specific case. Due to the constitution of a basic equation, this study tries to demonstrate the possibility of a developing quantitative research method on building lifetimes in replace of stereotypical assumptions. Consequently, it is envisioned that the subjectivity concerning the demolitions of buildings shall be controlled with the determination of prominent factors and their ratios in overall.

Introduction

Planned obsolescence, a theory of an economic strategy, provides persistence in production by impelling consumption, has become an ordinary reality of everyday lives. The lifetime of the products, such as mobile phones, clothes, computers and many other things, are apparently reduced, and *throw away culture* has increased along with the consumer society. Thus, planned obsolescence has become an ethical problem as responsible for excessive consumption and waste. On the other side, the strategy has been supported from a different point of view since shortening product lifetimes evokes technological improvements. The old products are improved and replaced with the new and assumedly better ones. At this moment, planned obsolescence whether it is resisted or assisted has stayed as a controversial debate since it is first manifested in 1932 by Russian–American real estate broker Bernard London.

Later on, the usage of plastic packaging and disposable products became widespread. Especially between the 1940s and 1950s, single-use products intensified the excessive consumption habits (Tischleder, Wasserman, 2015). Accordingly, in 1954, the concept of planned obsolescence was re-popularized by an industrial designer: Brooks Stevens who recognizes that maintaining the consumer's desire is much more crucial than the reducing the product quality (cited in Adamson, 2005). Likewise, in his book *The Waste Makers*, Vance Packard (1960) highlights the strict relationship between obsolescence and desire with three forms of obsolescence; function, quality and desirability. Consumers become more willing to change the 'obsolete' products with the new ones at their own discretions, even before the occurrence of the physical deficiency problems. Briefly, planned obsolescence has been evolved psychologically as well as physical in between the 1930s to 1960s.

In contrast to the heated debates until the 1960s, it is possible to say that planned obsolescence strategy stayed hibernated until 2010. In 2010, the unexpected announcement of Warner Philips about the design of a long-lasting LED light bulb drew attention to the vivid existence of planned obsolescence. This announcement was followed by similar product news from companies like GE and Panasonic. The paradox here is that those products and the used-technology were not new. The documentary entitled as *The Light Bulb Conspiracy* exposes that long-life light bulbs could be produced even in the 1950s, yet they are just not marketed (Dannoritzer, 2010). Thus, debates and publications on planned obsolescence started to rise once again.

Despite broad discussions in the fields of economy and industrial design through the years, the theory of planned obsolescence has found a limited place in architectural debates since its understanding and interpretation has evolved in architecture distinctly from any other industry.

Planned Obsolescence and Architecture

Throughout time, buildings are considered as living organisms created by architects, and always discussed within the stages of life; to be born, to grow, to live, finally and inevitably to die (Cairns, Jacobs, 2014). It can easily be agreed that buildings will not exist forever, yet the dates and records on demolitions are mostly undocumented. Cairns and Jacobs (2014) explain that the reason behind this is to hide 'inadequacy' of architecture. Besides, almost all of the studies on building lifetimes are based on qualitative observations full of stereotypes and guesses (Abramson, 2015).

While planned obsolescence theory emerged, two pioneer studies took place on building lifetimes: the theory of Reginald Pelham Bolton in his book *Building for Profit* (1911) and the research of National Association of Building Owners and Managers (NABOM) on Chicago Office Buildings (1930). The key point here is that in both studies, the lifespans of the structures that draw attention are not based on material and structural durability. Both of them depend on mainstream assumptions on the economic lives of the buildings, so that is why studies on the determination of building lifetimes have not come through and continued (Abramson, 2016).

Building lifetimes have begun to draw more attention when they decreased from 100 years to 10 years or even less (Stoner, 2016). Therefore, architects have developed counter strategies against obsolescence of buildings whether it is because of material durability, aesthetics or economic reasons (Abramson, 2016). Architects have been interested in modernism by rejecting the temporary and changing aestheticism and embracing Louis Sullivan idea that "form follows function" But this has also created other contradictions, since function and typologies may become obsolete separately from the form and structural features (Abramson, 2016). In this regard, architects have also tried to reverse obsolescence with the new solutions such as preservationism, vernacularism, adaptive reuse, concrete brutalism and "postmodernism" (Abramson, 2016). In this sense, physical obsolescence can be countered through several techniques, and a building may continue its 'life.' At this juncture, buildings may not share the same resistance, like in the very early example of the *Gillender Building* in New York, which was demolished only 13 years after its construction to build a higher skyscraper (Figure 1).

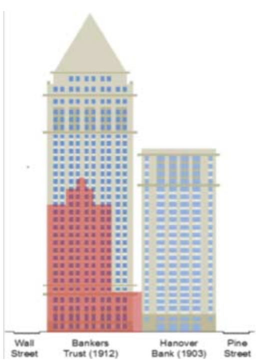

Figure 1. Gillender and Stevens buildings (in red) and the replaced by Bankers Trust Building ©https://upload.wikimedia.org/wikipedia/commons/thumb/6/61/BankersTrust_outline_1912.png/241px-BankersTrust_outline_1912.png.

Surely, the demolition of *Gillender Building* is not the first and only example. Without natural causes, buildings have been destructed in order to build the new ones on their plots. Thus, this continues within an endless cycle(s), causing a tremendous amount of refuse and wasted energy and time. In addition to the captivating demands of the construction of newer, higher and beneficial buildings, buildings are demolished in the name of obsolescence as a result of the political changes such as prominent demolitions in East and West Germany and the Soviet Union Period. Even registered symbolic and historical buildings may be demolished since buildings become 'obsolete' when they are labelled as such.

Planned obsolescence affects not only the individual buildings but also the city scale. Before the 1950s, buildings were continuously ruined as a result of the consecutive wars, and new buildings were built in their place. But then, planned obsolescence became a necessity to clarify the destructions of buildings at city scale (Abramson, 2016). Past and present, urban transformation projects are formed and designed according to the overall features of the defined city parts while individual characteristics, materials and the age of the buildings are ignored with the streets and also local people. Thus, through the declaration of buildings as obsolete, their residents automatically become obsolete, while the urban renewal projects justify and depoliticize the gentrification of the areas (Abramson, 2016).

In order to discuss this further, this study examines an ongoing debated urban renewal project in İstanbul, Turkey. Through the examination of Tarlabaşı Renewal Project, this paper aims to highlight the 'breaking point' of a building that leads to its decay or complete destruction.

Case Study: Tarlabaşı Renewal Project

Currently, under the name of beautification and rehabilitation, many urban transformation projects have been taking place all over the Turkey. In this manner, Taksim, Beyoğlu, the centre of multi-centred İstanbul, was aimed to be re-organized along with new buildings, new road systems, urban renewal projects, and the demolitions in the scope of Beyoğlu Grand Transformation Project.

In the framework of the study, Tarlabaşı Renewal Project, nearby Taksim Square, was selected, since Taksim and its surroundings have been struggling with the different aspects of planned obsolescence throughout the years (Figure 2). While, on the one hand, the conflicts concerning the reconstruction of Taksim Artillery Barracks on the site of Gezi Park continues, on the other hand, other polemic construction projects suggest that the identity of the Square is on the verge of alarming changes. Moreover, AKM (Atatürk Cultural Centre), a symbolic building built in 1968, has been closed since 2008, probably waiting its demolition day to be labelled as 'obsolete.'

Figure 2. Map showing the renewal site in Tarlabaşı and Surroundings © Map by Emrah Kavlak in Ünsal, Ö., 2013, and also edited by the author

Tarlabaşı, nearby the Taksim Square, is an important area where the first urbanization studies of Istanbul were carried out. In the 1910s, the original street structure of today's area was formed, and the symbolic masonry apartments with three and four stories were built (Figure 3).

Figure 3. Original streets and the masonry apartments in Tarlabaşı, the first phase of the project is marked. ©http://www.beyoglubuyukdonusum.com/tarlabasi/detay/Fotograf-Galerisi/39/43/0

The demographic and socio-spatial structure of the region changed when non-Muslim inhabitants left the area in the 1960s. Later, in the 1970s, the spatial and social collapse in the area begun to increase as a result of the inexpensive rents, abandoned buildings and internal migration (Dinçer and Enlil, 2002). Within all these negative situations in the area, due to architectural significance of the buildings, in 1978 hundreds of buildings were registered to be protected, thanks to the famous Turkish architect Sedat Hakkı Eldem. Unfortunately, in 1986 in order to extend roads, 368 buildings (167 of them were registered earlier) were destructed despite all objections, and the morphology of the area was seriously damaged (Ekinci, 1994).

Figure 4. Facades of the Project. ©http://www.beyoglubuyukdonusum.com/tarlabasi/detay/Fotograf-Galerisi/39/43/0#prettyPhoto[BuyukDonusum]/9/

In 1987, a Urban Design Competition for the Redesign of Taksim Square was organized, thus Turkish and foreign architects presented their designs for Taksim Square. Those projects might have also played a critical role in the future of Tarlabaşı, but none of them were actualized.

In 1993, a symposium was organized about Taksim Square and a well-known architect Rob Krier participated as a speaker (Taksim Tartışmaları-1,1993). The problems of the area were discussed, yet no solution or project was implemented.

As time passed, the region was sharply separated from Beyoğlu and İstiklal Street by Tarlabaşı Boulevard, so the collapse of the region was accelerated (Dinçer and Enlil, 2002). Despite their historical and symbolic values, most of the buildings became dilapidated and a renewal project was started as a consequence. According to Ünlü (2003), before the project started %62 of the buildings were in bad conditions, %11 of them almost ruined and only %27 them were in good conditions.

The first phase of the project was contracted in 2007 and started in 2012 by indicating a renewal of 269 buildings including 188 registered buildings. The street between the buildings was also subject to renewal. The infrastructure and the buildings summed up to 20.000 m2 area (Figure 3).

Although it was clearly highlighted that the buildings shall be protected, if it was not necessary to destruct, 18 in 20 buildings were destructed anyways in "Taksim 360 Project". With the project, small historical houses with the sizes of 50 to 100 square meters were combined into groups of five to ten and were converted into a single block. While the blocks are being constructed, it is planned that the exterior facades of the buildings will be preserved. However, as seen in the image (Figure 4), additional layers are included in these combinations. Furthermore, with 5 stories under the ground and 9 stories above, the new buildings will be turned into 14 stories (Url 01). According to Ahunbay and Batur (2014), these implementations are against conservation principles and will erase the important architectural traces.

The functional distribution of buildings will also be changed with the new design. Before the Project, 48.7% of the total 1057 structural units were dwellings, 19.7% were workplaces, 2.9% were storages and 28.6% were disused. The percentages that are suggested in the Project are 52% dwelling units, 12% commerce, 17% tourism facilities and 14% offices. In other words, commercial areas in the region are planned to be increased with the injection of touristic facilities.

The composition of residents of the area will be changed completely. Before the project, 75% of Tarlabaşı residents were tenants, 20% were homeowners, and the remaining 5% were occupiers. The tenants were forced to move to low-income family blocks in Toki, Kayabaşı which is 40km away from the area.

Before the Project, in 2006, the average monthly income of people living in Tarlabaşı was in between 900₺ and 1000₺ while 60% of the people had income under 750₺ (the hunger limit in 2006 was 555₺). Considering the tremendous increase (up to 1500%) in land prices in between 2005-2012, even before the Project actually start (Yeşilbaş, 2014), it definitely became impossible for the former residents of the area to live back there.

Through the Tarlabaşı Renewal Project which started in 2012, the area has been gentrified with the renovation of the structures, while the former residents are removed just like 'obsolete' buildings. This is a common sense that is clearly expressed by the many researchers and scholars (for example Ahunbay 2014; Dinçer, 2010; İslam, T. & Enlil, Z. M. 2006). Rather than a renovation of the buildings, the area transformed into a 'new' place for 'new' people. Just as Abramson (2016, pp. 118) declares:

"Gentrification is in effect the neutron bomb of urban renewal: buildings intact, people gone."

Developing a Quantitative Approach

In Tarlabaşı Renewal Project, despite the variety of solutions for reversing building physical obsolescence, the majority of the buildings are strategically demolished with the suspension of local people.

Through consideration of the process of this project, the expected variables in Table 01 as the factors affecting building lifetimes by triggering planned obsolescence either in positive or negative sence.

TThe increases in the land value (L), floor area ratio (F)

Variable	Unit	Estimated variable sign on Building Age
Land values (L)	% (changes in between selected years)	-(shortens lifetimes)
FAR (floor area ratio) (F)	% (changes in between selected years)	-(shortens lifetimes)
Physical Condition of the building (P)*	1-suitable 0-not suitable	+(lengthen lifetimes)
The Proximity to the central areas (K)	Numerical (km)	-(shorten lifetimes)
Registration (H)*	1-registered 0-not registered	+(lengthen lifetimes)
Resident of the building (O)*	1-owners 0-tenants	+(lengthen lifetimes)

**Physical Condition of the building in suitable condition, registered buildings and owner occupied buildings variables are expected to lengthen lifetimes of the buildings in Tarlabaşı.*

Table 1. The Table of the Variables Affect Lifetimes of the Buildings in Tarlabaşı.

and proximity to the centre (K) may shorten lifetimes of the buildings. Since the possibility of a construction of higher and larger buildings simply provokes replacement of the existent buildings with the new ones. The physical condition of the buildings (P), registration (H) of buildings as historical structures and the resident (O) of the building whether as owner or tenant possibly lengthen the buildings' lifetimes. The variables may alter and the number of them may be increased regarding contextual and regional differences. Surely, the equation only is not enough to explain all coefficients and age as well, ε is added to explain other variables that not considered in this equation. With these variables, the generated basic equation is as follows:

$$A_i = \alpha_1 L + \alpha 2F + \alpha_3 P + \alpha_4 K + \alpha_5 H + \alpha_6 O + \varepsilon$$

In this equation, the age of a building (A_i), where 'i' represents the age in a given period. This study aggregates those variables and suggests an equation under linear regression analysis method. If the model is applied, it is possible to find the different ratios of those variables on building lifetimes.

The coefficient of the model would explain which coefficient has the most effect on demolition age of the building that may increase or decrease of the lifespan. When the model is applied on time series of demolished buildings related to planned obsolescence, some coefficients may be irrelevant to explain the demolished age of the building.

To summarize, this equation is formed to explain planned obsolescence under the light of empirical data of demolished buildings during the urban transformation of Tarlabasi/Istanbul. Even though each urban transformation is carried out under different circumstances that can be explained with additional or fewer variables, characteristics of planned obsolescence remain the same.

Conclusions

"If you live long enough, you'll see all your buildings destroyed." (Louis Sullivan)

The limited studies on obsolescence in architecture suggest that economic, political, ideological, and psychological reasons affect building lifetimes more than the expected life predictions of the building and construction materials. In other words, obsolescence in architecture does not analytically depend on the use of substandard materials, unlike industrial products. It is related to politics and have different variables which are unique to each case.

This study envisions to develop an empirical model with linear regression analysis for planned obsolescence in architecture in contrast to early "guesswork." Therefore, it highlights the subjectivity of obsolescence in buildings and tries to discuss them through the prominent variables within a quantitative approach. In doing so, it is assumed that through the detection of the causes of planned obsolescence in architecture and their ratios in comparison to each other, this will lead to a way to control planned obsolescence in architecture. Thus, the result will be the less waste of energy, labour, time and materials.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-10

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Smart-circular systems: a service business model perspective

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Keywords
Circular Economy
Internet of Things
Smart Products
Business Model
Product-Service Systems

Abstract
The Internet of Things and the amplified capabilities of smart products can be increasingly utilised for the development of feedback-rich systems and loops throughout the entire product life cycle. By adopting the IoT and collecting data during product utilisation, companies can replace the end-of-life concept with product life extension and circular loops. In this sense, service business models hold the greatest potential to optimise the utilisation of goods over time. These models allow a reduction of the overall life cycle costs and contribute to resource-efficiency and the transition towards a circular economy. This paper introduces the concept of smart-circular systems that reflects the interplay between the Internet of Things, the circular economy and service business models and presents a conceptual framework for further empirical analysis of this phenomenon. The framework focuses on product-service systems and more broadly on services business models that optimise the utilisation of goods over time through the amplification of circular activities by the introduction of smart enablers. It also considers three main business models types and tactics for successful implementation of service business models.

Introduction

Two concepts have recently attracted the attention of scholars and practitioners: the circular economy (CE) (Ghisellini, Cialani, & Ulgiati, 2016) and the Internet of Things (IoT) (Porter & Heppelmann, 2014, 2015). The CE has been proposed as an alternative to replace the current linear economic system of production that implies significant loses of value, higher materials risks and negative effects for the environment (EMF, 2013). The adoption of the IoT brings about a new set of opportunities among practitioners for replacing the end-of-life with CE concepts like maintenance, reuse, repair, remanufacturing, and recycling loops. The capabilities of smart products, such as the possibility to monitor and report their own condition and environment (Porter & Heppelmann, 2015), are unlocking new ways of value creation by enabling information gathering and analysis after the product has left the production facility or distribution centre (EMF, 2016). Service business models (SBM) are a growing trend among practitioners and researchers and have great potential towards sustainable resource use and a CE (Stahel, 2016), but most companies struggle to successfully design and implement SBM. Hence, this research investigates the emergent opportunities to design and implement circular SBM considering the interplay between the IoT and the CE. This research address the following question: What is the role of the IoT in developing and implementing circular SBM? Given that this research is still in an early stage, the aim of this paper is to develop a (preliminary) conceptual framework based on an integrated literature review (which shall serve as the basis for qualitative empirical analysis in future steps).

Literature Review

The Circular Economy

The CE is an emerging topic that is receiving increased attention from scholars, policymakers and practitioners (Bocken, Pauw, Bakker, & van der Grinten, 2016; Geissdoerfer, Savaget, Bocken, & Hultink, 2017; Ghisellini et al., 2016; Lieder & Rashid, 2016). The CE is viewed as a solution for several environmental impacts of industrial societies and business-as-usual economic systems such as the rising scarcity and price volatility of natural resources, environmental pollution, and waste generation (Ghisellini et al., 2016; Lieder & Rashid, 2016). The concept of the CE has been evolving and integrates concepts and constructs from several disciplines like industrial ecology, environmental science, business managements, supply chain management, among others (Lieder & Rashid, 2016). The approach harmonizes different schools of thought through the shared idea of closed loops for extending or closing the product life cycle (Geissdoerfer et al., 2017) and includes activities like maintenance, reuse, repair, remanufacture and recycling (EMF, 2013). A prominent understanding of the CE has been framed by the Ellen MacArthur Foundation, introducing it is as "an industrial system that is restorative or regenerative by intention and design" (EMF, 2013, p. 7).

The Internet of Things

We are currently confronted with the convergence of a set of technologies that emphasize the interaction among objects through the internet beyond traditional objects like personal computers, servers and smartphones (Li, Xu, & Zhao, 2015; Mishra, Gunasekaran, Childe, Papadopoulos, & Wamba, 2016). The IoT, or "the networked connection of physical objects" (EMF, 2016, p. 15), refers to everyday objects like washing machines, cars or doors and any kind of industrial machinery like cranes, engines or pumps that are equipped with a variety of identifying, sensing, networking and processing technologies. These new capabilities allow objects and products to process data and information, to communicate with other devices over the internet and to even automatically actuate according to specific purposes (Whitmore, Agarwal, & Xu, 2015). Smart components not only amplify the capabilities and value of physical products, but they bring about a fusion of the digital and physical world. Some of these capabilities even exist outside the physical product itself in a digital form or what is known as the product cloud (Porter & Heppelmann, 2014).

One of the advantages of physical and digital components is their flexibility. Different components can be embedded and developed into products according to the additional value the organisation wants to offer to the market (Noll, Zisler, Neuburger, Eberspächer, & Dowling, 2016). The resulting "smart product" (Novales, Simonovich, & Mocker, 2016, p. 3) is built with a specific set of technological building blocks (e.g., Noll et al., 2016) or *smart enablers* that amplify its physical capabilities, add new value (Noll et al., 2016; Porter & Heppelmann, 2014) and enable the implementation of circular activities. Smart enablers can be divided in physical components, digital components and technological services. Table 1 provides a list of selected smart enablers.

Service Business Models

Research on the CE has focused on environmental issues and resource scarcity while disregarding business and economic perspectives (Lieder & Rashid, 2016).

Smart Enablers	
Physical	Sensors Actuators Wearables Hardware (in general)
Digital	Mobile Applications Platforms Software (in general)
Technological Services	Location Tracking Wireless Connectivity Storage Services Data Analytics Condition Monitoring (status, availability) Remote Usage and Control Intelligent Robotics Virtual/Augmented Reality

Table 1. Smart Enablers

Additionally, advances in technological, material and production capabilities are carried out incrementally, while the design and implementation of radical solutions through new business models is seen as a key pathway for disruptive transformation towards a CE (Geissdoerfer et al., 2017; Lieder & Rashid, 2016). The business model concept refers to the "design or architecture of the value creation, delivery, and capture mechanisms" of a firm (Teece, 2010, p. 172) and can be deliberately extended to consider wider social and environmental issues (Schaltegger, Hansen, & Lüdeke-Freund, 2016). Moreover, the business model is a key lever to address life cycle improvements in innovation management (Hansen, Grosse-Dunkler, & Reichwald, 2009), which enables the implementation of circular activities along the whole life cycle.

In contrast to product and product-oriented business models, SBM hold the greatest potential to generate positive environmental benefits and contribute to resource-efficiency and the CE (Tukker, 2004, 2015). They can lead to: (1) a higher use rate of capital goods, (2) a design that accounts for true life cycle costs to optimize energy and consumables, (3) less use of energy in the use phase, (4) efficiency gains due to economies of scale and (5) application of radically different technologies (Tukker, 2004). SBM also decouple value creation from resource throughput, allowing continued ownership and zero transaction costs, a reduction of the overall life cycle costs, a preservation of value over time and job creation (Stahel, 2010, 2016). Both, Tukker (2004) and Stahel (2010) identify different SBM (rental, leasing, sharing, outsourcing, functional result, among others) that emerge out of the efficient utilisation of goods and resources. Such SBM require the implementation of product life cycle extension strategies (producing long-life products, reusing, repairing, remanufacturing, upgrading and recycling) and offer profitable opportunities for innovative firms (Stahel, 2010).

Operational-level tactics has been recognized as being central for ensuring successful implementation of SBM (Reim, Parida, & Örtqvist, 2015), because many companies struggle to engage in SBM (Huikkola, Kohtamäki, & Rabetino, 2016; Reim et al., 2015; Tukker, 2015). Tactics are understood as residual choices at an operational level after the firm has chosen a particular business model through which it intends to compete (Casadesus-Masanell & Ricart, 2010). There is a range of tactical sets available to the firm according to the business model it has chosen (Reim et al., 2015). After a literature review, Reim et al. (2015) identified five influential tactics for implementing SBM: (1) contracts, (2) marketing, (3) networks, (4) product/service design and (5) sustainability. However, this list is not complete and a more comprehensive list of tactics based in empirical data is required. In addition, the interaction between these tactics and the different internal and external conditions can have an important influence in the success of the implementation of SBM.

A preliminary framework for a business model perspective on smart-circular systems

Smart-circular systems

According to Lieder and Rashid (2016), technological developments seem sufficiently mature to support the implementation of the CE at large scale. As the usage of the IoT grows, the capabilities of smart products, such as monitoring and reporting their own condition and environment (Porter & Heppelmann, 2015), can be increasingly utilised to allow for the development of feedback-rich systems and loops throughout the entire product life cycle (EMF, 2016). Smart products and digital tools enable better performance monitoring, data-driven design, and an extension of the product life cycle. They also remove barriers and offer the infrastructure to keep materials in circulation (EMF, 2016). For example, by assigning a unique identifier to smart products, companies are able to collect data during product utilisation, allowing for IoT-enabled full life product traceability (Whitmore et al., 2015). Moreover, smart products could adopt the characteristics of software products (Porter & Heppelmann, 2015) and be dynamically adapted or upgraded during the use phase according to new developments, user needs or the natural environment (Erler & Rieger, 2016). From this perspective, products change from something that is sequentially developed, manufactured and used into something that is dynamic and evolving (Erler & Rieger, 2016).

In order to better understand and conceptualize the scope of the transition of the industrial economy to a CE in the light of the emergence of smart products and the IoT, the authors introduce the concept of **smart-circular systems** (Figure 1). Smart-circular systems refer to product-service systems (PSS) (Tukker, 2004) and SBM that optimise the utilisation of smart products over time by introducing smart enablers that amplify circular activities like maintenance, reuse, repair, remanufacture and recycle.

Business models for smart-circular systems

Smart products and their amplified capabilities are reshaping the way value is created and enabling organisations to develop and offer new SBM (Lerch & Gotsch, 2015; Porter & Heppelmann, 2014, 2015). Their ability to remain connected and generate product life cycle data has led manufacturing and industrial companies to shift to SBM in order to maximize the value they provide to customers over time (Porter & Heppelmann, 2015). Companies like Caterpillar have begun to offer services like predictive maintenance powered by IoT and big data analysis (Marr, 2017).

Smart capabilities and the IoT can also expand the boundaries of an industry (Porter & Heppelmann, 2014). Companies are now offering a "set of related products that together meet a broader underlying need" (Porter & Heppelmann, 2014, p. 13). Therefore, the business model transits from offering products and a minimal number of services to offering a bundle of smart products and services (Lerch & Gotsch, 2015; Porter & Heppelmann, 2014) or smart PSS (Valencia, Mugge, Schoormans, & Schifferstein, 2015). In this sense, smart products and the IoT emerge as what might be the missing link in the widespread development and adoption of circular SBM. Moreover, moving from products towards "total system performance" (Porter & Heppelmann, 2014, p. 14) expands the scope of the business model towards an economy based in services or a "performance economy" (Stahel, 2016, p. 436) where the focus of the business model changes from production to utilisation (and end-of-life) of goods over time. The expansion of the traditional business model focus allows for a classification of distinctive business models types: (a) Product sales with quality services (traditional business model), (b) use-oriented business models and (c) performance-oriented business models (cf. Tukker, 2004) that can be linked to specific operational-level tactics to facilitate the design and implementation of SBM among practitioners.

Conclusions

This paper contributes to the body of knowledge by providing with a conceptual framework that establishes generic links between the IoT, the CE and SBM and serves as basis for further analysis of this emergent phenomenon. We also introduced the concept of smart-circular systems to highlight the interplay of these concepts in the transition towards a CE.

Acknowledgments

This publication is part of the research project "Business Models for Extending Industry 4.0 towards the entire Product Life Cycle (I4L)" conducted at the Institute for Integrated Quality Design (IQD). The IQD is jointly funded by Quality Austria (Quality Austria - Trainings, Zertifizierungs und Begutachtungs GmbH, Vienna), the State of Upper Austria and the Johannes Kepler University Linz (JKU).

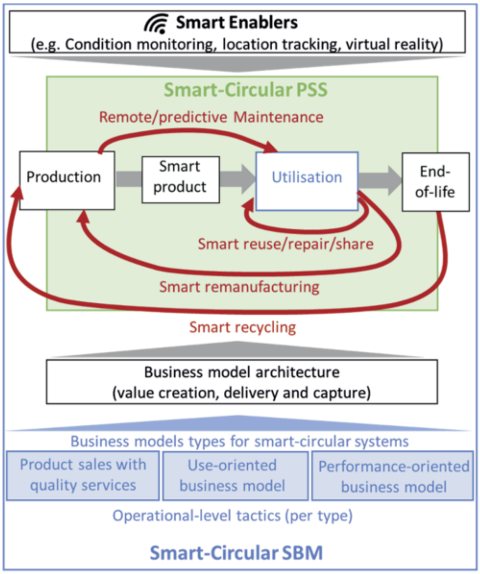

Figure 1. Smart-circular systems

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-14

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Design for sharing: libraries of things as a product-service system

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Keywords
Sustainable Design
Sharing Economy
Product-Service System

Abstract
Sharing can be a way to confront ecological and social challenges. Libraries of Things offer the process of sharing in a convenient way that fits into the users' everyday life. These Libraries offer access to a broad range of items to everyone at a low price. The items offered should be of high quality to minimize risks, to enhance the flow of the sharing process and to create as little maintenance effort and cost as possible for the library. The contradiction of offering high quality products for a relatively low price could be solved by a cooperation between manufacturers using Libraries of Things as a distribution platform. The Libraries could thus help the manufacturers to adapt their business to the circular economy. This paper does not present a ready-made solution yet, but rather reflects upon the role of design within this area of product-service system and defines further fields of research since Lending Libraries have not yet been reflected upon from a design-angle.

Introduction

The scope of design is widening: in the recent past the focus has shifted from designing an object to designing Product-Service Systems (PSS), in which the product is embedded. In the past, the drill was designed in a linear design process, following aspects of functionality. Design for Sustainability approaches from the very beginning (Green design, eco-design…) mainly included aspects of ecological matters (e.g. Burall, 1991; Fiksel, 1996; Mackenzie, 1997; OECD, 1998; Tischner & Charter, 2001; Boks & McAloone, 2009; Pigosso et al. 2015).

The focus shifted to PSS as "a mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customer needs" (Tukker & Tischner, 2006). In a corporate context, McAloone and Pigosso (2017) in their review described the shift of focus from products towards PSS and even predicted the upcoming development, which will be referred to within this paper. The reason for the analysis was, amongst others, whether "we are effectively developing our competencies, in order to be more effective in our approach to continued sustainability enhancement" (McAloone, Pigosso, 2017). For the years to come they predict a collaboration within and beyond the borders of value chains (see Figure 1). Within this paper, Libraries of Things (LoT) will be analysed using this framework as a referencing set.

LoTs are PSS and they are hubs focussing on collaborative consumption and sharing of items for everyday use (Robison & Shedd 2017). There are at least three reasons to expect that LoT will spread in the future:

(1) In industrial nations, the digital transformation leads to a growing gig-economy, which is leading to unsecure income. At the same time, digitization, the rise of the robots as well as artificial intelligence lead to a growing low-pay sector and, in these societies, the rate of unemployment due to technological displacement of people by machines (Stengel, 2017; Chang et al., 2016; Berger & Frey, 2016; World Economic Forum, 2016; Ford, 2015; Cowen, 2013; Frey & Osborne, 2013). LoT

	-20 years	-0- today	+10 years
Main goal / objects	Product	PSS	Collaboration
Expected results	End-of-pipe -> proactive	Proactive -> Sustainable	Sustainable -> restoratory
Main aim	Tool building	Tool implementation	Consolidated integration
Basic Approach	Singular problem approach	System approach	Holistic approach
Envisaged cost-benefit	Sustainability = cost	Sustainability = no extra value	Sustainability = business
Sustainability ambition	Environment	Environment + (social)	Environment + social capital + economic
Business mindset	Linear economy	Closing the loops	Fully circular economy
What are we changing	Improve the product	Improve the process	Improve our competencies
Decision-making level	Operational	Tactical	Strategic
	The rise and establishment of ecodesign (1990-2010)	*A systems perspective on ecodesign (2010-2020)*	*Perspectives for a sustainable and circular economy (2020-2030)*

Figure based on: Mc Aloone; Pigosso (2017)
From Ecodesign to Sustainable Product/Service-Systems: A Journey Through Research Conributions over Recent Decades.
In: Stark et al. (eds.) 2017: Sustainable Manufacturing, Challenges, Solutions and Implementation Perspectives.
Springer Open, pp. 99-111.

Figure 1. Shift from Ecodesign to Sustainable PSS. Source: own picture based on McAloone & Pigosso 2017.

guarantee access to everyday items even for people with low income or unsecure income, without the necessity to buy anything.

(2) LoT have the potential to reduce the energy and resource demand to produce these items, since fewer items are needed to cover the same number of users. LoT reduce the consumption of new products, since collaborative usage is enabled and organized. Thus, fewer items are used more efficiently, a) because they are used longer until they can't be repaired anymore and b) they are used more intensely since the otherwise idle times are utilised (USND, 2014; Tabor 2013). Rising world population will lead to a rising number of consumers in the next decades. Already today's world population is consuming resources 30% faster than the planet can provide them (WWF 2016). Consequently, there is a high demand for a smarter way of meeting humans needs. LoT could be a smarter way to maintain the material standard of living and simultaneously reducing resource consumption.

By focusing on supporting projects dealing with home energy efficiency, a much greater effect can even be achieved. A study of the Pacific Energy Center showed that Tool Lending Libraries that are lending tools to residents for free, in order to perform home energy audits, "reduce energy demand by 157 megawatts and save 92.5 million kilowatt-hours of electrical energy in the year 2011" (DENT Instruments, 2013).

(3) Due to ecological and technological change, two decisive societal constraints will change and societies affected by this change will have to adapt to the new "environmental" constraints to avoid negative consequences. This is the central idea of the transition theory. It implies the observation, which is taken over from natural evolutionary process, that societies feature experimental niches in which innovations can evolve and be tested, which differ from standardized structures and conventions, as shown in Figure 2. In case the development of LoT, which are more easily adaptable to changing constraints, takes place in these niches, they have the potential to become the new predominant institution (Rotmans & Loorbach, 2010).

Research Questions

Currently, LoT gather their items following two different strategies: in one model, functioning items are donated by private people and the LoT will lend these items as 2nd hand items, prolonging their lifetime. But "many consumer products are of mediocre build quality and hence fail quickly when subjected to the intensive use that a lending service entails. Poor design and a lack of spare parts often make it impossible to repair such products, leaving no alternative but to discard them at the first failure. Even if repair and maintenance are possible, the efforts required to keep these products in proper working condition is often disproportionate." (Opsomer, 2017) These items must be filtered out. Furthermore, gathering items by donations can only be an interim solution. When the attics and garages will have been emptied, a new model needs to be found to provide the LoT with the needed items.

The second possibility is to purchase the items, which partly is already done today. If products are bought to be used collaboratively, they should be long-lasting and be designed to support the sharing process as well as possible. The research questions this study is dealing with are:
1) How can companies be convinced to design items that are shared easily, even though this is against their own business model?

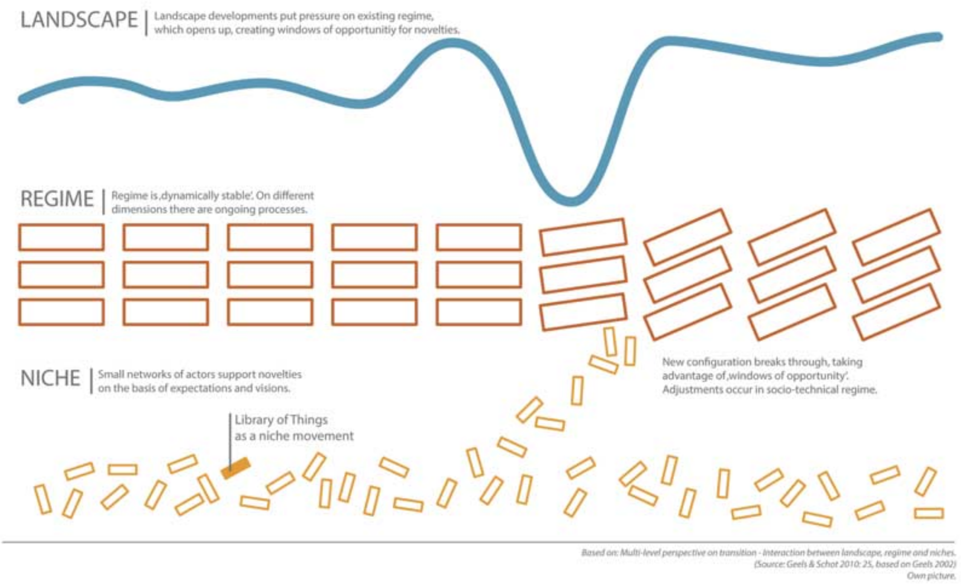

Figure 2. LoT as a niche movement - Transition Theory. Source: own picture based on Geels & Schot, 2010.

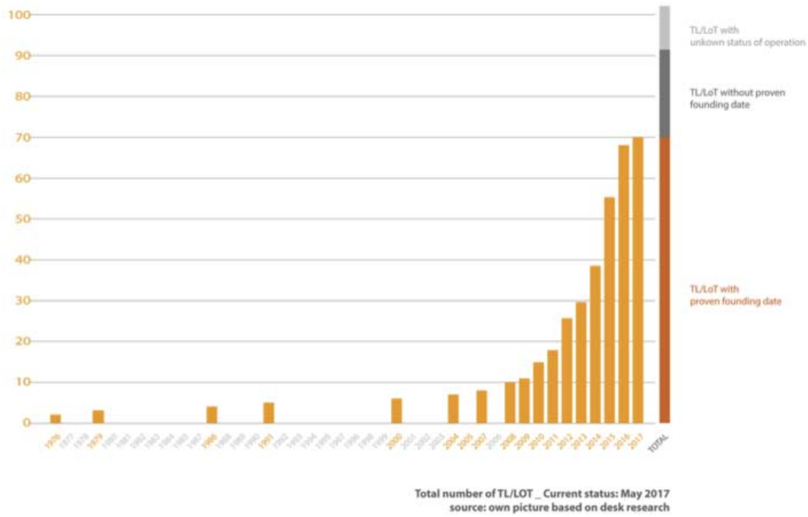

Figure 3. Total number of TL/LoT _ Current status: may 2017. Source: own picture based on desk research.

2) What can a business model look like, which is based on a LoT as a distribution-platform for existing companies?

This study focusses on the possible contributions of the product within the Product-Service System and the possible changes of the underlying business models.

Methodology, Limitation and Scope

In order to answer the research questions, first a desk research about existing LoT was conducted and their potential contribution for transformation was reflected using the transition theory. A full survey of relevant LoT, as well as interviews with the providers, are still ongoing. The most relevant topics were identified and starting from there preliminary criteria for improvement of existing LoT were derived. In a further step, these were transferred to entrepreneurial activities to show the potential for action. Finally, it is shown that companies can contribute to establish LoT in the mainstream of societies if they consider the identified criteria when designing their offer.

Research Outcomes

Libraries of Things – the ongoing movement up to now

LoT function like a traditional library, except that, instead of borrowing books, members can borrow all kinds of items. Up until now LoT still represent a niche, which is expanding quickly as desk research has shown (especially in a reduced version of a Tool Library).

The expansion rate is shown in Fig.2. Before the year 2000 there were just 3 LoT worldwide: Columbus (OH): 1976, Seattle (WA): 1977, Berkeley (CA): 1979. Figure 3 visualizes that since 2000 the number has increased to approximately 100, showing a faster expansion rate after 2010 (see localtools.org).

The insights gained so far demonstrate that LoT have the potential to overcome the barriers of current sharing economy offers, because they are rooted in the neighbourhood.

Nevertheless, discrepancies between the offer of the LoT

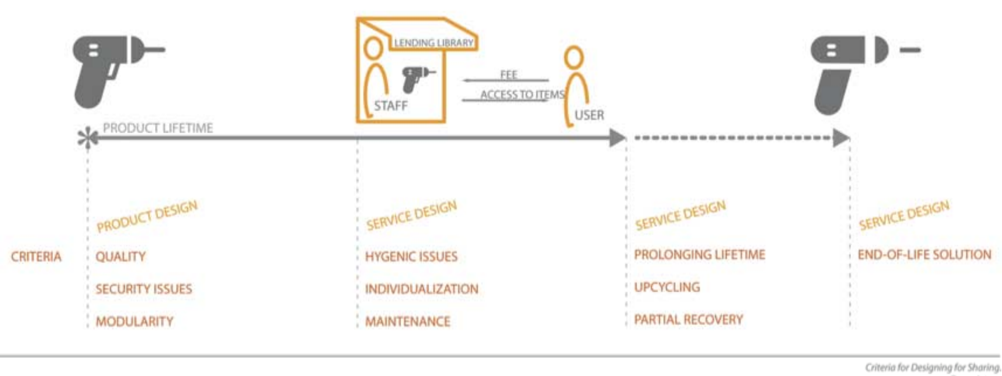

Figure 4. Criteria for Designing for Sharing. Source: own picture based on interviews, survey and desk research

and the demand of the users can already be identified: They should guarantee better access (central location, frequent opening hours) and provide a wider range and a higher quality of items in the pool (Ameli 2017). This means that LoT can evolve faster from a niche-phenomenon to a mainstream offer, if they become more user-friendly.

As was shown, the user friendliness is getting better when a wide range of products is offered at an affordable price, which once again leads to the question of how to gather items for the LoT.

As mentioned at the beginning, they can either be donated or exclusively bought for the LoT.

A first survey of the existing LoT has shown that gathering enough items by donations is no problem at all. Most libraries have way too many items and too little storage room. But at some point, this will not be an option any more.

In case of a new purchase it became obvious that many products are either of poor quality or far too expensive for the concept of a LoT, which wants to lend items for a small fee. Up until now there are no incentives for producers to change their production patterns. The market is asking for new products at an ever-faster pace for falling prices. With the concept of a LoT, an alternative to individual consumption is offered. In this model, the LoT can guarantee the purchase of high quality equipment, their maintenance and control of their professional disposal at the end of life. It can organize a recycling or upcycling process of their items.

Libraries of Things from now on

A) Criteria and their location within the bigger context

This study is part of a PhD project. Within this PhD the main research question is how the gap between the willingness to share and the actual lacking practice of sharing can be overcome with the help of a LoT.

Focusing on the aforementioned research question, the criteria described above were derived. These criteria will be connected to the phases of a product life cycle, as shown in Figure 4. All of these have to be considered while designing the product, although they might not come in effect until much later. Unlike an eco-design or green design approach (e.g. Burall, 1991; Fiksel, 1996; Mackenzie, 1997; OECD, 1998; Tischner & Charter, 2001; Boks & McAloone, 2009; Pigosso et al. 2015) the usage and the sharing context have to be taken into account from the very beginning.

Companies as provider of products AND services

It can be observed that the willingness of manufacturers to broaden their portfolio, including services (Deloitte Research, 2006; Visnjic, 2011), is increasing. Thus, even well established companies, such as Otto Group or Media Markt, have started online lending services lately, which are at least theoretically enhancing collaborative consumption patterns (Otto Now, 2016; Media Markt, 2017). In both cases products can be borrowed directly from them on a monthly base. Once the customer does not need them anymore, they can be sent back and possibly be replaced by an up-to-date model or something completely different. These examples show, that even enterprises located in the nowadays mainstream do experiment with business models, which have up until now been part of the niche movement.

If the manufacturers look at a LoT as a partner to distribute the own product portfolio as part of an alternative ownership model, both sides can profit from it:

a) The LoTs gain access to a high quality product range, which they can offer to their users. Thus the LoTs could react to the criteria identified.

b) Manufacturers could still focus on their core activities and outsource the task of creating their own service infrastructure. The LoT is the partner, being a specialist in delivering a service model and having completely different channels to the users, since the LoT is a place for social interaction, networking, gathering information and counselling (Ameli, 2017).

Thus a LoT can be pushed out of the niche into the mainstream (Figure 5).

Preliminary Conclusions

The willingness to share items, skills and time can be noticed internationally (Nielsen, 2014). Nevertheless, so far this willingness did not necessarily lead to a collective shift of daily consumption practices (BMBF, 2016; Gfk Verein, 2015; INGDiBa, 2015; UBA, 2015; Verbraucherzentrale, 2015). The sharing of everyday goods, however, is lagging behind its potential (Sundararjan 2016). This is partly due to the fact that currently offers that are focussing on sharing daily items are not user friendly enough (BMBF, 2016; Pelz, 2012): Nowadays offers are mainly online, the effort for arrangements between the users are mainly high, people want to borrow things but not to lend things and trust between strangers is an issue as well as liability in case of problems. LoT confront these issues as the offer is located offline (and online) within a neighbourhood, opening times as well as borrowing conditions are organized and fixed, which reduces the organizational effort and the LoT as institution acts as person in charge which minimizes trust and liability issues (Ameli 2017).

If a LoT succeeds in overcoming these sharing-barriers, it can lead to changed consumer choices and enhance collective behavioural changes: fewer items will then be consumed individually but they are shared and used collaboratively.

To confront the global challenges mentioned in the very beginning, manufacturers should design up-to-date, long-lasting products that are supporting collaborative usage. LoT can be seen as a solution for the company goal of including services in their own portfolio. LoT can be cooperation partners for sustainable business models (Figure 6).

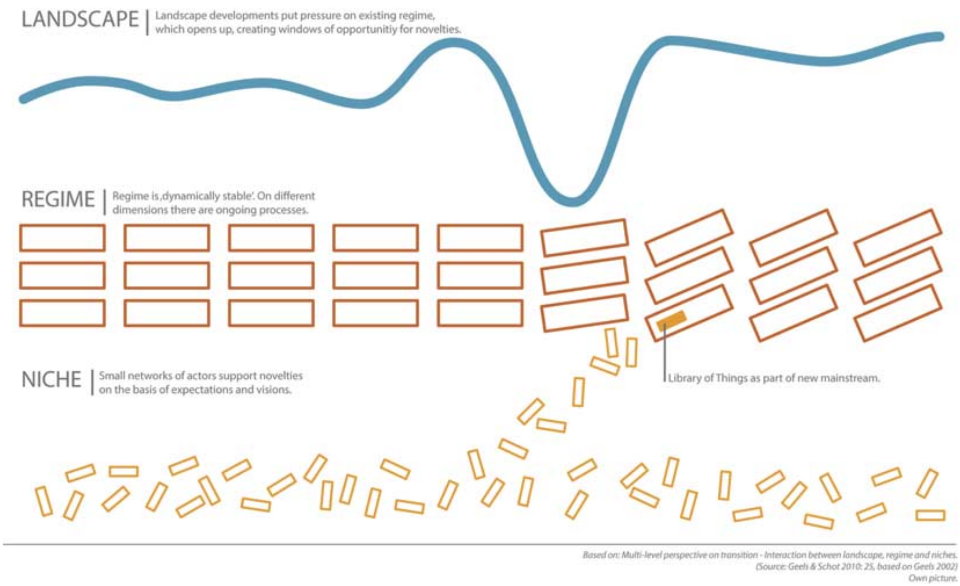

Figure 5. LoT as part of new mainstream. Source: own picture based on Geels & Schot 2010.

These findings lead to the answer for research question 1 and 2:

As soon as companies look at LoT as a distribution channel for their own products and use them as a hub for communication with users, there will be an opportunity to derive at a business model, which according to McAloone & Pigosso does not focus any more on products and also not only on PSS but on a collaboration with initiatives, such as LoT, and their user. With the help of the institution of a LoT it is possible to move from a linear economy towards a circular economy, since the LoT can take over strategic tasks, which so far have not been affordable for the companies themselves. If seen as a hub where the manufacturer connects with the user, the LoT can enhance the process of collaboration and lead to a holistic approach. LoTs can thus help to speed up the change.

Further Research

There is still no answer to the question of how to reach this form of cooperation. So far there are not enough LoTs out there yet. Thus, the critical mass of items to attract the manufacturers' attention to adapt their products for this new model of sharing is not yet in demand. For a LoT the cooperation only makes sense if the items are affordable, in order to keep user fees low and to guarantee future access for everybody. But following the argumentation of the transition theory, the changing ecological and technological constraints will lead to the fact that this critical mass will be reached.

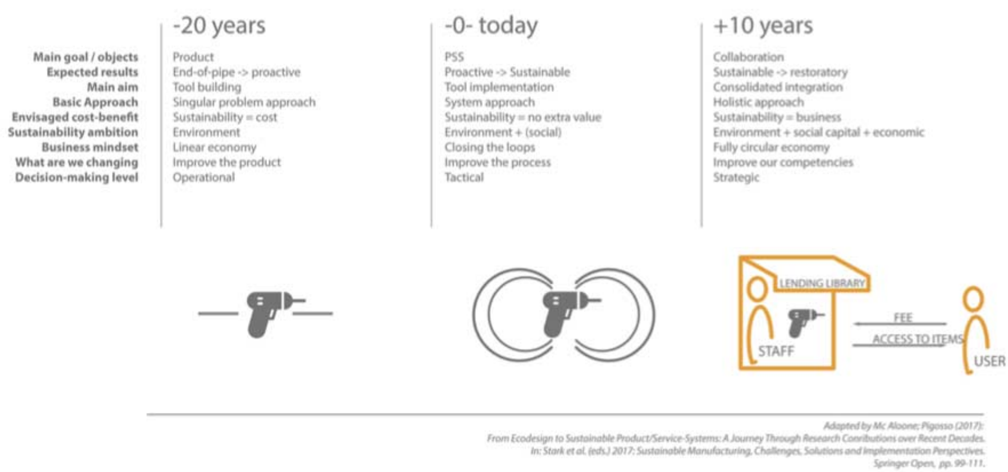

Figure 6. Designing for Sharing. Source: own picture based on McAloone & Pigosso 2017.

Acknowledgments

This work is funded by the North-Rhine Westphalian Ministry of Innovation, Science and Research (MIWF NRW) under research grant no. 322-8.03-110-116441.

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PLATE conference
Delft University of Technology
8-10 November 2017

Uniquely for you: the individualised avenue for longer product lifetimes

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Keywords
Product individualisation
Product lifetimes
Automation
Consumer type and behavior

Abstract
Object customisation has historically been a regular practice as a form of self, or group-identification. A product we can identify ourselves with, is one that we keep for longer, tend to repair when it breaks and dispose of later as a result of an emotional bond with it. Such bond is strengthened when we invest time and effort customising. Consumer involvement when customising is facilitated by new technologies in design and manufacturing. For example, computer algorithms can automate customisation, meaning products are customised *for* consumers rather than *by* consumers, (namely *individualisation*). However, the adequate 'amount' of consumer interaction is still debated amongst researchers. This paper questions the consumer benefit and extent of an emotional bond with *individualised* products. Using a mixed-method approach, 63 participants responded to in-depth interviews while engaging with individualisation exercises. Respondents were profiled as either of two types of consumers depending on their interest in art, design and critical engagement with what they consume, namely *Active Consumers* (AC) and *Passive Consumers* (PC). Results suggest individualisation attracts PCs, showing signs of greater engagement in the process and attachment to the product than ACs. PCs welcomed the automated decisions taken by an individualisation toolkit, whilst ACs found it detrimental to the experience. It is claimed that individualisation can strengthen emotional bonds between PCs and the resulting products. The paper concludes that individualisation could offer PCs new experiences, enriching their lives, generating an emotional attachment leading to longer product lifetimes, and potentially changing consuming behaviours otherwise unlikely to be nurtured.

Introduction

Object customisation has historically been a regular practice as a form of self, or group-identification. Egyptian pharaohs, for example, had their coffins custom decorated with messages and symbols preparing them for the afterlife. Those same sarcophagi would later be reused and re-customised when other members of the family died, as explained in (Cooney 2007). Millennia later, manual processes of production and customisation were still common practices, with examples from jewellery pieces made to order, to tailored clothing. The arrival of industrialised methods of production took manufacturing from the domestic environments or small garages and into factories, making customised products a thing of a rarity reserved for the skilled person. Technology developments in the fields of design, digital manufacture and communication since the early 1980's rediscovered the power of consumers to choose and create what they consume in an environment of products otherwise characterised by the 'one size fits all' mind set. Indeed, studies in the field of product customisation, have identified product uniqueness as a consumer need for achieving satisfaction (Tepper et al. 2001; Etgar 2008). Additionally, a product we can identify ourselves with, is one that we keep for longer, triggers a rediscovery for repairing and re-using, and we dispose of later as a result of an emotional bond (Mugge et al. 2009; de Beer et al. 2009; Mugge et al. 2009; Ariadi et al. 2012) suggest consumers develop such emotional bond when they are involved in the customisation process themselves as they invested time and effort (both physical and intellectual) in that process.

Computer algorithms are capable of making automated product optimisation processes possible, such as in aerospace and medical industries (Yang & Bouchlaghem 2010), guaranteeing speed to obtain safe and manufacturable results. Such an automated approach is becoming a common practice amongst designers, artists and architects for the generation of a wide variety of customised artefacts. It is therefore necessary to establish whether such an automated approach to customise products (namely product individualisation) is capable of generating products that users can emotionally attach to, thus achieving similar results to products customised by consumers themselves in terms of product lifetimes.

Background

Computer algorithms applied to automate the customisation of consumer products, means products are customised for the consumer rather than by the consumer. The amount of consumer interaction, or freedom, in customisation processes, is a topic of debate amongst researchers and practitioners in the field (such as Franke et al. 2010; Piller 2010 and more). For example, Mugge et al. (2009) argue restrictive toolkits could hinder the development of an emotional bond with products, whilst Campbell et al. (2012: 7) claim that toolkits should "limit user freedom" in order to secure standards of safety, functionality and manufacturability. This paper builds on that body of work by questioning what are the benefits of individualisation for consumers. Particularly, it looks at the relationship between the engagement of consumers with customisation process governed by automated means, such as individualisation, and the extent of an emotional bond with the resulting products. The study goes on to determine if such bond can also make consumers keep individualised products for longer, extending the product lifetime.

Methods and Sample

This work had a mixed-method approach using semi-structured interviews, experiments and observation for data collection. The interviews were designed based on Ariadi et al. (2012), and Franke and Schreier (2010), assessing both: the participants' engagement experience with a customisation exercise (individualising a white t-shirt with a pattern of painted marks) and their attachment with the resulting product (participants were allowed to keep the t-shirt). That t-shirt was both a vehicle to illustrate the exercise and a motivator to attract participants. A total of 63 participants responded the interview while doing the proposed individualisation exercise, which required them to choose their favourite coloured pattern design to apply on a t-shirt.

Individualisation exercise

To start the exercise, each participant had to roll two dice to find out how many paint marks his or her t-shirt would have. The reason for using dice to find out such number was twofold: it gave the participants a sense of participation, and portrayed an element of uncertainty in a process that takes over the decision-making. Second, the participant interacted with computer software (the toolkit), which worked with an algorithm designed using Processing software (Fry and Reas, 2017). The toolkit featured a white t-shirt on the computer screen, as shown in Figure 1.

Figure 1. Screenshot of the toolkit.

Each time the participant pressed the space bar, the toolkit would randomly place a coloured mark (using one of six available colours) over the front of the t-shirt on screen. The space bar was pressed as many times as dictated by the number obtained by rolling the dice, ending with a pattern of colours over the on-screen t-shirt. Once the space bar was pressed all the required times, the participant had to choose between keeping the resulting pattern design and turn it into a real t-shirt, or use the toolkit again. The participant could use the toolkit as many times as desired until achieving a pattern design he or she liked on screen. Finally, using syringes loaded with paint, the participant physically applied paint marks over a real t-shirt, copying the chosen design on screen (see Figure 2, below). The physical interaction with the syringes and paint offered the participant an opportunity to feel as an active part of the customisation process even though they could not create their own design. This last part of the exercise was designed based on previous studies in product customisation that indicate a consumer needs to invest physical effort in order to engender an emotional bond with the product (Mugge et al. 2009).

Sample

The sample considered for this work were consumers that grew up with mass manufactured products and demand more personal products with which they can make an affective connection. These are consumers who are independent to decide their own purchases, familiarised with computers, software, online shopping, modern communication channels, interaction with retailers, and are aware of customised design (from computers, mobile phone deals, clothing, accessories, and more). This group includes the "prosumer": a "22 to 42 year old consumer activist" who is "powered by connectivity and interactivity" (Konczal, 2008). After a comprehensive

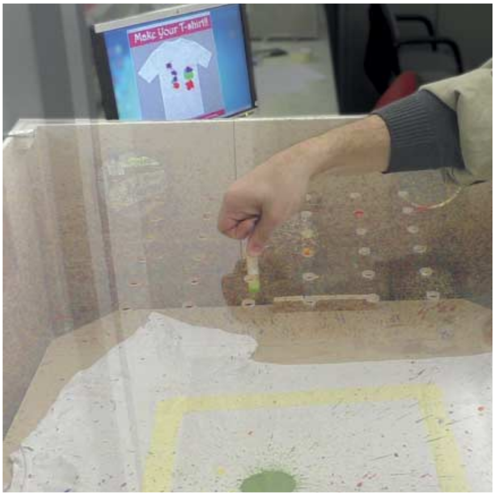

Figure 2. Participants applied paint on a real t-shirt following the design on the toolkit.

review of product customisation literature (particularly Ariadi et al. 2012, Franke et al. 2010 and Sinclair and Campbell 2009), it became clear that the sampling criteria should explicitly profile the respondents' as either of two proposed types of consumers:

- *Active Consumers* (AC) group or 'makers' – Individuals who are interested in art or design activities, by profession, study, hobby or keen interest, and who are interested in getting a customised t-shirt (40 participants).

- *Passive Consumers* (PC) group also called "lay-designer" by (Hermans 2014) – Individuals with no particular interest in art or design activities, but who are interested in receiving a customised t-shirt (22 participants).

Each participant was profiled during an introductory questionnaire at the start of the interview. That questionnaire asked whether the respondent:

- Had customised a list of products and when this was
- If they did customise products, what sort of participation they had
- Whether they had any art, design or craft-related hobbies
- Whether they would "self-identify as interested in design" (Sinclair and Campbell 2009) and art.

That differentiation of consumer types was deemed necessary given the automated characteristic of individualisation and the possible degree of consumer interaction allowed, generating different effects on either type of consumers.

Responses were analysed using thematic coding analysis, producing 26 major codes and four overarching themes. Eight weeks after the interview took place, further questioning was sent to the participants via email, assessing their attachment to the product over that period of time. After the thematic coding analysis, the qualitative codes were quantified using a scoring system based on Henerson et al. (1988) that allowed identifying which were the key codes that could best explain the participants' behaviour.

Findings

The proposed participant groups, AC and PC, showed distinct behavioural characteristics. ACs spontaneously looked for an opportunity to customise the t-shirt according to their preferences. Meanwhile, PCs expected indications of how to do the exercise. Both groups of participants obtained t-shirts of similar quality. Figure 3 shows a sample of resulting t-shirts.

Figure 3. Sample of finished t-shirts.

The PCs felt the automated toolkit allowed them to participate in the individualisation process without the responsibility of deciding how to design a pattern. PCs felt comfortable with the exercise, engaged with the process and valued the individualisation experience. Further, PCs explicitly highlighted that the automated decisions taken by the toolkit was a beneficial feature of the individualisation exercise. PCs valued their chance to have an input on the otherwise automated process (rolling the dice, pressing the space bar and using the syringes) thus feeling ownership over the resulting design. On the other hand, ACs struggled with the software that restricted their personal choices as they hoped to design a pattern by themselves. When they found that the automated nature of toolkit dictated how the design should be (participants were invited to customise a t-shirt but were not advised how that would happen), they become frustrated and did not engage with the process or felt ownership over the final design. ACs results were evidenced not only through their responses to the interview, but also through other verbal expressions of disapproval and their body language.

During the physical participation of painting the t-shirts, ACs talked more positively and frequently than PCs, even though ACs showed signs of frustration with the overall experience (which included the use of a restrictive toolkit), highlighting the differences that characterise the two groups. The PCs referred to the physical painting part of the exercise (e.g. using painting tools) less positively than ACs, but it triggered the sense of achievement and pride at the end.

Once the exercise was finished, the PC participants referred to the resulting t-shirt more positively and felt attached to it more than AC participants did. Responses to the additional questions that were emailed to all participants eight weeks after the interview, indicate that whilst not all PCs wore the t-shirt, they did still have it, keeping it with other clothing and took care of it. On the contrary, ACs referred to the t-shirt more negatively: only one of them wore the product, some forgot were they kept it and some no longer had it (they lost it or gave it to someone else). Two of the ACs did keep the product only because they further customised the t-shirt (e.g. cut the sleeves or added paint marks).

Finally, only two participants (both ACs) commented on the risk of waste due to unwanted individualised results, given that the exercise did not allow them to customise exactly as they initially wished. This did not seem to be a relevant issue for the PC group, as they did not mention it.

The qualitative responses were quantified using Henerson et al. (1988), and suggest that ACs' attachment to the product was weaker than that of PCs'. The difference between PCs and ACs behaviour was key when evaluating individualisation as a driver for extended product lifetimes.

Discussion

Consumers that align with the PC profile as described in this study, do not regularly seek to engage in product customisation activities that require a level of effort they are not keen to make (as well as art and design skills they do not possess). It is argued that PCs' positive response to automated customisation was due to their lack of experience in art, design and craft. In other words, the software aided them to find a coloured pattern that they liked with a minimal amount of effort, making those participants engaged with the experience and valuing it positively. Although the act of physically painting the t-shirt (following the pattern on the computer screen) was a challenge for PCs and they perceived it negatively (probably due to their unfamiliarity with that sort of activities), it arguably allowed PCs to be proud of the finished t-shirt. It could be said that the opening of new design and customisation avenues driven by the automated means as discussed on this study, could have the potential to alter the consumer behaviour of PCs as they benefit from new and attractive new experiences.

ACs approached the exercise with more developed art and design skills than PCs and higher expectations of the pattern design they could generate. Those expectations were not met, turning their engagement with the process unsuccessful. Whilst the ACs cohort did welcome the act of physically painting the t-shirt, it was not enough to generate an emotional bond with the product as they did not feel authors of the design, leading to not keeping the product as PCs did.

The evidence suggests that individualisation experiences (which technically restrict the consumer freedom when interacting with the customisation process) can engage PCs, and the resulting products can generate an emotional attachment. In line with Mugge et al, (2009), PCs' emotional bond with the t-shirts resulted in keeping them for longer than ACs, who did not experience an attachment. Therefore, the argument that restrictive toolkits deteriorate the emotional bonding with customised outputs is challenged in cases where the user matches the proposed PC description.

The automated customisation process studied in this paper, generates designs that give PCs the opportunity to obtain unique goods. This paper, however, only considers individualisation at small scale: 63 participants who obtained 63 unique t-shirt designs. It is uncertain what could be the effects of individualisation over the uniqueness value (as identified in (Tepper et al. 2001; Etgar 2008) of products if individualisation was applied at an industrial scale. It is speculated that mass-individualisation (generating uniqueness en-mass), could hinder its uniqueness value as it becomes an ordinary thing instead of something exclusive.

Conclusions

PCs (individuals with no particular interest in art or design activities) welcome the automated decisions taken by an individualisation toolkit to customise. This study concludes that an individualisation approach to customisation can offer a beneficial opportunity of consumer interaction and product attachment, particularly for PCs. As such, those consumers obtain more opportunities to obtain unique, customised belongings with which they can establish an emotionally bond. The study also concludes that limiting the level of consumer participation in the process can generate added value products and emotional attachment them. ACs on the other hand, are not attracted to automated process of customisation due to the uncertainty over the resulting product.

An automated process of customisation can offer an interesting avenue to customise and open up novel channels for artistic expression assisted by computer algorithms, attracting those consumers who would not spontaneously be persuaded to invest time or effort customising. As a consequence, those consumers benefit from living new experiences that enrich their lives, potentially changing consuming behaviours. Individualisation could therefore be considered as a valuable opportunity for practitioners, developers and entrepreneurs to generate new businesses around customised goods for PCs, generating the necessary emotional attachment for longer product lifetimes, which would otherwise be unlikely to be nurtured.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-25

"Crafting the waste" as a stimulus to collaborative learning and collective production: an example from Turkey

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Keywords
Craft
Cooperatives
Collaborative learning
Collective production
Upcycling

Abstract
Craft, playing a significant role in the story of sustainable fashion design, is a deep-rooted tradition in Turkish society. Besides the symbolic meaning of the hand-made, by generating emotional bounds it hinders consumers from throwing their products away (Clark, 2008). Therefore it is used as a design strategy to eliminate waste. Moreover, many of the Turkish craft techniques are based primarily on the reuse of the old and wasted materials. Over the last few years, many women-centred initiatives and cooperatives started to value craft and labour-intensive production outside of a home. However, many traditional craft techniques are on the verge of extinction since the Turkish youth is not willing to learn them. It is an uneasy fact that in design education, craft-based practices, and collaborative work are generally ostracized. However, craft based practices promise to be valuable methods for the development of sustainable design in developing countries. Regarding the current situation of craft and design education, the aim of this research is to explore how design education can be re-contextualized in order to generate social change, stimulate collective production and question the hierarchies in the existing system. The main objective of the study is to generate alternative ways of learning and designing through craft and upcycling. Therefore; in addition to the literature review, a case study has been conducted. As part of the case study, a small group of volunteer Textile and Fashion Design students were asked to collaborate with a women's cooperative and create a collection of accessories collaboratively.

Introduction

Craft, playing a significant role in the story of sustainable fashion design, is a deep-rooted tradition in Turkish society. Reusing and reclaiming old materials are very common techniques used in traditional Turkish crafts. Many women-centred initiatives and cooperatives started to value craft and labour-intensive production outside of a home in the recent years because craft based production fights with unemployment of uneducated women who are oppressed by patriarchy. It is a powerful tool in bringing a community together and enhancing collective production. However, in Turkish design education, craft-based practices, and collaborative work are ostracized. The education system is substantially market-oriented and it works for the benefit of the linear economy where products are disposed at the end. Young generations taking design education are quite alien to traditional handcraft techniques. For Papanek, design education is based predominantly on commercial concerns (2009). It ignores considering social and ecological circumstances that surround designers and designed objects. Margolin argues that general design education is restricted to the act of giving form to materials and design's relation to other disciplines and natural or cultural systems are rarely considered in that structure (1998). It is a gratifying fact that within the last two decades, design paradigm has been heading towards sustainability in the developed world. On the other hand, for economically emerging countries such as Turkey, there is still a long way to go. However, craft promises to be a strong tool for sustainable design in developing countries because it brings a slow approach to design and consumption, fights with unemployment and supports the preservation of cultural heritage. Considering these, the aim of this research is to explore how design education can be recontextualized in order to generate social change, stimulate collective production and question the hierarchies in the existing system.

Research Method

This study seeks to generate alternative ways of learning and designing through craft and upcycling. Therefore; in addition to the literature review, a case study was being conducted. As part of the case study, a small group of volunteer Textile and Fashion Design students were asked to collaborate with a women's cooperative which is in the same neighbourhood with our university.

The Role of Craft in Sustainable Design

Critical approaches against production and consumption habits of the post-industrial era opened the way of sustainability in the 1960's. Yet, the notion of 'sustainability in design' started to be on the agenda of designers since 1970's. Design theorists and designers such as Papanek spearheaded the flow of environmentalism by criticizing the position of design in creating wasteful products. "There has been a growing feeling in many environmental circles that design and manufacture is responsible for many of the man-made stresses imposed on the planet" (Bahmra and Lofthouse, 2007: 1). This flow of environmentalism continued in the following decades. Following the consumerist approaches of the 1980s, "in the 1990s the consumer's consciousness was raised again, this time under the banner of environmentalism" (Welters, 2008: 24). The United Nations Conference on Environment and Development (UNCED), took place in 1992, in Brazil became influential on lifting the effectiveness of environmentalist movements. Terms such as green products (Black, 2008), eco-efficency (Braungart and McDonough 2007) provided a ground for the "green consumerism" took place in the 1990's.

However, 2000s became different from the 1990s. Changing the consumption focused lifestyles of masses through the power of design became more important than simply greening the products (Thorpe, 2010). It is understood that, the role of design became more important and extensive in changing unsustainable production and consumption patterns. Margolin pointed out that there has been a shift from green design to sustainable design by the end of 1990s (1998). This change was necessary in the way of broadening the scope of design from being an instrument for shaping objects. For him, the future of design can be sustainable providing that designers that belong to design culture can go "outside of mainstream consumer culture" (1998: 86) and adopt a more socially responsive role.

Sustainability coincided the term "slow" in fashion terminology. Slow fashion manifest published in Milan in 2006 became highly influential on the fashion system. Clothing designed within the scope of slow fashion are qualified, crafted, sustainable and local. Production systems are transparent so that the buyers are aware of the processes that their products are imposed and aware of the social position of manufacturers. As Kate Fletcher (2008) put forth, slow is about producing, appreciating and cultivating "quality". Valuing craft based design has become an important part of slow fashion since craft elevates the quality of a product and supports communal production. Craft based design is a highly challenging phenomenon for the rapidly changing global fashion industry because craft undermines the obsession of novelty and constant change imposed by the conventional fashion system. It intensifies users' attachment to products by generating social and cultural meaning, accordingly eliminates the problem of waste (Clark, 2008).

Upcycling engaging Craft Culture in Turkey

The design understanding that regards consumer culture as the primary shaper of its identity leans on a system of operation which is linear and this system includes four phases; design-production-consumption-disposing. Disposal is the ultimate phase that clothing can reach in consumer culture. Intrinsically, the principal problem is considering unfashionable clothing as "waste" (Fletcher, 2008). However; as it is discussed by McDonough and Braungart, waste does not really exists because we cannot annihilate any product 100 per cent, whatever is conducted to it, the traces will remain on the ecosystem (2009). An approach that can change the perception of "waste" and thinking it in a different context can eradicate its initial meaning and praxis. Up-cycling, reconditioning and reusing practices aim to transform this linear operation to a cyclical one by reconsidering the last phase as the first one. In this way waste becomes a source for creating and producing new clothing in an ethical way. Thus, "waste is elevated to a thing of use and beauty" (Fletcher, 2008:98).

Turkey, located in between Asia and Europe, being a transitional country, possesses a substantial amount of traditional craft techniques. Anatolian heritage is one of the most wealthy craft treasures in the world since many different cultures such as Sumerian, Hittite, Phrygian, Lydian, Hellene, Roman, Byzantine, Persian, Mongolian, Selcuk, Ottoman… etc. left their marks on Turkish culture. Effective use of resources and evaluating wasted materials has always been a way of life for the Anatolians. Although capitalism and fast fashion affected the country in the last three decades; talking specifically on the Turkish crafts, one can clearly observe that many of the techniques and practices are based primarily on the reuse of the old and wasted materials. For instance; old cardigans and pullovers can be unravelled and knitted to form beautifully made rugs, or sweaters and dresses can be cut into small pieces and be crocheted to create table cloths. This means the method of "upcycling" has already been a part of Turkish textile craft traditions. The tacit knowledge and practices should be transferred to younger generations as well.

Case Study: Collaborating Sarıyer Women's Cooperative and Producing Collectively

Sarıyer Women Entrepreneurs Cooperative was founded in 2012 in Istanbul to support women that live in eight different villages around Sarıyer. Their establishment was supported by the Consulate General of Sweden. The cooperative is managed by women with the aim of helping the needy villagers. All of its partners are women. They aim at supporting women to satisfy their economic, social and cultural needs. In order to do this, they encourage women to produce various products either from home or at the atelier which is located in Sarıyer. Moreover, the cooperative is supportive in marketing their products. Various training activities held in the cooperative induce women to create products such as bags, yoga mats with high added value. However, they still needed support in design development phase.

This year, one of the biggest department stores; Boyner, in Turkey, donated discarded fabrics to the cooperative. In this project, 5 students were asked to learn a different traditional craft technique in order to create accessories by adopting upcycling method as a design strategy. Although they learnt different techniques, they collaborated during the project. It was required to visit the cooperative on a regular basis to understand and know each other very well. Partners of the project were a sustainable design consultant (at the same time one of the founders of the cooperative), the group of students, a group of villagers and I as an academic. Our major objective was to create accessories made of donated fabrics which are peculiar to the unique identity of the cooperative. Without a definitive hierarchy among the group, they aimed to develop multiple relationships and design solutions underlining the significance of collaboration.

Collaborative Learning and Collective Production

Competitiveness and individualism have become the two principles of design education since the Industrial Revolution. The necessities of capitalism and the expansionist economic model have been forcing designers to a 'quantity' focused production and design philosophy. This "philosophy is an equal mixture of the kind of self-expressive bohemian individualism best expressed in la vie boheme and a profit-oriented, brutal commercialism" (Papanek, 2009: 285). When the only goal of a designer is to increase the sales of his/her designs s/he is alienated from the society. Traditional way of teaching and design education in the developing world and in Turkey is still highly individualistic, alienating the designers from the environment that they are surrounded by.

> *The main trouble with design schools seems to be that they teach too much design and not enough about the social, economic, and political environment in which design takes place. It is impossible to teach anything in vacuo, least of all in a system as deeply involved with man's basic needs as we have seen design to be (Papanek, 2009, p.290).*

This way of an education system leads to the division between the real world and the world of school (Papanek, 2009). Thus the system of education, itself, becomes the main obstacle in authentic learning by generating a barrier in front of real life experiences. Fortunately, the individualistic and competitive way of teaching has been questioned by many academics, and collaboration has become a rising trend in the 21st century. "Collaborative learning is based on the idea that learning is a naturally social act in which the participants talk among themselves" (Gerlach, 1994). It is an educational approach that involves groups of students work together to complete a task or create a product.

> *There is a sharing of authority and acceptance of responsibility among group members for the groups' actions. The underlying premise of collaborative learning is based upon consensus building through cooperation by group members, in contrast to competition in which individuals best other group members. CL practitioners apply this philosophy in the classroom, at committee meetings, with community groups, within their families and generally as a way of living with and dealing with other people (Panitz, T., 1996 cited in Laal and Laal, 2012, p.493).*

Collaborative learning puts emphasis from individual efforts to group work, from independence to community (Leonard and Leonard, 2001). It requires active involvement of all of the participants and underlines the importance of notions such community, sharing, responsibility. In this respect, outputs of collaborative learning and slow design are parallel. "Slow Design processes are open-source and collaborative, relying on sharing, co-operation and transparency of information so that designs may continue to evolve into the future" (Straussi and Fuad-Luke, 2008).

Figure 1. Denim laptop bag with hand knit closure detail made of discarded materials.

In this project a collaborative approach was adopted. When engaging craft and design education together we aimed to form a democratic and collective environment of learning and production in which the traditional roles of master-apprentice, student-teacher, designer-producer reversed over and over again among the students and women of the cooperative. As Schrage defined collaboration as 'the process of shared creation: two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own' (1995, p.33), in this collaboration with the women's cooperative, students provided a designerly approach, focusing on elements such as function, simplicity, identity, uniqueness, while women provided a craft and practice based approach. They shared their knowledge and practice.

Figure 2. Denim bag with braiding made of discarded materials.

"Crafting the Waste" as a Design Strategy

Craft culture, itself encapsulates collaboration and sustainability because craft techniques and objects are the products of cultural heritage and they are collectively made. Therefore within the practice of sustainable fashion design craft plays a significant role. Besides the symbolic meaning of the hand-made, by generating emotional bounds, it hinders consumers from throwing their products away (Clark, 2008). Therefore it is used as a design strategy to eliminate waste.

In Turkey, even though generation X is slightly familiar to craft based activities, generation Y and Z are pretty alien to them. Many traditional craft techniques are on the verge of extinction since Turkish youth are not willing to learn them. It is an uneasy fact that in Turkish design education, craft based practices and collaborative work are ostracised. Education system is substantially market oriented and it works for the benefit of linear economy where products are disposed at the end.

The project aimed solving two problems at the same time; students' engagement with craft based activities and eliminating waste. As a result, the idea of "crafting the waste" emerged as a design strategy. As it is noted previously in this paper, traditional Turkish crafts heavily rely on the re-usage of the formerly made handcrafted

Figure 3. Denim bag and clutch with braiding and crochet details made of discarded materials.

Figure 4. Denim I-pad bag with hand knit details made of discarded materials.

objects, we tried to mimic the same structure. Although the students had never practiced traditional handcraft techniques before, during the project three of them have learnt how to knit, one of them has learnt how to crochet and one of them has developed a technique from braiding. All of the students used discarded jersey and denim fabrics because they were asked to create a unique design identity associated with the cooperative.

Denim fabrics became the base for their collection and jersey fabrics were cut into small pieces and used as knitting threads. They have chosen to develop a simple, functional and timeless design language and produced one clutch, a laptop bag, a backpack, a tablet bag and a laptop cushion. The collection was given to the cooperative and it is open for development. The women of the cooperative will stick to this new design language that has been created collaboratively and develop new products.

Figure 5. Denim laptop cushion with hand knit details made of discarded materials.

Conclusions

The main purpose of this study was based on the idea of cherishing traditional craft culture while creating a collaborative learning environment for design students with the occasion of supporting local producers. The outcomes of this project were quite favourable for design students and local woman producers. In women's cooperatives of Turkey the quality of design was problematic. They usually become objects of souvenirs. In this project students played a significant role in elevating the design quality of what is produced in cooperatives. The interaction changed and improved both sides' perspective to design and production. The students have learnt going beyond feeding their ego. Instead of expressing their individuality, they grasped the importance of sharing and designing in a socially responsive manner during the design process. They also understood the importance of respecting traditional production methods. Moreover, it changed their approach towards material usage. In a regular design education they were free to choose any material that they wanted but in that project they limited themselves with what is given and what was wasted. This helped them to be real problem solvers. To sum up, the project has embraced various concepts introduced within the discourse of sustainable design such as; revaluation of discarded materials, collaboration with local workforce and preservation of local know-how and traditional crafts. In this regard, it became a valuable example for further studies that will take place in the developing world.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-30

Sustainable product management by integrating physical and digital lifecycles

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The concept of circular economy has received an increased interest of public, societal and corporate actors in the last years. The basic idea is that the current linear industrial system, which uses raw materials for infrastructure, products and services, which are disposed after their life time, is changed to a circular system where products and materials are used in cycles as long as possible and where energy efficiency is maximized. The advocates of a circular economy ascribe different benefits coming along with this change from a linear to a circular economy; especially environmental benefits like less/zero waste, increased resource efficiency and less negative impacts in ecosystems, but also societal and economic benefits are discussed. To realize the vision of a circular economy products, have to be designed and managed in a way that material flows are closed and energy use is minimized along the physical lifecycle of a product. If materials and products should be kept within the economic system, i.e. if their circularity is maximized, a lifecycle-wide product management is needed.

The digital revolution can be an immense enabler for a transition towards a circular economy and for sustainable product management. The physical lifecycle is represented in data systems of companies and institutions involved in a value chain. Products themselves collect and report more and more data during their usage. But until now, all these data sources are disconnected and not used for a sustainable product management. If it is possible to map the digital product lifecycle by connecting different data sources, a digital twin of the physical product lifecycle can be created. This digital lifecycle enables a dynamic management of the physical lifecycle by using actual, up to date and correct data for sustainable product management. The goal of this contribution is to describe sustainable product management as a combination of the physical and the digital product lifecycle, the research is based on a literature analysis and conceptual modelling.

Sustainable product management combines the physical and the economic lifecycle. There are two different definitions of a product lifecycle, both are relevant for sustainable product management. From a business management perspective, a product lifecycle is defined as the development, market introduction and market success of products and services. i.e., the 'economic lifecycle'. Conventional product management is defined as the holistic management of a product, product line or product portfolio level and includes all activities throughout the economic product lifecycle: idea conception, product development, market introduction, product management, product marketing and support until its withdrawal (Haines, 2008). In environmental and sustainability studies, a product lifecycle is defined according to the 'physical life' of one product, including the phases of raw material extraction, production, distribution, product use and end-of-life. The task is to optimize these different lifecycle phases and their interconnection along the lifecycle.

Lifecycle management is built upon an integrated framework of concepts and techniques that address environmental, economic, technological and social aspects of products, services and organizations. This is applied on a voluntary basis and can be adapted to address the specific needs and characteristics of individual organizations (Hunkeler et al., 2003). Product lifecycle management is a business strategy that consolidates information about the product and processes throughout its physical lifecycle, so that the right information is available at the right time. This enables the management of the entire lifecycle of a product (Vadoudi et al., 2014). If the business and the physical lifecycle are combined, three main phases of a product life can be distinguished:

Beginning-of-life (BOL), Middle-of-life (MOL) and End-of-life (EOL) (Kiritsis et al., 2003). The BOL stage includes the initial design of a product, its development, testing and initial marketing. During the design phase, many tools, techniques and methods are used, and the initial design of a product is defined. This design then enters the manufacturing phase, which includes the processes of production and planning, as well as the production and manufacturing facilities. The MOL includes external logistics and use and support in terms of repair and maintenance. During this phase, the product is in the possession of the final product user or consumer and/or some service providers, maintenance or logistic actors. Finally, in the EOL, retired products are re- collected and remanufactured for the recovery of materials.

The product recovery processes consist of collection, inspection, disassembly, reuse, remanufacture, recycling, redistribution and disposal (Terzi et al., 2010).

Sustainable product management is based on this conventional product lifecycle management but is enhanced by environmental issues and by social issues, including the idea of circularity. Tasks of sustainable product management are product design and the assessment of a products sustainability performance, identification of optimal repair, refurbishment and reuse strategies, as well as business model development to realize circular strategies. In product design, the task is to integrate sustainability aspects and an optimized circularity, for instance through reparability, upgradability or modularization, into the design process. To identify optimal 'circular strategies', i.e. strategies for optimal repair, refurbishment, and reuse, it is essential to define whether, when, and how a certain product or material should be kept within the economic system. In this paper this concept of sustainable product management will be described in detail with a focus on the advantages of using actual real world data coming from the digital lifecycle.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-32

Decontaminating experiences with circular offerings

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Keywords
Contaminated Interaction
User Experience
Circular Economy
Design Strategies
Perceived Value

Abstract
Keeping a product offering in the system through continued use and between multiple users creates the potential for interactions which become contaminated. These contaminated interactions can cause a barrier to material circulation and extended product lifetimes. This study seeks to identify the underlying design strategies useful in addressing contaminated interaction. Strategies were identified through an exploration of possible solutions to negative contamination in two phases. Phase I involved identifying 70 existing solutions to instances of negative contaminated interaction and abstracting these to identify a more fundamental underlying principle. In Phase II, designers participated in a brainstorming session to identify as many solutions as possible to several contaminated interaction design briefs. The resulting 155 solutions were analysed together with the other data to generate a final set of strategies. In the end, eight strategies distilled from the analysis which are used to address contaminated interaction. The strategies represent preventative and responsive solutions applicable to various elements of the contamination process.

Introduction

A circular offering is some combination of products and services which keep material goods in productive use rather than going to landfill. Circular products and services must provide value to consumers such that the offerings are adopted and used as viable alternatives to linear options. The task of providing said value differs from traditional linear economic offerings in that the circular economy involves some degree of reuse. Thus, the circular economy requires more than the creation of value as perceived by the user—it also demands maintaining value as products move through multiple uses and between users.

Products moving through use and between users can alter in meaning. Though there are instances in which the product becomes more desirable, this tends to be less frequent as products are typically designed to a high standard from which their quality diminishes. In such cases, interactions with products are thought to be contaminated as they differ from some ideal (Baxter, Aurisicchio, & Childs, 2016a). For instance, recyclables, once altered, are erroneously sorted as trash (Baxter, Aurisicchio, & Childs, 2016b; Trudel & Argo, 2013; Trudel, Argo, & Meng, 2016); the quality and cleanliness of shared objects is questioned (Liu, Li, Zuo, Zhang, & Wang, 2009), or negatively experienced (Bardhi & Eckhardt, 2012; Petworth, 2016); some individuals refuse to drink recycled water no matter how many times it has been cleaned (Rozin, Haddad, Nemeroff, & Slovic, 2015); and even remanufactured food processors are seen as disgusting and unfit for reuse (Abbey, Meloy, Blackburn, & Guide, 2015; Abbey, Meloy, Guide, & Atalay, 2015).

There are three effects of this negative contaminated interaction on the circulation of materials: premature disposal, hindered circular opportunities and downcycling (Baxter, Aurisicchio, & Childs, 2017). Eliminating negative perceptions and interactions with used objects then becomes central to realizing extended product life in many scenarios. This work is about understanding how to maintain a positive user experience as material is circulated within the larger system. Specifically, the aim of this research is to identify a list of design strategies that can be used to deal with the issue of negative contaminated interaction. Such strategies can then be used to overcome barriers to realising the adoption of a broader circular economy and overall product life extension.

Background

The changing emphasis of user experience in the circular economy compared to typical linear ownership highlights the importance of addressing contaminated interaction. This changing emphasis is driven by two key dimensions, see Figure 1 (Baxter, 2017). First, circular processes necessitate that user interactions with products be considered across the entire lifecycle of the product. Designers need to seek to maintain or enhance user experience with products as they are kept in use and ultimately disposed rather than solely focusing on the point of sale as is typical with current ownership. Building on Jonathan Chapman's work on emotionally durable design (Chapman, 2005), products which achieve positive affect throughout their use are thought to provide a durable user experience. Contaminated interaction plays a major role in influencing how durable an experience is since products often change meaning with use. The aforementioned example of how altered recyclables are erroneously sorted as trash demonstrates this point (Baxter et al., 2016b; Trudel & Argo, 2013).

Second, increased circulation of products will mean that more users will engage with the same product. This is obvious in rapid cycles of use as is the case with access-based schemes but will also arise from more involved circular processes such as remanufacturing and recycling. If an object maintains a positive user experience as it moves between users it is thought to offer a resilient user experience. The dominant influence here is contaminated interaction since each user can alter the perceived value of an offering before passing it along. For instance, even saying a product is as good as new induces thoughts of prior use (Ackerman & Hu, 2016).

There are times when either of these exist independent from the other and this may, at times, be adequate. The ideal, however, is when both durability and resilience occur together. In such a case the offering is thought to offer experientially transferrable experiences—experiences that are maintained or improved as they move through uses and between users (Baxter, Aurisicchio, & Childs, 2017).

Addressing contaminated interaction requires understanding what it is and how it occurs. Prior work has explored contaminated interaction in both a positive and negative context and has identified a model to describe contamination (Baxter, Aurisicchio, Mugge, & Childs, 2017). The first step of the model is to identify the user, the target object and the interaction between the two which has been or may become contaminated in some way. Next, the relevant perspective should be identified from which the interaction is considered. This may be from the user's perspective or an external perspective (e.g.

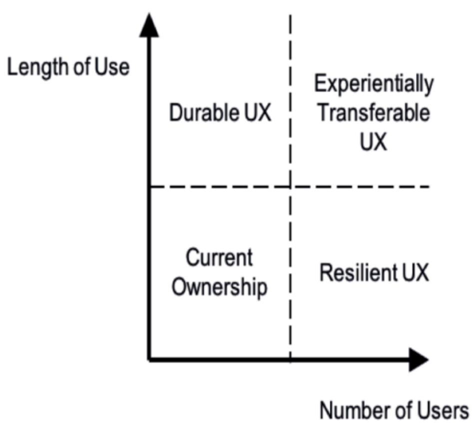

Figure 1. Dimensions of user experience (UX) for circular offerings. (Baxter, 2017)

company perspective). The user or external organization contrast the contaminated state of the object to some ideal or expected state of the object, e.g. used versus new or dirty versus clean.

It may be useful to further describe the contamination process to better inform design directions (Baxter, Aurisicchio, Mugge, et al., 2017). The contaminator may be the user, another user, the object itself, or some other object. The contaminant can be characterised as real or imagined. Real contaminants include objective, measurable factors such as the smell left in a car or markings left on the surface of an object. Imagined contaminants occur through mental associations or beliefs. The latter is why we value things touched by celebrities but destroy things owned by murderers (Hood, 2009). This imagined contaminant in particular may be difficult to deal with in used goods (Hood, 2016).

The process of contamination may be static or dynamic. Static contamination means that the process of contamination has already occurred whereas dynamic contamination is ongoing. All contaminants, real or imagined, static or dynamic, are led by evaluations of the same three fundamental drivers: hygiene, territory, and utility of a product. These drivers dictate the positive or negative evaluation of an interaction that has altered from the reference state. The possible outcome from this alteration is a positive, negative or neutral contaminated interaction.

Notably, contaminated interaction is not limited to issues around material circulation. The term describes any type of contaminated interaction from noise in an office space to trying to disconnect with a former loved one on social media. Still lacking from design discourse is a clear description of what can be done to address these issues.

Methods

Strategies were identified through an exploration of possible solutions to negative contamination. This took place in two phases. Phase I involved identifying existing solutions to instances of contaminated interaction and abstracting common themes to identify broad, underlying principles. Examples were gathered from a range of interactions, not just those related to the circular economy to provide a more holistic analysis. Example solutions include air fresheners used to cover a bad smell or fabric used to hide stains on shared seats (e.g. seat coverings on public transport). Both solutions share a common strategy of concealing the contaminant by either covering it or disguising it.

Phase II of this study involved conducting an ideation session with design students to come up with possible solutions to contamination issues. Ten design briefs were constructed and presented to seven designers split into two groups. As was the case with Phase I, briefs include physical contaminants and digital contaminants in many settings to achieve a wide range of outputs. The

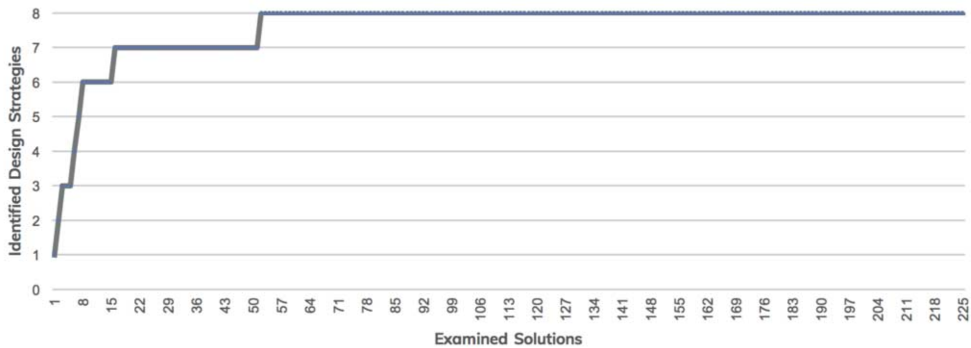

Figure 2. The number of design strategies identified versus the number of solutions examined.

Strategy	Description	Example Activities
Change meaning	Alter how the user thinks about the contaminated target	Branding, educating, or reframing of interaction
Withdraw	(Help) move the user to another situation	Engage with equivalent products, services, and environments or disengage altogether
Condemn the contaminator	Make the act of contaminating punishable	Establish social norms, terms of use or fines for misuse that carry social or financial burden
Restore the target object	Bring the target back to an uncontaminated state	Clean, air out, or otherwise purify the object
Protect the target object	Prevent object-level changes	Design for technical durability or script desired behaviour
Block the contaminant	Prevent contact with the contaminant	Create a barrier between the user and the contaminant
Remove the contaminant	Eliminate the contaminant altogether	Remove specified touchpoints or offenders
Conceal the contaminant	Disguise or cover the contaminant	Add some stimuli of proportional power that conceals the contaminant

Table 1. Eight strategies to address contaminated interaction.

resulting ideas generated in this section were added to the analysis in Phase I and a final set of design strategies were determined.

Results

Seventy solutions were identified and analysed in Phase I and a further 169 solutions were identified in the creative session held in Phase II. 14 of the Phase II solutions were determined to be too vague to be considered in the analysis resulting in a total of 225 usable data points. The thematic coding of these data resulted in the identification of eight unique strategies. Strategies are summarised in Table 1 and described below. Broadly, these strategies can be considered in terms of the element of the system which is targeted in the solution: the contaminator, the user, the target object and contaminant itself. All strategies were identified after examining 52 solutions, see Figure 2.

The strategy of **condemning one's actions** was the only strategy to target the contaminator—the person doing the contaminating. Condemning solutions consisted of financial punishments (e.g. imposing fines), social punishments (e.g. shaming) and social pressure (e.g. social norms, rules, and expectations). This could be enforced by another person, by unwritten rules of etiquette or by some form of technology such as a smoke detector or security cameras.

Two strategies target the user. The first is to **change the meaning** of the contaminant. This strategy involves changing perceptions of a contaminant without altering the contaminant itself. Methods used here included various forms of marketing, and educational campaigns. The second user-targeted strategy is about **withdrawing** from the contaminant. The focus of this strategy was to remove the user altogether. This includes various aspects of going to another place such as leaving a noisy office and finding another place to work. It also includes withdrawing from one situation where it is replaced with an equivalent. For example, switching rental cars if the one you get is unpleasant. Either way, the user makes the decision to withdraw from the situation and design can stand ready to help in that process.

Two strategies also focused on the target object. First is to **restore** the object to some prior state. This strategy includes cleaning, repair, airing out or other processes through which an object can return to a previous condition. The second strategy is the preventative counter to this, **protecting** the target object from change. Protecting is about preventing perceived change in the first place and often focuses on an ability to withstand wear. The most obvious example of this is designing for technical durability.

The final three strategies dealt with the contaminant specifically. **Blocking** is a strategy in which the contaminant is still present but blocked from interacting with the user. Examples include blocking others from social media and placing a physical barrier up to avoid the contaminated object such as a mask. A related strategy is to **remove** the contaminant itself. For instance, an online account may be revoked in which case a user is removed altogether or a doorway to a restroom may be taken out so there is no handle to grab (or avoid). This also includes more subtle forms of removing the contaminant such as rearranging rooms to prevent sound from travelling. Removing is a distinct strategy from withdrawing since it is focused on the removal of the contaminant rather than the mere withdrawal user. The last strategy is to **conceal** the contaminant. Concealing does not remove or block the contaminant but merely overpowers it by some other stimuli. For instance, a smell may be covered up by an air freshener, an unpleasant noise may be treated by some music played over it, and pattered seats do a better job of hiding stains than would different fabrics.

Discussion

The identified strategies are meant to offer a starting point for creative ideation when dealing with contaminated interaction. Each strategy can be used as a "how might we" statement to guide in this process. A designer should first identify the user, object and contaminated interaction. Next, they can use the strategies to address this. An example may come from a company seeking to engage in a sharing scheme but finding that there is a general concern towards hygiene. The design team may ask, "how might we remove the contaminant/change the meaning of the target/conceal the contamination?" and so on. Answers to each statement will be some combination of preventative and responsive solutions to the issue at hand.

The use of the strategies still requires good creative skills to develop innovative ideas. Subsequently, it is important to treat these strategies as a tool to aid in the ideation process and not a substitute for proper exploration. The types of interventions to decontaminate the user experience will be limited by practical constraints of the specific context including important ethical concerns. There is still a debate to be had regarding the obligation to disclose information about an object (Baxter, Aurisicchio, & Childs, 2017). In many cases, information provides a negative narrative for material circulation. This is important since it is often knowing the information, not the fact itself, which is detrimental with regards to contaminated circulation. An example of this is the lost value in refurbished products. If the product has been refurbished by the original equipment manufacturer and evaluated to be the same quality as a new item, why then does the information about its refurbishment need to be disclosed as this is the actual contaminant?

This study approached the problem by understanding a range of solutions in differing contexts and two separate data sources. In the present study, all strategies were identified after only a quarter of the solutions were examined. This gives strength to the idea that the solutions identified in this document represent a complete list and adequate saturation of strategies was reached in the research process.

Conclusions and future work

The circular economy shifts the user experience focus to one that must account for how product meaning changes as it moves through use and between users. This requires examination of how interactions become contaminated. Such contaminated interactions are addressed through the eight strategies identified in this paper. The strategies include preventative and responsive measures that can be implemented to various aspects of the interaction.

Though his work offers a promising direction for design, it stops short of applying these strategies to a specific problem. Future work should seek to validate the usefulness of these strategies in the context of addressing contaminated interaction with a circular offering. More broadly, this work will hopefully contribute to a needed discussion in maintaining positive user experience with circular offerings.

Acknowledgments

Thank you to colleagues in the Human Performance and Experience (HPX) theme in the Dyson School of Design Engineering for their support in this work.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-37

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Personalisation from a design practice perspective

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Keywords
Personalisation
User-completion
Craft
Mass customisation
Products

Abstract

The Internet is facilitating new ways of designing, manufacturing and distributing products. This has led to a more democratic, open-design approach and has resulted in users having more involvement in the design process than ever before. In particular, designers are shifting away from designing a finished product, to either designing components, a template or a set of tools which the user interacts with to finalise and/or personalise the product. This way of approaching design is still in its infancy. The authors' have termed this design framework, as it applies within product design, 'user-completion'.
The authors' propose that the user-completion framework operates at the intersection between mass-customisation and craft. The skills and knowledge sets associated with mass-customisation and craft, presents challenges and opportunities for both the designer and user. The user-completion framework enables users to personalise the end product and therefore requires designers to shift their conceptual approach, by handing-over more design control to the users. It is hoped that by doing so, and by engaging the user in the product's completion, a stronger emotional bond will be generated between the user and the final product. This design process also anticipates an added value and a longer life cycle for the product.
The 'user-completion' framework proposed by the authors will be outlined, and supported with the three case study examples of work. Through these case studies the value of users being involved in the design process is explored, as is their engagement with craft and their perceived emotional value of the resulting products.

Introduction

Today there are numerous ways in which the end-user can become part of the design process, and many of these methods are well established and documented. In this paper two established approaches will be discussed; co-design and mass customisation, as well as an approach developed by the authors through practice called 'user-completion.' In both of the established approaches the end-user is involved in the early stages of the design process in order to customise or individualise their needs. The user-completion approach as will be outlined through three product case studies, allows for the user to be part of the design process in the final stages of assembly and finishing of the product, enabling personalisation of the visual appeal of the product, and to some extent its form and function.

In the course of applying the user-completion approach to the established design practice of one of the author's, a deeper insight was developed into how user-completion could become a tool used more widely by designers in practice. The basis for developing this approach was to enhance the emotional bond between user and product with the aim to create a higher value and longer lifespan for the final product.

Co-design and mass customisation

The recognition of individual creativity and the value of involving the end-user in the design process has resulted in a number of user design approaches. Two models that enable personalisation and engagement in the design process are co-design and mass customisation.

The term co-design has been described as having "gained currency as a general term" (Binder et al., 2008, p. 82). Although it might be used in various applications and across multiple fields of design, it will be considered here in relation to product design. Co-design, as the authors understand it, is often utilised early in the design process. Leading practitioners in the field Elizabeth Sanders and Pieter Jan Stappers (2008, p. 6) to state that co-design does not simply refer to the collaboration between trained designers, but importantly also encompasses designers collaborating with non-designers during the design process. According to this definition, co-design is unlikely to take place during or after the manufacture phase, as the co-design approach relies on facilitating collaboration between the involved parties (Bernabei and Power, 2013).

Mass customisation is the process in which "the end user gets to choose certain features such as colour and apply

Figure 1. Stitch Light, Pop Light, and Hybrid 3D- printed woven vessels. Images Dieu Tan and Rina Bernabei.

them to a pre-designed product" (Szita, 2009, p. 109). The website *MINI* [https://www.mini.com.au/configurator/] provides an example of mass customisation in relation to the automotive industry. Frank Piller (2008, p. 631) explains the economic efficiency of mass customised personalisation, explaining that it "meets the demands of each individual customer, but that can still be produced with mass production efficiency." In a mass customisation model, the final finished product is provided to the end-user. As a result, the emotional connection between the end-user and the product is likely to be minimal. Ruth Mugge believes that in order for an emotional bond with the product to emerge, effort is required during the personalisation process. Mugge et al. (2009, p. 473) feel that often in relation to mass customisation this effort, both mental and physical, is low (and physical is generally absent altogether). With such thinking in mind, the authors propose an alternative approach – *user-completion.*

User-completion model: an overview[1]

The user-completion approach is one that the authors have proposed after developing it to design a new interior lighting solution for the Australian market. To best understand the user-completion approach, we must look at the design process and where to best apply it. The user-completion approach focuses on a specific point in the product design process - assembly and completion (although it will be shown that it may also be applied to the manufacture stage). It is important to note that while the authors believe that the user-completion approach has the potential to be applied to various fields of design, it is considered here specifically in relation to product design.

In the design process the final stages are usually product assembly and finishing, or sometimes occurring in reverse order. 'Finishing', in product design usually refers to a paint or surface finish, or it may be a hand applied process, such as upholstering, or other decoration. In assembly the product, which is usually made up of separate components, is assembled to designer specifications. As in the mass customisation approach, the different components may be configured in different combinations to offer different functions, size, or visual appearance to the end-user or retail business requirements. The user-completion approach is no different to this, in that the end-user decides how the final product will look, how it will function and its visual appeal. The difference is that in mass customisation, the manufacturer will assemble to end-user requirements, whilst in the user- completion approach, the end-user assembles, and hence they can 'try out' different combinations, functions, visual appearance – thus they have creative control over this part of the design process. This also applies to the finishing of the product in which end-users are given creative control and become part of the creation process. Allowing users to have this control and involvement, to customise and personalise the product to their wants and desires can have, as previously mentioned, a positive effect on their relationship with the end product.

The user-completion approach is best suited to product design, particularly where a hands on approach to assembly and finish is embraced. For these reasons it draws similarities to the 'hand of the maker' in hand crafted objects. One of the authors (and her design partner) of the award winning design practice bernabeifreeman recently applied this approach when designing a series of products – the *Stitch Light, Pop Light, and Hybrid 3D-printed woven vessels* (Figure 1). These products were developed sequentially and as such, the learning from each product informed the refinement of the user-completion model and the possibility of user attachment and personalisation for the next product.

From the initial stages of the design process, it was decided that the product would be designed in such a way to allow the end-user to assemble and finish the products, allowing the objects, in some cases to take on different forms and aesthetics. To do this, the designers believed that the product would be presented as a 'design kit', or a series of specifically designed components, that could then be fitted together in various combinations that the end-user would assemble to their individual needs and tastes. In the final iteration using the 3D-prined hybrid vessels, the kit was not only physical but digital. This will be discussed further through the case studies. The user-completion approach relies on the specialised skills of the designers to provide the components and understand

[1] Adapted from (Bernabei and Power, 2013).

the manufacturing options, whilst leaving some details of the finished product to the end-user to decide upon. It should be noted that the skill of the designer is in no way diminished by embracing the involvement of the end-user – instead, the designer is required to understand the product in new ways and forecast its potentialities.

Case Studies

Stitch Light series

The *Stitch Light kit* is made up of a variety of different lighting pendant forms, made from aluminium spinnings (Figure 2). These spinnings are carefully designed to be joined in different combinations. The 'design kit' also includes a selection of different perforated aluminuim diffusers that can work with the spinnings in numerous combinations. It also comprises a lamp holder, electrical wiring, and nylon cord that can be embroidered to customise the light. It was envisioned that the end-user could customise their kit on purchase, either online or in a retail environment. This decision would be aided by looking at examples of different light combinations that are achievable.

The designers spent time conceptualising how an element or technique could be designed into the product to allow the end-user to personalise the product during its making, without any assumption that the end-user had any prior skills.

Craft practice results in one-off unique pieces. The user-completion model has parallels with craft, in that the end-user ends up with a one-off-design to some extent. Yet it is important to note that all components of the *Stitch Light* kit were mass produced. The designers felt that the *Stitch Light* would appeal to the end-user who wanted to engage in "doing". By combing craft and mass manufacture in the user-completion approach, the end-user is allowed to personalise mass manufactured elements in a craft-like manner, which allows for all the appeal of craft to be transferred to a mass consumer product.

One important consideration when designing a product using this method is the amount of effort required by the user, if the product is too difficult to assemble and finish the end-user may give up and not finish the product due to frustration with the process. For a truly successful final product, the kit of components should allow people with differing level of skills, both low skilled and highly skilled, to be challenged and obtain a satisfying result.

It was found that the Stitch Light required a higher level of skill than most users were prepared or able to achieve. This lead the designers to re-think the level of skill involved in the user-completion model. This informed the next iteration of the user-completion in the *Pop Light*.

Pop Light

The *Pop light* is a cardboard pendant light kit comprised of six semi-perforated cardboard panels, a polycarbonate crossbar, and an electrical kit. Like the *Stitch light*, each of these core design kit elements can be mass-manufactured. Following the instructions, the user assembles the card panels to create a predetermined pendant light form. Users are then invited to 'pop' out any of the 300 semi-perforated holes on each panel, into any pattern they wish (Figure 3). Several patterns are illustrated in the instructions, as examples, with encouragement for users to design their own patterns. Popping out the cardboard holes is a much simpler and quicker method of personalisation, than the embroidery of the previous *Stitch light*.

Through the simplification of the personalisation in the *Pop light*, the product may have lost its ability to be personalised to the same level as the *Stitch light*. In addition, for someone with a higher skill set, the product would not hold the same challenge. This highlights that there is a fine line that needs careful design and user testing to understand these gradations of user interaction and satisfaction. As Mugge et al (2009, p. 469) explains:

> *"[the] personalization process requires the investment of a great deal of effort, the person is occupied with the product for an extended period of time, which may positively influence the strength of the emotional bond with the product".*

After designing the Pop light, the author's co-ordinated a workshop to understand if there was value in the user-completion model from a user's perspective. Results from the user questionnaire illustrated that everyone felt generally positive towards the light. Most users said they were 'very satisfied' and 'happy' about the light as it gave them a sense of accomplishment. Two users even regarded the light to now having a sentimental value to them, seeing their own designed pattern on the product. According to one user, despite the complexity in designing a pattern, the end result definitely creates excitement and achievement. Everyone stated that due to their own pattern being on the light, they are less likely to dispose of the product. The Pop Light according to most of the participants, not only acts a physical product but transformed into a memory due to the fun experience, effort and time they gave to it.

Figure 2. Stitch Light embroidery detail, Stitch Light in various configurations, Stitch light components of the 'design kit'. Images Dieu Tan

Figure 3. Pop Light with diverse hole patterning, Pop Light - 'unpopped' and 'popped'. Images Dieu Tan.

Fourteen out of fifteen users felt the light to be personally valuable.

Vessels

From the experience gained through the development of the Stitch and Pop lights using the user-completion approach, the authors wanted to apply this method to a product that gave the user involvement in the manufacturing process as well. They turned to 3D digital printing with an incorporated hand-finished component (Figure 4). The 'hybrid' vessels are made of a 3D-printed body that the user selects from a pre-designed web-based suite of options. The user prints their chosen vessel at home or through a printing agency. The vessel design allows for a handwoven, in this case "basketry", element to be added for functional and/or visual appeal. The development of the hybrid vessels differs from those previously discussed in that the designer does not provide a kit of components but rather a selection of digital files that the users can print, and in doing so users can determine; scale, resolution, materiality and colour. This gives the user more control over the manufacture of the product. This is quite different to mass-customisation, in that the user manufactures the entire product, including the components. The authors believe that the incorporation of the user-design approach and personalisation, in the design and development of new hybridized digital/craft products, will allow the user to fully engage in the adoption of this new emerging materiality and language. Also through engaging users in the digital fabrication and basketry it allows them to become more fully part of the creative process and therefore strengthens the user/product bond, as well as attach a high value through engaging the hand of the maker.

Through the design of the 3D printed component, the designers were very aware of the skill level of the users, and designed the vessels in such a way that the incorporation of hand-weaving was pre-determined. The design of the vessels, allows for different flexible materials to be slotted into the 'tubes' of the vessel wall. The user could use organic and/or synthetic filaments or other materials such as metal to vary colour, texture and visual language. To facilitate the basketry and weaving, users would have access to weaving diagrams (through a web source) to mimic or they could weave their own design. The role of the designer remains integral to the output of a successful product and integrating the technologies and providing the skill-set supported with examples.

In the design of the vessel, we extended the user-completion approach to be more fully integrated into the whole process. Designing the vessels using the user-completion approach differs from the Stitch and Pop light because the approach encapsulates the full manufacture of the product in the design process, where previously it was only applied to the assembly and finishing

Figure 4. Hybrid Vessels - Details and various configurations. Images Rina Bernabei.

Conclusions

As academic designers, having developed a participatory-based framework and applying it to the practice of product design, we have been able perform, refine and test our theories. Over the past years we have been able to apply the user-completion framework and adjust it to a variety of products and feedback from workshops have confirmed the value and shortcomings of the framework. We have found that the design of the kit, either physical or digital, is crucial to the success of the product. Pre-determining the level of skill needed by the user is important; if the skill set is too high the users will fail, as seen in the Stitch light, and if the skill is too low, the value of the final product is diminished. While most people like to be involved in the design process, they are not designers and need to see examples and options, either through digital or printed support. Most users will mimic an option provided. Very few users are unlikely to take the designs to a highly personalised level. Digital literacy is also needed when using a digital took kit to be able to manipulate the product successfully.

Through the feedback received from the Pop light workshop, most users said that the light had more value and that they would not dispose of it readily but this needs to be examined in more detail. The next step is to understand how users may undertake more iterations of the design or update their product overtime through re-printing, re-weaving and re-stitching. There is an opportunity for the digital toolkit to be constantly updated with technological advancements in materials and technology. This model may provide a new way for users to live with their products for longer, building memories, value and ecological benefits.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-41

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Business experiments as an approach to drive sustainable consumption: the case of HOMIE

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Keywords
Sustainable business model;
Sustainable business experimentation
Business experimentation
Circular economy
Sustainable consumption

Abstract
Sustainable business models and in particular Product Service Systems (PSS) are often linked to increased environmental performance. However, such benefits can only be achieved when the business model is intentionally set up to deliver those positive impacts, by incorporating issues around efficiency gains, through-life issues and sustainable consumption patterns into the design. Several start-ups are emerging who are pursuing new PSS business models but sustainability impacts are not always measured. Also, knowledge on how to iterate new sustainable business models through experimentation is sparse. This paper explores how companies can contribute to sustainable consumption through experimentation with new business models and in particular 'pay per use' business models. We apply knowledge on influencing consumer behaviour to develop business experiments. This paper includes an in-depth case study of HOMIE, a start-up pursuing a pay per use business model for home appliances (washing machines). An experimentation roadmap is presented for HOMIE. Effects of a range of experiments are included, such as providing information and social comparison. The pay per use business model was found to have the potential to help stimulate sustainable consumption patterns. For example, social comparison could be used effectively to stimulate more sustainable laundry behaviour. Future research could focus on mapping ideal sequences of experiments to achieve the greatest levels of sustainability impacts, and investigating other sustainable business models such as renting and sharing using the experimentation approach.

Introduction

This research investigates how companies can contribute to sustainable consumption through experimentation with sustainable business models. Specifically, the focus is on pay-per-use as an example of a Product-Service-System (PSS) business model. A brief overview on sustainable business models is presented, followed by start-ups influencing consumer behaviour, business model experimentation and the research question and structure.

Sustainable business models

Business models describe the way business is done (Magretta, 2002). Emerging research positions sustainable and circular business models as a key driver for 'systems level innovation' and achieving greater levels of sustainability (Stubbs and Cocklin, 2008; Bocken et al., 2014; Geissdoerfer et al., 2017). Sustainable business models can help business gain a competitive advantage while reducing environmental impact and contributing positively to society (Boons and Lüdeke-Freund, 2013; Bocken et al., 2014; Schaltegger et al., 2015). Typically business models are depicted as comprising of a 'value proposition', value creation and delivery, and value captured (Richardson, 2008; Bocken and Short, 2016). In a sustainable business model, value is not only created for the customer, but also for the wider society and environment (Stubbs and Cocklin, 2008). The business makes conscious decisions about how positive value is captured and measured, as well as the growth strategy and ethos (Bocken and Short, 2016). While the popularity of such business models is on the rise (Geissdoerfer et al., 2017), a lot of this work remains conceptual and there is insufficient evidence on the generated positive impact.

Seminal work by Tukker (2004) investigated product service systems (PSS) as a potential driver for positive environmental impact. In the case of "pay per use", the company takes responsibility for all life cycle costs, thus creating a powerful incentive to design products optimised for the product life cycle, where elements can be re-used - plus companies would have a continuous drive to improve the life-cycle product performance (Tukker, 2004). Indeed, PSS have the potential to break the link between profit and production volumes, can reduce resource consumption and material use, motivate inclusion of life cycle issues, and lead to enhanced efficiency in use and product longevity (Bocken et al., 2014).

The PSS would need to be deliberately set up to achieve the greatest impact. As an example, implementing a PSS for cars (e.g. car sharing) without an efficiency focus (e.g. fuel efficiency) or motivation to drive less (e.g. pay per kilometre) is unlikely to enhance sustainability, since the vast majority of environmental impact is in the use phase and not in the manufacturing of the car (Bocken et al., 2014). Certain PSS models (e.g., paying for car usage or clothing wash cycles rather than cars or washing machines) could also make customers more conscious of usage and consumption patterns (Chase, 2012; Bocken, 2017).

Start-ups influencing sustainable consumption

Several successful 'start-ups' are promoting the environmental and social sustainability of their business and business models. For example, Zipcar estimates that every Zipcar takes six personally-owned vehicles off the road and that after joining Zipcar, 60% of its members drove less than 1,000 miles per year, saving 829 litres of petrol each (Chase, 2012 in Bocken, 2017). Airbnb estimates that its guests use almost 80% less energy than average hotel guests (Airbnb, 2014). Whereas various new 'sustainable' start-ups are emerging, their impact on the environment is not always clear.

Sustainable start-ups do have the potential to influence consumption patterns. One reason why these may be so hard to influence is complexity, as consumer behaviour needs to be understood within a social, cultural and institutional context (Jackson, 2009). Intentions are formed by people's attitudes, perception of social pressure and perceived and actual control over their behaviour, which subsequently influence actual behaviour (Ajzen, 1991).

Pro-environmental behaviour appears to be influenced by individual, as well as social and wider (e.g. political) factors (Kollmuss and Aygeman, 2008; Bocken, 2017). Summarized from literature, "[s]ocial norms and peer education, goal setting and feedback, incentives, engaging people in the solution and choice editing and defaults" could help stimulate pro-environmental behaviour (Bocken and Allwood, 2012, p. 121). In the field of sustainable design, key authors have established design strategies for behavioural change including eco-information, eco-choice, eco-feedback, eco-spur, eco-steer, eco-technology and clever design (Bhamra et al., 2008; Tang, 2010). Whereas some of these are more focused on providing information and making customers more aware of their behaviour (e.g. eco-information and eco-choice), options on the other side of the spectrum either seek to control behaviour (eco-technology) or 'build in' behaviour automatically (clever design; Bhamra et al., 2008). The key is to not annoy people and build in sustainable consumption in such a way that people do not switch off functionality (Wever et al., 2008) or get demotivated.

Whereas studies have taken place on influencing energy consumption in the home (e.g., Van Houwelingen and van Raaij, 1989; Kobus et al., 2013), the links between sustainable consumption, new business models and the role of companies has been underexplored.

Business model experimentation for sustainability

How can sustainable business models be iterated to achieve the greatest measurable customer value and societal impact? 'Business experiments' support the development of (sustainable) business models, by creating hypotheses about the business to be tested (Chesbrough, 2010; Ries, 2011; Blank, 2013; Weissbrod and Bocken, 2016). Business experiments, as opposed to experiments in the natural sciences, are context-sensitive and aim to explore the diverse possibilities that a business could create value from, or understand what works in which particular situations (Bocken et al., 2016). Being focused on quick learning, experiments would precede more expensive and resource-intensive pilot and could help give direction to developing such larger pilots (Bocken et al., 2016).

Research question and structure

Sustainable business models and in particular PSS have been described as a key driver for (environmental) sustainability. It is yet unclear how new business models can stimulate sustainable consumption. To achieve this, business model experiments can be developed to encourage sustainable behaviour. This work presents a case study of start-up HOMIE and its pay per use business model. This paper explores the following question: *How can companies contribute to sustainable consumption through experimentation with new business models, and specifically 'pay per use' business models?*

First the method to address the research question will be explained, introducing the case company and types of experiments, followed by the results focusing on the experimentation roadmap and outcomes of the experiments. Finally, a combined discussion and conclusion section comparing the findings to earlier work in the field.

Method

This paper presents and in-depth case study based on the work by the Delft University of Technology spin-off HOMIE since its inception in February 2015. HOMIE wants to significantly reduce the environmental impact of domestic appliances, by moving from product ownership to "pay per use". The aim is to test and iterate new business models in order to reduce the environmental impact associated with home appliances. Starting with washing machines, HOMIE offers free installation and maintenance of high-quality washing machines, with the cost of water and electricity included in a small fee charged per washing cycle, offering a 'pay per use' business model (www.homiepayperuse.com).

This paper uses an 'action research case study' method, based on inquiry and action used in action research, and the case study methodology (McManners, 2016). The researchers take on a participatory role whilst retaining academic rigour, which is instrumental in the transition to a sustainable world (Gustavsen, 2008 in McManners, 2016). A single case study was chosen because of unusual research access and the uniqueness of the case (Eisenhardt and Graebner, 2007; Yin, 2013). The authors were involved in developing and setting up the business experiments, and collecting and analysing data for the experiments.

The unit of analysis is the experimentation process to achieve sustainable consumption. This study aims to develop future insight for companies aiming to contribute to sustainable consumption and wanting to understand the environmental impact of newly developed business models.

Insight from former work on influencing consumer behaviour is used to develop an initial set of experiments (Ajzen, 1991; Kollmuss and Aygeman, 2002; Wever et al., 2008; Bhamra et al., 2008; Bocken and Allwood, 2012; Bocken, 2017). In this case the knowledge is applied to a pay-per-use business model. Based on these insights, we started with the following simple interventions:

1. ***Paying per use.*** First of all, we wanted to test if paying per use would drive customers to wash differently. Customers were surveyed about their washing behaviour in advance of installing the washing machine in their homes and also received a free month of washing in order to check how often they would actually wash. We then differentiated the pricing so that a lower temperature cycle would be cheaper than a higher temperature cycle. Customers would receive rebates for their energy costs to offer a more inclusive price and additional incentive to wash at lower temperatures.

2. ***Providing information.*** Second, the most basic intervention would be giving customers an informative mailing about how they wash. Information could make customers more aware (e.g., Bhamra et al., 2008; Wever et al., 2008).

3. ***Social comparison.*** Comparison with others could stimulate customers to wash differently, because people are influenced by social norms and comparison with others (Ajzen, 1991; Kollmuss and Aygeman, 2002; Bocken and Allwood, 2012).

4. ***Goal setting.*** Setting goals could help stimulate sustainable behaviour (Bocken and Allwood, 2012) and has been found to be effective for energy conservation (Van Houwelingen and Van Raaij (1989). Whereas 'goal setting' is part of the experimentation roadmap (Figure 1), insufficient customers had yet gone through this intervention to report on the outcomes.

The data is based on a sample of 20 customers. Sometimes not all data were available (e.g., because a customer signed up later, or they did not answer certain interview questions) so we indicate the number of customers the data is based on for each finding. This lack of 'controlled data' reflects the nature of experimentation in a 'real business environment' compared to an experiment in a lab environment (Bocken et al., 2016).

Each intervention took a month, for example, there was one month between the introduction of the pay per use business model and the first information mailing, and one month between the information mailing and the next social comparison mailing. Customers are compared against themselves over time.

Results

Figure 1 shows HOMIE's experimentation map, including the activities to develop the pay-per-wash business model and influence sustainable consumer behaviour. While the research is preliminary some early results can be identified.

Pay-per-use business model

First, experiments have helped to refine the uniqueness of the sustainable business model and value proposition based on interviews with the general public customers and A/B testing Marktplaats advertisements. Customer interviews helped refine the proposition: improve the payment interface, simplify the pricing, as well as giving further laundry tips based on requests by users. Observed benefits from the interviews about the pay-per-use system relate to: the service (repair, feedback) combined with a quality washing machine; affordability; convenience and flexibility (not having to own a device) and improving environmental consciousness through paying per use and feedback on washing behaviour.

Second, early customer data comparing customer interviews to the actual number of laundry cycles run show that customers run more cycles than estimated - 11 out of 19 customers wash more than they think (70% more cycles on average).

Third, interviewees when asked, think they changed their laundry behaviour since being part of the pay per use business model. Eight of 20 interviewees say they wash at lower temperatures and two indicated that they already used the washing machine at more environmentally sustainable temperatures before. Four people said that they used the eco-button more often. Two customers specifically said that they consciously run fuller laundry cycles when paying per use.

The data shows that 10 out of the 20 customers reduced their laundry temperature after introducing the pay per use model - for 3 customers it stayed the same, but for 7 it went up. The data also shows that four people indeed use the eco-button more often after implementation of the pay per use business model.

Providing information

The effect after the informative mailing about their laundry behaviour was mixed: 8 out of 18 people reduced their laundry temperature after mailing 1; 3 stayed the same; 7 increased the temperature. Whereas for 11 out of 18 people the effect was positive or neutral, for 7 the temperature went up.

Social comparison

In order to motivate sustainable washing behaviour, comparisons with other customers seem to motivate customers more than comparisons against customers' own historical laundry data. Seven out of 14 customers reduced the number of cycles run, 3 stayed the same and 2 went up after the social comparison mailing.

Discussion and conclusion

In this study we show how the case company HOMIE has iterated its sustainable business model with the aim to achieve greater levels of sustainable consumption. An experimentation roadmap was presented as well as early insights on the outcome of the experiments. Social comparisons matter, which confirms earlier behaviour research (Ajzen, 1991). While preliminary and based on a small sample, it seems that pay-per-use business models need to be combined with specific stimuli to achieve the desired effects (e.g. mailings with tips and comparisons to others).

This research contributes to the emerging literature on business experiments (Chesbrough, 2010; Weissbrod and Bocken, 2017) by providing a novel example of an experimentation roadmap of a real business outside a controlled 'lab environment'.

Furthermore, it adds to research on stimulating behaviour change through new business models as well as understanding how to develop sustainable business models more generally (Tukker, 2004; Bocken, 2017). It gives new insight on the role of new business models and experimentation in driving sustainable consumption patterns, in addition to the established research on sustainable consumption.

The research is limited by a small sample of customers over a short period of time. It could be beneficial to investigate the impact of experiments over a longer period of time with a larger number of customers while taking into account specific factors and effects on laundry behaviour (e.g. holiday periods, customers having access to multiple

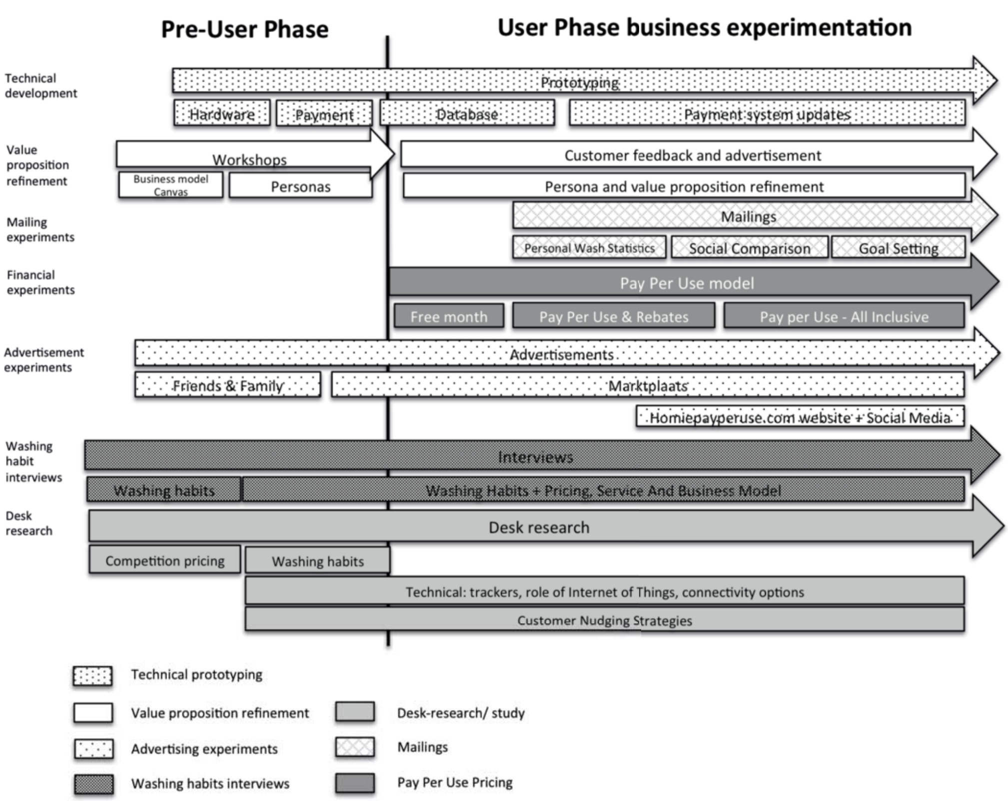

Figure 1. Experimentation roadmap HOMIE.

washing machines). Also, within the limited space of this study, not all possible analyses and experiments could be presented in this paper.

Importantly, the study could have benefitted from a control group, which is common in behaviour science (e.g. Van Houwelingen and Van Raaij, 1989). To explain, in the study, all customers were subjected to the 'pay-per-use model' and the different experiments. The decision was made to work without a control group, because the influx of new customers was uncertain and types of customers could not be controlled for in this real business environment, making it difficult to establish a reliable control group.

Future research can focus on mapping out ideal sequences of experiments to achieve the greatest levels of environmental, customer and business impact. Also, other sustainable business models such as renting and sharing could be tested in an iterative way using the business model experimentation approach.

Acknowledgments
We would like to gratefully thank the HOMIE customers for their time and input.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-46

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Assessing the sharing economy: analyzing ecologies of business models

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Keywords
Sharing business models
Sustainable consumption
Environmental assessment
Life cycle assessment
Sustainable business

Abstract
Current attempts to improve the ecological and social impact of production and consumption practices build on the recognized relevance of business models. Business models are distinct ways of coordinating the provision of goods and services, and they affect the ecological impact and social sustainability of the technologies underlying that provision. This is especially true for so-called sharing business models focused on peer-to-peer-based activities of obtaining, giving, or sharing the access to goods and services, coordinated through community-based online services.

Research on business models is rapidly developing. One characteristic of this work is that it tends to see business models as entities in themselves, with scant attention given to the context in which they occur. This is problematic, as the provision of a specific good or service is interlinked with others. As a result, the ecological and social impact of any business model is partially determined by the constellation of business models of which it is part.

In this paper, we address this gap in the literature, by conceptualizing the economy as an ecology of business models. Building on work in organization studies and biology, we identify typical relationships between business models, ranging from competitive to mutually supportive. We also identify typical relationships between business models and their habitat, which includes physical resources and spatial embedding, but encompasses the institutional infrastructure in a given society.

Background

One recent advance in research on business and sustainability addresses the way in which business models affect the ecological impact of production and consumption practices. Business models are distinct ways of coordinating the provision of goods and services, and they affect the ecological impact and social sustainability of the technologies underlying that provision. This is especially true for so-called sharing business models, which Hamari et al. (2015, p. 2048) define as the *"peer-to-peer-based activity of obtaining, giving, or sharing the access to goods and services, coordinated through community-based online services"*. Sustainable business models as an 'ideal type' generate a competitive advantage through superior customer value while contributing positively to the company, the environment and society and minimizing harm (Bocken et al., 2015). The business purpose, performance management and metrics incorporate the triple bottom line of people, profit and planet, multiple stakeholders are concerned and systems rather than a firm centric perspective are taken on the way business is done (Stubbs and Cocklin, 2008).

A first issue is that business models need to be deliberately designed to drive sustainability as part of the business model. The way business models are designed drives the eventual outcome. Ample research suggests the potential positive role of sustainable business models, and in particular Product Service Systems (PSS), in delivering positive sustainability impacts (Tukker, 2015). Producers would have a higher degree of responsibility of the product's full life cycle and associated impacts, and could influence the product as well as service design to emphasize sustainability impacts, whereas consumers would move to buying service and system solutions with the potential to build in 'sustainable behavior' and educate customers (Mont, 2002). However, in order to achieve desirable and measurable sustainability results, these elements will need to be built into the business model. Tukker (2015, p. 88) argues for a clearer "*emphasis on requirements that should drive PSS design, how to organize co-creation processes, sustainability opportunities (…) This, together with more on the ground experimentation and evaluation of PSS design in different industries, should form the research agenda moving knowledge on PSS design forward*".

A second issue in addressing the impact of sustainable business models is associated with the fact that business models are intertwined. This is not yet recognized in current work on business models, which tends to conceptualize business models as entities in themselves, with scant attention given to the context in which they occur. Even though authors see 'sustainable business models' as taking systems rather than a firm centric approach (Stubbs & Cocklin, 2008), business models are conventionally investigated from a single firm perspective. This is problematic, as the provision of one specific good or service is interlinked with others. As a result, the ecological and social impact of any business model is partially determined by the constellation of business models of which it is part.

In this paper, we address this gap in the literature, by conceptualizing the economy as an 'ecology of business models'. Better understanding of this gap is relevant in the transition to a future sustainable, or, more recently, Circular Economy, where hope is vested on new business models (Geissdoerfer et al., 2017). Building on work in organization studies and biology, we identify typical relationships between business models, ranging from competitive to mutually supportive. We also identify typical relationships between business models and their habitat, which in social systems translates into the institutional infrastructure in a given society (see Figure 1).

Studying the emergence of business models within their context poses specific problems: (1) a coherent and practically feasible boundary must be drawn around an interconnected set of business models, i.e. the ecology, (2) in order to asses the ecological impact of the business model, material and energy flows within that ecology need to be mapped, and (3) relationships between different business models must be identified.

The paper builds on our conceptual work (Boons and Bocken, in review) and introduces a methodological approach to tackle these issues, and illustrate this approach with examples.

To summarize, the research questions that are addressed are:

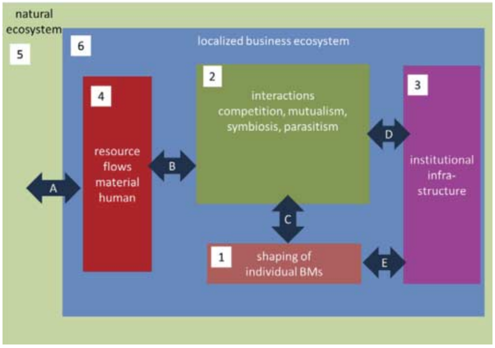

Figure 1. An ecology of business models.

1. How can we conceptualize the context of individual business models in a way that allows us to address their impact in a more comprehensive way?

2. What methodological requirements must be met to collect and analyze data that fit with an ecological approach to business model assessment?

An ecosystem of business models

Figure 1 summarizes an ecosystem perspective on business models. Referring to Figure 1, the shaping of individual business models (1) takes place in an institutional context (3) which provides rules that are more or less conducive to certain forms or providing products and services. For example, in the case of electronics in Europe where the Waste of electrical and electronic equipment (WEEE) directive applies, the focus for original equipment manufacturers such as Apple and IBM has been on recovery schemes to collect used electronics which are processed into refurbishment options offered with a limited warrantee (Parker et al., 2015). The focus on 'waste' and collection in terms of weight in the WEEE may have provided less of a focus on new business models, with built in service offering and remanufacturing capabilities, but rather a focus on end-of-life recovery. Existing sales-driven business models prevail. In addition, such shaping of individual business models occurs in the context of other business models (2), some of which compete with the new business model, while others are complementary, or even provide vital inputs for the new business model, For example, the organization iFixit, 'a global community of people helping each other repair things' (www.ifixit.com), has emerged which could help Apple users and others fixed their own devices, with repair services being limited in existing business models. This may be seen as a complementary organization allowing customers to keep their own devices for longer. Our main thesis is that the ecological impact of a business model is difficult to assess; this impact is shaped by the interaction with other business models. This eventually determines the material, energy and labor flows (4) associated with the provision of products and services. Our claim is thus that, in order to understand how the provisioning of goods and services impacts on the natural ecosystem (5), we will need to look at a localized business ecosystem (6), rather than an individual business model.

One insightful interrelation between business models is the fact that many emerging sharing business models build on the availability of mobile devices and wireless infrastructure to facilitate the efficient allocation of the physical objects to be shared (e.g. Uber, Lyft, Airbnb, Couchsurfing). This effectively links such sharing business models (of for instance cars and bikes), with the business models through which mobile devices and related infrastructure is provided into a mutualistic relationship. In our view, an assessment of ecological impact of such sharing business models needs to take the ecological impacts of mobile communication into account. A second interrelation exists between the business model and existing infrastructure (e.g. home sharing platforms using existing homes, car sharing using existing cars and parking spots). A third interrelation is related to increased affordability and increased usage of products or infrastructures not originally designed for intense use. As Mont (2002) and Tukker (2004; 2015) already argued, a PSS would need to build in 'the right behaviours' and desirable sustainability impacts more generally. This issue linked to product usage and rebound effects, as well as the way products and product service systems are designed. Product sharing platform Peerby in its crowdfunding campaign for example aims for 'circular products' optimized for quality, durability and shared usage, making use of smart communities and technologies (One Planet Crowd, 2017). With more intense use, product design would need to factor in reusability and reduced resource use in the consumer use phase. Moreover, with higher affordability of cars/ taxis and holidays, the usage of services might increase.

Environmental assessment methods

When seeking to assess environmental (and social) impact in terms of ecologies of business models it should be noted that the environmental assessment of individual *business models* is also still under development. We therefore first discuss relevant developments in Life Cycle Assessment (LCA), and then look at urban metabolism as a way of getting to the ecosystem level.

There are several examples where LCA (and related methods such as LCC and SLCA) have been applied to assess the environmental impact of business models. In part this has been done to assess the shift from products to services (Chun & Lee; Lindahl et al. 2014), but also to other dimensions of business models (Suckling & Lee 2015). More generically, the application of LCA in relation to individual business models in our view requires:

A systematic inclusion of the impacts of actors and organizational embedding of production and consumption activities (for an example of their relevance, see Brunklaus et al. 2010).

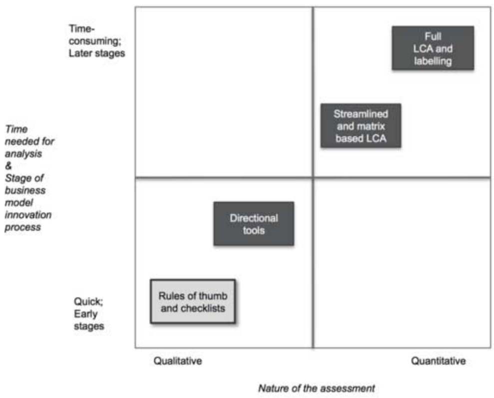

Figure 2. Types of Environmental Assessment.

The use of inventory data that go beyond global averages, to include the local diversity produced by business models. Although primary data from production and logistics processes and so on are preferred for environmental analyses, databases with proxies are often used because such detailed data are not available. Lindahl et al. (2014) for example compared different PSS offerings but were also limited by the lack of available data.
Environmental assessment could range from rules of thumb up to high levels of detail (Fig. 2).

Urban metabolism

Urban metabolism analysis is a comprehensive approach, accounting for all the material and energy flows that occur in cities, including their socio-economic embedding (Kennedy et al. 2007). *"Urban metabolism can be thought of as the inflows of material and energy resources, the outflows of wastes and emissions and the retention of materials as stock in the built environment and infrastructure."* (Clift et al., 2015, p. 4)

Impacts analyzed could include environmental indicators such as materials, waste, water and emissions, as well as economic and social indicators. Analysis applied in this context could include Mass Flow Analysis; analyses of per capita emissions, or Environmentally-extended input-output analysis methodology (EEIO) (Clift, 2015).

This comprehensive and systemic analysis could also be viable for business model eco-system analysis. The challenge here is how the systemic view may be pursued by companies/entrepreneurs wanting to understand the impact of their business models for strategic decision-making; there are relatively high time and data requirements and data uncertainty, and coordination with other system actors seems a requirement.

Single metrics

To get around the complexity of needing to consider multiple dimensions, one way for businesses to assess their impact is to focus on single issues targeted through their business model: e.g., avoided kilometers driven; laundry cycles run; or avoided new cars and washing machines sold. While a pragmatic solution to start designing new business models, other indicators such as the 'additional products or infrastructures required' would be needed.
Table 1 provides examples of the considerations per case.

From Table 1, it is clear that for a company the easiest way is to report on single issues, such as the 'number of wears per item' in clothing sharing. However, this may lead companies to choose the metrics that are easiest to report but are not necessarily material issues to the company.

The 'urban metabolism approach', which could be the basis for the ecologies of business models approach potentially allows for a more 'honest' and comprehensive approach to environmental impact. Table 2 builds on this notion to suggest business model design considerations taken into account the examples in Table 1 and Figure 2.

	Urban metabolism approach	Single metric approach
Car sharing (e.g., Blabla car)	- Type of car used (car design & efficiency) - Dependency on other products (mobile phones, Data centres) - Dependency on infrastructure (e.g. parking) - Interactions with existing business models such as those of car manufacturers (e.g. cannibalization, parasitism, symbiosis) - Rebound effects	- New car sales (decrease) or - Number of users per car (increase)
Clothing sharing (e.g. LENA Fashion library)	- Clothing design and design for use phase (easy to wash; stain repellant etc.) - Dependency on other products (e.g. apps, phones) - Dependency on infrastructure (e.g. physical stores) - Interactions with existing business models such as clothing manufacturers (competition, mutualism, symbiosis, parasitism.) - Rebound effects	-New clothing sales (decrease) or -Number of wears per item (increase) or - Reduced clothing to landfill

Table 1. Sharing examples. Environmental considerations per case.

Business model design consideration	Examples
Product design	- Design for low embedded carbon footprint (material/ resource use per product) - Product reusability (e.g. reparability,) - Product use phase (e.g. energy and water use in the product use phase)
Business model dependency	- Dependency on other products (e.g. mobile phones) - Dependency on infrastructures (e.g., public spaces)
Interactions with existing business models	- Competition - Mutualism - Symbiosis - Parasitism
Rebound effects	- Any unforeseen negative (or positive) effects not yet captured in the above considerations

Table 2. Ecologies of business models – business model design considerations for sharing economy business models.

Conclusions

New business models are often quoted for their potential system-level impact on societal and environmental issues. In this research we identified the following gaps in current understanding of business models and sustainability:

1. Business models require intentional design if they are to deliver sustainability; for this assessment tools need to be employed that can capture the effect of business models;
2. In assessing impact, it is crucial to acknowledge that business models are intertwined, and their sustainability impact is affected by other business models.

To assist in the design of new sustainable business models, we introduce an Ecology of Business Models arguing that:

1. The shaping of individual business models takes place in an *institutional* context, which provides rules that are more or less conducive to *certain forms* or providing products and services.
2. Such shaping occurs in the *context of other* business models.
3. Some of which *compete* with the new business model, while others are complementary, or even provide *vital inputs* for the new business model.
4. The ecological impact of a business model is difficult to assess as this impact is *shaped by the interaction* with other business models.
5. This eventually determines the material, energy and labor flows associated with the provision of products and services.
6. To understand how the provisioning of goods and services impacts on the natural ecosystem we will need to look at a localized business ecosystem rather than an individual business model.

We propose and approach of "Ecologies of business models – business model design considerations for sharing economy business models" in Table 2.

Business model design considerations are included focusing on: Product design, business model dependency, interactions with existing business models and rebound effects.

Future research could build on the Ecology of Business Model thinking to develop business models with a positive societal and environmental impact.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-51

Repair vs. replacement: what is the best alternative for household small electric and electronic equipment?

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Keywords
EEE
Repair
Replacement
LCA
Environmental performance

Abstract

This study presents a methodology designed for selecting, from an environmental point of view, the best end-of-life strategy for electric and electronic equipment which breaks before the end of its life span. For that, the environmental impact of the life cycle of the equipment is evaluated considering two alternative end-of-life strategies: repair & reuse or replacement. The Life Cycle Assessment methodology is applied to evaluate the environmental performance of each scenario, taking ReCiPe as end-point impact assessment method. The methodology is applied to a representative sample of nine categories of small household electrical and electronic equipment, considering different types of repair for each category and the replacement of the equipment in different years of its lifespan. For all the analyzed categories, the repair & reuse strategy generally proved environmentally better performance than replacement. However, for some types of repairs, e.g., those related to engines or printed circuit boards, if they occur in later product life cycle stages, it is better to replace equipment as the environmental impact from their repair operations is so high than it does not compensate prolonging the years of useful life obtained.

Introduction

End-of-life of electrical and electronic equipment (EEE) needs to be aligned with the objectives and principles promoted by both Directive 2012/19/EU and Circular Economy action plan (COM 614, 2015). To this end, preparing for the reuse of EEE is prioritized against other valorization options. However, aspects such as the life span of the EEE and the age when it fails and the type of failure, need to be taken into account during the decision-making process.

In this context, this study presents a methodology capable of assessing the environmental performance of the life cycle of the EEE considering two alternative end-of-life strategies: 1) repair & reuse or 2) replacement. It is applied to a representative sample of nine different categories of household small electric and electronic equipment (sEEE).

Methodology

Figure 1 shows the proposed three-step methodology to evaluate the environmental performance of the life cycle of sEEE, considering different end-of-life strategies (repair & reuse or replacement). The content of each stage is described below:

- *Stage 1: Data collection*
  Information about the material composition of sEEE, consumer use habits, commonest failures and repair activities of sEEE, need to be obtained to model the life cycle of each scenario.
- *Stage 2: Scenarios definition*
  Alternative scenarios are defined by considering the different variables that affect each one. For the replacement scenarios, the manufacturing, distribution and use of not only the initial sEEE, but also the replacing sEEE, have to be considered, along

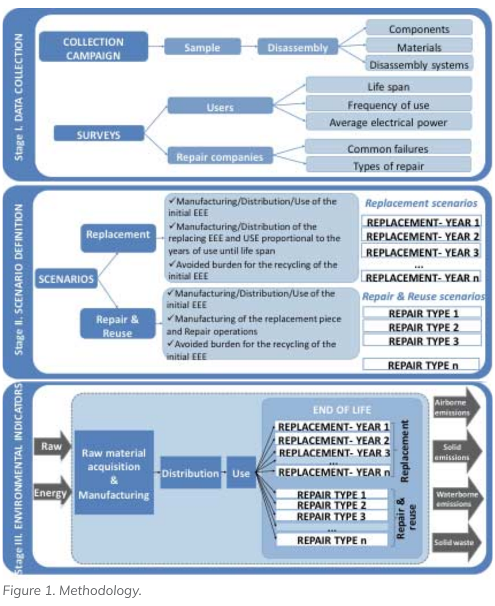

Figure 1. Methodology.

with the proportional impact associated with using replaced sEEE in the years left until its lifespan ends. It is assumed that the replacing sEEE is the same that the equipment that replaces. For the repair & reuse scenarios, the manufacturing, distribution and use of both initial EEE and replaced pieces/components needed for the repairing process have to be considered, along with their environmental impact during repair operations. This results in the configuration of the same number of replacement scenarios as the lifetime years of sEEE under study, and the same number of repair & reuse scenarios as the types of repair operations identified in the previous methodology stage.

- *Stage 3: Environmental indicators*
  The life cycle assessment (LCA) methodology (ISO 14040-44, 2006) is applied to obtain the environmental performance of each scenario. SimaPro 8 LCA software (PRé Consultants, 2015) is applied to model each alternative scenario, being Ecoinvent 3.2 (2014) and ReCiPe method (PRé Consultants, 2014) the inventory database and the end-point impact assessment method applied, respectively. The obtained environmental indicators help to identify the best end-of-life strategy for each sEEE category, depending on the type of failure and the age of the equipment when it fails.

Product category	**Weight (kg)**	**No. of appliances**
Vacuum cleaner	32.57	7
Hand blender	14.68	17
Heater	11.7	7
Iron	44.15	30
Hair dryer	8.92	17
Toaster	18.65	14
Coffee maker	26.28	13
Juicer	8.89	8
Sandwich maker	14.84	7

Table 1. Classification of the small EEE domestic category.

Figure 2. Small household electrical and electronic equipment categories analysed.

Case study

The proposed methodology was applied to different small household EEE categories. To model the alternative scenarios for each category, information was collected from two different data sources:

- Primary data needed for the equipment material model was obtained directly from the characterization of a representative household sEEE sample collected from a collection campaign designed and implemented in the city of Castellón de la Plana (Spain) (Bovea et al., 2016), with 138,131 inhabitants. In this case study, 120 of the collected appliances were analysed, belonging to the categories reported in Table 1 and Figure 2.

- Primary data needed for the equipment use model was obtained from a survey focused on identifying the consumer use habits (Pérez-Belis et al., 2017).

- Primary data needed to model the end-of-life alternatives, was collected from surveys to repair companies and second-hand shops focused on identifying the more frequent repair types characterizing each small household EEE category (Bovea et al., 2017). The repair types analysed for each category are reported in Table 2.

	Vacuum cleaner	Hand blender	Coffe maker	Heater	Juicer	Iron	Sandwich maker	Hair dryer	Toaster
Rep. 1	MOT	PCB	CAB	FAN	CAB	CAB	CAB	CAB	CAB
Rep. 2	FIL	CAB	PLU	PCB	PLU	PLU	PLU	PLU	PLU
Rep. 3	CAB	PLU	ACC	CAB		VSP			RES
Rep. 4	PLU	MOT	RES	PLU		SOL			
Rep. 5	DEP	POC	PIT	MOT		DEP			
Rep. 6	ACC	ACC	COV	TIN		THE			
Rep. 7	PCB		POC	RES		RES			
Rep. 8	POC		FIL			TSW			
Rep 9	SWH		ANT						

MOT: motor; FIL: filter; CAB: cable; PLU: plug; DEP: deposit; ACC: accessory; PCB: printed circuit board;

POC: power control; SWH: small wheel;

RES: resistance; PIT: pitcher; COV: cover; ANT: anti-slip pieces; TIN: temperature indicator; VSP: vapor spray; THE: thermostat; TSW: temperature switch; SOL: soleplate; DEP: deposit.

Table 2. Repair types by small household EEE category

Results

Once each scenario is modelled, an environmental indicator was obtained for each one, as previously described in the methodology.
Then, the environmental indicator is compared between:

- Repairing the broken small household EEE and continue using it until the end of its life span.
- Discard the broken small household EEE and replace it for an equivalent one.

Table 2 reports the best end-of-life strategy (repair & reuse or replacement) for each comparison of scenarios. The number of columns for each small household category depends on its life span, while the number of rows depends on the number of commonly types of failures identified for each equipment category. If the cell in Table 3 is colored green, it means that the environmental impact of repairing and continuing using the same small household EEE is lower that replacing the broken equipment by an equivalent one for the remaining years until the end of its life span. The cell is colored red on the opposite case.

TYPE OF REPAIR	LIFE SPAN (YEAR)								
	1	2	3	4	5	6	7	8	9
VACUUM CLEANER									
Rep.1									
Rep.2									
Rep.3									
Rep.4									
Rep.5									
Rep.6									
Rep.7									
Rep.8									
Rep.9									
HAND BLENDER									
Rep.1									
Rep.2									
Rep.3									
Rep.4									
Rep.5									
Rep.6									
COFFEE MAKER									
Rep.1									
Rep.2									
Rep.3									
Rep.4									
Rep.5									
Rep.6									
Rep.7									
Rep.8									
Rep.9									
HEATER									
Rep.1									
Rep.2									
Rep.3									
Rep.4									
Rep.5									
Rep.6									
Rep.7									
JUICER									
Rep.1									
Rep.2									
IRON									
Rep.1									
Rep.2									
Rep.3									
Rep.4									
Rep.5									
Rep.6									
Rep.7									
Rep.8									
SANDWICH MAKER									
Rep.1									
Rep.2									
HAIR DRYER									
Rep.1									
Rep.2									
TOASTER									
Rep.1									
Rep.2									
Rep.3									

Repair & Reuse
Replacement
Not applicable

Table 3. Results: best end-of-life strategy for each comparison of scenarios.

Conclusions

For all the analyzed household's EEE categories, the repair & reuse option generally proved environmentally better than replacement, as Directive 2012/19/EU promotes. However, for some failures, e.g., those related to engines or printed circuit boards, if they occur in later product life cycle stages, it is better to replace equipment as the environmental impact from their repair operations is so high than it does not compensate prolonging the years of useful life obtained.

This study can be useful to target the proper audiences and future awareness campaigns. In doing so, extending the lifespan of EEE can be promoted by repairing and second-hand purchases.

Acknowledgments

The authors are grateful to the Ministerio de Economía y Competitividad, Programa Estatal de Investigación, Desarrollo e Innovación Orientada a los Retos de la Sociedad for funding for this study (Project DPI2013-40815 R).

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-54

Understanding material change: design for appropriate product lifetimes

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Keywords
Material change
Cosmetic obsolescence
Patina
Graceful ageing
Materials library

Abstract
From the moment of purchase, pristine objects are subjected to an array of stimuli including wear, impact, heat, light, water and air which alter their tactile and aesthetic properties. Material change is often regarded as 'damage' or 'degradation', but has potential to be used as a tool to engender emotional engagement to an object and extend product lifetimes. The potential benefits, and complications, associated with material change in the context of designing for the circular economy and other sustainable product service systems is discussed. We present a framework for designers to better understand how materials change with use, and in turn how people respond to materials as they change. Key challenges are identified which must be overcome to use this framework in design practice: people's physical interaction with objects is poorly understood, it is difficult to simulate material change, materials resources for designers do not provide information about material change, and people's responses to aged materials depend on a complex web of interacting factors.

Introduction

Materials change: *"…the formal language of design has notably shifted to a space dominated by the smooth and opaque surface. Such impenetrable surfaces make it easy to forget that the materials from which it was made are kinetic, that it is their 'will' to decay or change state"* (Carr & Gibson, 2015, p. 9).

The process of material selection is usually focused on the pristine, mass-produced object that entices the purchaser, but from the moment of purchase the surface of an object changes in response to use and interaction with its environment (Figure 1). Abrasion, polishing, ablation, impact, accumulated dirt, mould and oxidation combine to create a surface 'patina' that discloses the life of the object (Candy et al., 2004; Giaccardi et al., 2014; Nobels et al., 2015): *"Industrial design usually produces objects to be used in the future, but rarely investigates how these objects will change in time"* (Nobels et al., 2015). Delight at the untouched, often shiny, appearance of new products which "invites sensual engagement" (Maffei & Fisher, 2013, p. 231) can rapidly change to dis-satisfaction with 'worn' or 'aged' materials which, coupled with persuasive advertising, drives the cycle of replacement of products which are still fully functional (Nobels et al., 2015; Woolley, 2003). Material change is commonly perceived as damage or degradation, and for many types of product 'cosmetic obsolescence' contributes to premature disposal and unsustainably short product lifetimes (Cooper, 2005; Lilley et al., 2016; Manley, Lilley, & Hurn, 2015b; Packard, 1963): *"Many objects lose value in time because they lose newness, which is the attractive factor in the purchase phase. Newness is a complex mixture of different sensorial properties like odour, shiny colour and the integrity of surfaces."* (Nobels et al., 2015).

Whilst 'graceful ageing' of material surfaces is a potential strategy for creating enduring products, emotional attachment is difficult to predict and often elusive (Connor-Crabb, Miller, & Chapman, 2016; Cooper, 2005; Tasaki, 1992). *"Objects capable of sustaining long-lasting relationships with consumers are rare"* (Chapman, 2005, p. 66) due to unreasonably high expectations, rapid 'acclimatization' and loss of novelty.

In this paper, we ask: "with a better understanding of material change and how it is perceived, could product lifetimes be extended by designing for positive experiences of material change through the life of a product?"

This paper explores how aesthetic changes to the surface of a material are perceived, and how material change could be more widely utilised as a design tool. Combining a literature review with user studies, a complex web of factors is identified which are presented in a 'framework for understanding material change'. The considerable challenges which must be overcome to enable designers to understand material change throughout the product lifespan are identified.

Figure 1. Materials change (clockwise from top left): a plastic spade is severely faded by sunlight (despite it being designed for outdoor use); sandstone develops a rich patina of lichen; wood has lost colour but the surface texture is accentuated after exposure to sunlight and salt from the sea; mild steel reacts with oxygen and water to produce beautiful but fragile rust. In each case the new material is on the left. Except for the spade, the new and old materials are similar but not identical samples.

A framework understanding material change in product design

An understanding of material 'durability', i.e. how a material changes in response to a wide range of physical, chemical and biological stimuli, is a vital first step in understanding how material change will influence the lifespan of a product. But this is not enough. A combination of material changes, interwoven over time, combine to create a surface 'patina' that discloses the life of an object. There is a dichotomy in how this patina is interpreted; it can result in dissatisfaction or allow an emotional bond to be forged with the object (Baxter, Aurisicchio, & Childs, 2016; DeSilvey, 2006; Giaccardi et al., 2014). *"It is important to note here that patina is not an issue to do with material resilience or durability, but rather, a societal preoccupation with what an appropriate condition is for certain typologies of material and objects to be in"* (Chapman, 2013, p. 141).

We propose that a complex web of factors must be considered which require a multi-disciplinary approach to understand an individual's response to a particular product in a particular condition. The interaction of these factors is summarised in Figure 2.

Materials engineering is required to understand how the choice of materials (intrinsic properties), and the specific application of these materials in a product (extrinsic properties) combine with an array of stimuli to produce changes to the material surface. Material properties, such as surface roughness, thermal conductivity and hardness, can be used to give an indication of sensory attributes, i.e. how the object will look and feel, and even how it will smell, sound (when struck) and taste (Ashby & Johnson, 2013; C.J. Barnes, 2004; Skedung et al., 2011; Wongsriruksa et al., 2012).

But there is a further step to move from sensory attributes to people's perception of the material – how does it make them feel? What is their emotional response to the material, and to the object of which it is part? (Chapman, 2005; Karana, Hekkert, & Kandachar, 2010; Manley et al., 2016; Mugge, Schoormans, & Schifferstein, 2005). For a new product, there is a complex set of interacting factors that mediate the owner's emotional response, including cultural influences, fashion, expectation, product context, past experience and preconceptions, provenance and duration of ownership, and uniqueness and personalisation. For older products that have undergone material change, these factors are still valid, but are joined by a further set of considerations:

- Has the owner spent time caring for the object, repairing, cleaning and maintaining it (Gregson, Metcalfe, & Crewe, 2009; Salvia, 2015)?

- How did the changes to the object's surface occur – rapidly or gradually; accidentally, deliberately, or during a memorable event (for example during a particular sporting event) (Manley, Lilley, & Hurn, 2015a; Odom & Pierce, 2009)?

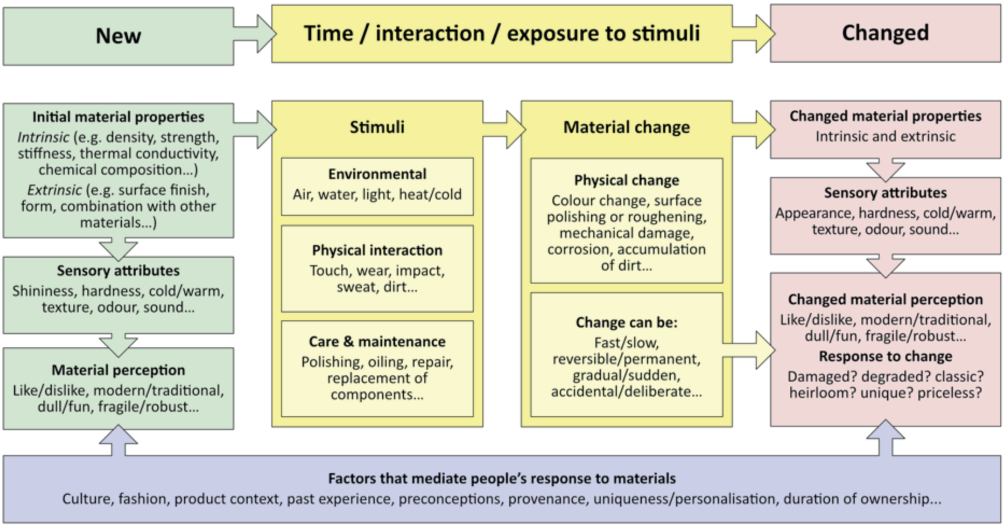

Figure 2. Framework for understanding material change in product design, showing interaction of material type, intrinsic and extrinsic properties, stimuli, and physical material changes, and experiential responses to those changes.

- Are the changes reversible or permanent?
- How do the changed sensory attributes compare to the original condition of the object (Pedgley, 2014)?

These myriad factors combine to demarcate the elusive difference between wear, damage, degradation and 'graceful ageing'. Understanding these factors is vital to enable designers to create enduring (as opposed to durable) objects: *"Some materials 'degrade' while others 'mature' by maintaining or improving certain qualities. The positive term of maturity is usually used for natural materials such as stone, paper, wood, and leather, which over the years can acquire scents, colours, and textures: characteristics that far from diminishing their quality, instead acquire an aura of antiquity and preciousness"* (Rognoli & Karana, 2014).

Designing for appropriate product lifetimes in the context of the circular economy

In response to the negative impacts of the linear 'take-make-waste' economy, and its increasing fragility in the light of material scarcity and price volatility, there is a growing focus on 'closing the loop' on resource use through a transition to the 'circular economy' (Braungart, McDonough, & Bollinger, 2007; British Standards Institution, 2017; Ellen MacArthur Foundation, 2015; European Commission, 2015; The Great Recovery, 2013). In addition, there is an increasing awareness of the importance of engaging citizens in the circular economy, in terms of consumer acceptance of new 'models of consumption' (Gullstrand Edbring, Lehner, & Mont, 2016; Hobson et al., 2017) and wider questions about the social and cultural consequences of the proposed circular production and consumption systems (Hobson & Lynch, 2016). As an alternative to the circular economy, or as part of an enabling strategy, new 'Product Service Systems' often involve a move from private ownership of products to provision of services, leasing, or shared ownership (Bardhi & Eckhardt, 2012; Rogers et al., 2015; Wilson et al., 2015).

The circular economy is normally described in terms of circular flows of materials, being: *"a simple, but convincing, strategy, which aims at reducing both input of virgin materials and output of wastes…"* (Haas et al., 2015, p. 765). However, it can equally be seen as a way of maintaining the value of products, components and materials. One approach advocated by proponents of the circular economy is 'design for longevity' (Park, 2009; The Great Recovery, 2013), with carefully orchestrated material change being one strategy to potentially increase product lifetimes through emotional attachment to an object.

In the context of material and product reuse through the circular- or sharing- economy, is it beneficial to engender attachment through material change? The answer is, of course, complex and answering it requires speculative life-cycle analysis of multiple possible product life scenarios, which will be different for every product. Any form of re-use, re-manufacturing or recycling will entail negative environmental impacts due to transportation and processing. Product longevity avoids these impacts and therefore has the potential to minimise environmental impacts. However, for products which require energy in the use phase (e.g. cars and electronic devices) (Suckling & Lee, 2015; Van Nes & Cramer, 2006) or substantial maintenance (Kara et al., 2008), it may actually be beneficial to replace (or upgrade) older inefficient products with newer models. Whether increasing product longevity minimises environmental impacts depends on the balance between impacts at the various stages of the product lifetime, and the end-of-life strategy (Cooper, 2016; Kwak & Kim, 2012), and currently the tools are not available for designers to carry out this type of analysis quickly and cheaply (Bridgens et al., 2017; Lee et al., 2015).

A key consideration is that whilst material change may be viewed positively for a product that is owned by an individual, it is likely to be seen as 'contamination' when the object is shared, changes owner or is in public ownership (e.g. public spaces and public transport vehicles) (Gullstrand Edbring et al., 2016). There are two distinct forms of contamination: technical contamination in which the purity of the materials is compromised making them more difficult to recycle (as opposed to downcycle) (McDonough & Braungart, 2002), and *interaction contamination* in which material change leaves traces of use on an object (Baxter, Aurisicchio, & Childs, 2017).

Challenges

Materials resources for designers

A range of material selection resources are used both to educate design students, and to inform material selection in design practice (Akin & Pedgley, 2016; Sörensen, Jagtap, & Warell, 2016; van Kesteren, 2008). Physical collections of materials provide the benefit of being able to handle samples and experience their tactile and aesthetic properties. Physical materials libraries present material samples in pristine condition, or in an unquantified state of degradation following handling and exposure to light (Figure 3). Akin and Pedgley (2016)'s review of materials library provision makes no reference to material change or durability.

Online resources provide detailed technical engineering properties including some measure of functional durability, for example numerical durability ratings for different types of environmental exposure (e.g. acid/alkali, fatigue, ultraviolet). These resources are just beginning to include sensorial properties (Ashby & Johnson, 2013) (Figure 3), but provide no information about aesthetic and tactile change with use. Material libraries are also typically devoid of context and extrinsic material properties, such as the influence of material form, thickness, processing, and combination with other materials in a product.

It could be argued that tacit knowledge built up from personal experience observing material change in a wide range of products equips designers to specify materials which will 'age' well in a particular application. This may be true for certain commonly used materials (e.g. ABS plastic, copper, oak, and so on), but tacit understanding is hampered by the complex web of factors that influence how a material will change in use, including the vast number of material variants and new materials, different surface finishes, different manufacturing processes and so on.

Simulating physical interaction

To study people's response to materials that are worn or changed, to create resources to improve designers' understanding of material change, and to facilitate the development of material surfaces which age in particular ways, it is necessary to simulate material change. *Accelerated ageing* is standard practice in many industries from wear testing of prosthetic joints to artificial

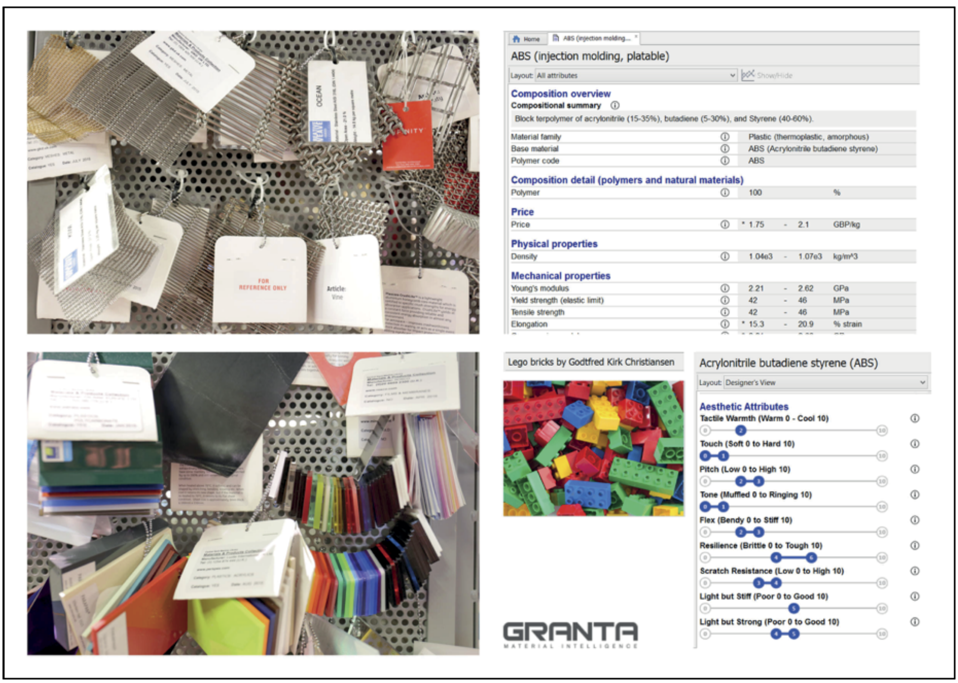

Figure 3. Pristine material samples presented at Central Saint Martins College of Art and Design Materials Collection, London (left); Granta CES Edupack materials database provides detailed engineering material properties (top right), and the new prototype Granta CES 'Products, Materials and Processes' database which includes design case studies and aesthetic or experiential material properties (bottom right).

weathering of construction materials, but there are no test methods for assessing the aesthetic and tactile changes of products in response to normal use, and very limited published work about how people physically interact with products.

In a recent study the authors attempted to develop accelerated ageing methods to simulate both 'careful use' (e.g. holding whilst in use and carrying in a pocket) and 'severe use' (e.g. carrying in a bag with keys, accidental dropping) of a mobile phone, to enable 'aged' material surfaces to be created for user testing, and to test a prototype layered surface finish which was designed to age spectacularly (Bridgens et al., 2017; Bridgens et al., 2015; Lilley et al., 2016). User testing of this layered material surface resulted in chipping and scratching of the surface, not the gradual wear that was anticipated. This damage to the layered phone surface demonstrated that it is not understood how people interact with their possessions and how this interaction impacts the object's surface. Hence physical test methods cannot currently simulate material use and ageing, making material evaluation and development difficult (Bridgens et al., 2017).

Conclusions

A framework has been presented which is intended to provide a tool which can be used to combine information from multiple sources to better understand the interaction of how products are used, how materials change in response to stimuli, and how people will respond to those changes (Figure 2). In each of these areas further work is required to provide sufficient information to enable this tool to be used in the design process.

The need for this information is becoming increasingly important as myriad new materials such as fibre reinforced composites, bioplastics and 'DIY materials' (Salvia, 2016; Tanenbaum et al., 2013) are developed, for which designers lack any tacit knowledge of how they will change. Accelerated 'wear and tear' testing should enable more rapid, lower risk, adoption of new materials in products.

Even if people's physical interaction with products was better understood, and suitable accelerated ageing tests could be developed to simulate 'wear and tear', a generic test is unlikely to achieve 'graceful ageing' as the stimuli required are different for each material, and may require a combination of stimuli over varying timescales. For example, ultraviolet light is required to emphasise grain in wood, wax and oil are beneficial to material change of leather and wood, moisture and oxygen are required for patination of copper.

Improved understanding of material change will enable designers to consider material change throughout the design process. Once material change is considered in tandem with form, use, ergonomics and operating environment, then it may be possible to design for a particular form of material change and extend the emotional durability of products: *"patina is a necessary design consideration to assist the extension of product life spans in graceful and socially acceptable ways"* (Chapman, 2013, p. 141).

For many types of product, lifetime extension and the avoidance of premature disposal due to 'cosmetic obsolescence', is the most effective strategy to reduce environmental impacts from the manufacturing and disposal of the object. However, as industries transition towards the circular economy or other modes of consumption, care must be taken to not jeopardise future re-use and recycling for the sake of modest increases in longevity. Simple, accessible lifecycle assessment tools are urgently required to enable designers to make informed decisions based on multiple product lifetime scenarios.

Acknowledgments

The authors would like to thank the UK Engineering and Physical Sciences Research Council who provided all funding for this work as part of the Closed Loop Emotionally Valuable E-waste Recovery project (EP/K026380/1), and Granta Design (https://www.grantadesign.com) and SCIN (http://scin.co.uk) who provided access to their materials specification resources.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-60

Satisfaction matters: design that learns from users' sensory and emotional responses to clothing

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Keywords
Clothing durability
Satisfaction
User experience
Sensory ethnography
Design for continuity

Abstract

Researchers across disciplines increasingly acknowledge that embracing the multi-sensory character of everyday perception can provide invaluable insights for social and design interventions that aim to improve the experience of products and services. Where fashion design traditionally focuses on the aesthetic, visual side of design, empirical studies prove that the way clothes feel, sound, or smell, is equally important for the way they are experienced and appreciated in everyday use. The aim of this paper is therefore to explore how users' sensory engagement with clothing can inform the creative practice of designers who wish to design for continuity and increased user satisfaction. Satisfaction with a garment often leads to its repeated use and accumulation of pleasurable memories that can both positively influence the active lifetime of the garment. The paper draws on my on-going PhD research and presents initial findings of the second phase of my project (in-progress), which consists of a series of wardrobe studies conducted in participant's homes. The results so far indicate that sensory experiences connected with clothing, although rarely explicitly acknowledged by users, can significantly affect user satisfaction and therefore deserve a greater attention in the context of sustainable design and design for longevity.

Introduction: Design for continuity

Consumption patterns associated with fast fashion often reduce the active lifetime of a garment to less than a season (WRAP, 2013), contributing, on the one hand, to alarming volumes of textile waste (Alwood et al., 2006) and, on the other, to frustration with low-quality garments experienced by consumers (Niinimäki, 2014). At the same time, extensive research evidence shows that people often form deep attachments to clothing which make them want to wear the same piece again and again (Solomon, 1986; Schultz Kleine, Kleine III & Allen, 1995; Klepp, 2010; Skjold, 2014; Fletcher, 2016). This long-term satisfaction with garments considerably contributes to their longevity as it is often connected with care and repair that extends the active lifetime of the cherished piece (Niinimäki, 2013; Niinimäki & Koskinen, 2011).

Fashion design traditionally focuses on the aesthetic, visual side of design, however, empirical studies prove that the way clothes feel, sound, or smell, is equally important for people who wear them (Woodward, 2007; Johnson & Bradley, 2007; Fletcher, 2016). Researchers across disciplines increasingly acknowledge that embracing the multi-sensory character of our perception can provide invaluable insights for social and design interventions that aim to improve the everyday experience of products and services (Pink, 2015). A recent pilot study conducted by Riisberg, Bang, Locher & Moat (2015) was among the first attempts to examine user's tactile reflections on fabrics and garments as a resource for participatory approaches to fashion and textiles that could open up innovative ways of sustainable design education. The aim of this paper is to explore how multi-sensory perceptions of clothing affect user satisfaction and how these perceptions could inform the creative practice of fashion designers who wish to design longer-lasting garments.

The paper draws on my ongoing practice-based PhD research that investigates how the concept of emotional durability can be applied in fashion design and making. The research process is underpinned by my designer-maker practice and the overarching focus of the enquiry is on the ways in which designers can positively affect user experience of clothing and so create garments with a long-term appeal to their users. The paper presents initial findings of the second phase of my project which is currently in-progress and includes a series of wardrobe studies that employ sensory ethnography and visual ethnographic methods to study user's sensory and emotional responses to clothing.

Context: Sensory and emotional responses to clothing

In his *Emotional Design: Why we love or hate everyday things* (2004) Norman explains that humans process experience on three levels, associated with different levels of the brain. As each of the three levels play a different, yet important, role in our everyday interactions with the world, Norman argues that each level also requires a different approach to design. The first, *visceral* level of brain, requires design that focuses on appearance – the way things look. The second, *behavioural* level of brain, needs designers to consider the pleasure and effectiveness of use – the way things work and feel. The third and last, *reflective* level, is directed towards self-image and memories associated with the product – in other words, the meaning of things.

Fashion designers, however, are traditionally trained for the magic moment of the first impression. Glamorous fashion photographs present the utopian ideal of owning the garment, presenting it, as Fletcher remarks, "unworn and uncrumpled" (2016, p. 101) – no more than a static object designed for a strong visual impact. In the context of Norman's three level design, fashion design is directed towards the first, *visceral* level, that focuses on looks. Powerful branding then addresses our self-image and hence the design's potential appeal on the third, *reflexive* level. What is often omitted in fashion, however, is Norman's second, *behavioural* level of design, which considers how things work or feel in everyday use.

The significance of everyday experience of clothing, including the way clothes work and feel in daily use, is increasingly recognized by fashion researchers. The ethnographic studies conducted by Woodward (2007), Klepp (2010) or Skjold (2014) unanimously demonstrate that the apparently straightforward visual appeal of a piece of clothing, presented by commercial fashion photography, in fact becomes much more complex in the everyday reality of our lives. For instance, Woodward, who studied women's decisions on what to wear, points out that the everyday moment in front of the mirror extends far beyond the visual/aesthetic aspects of a garment and has a considerable impact on the extent to which women feel comfortable in their clothing. Comfort, according to Woodward, "emerges in a dialectic between how clothing looks and how it feels" (2007, p. 99). Niinimäki & Koskinen also note that the beauty of clothing includes "tactile, olfactory and kinetic experiences, such as the feeling of comfort, the weight of the material against our body, and pleasant touch and odour" (2011, p. 170).

Research design: Wardrobe studies

The significance of multi-sensory appreciation of the world around us is also reflected in the research of anthropologist Sarah Pink (2005, 2007, 2012, 2015) who demonstrates, on numerous applied projects, that employing sensory perspectives in fieldwork can contribute valuable insights on how everyday products and services are experienced. The research process of my wardrobe studies has been informed by Pink's work as well as by my own designer-maker practice which has often enabled me to visit clients in their homes to discuss new commissioned pieces in relationship to other garments they own. From a design point of view, these home visits have invariably served as a valuable source of information about each person's preferences regarding style, fit, colour, material and also about their general attitudes and views on clothing. In line with observations made by Woodward (2007), Klepp (2010) and Skjold (2014) who conducted in-depth wardrobe studies in participants' homes, during my home visits of clients I have noticed that the presence of their whole wardrobes and other personal objects often triggered conversations and narratives that would hardly have been possible in a situation removed from the home environment. As Klepp & Bjerck point out, experiences connected to clothing are not always easily verbalized and often assume tacit understanding (2014, p. 374). The opportunity to study pieces of clothing in the home environment can therefore not only help facilitate discussion but also enables researchers to observe and explain daily practices in context – a method that has become widely known through the work of Clifford Geertz (1973) as "thick description".

As a result, my empirical research, currently in-progress, includes a series of wardrobe studies with female adult participants aged between 25-70 and focuses mainly on clothing owned and used for an extended period of time (3+years). Since establishing rapport between the researcher and each participant is a sine qua non for studies that take place in the intimate spaces of participants' homes, snowball sampling and word of mouth have been identified as the most suitable methods of recruiting participants to this research. To date, the sample has developed organically, using contacts from my designer-maker practice as 'gatekeepers' that can engage more participants in the research. This has also influenced the age group contributing to my studies as the clients of my studio are mainly mature women over 25. To attain the richness and depth of "thick description" (Geertz, 1973) within the time limitations of the PhD research, it is anticipated that the total number of studies will be no more than twelve. Five studies have taken place between January 2017 and May 2017.

The initial direction of each wardrobe interview is shaped with questions about the newest and the oldest items in each participant's wardrobe and the discussion is later led by the participant, with the occasional interjection to ensure that the conversation remains in context. All interviews are audio-recorded and participants' emotional and sensory responses to clothing are also documented through photography. Special attention is given to capturing the ways in which participants handle their clothing.

Initial findings and discussion: Making sense of satisfaction

Articulating satisfaction

The process of analysis includes verbatim transcription of each conversation and all transcripts are subsequently paired with the visual documentation collected during the interviews. This way of arranging the research material highlights that tactile engagement with clothing invariably accompanies the visual showing. This aligns with Pink's claim that our engagement with materials is often quite performative, as people tend to "stroke, feel, smell, visually show and as such engage sensorially" with objects during conversations (Pink, 2015, p. 127). Throughout the wardrobe interviews, such sensorial engagement often precedes any verbal description, other times it goes along with it and, perhaps most importantly, it also helps articulate what may first seem hard to put into words. Figure 1, for example, illustrates a situation in which a participant struggling to describe her difficulties in finding "the perfect pair of trousers" searched through her wardrobe and found a pair which helped demonstrate her experiences with fit. Figure 2 then shows how a deep satisfaction with a piece of clothing becomes explicit through facial expressions as well as through the ways in which a garment is handled by its owner before any verbal comments have been made. These observations indicate that sensory approaches to wardrobe studies contribute useful layers of information on the complex issues of user satisfaction and emotional attachment.

Focus on detail

During the interviews, favourite clothes are touched repeatedly and the participants often accompany their verbal descriptions by stroking the garment and pointing out its most appreciated details – such as interesting buttons, stitching, necklines, linings or belts (see Figure 3). Hidden details sometimes also serve as traces of personal stories connected to the garment and can be reminders of its longevity. This is well illustrated on an example of a dress worn by one of my participants for nearly twenty years. During this time, the dress had become one of the key pieces of her wardrobe. She describes, with a sense of pride, how this long relationship is reflected by a detail only known to her – an inside of a pocket (see Figure 4):

…. but here, what I want to show you on this dress – what is important…is…this…this is what I really like about it… that somewhere you can see…that originally…the original colour almost nowhere…well, in short that the colour is ever so lighter and lighter…you know, here you can see…that the dress used to be dark blue…but not anymore…

Pockets, it appears, are one of the key features of favourite garments and the importance assigned to them is shared by all five participants interviewed to date. If a garment is liked despite their absence, the lack of pockets is often commented on and described as "the only shame" or "the only disadvantage" of that piece of clothing.

The significance of garment details for a pleasurable use has also been recognized by Fletcher during her research for the Local Wisdom project which included nearly 500 participants interviewed about one favourite garment of their choice (2016). The importance of construction details is also highlighted by the *Design for Longevity* report (WRAP, 2013). All this evidence suggests that garment details positively affect user satisfaction and as such offer a rich ground for creative exploration by designers who wish to design garments for long-term use.

Learning through the senses

Participants' reflections on tactile properties of materials also provide important clues about pleasurable use and the emotional value of a piece of clothing. The hand of fabric, for instance, as well as its feel on the body are often mentioned in connection with favourite garments. Softness and weight of fabrics are repeatedly commented on, as for example in the following description of a top one participant often wears to work in combination with

Figure 1. A participant demonstrating her difficulties in finding "the perfect pair of trousers". (Photo: author, 2017)

Figure 2. A deep satisfaction with a garment often becomes explicit through facial expressions. (Photo: author, 2017)

Figure 3. A participant shows her favourite details on a jacket. (Photo: author, 2017)

Figure 4. Long-term satisfaction with this dress is demonstrated by the difference between the original colour (now only visible on the inside of the pocket) and the faded colour of the rest of the garment. (Photo: author, 2017)

various jackets: "it's very comfortable to wear…feel how soft it is…it's like…not wearing anything" (see Figure 5).

These perceptions of tactile qualities of garments confirm the findings of previous studies such as for example Niinimäki & Koskinen, (2011) or Riisberg et al. (2015). However, it is interesting to note that in contrast to the participants of the study conducted by Riisberg et al. (2015), where participants mainly admitted that their clothing choices were based primarily on visual perceptions of materials, the participants of my studies had a strong preference for tactile qualities of garments. This could potentially indicate shifting preferences in relationship to age as the participants of Riisberg's et al. (2015) study were high school students aged 18 to 20, while the youngest of my participants has been a woman in her late twenties.

In terms of olfactory perception of clothing, at this stage of the research the collected data does not clearly indicate a connection between olfactory qualities of materials, user satisfaction and emotional value of garments. Mugge, Schoormans & Schifferstein (2005, p.42) suggest that implementing odours in products can stimulate product related memories and hence potentially encourage the emotional bond between the user and the product. The initial findings from my wardrobe studies show that a garment's ability to resist perspiration and hence stay odour-free for longer seems to encourage more frequent wear for practical reasons - which potentially results in accumulation of memories and associations with the garment. As suggested by Laitaila & Boks (2012) who recommend using naturally anti-bacterial wool fibres that smell fresh for longer, my empirical studies also indicate that considering fabric quality and garment cut with the view to minimize the effects of perspiration, could contribute to the emotional value of a garment.

Sensory fashion designer

Pink proposes that sensory ethnographers should prepare for their fieldwork by an auto-ethnographic exercise which involves them developing an understanding of their own sensory perceptions (2015, p. 60). Despite the preliminary character of my findings, the material collected to date provides additional support for results reported by previous studies that explored sensory engagement with clothing and textiles (Riisberg et al., 2015; Delong, Wu & Park, 2012; Zuo, Hope & Jones, 2014); and so it seems possible to suggest that designers who wish to design for continuity and increased consumer satisfaction could usefully benefit from an auto-ethnographic sensory exercise such as the one Pink recommends to sensory ethnographers. Developing a deeper understanding of their own sensory responses to the clothes they wear could be the first step in shifting the focus of designers from the still prevailing visual perspective, to also considering how style, cut, garment details and materials and fastenings could affect user's tactile, olfactory or sonic perceptions of garments. As the examples presented in this paper demonstrate, these equally contribute to user experience and satisfaction with clothing and should therefore receive due consideration in the design process.

Figure 5. A participant demonstrating the soft feel of one of her favourite tops. (Photo: author, 2017)

Summary and next steps

This paper has introduced ways in which sensory experiences connected with clothing can enhance our understanding of clothing in use. Despite the preliminary character of this study, based on five in-depth wardrobe interviews conducted to date, this research indicates that sensory experiences connected with clothing, although rarely explicitly acknowledged by users, can significantly affect user satisfaction and therefore deserve greater attention in the context of sustainable design and design for longevity.

While more research is still needed to fully evaluate how sensory approaches to wardrobe studies can enhance our understanding of user attitudes and experiences with clothing, the initial findings discussed here signal that a shift towards design that adopts the multi-sensory quality of our daily experiences could enable more pleasurable experiences with clothing and increased user satisfaction.

The next steps in the research will include further wardrobe studies to enable comparisons with a greater number of participants. The potential of implementing user's sensory responses to clothing in the design process will be explored in the parallel practical element of my PhD research. The full findings of this research will be presented in my PhD thesis with expected completion date in the autumn 2018.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-65

Consumer and user acceptance in the circular economy: what are researchers missing?

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Keywords
Consumer acceptance
Circular economy
Product Service System
Remanufacturing
Literature review

Abstract
The circular economy is a platform to transition towards a more resource efficient system. Product service systems (PSS) and remanufacturing have been proposed as strategies to achieve material decoupling. Recent studies have found that their adoption has fallen short in the business-to-consumer sector, due to lack of consumer acceptance. Literature addressing this issue has failed to provide a systematic approach to the problem. By performing a structured search on Scopus and Web of Science, 24 papers focusing on consumer and user acceptance of remanufacturing and PSS were identified. By applying qualitative research methods, the articles were analysed using six categories: problem and research questions, definitions, theoretical background, issues, methods and research gaps. Resulting from the analysis an outline for a research agenda on the topic of consumer and user acceptance of PSS and remanufactured products is suggested. Such program needs to provide a definition of consumption, consumers and users in the circular economy including their role. It should explore external factors influencing acceptance, adoption and diffusion of PSS and remanufacturing such as cultural (norms, beliefs, codes) and demographic and their interaction to each other, to guide action. Answering this questions requires tools and devices from additional fields such as anthropology and sociotechnical studies complement the contributions already made by psychology and sociology.

Introduction

The circular economy is a concept advocated by many as an idea that favours increased or optimal resource efficiency (Preston, 2012; Roos, 2014). Activities within a circular economy include cascading, re-use, repair, maintain, remanufacturing and recycling (Ellen MacArthur Foundation, 2013). Two examples strategies incorporating such activities are Product Service Systems (PSS) and remanufacturing (Hazen et al., 2016; Tukker, 2015).

PSS are the result of a transition from a goods economy to a service oriented system (Baines et al., 2016; Mont, 2002; Sakao et al., 2009; Stahel, 1982; Tukker, 2004, 2015). Remanufacturing is a reuse process that repairs, replaces or restores components of a product that are not useful anymore and aims at ensuring "operation comparable to a similar new product" (Abbey et al., 2015, p. 488). However, and despite their environmental benefits, both strategies have yet to be widely adopted in consumers markets (Abbey et al., 2015; Baines et al., 2016; Tukker, 2015).

Consumer acceptance has been highlighted as one of the main reasons for such delay. In response to this, a significant work has been done exploring different aspects of the topic for both strategies (Abbey et al., 2015a; Khor & Hazen, 2016; Rexfelt & Hiort af Ornäs, 2009; Schotman & Ludden, 2015; Van Weelden et al., 2016). However, no systematic literature review on the topic has been done so far, to the extent of the researchers' knowledge. This paper aims to address this gap by performing a critical review of the literature that looks into the contributions made by different authors to the issue of consumer/user acceptance of particular strategies contributing to the circular economy, regarding definitions, questions, theories and fields, methods, issues raised and research gaps, and by proposing a research agenda.

Methods

To answer the research questions, several steps were taken as illustrated in Figure 1. First, a web-based query was conducted on Scopus and Web of Science databases using relevant keywords. Second, different filters were applied to the results to get a robust set of papers. This resulted in 24 papers focusing on the topic. Third, each paper was read and analysed regarding the elements defined in the research questions, i.e. definitions, questions, fields, methods, issues raised and research gaps identified. To achieve this each article was coded with Nvivo11 using the predefined categories 'definitions', 'questions', 'fields', 'methods' and 'research gaps'. To identify issues, an

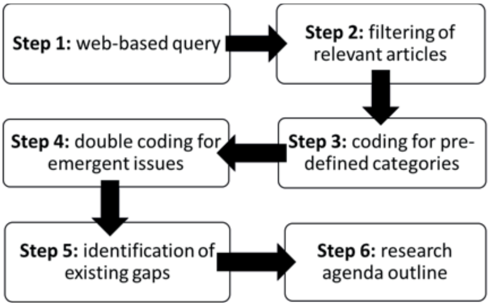

Figure 1. Steps taken to answer the research question.

inductive approach was used based on a double cycle technique (Saldaña, 2010). A first cycle was executed looking for issues emerging from the text by means of word and text queries, and a second cycle was performed by the researcher through in-depth reading and coding looking for additional codes. The results were then combined to achieve a comprehensive list of topics following the research questions of this review.

Results

This section presents the analysis of the contributions by the literature regarding the different topics explored and the proposed research agenda outline based on such analysis.

Definitions

Most articles provided harmonised definitions for PSS and remanufacturing based on seminal papers such as Mont (2002) and Tukker (2004). However, it was evident the absence of definitons of consumer and user acceptance considering that this is the departing point of most of the studies.

Problem and questions asked

Three sets of questions dominate the literature on consumption and PSS and remanufactured products as presented in Figure 2.

- The first set investigates the role of consumption in a use-based economy (Bardhi & Eckhardt, 2012; Briceno & Stagl, 2006; Catulli et al., 2017; Dewberry et al., 2013; Mont, 2004; Mylan, 2015).

- The second set of questions explores what factors explain acceptance or lack thereof, and is addressed by the majority of the literature for both PSS and remanufacturing (Abbey et al., 2017; Abbey et al., 2015; Abbey et al., 2015a; Armstrong et al., 2015; Catulli et al., 2013; Catulli et al., 2016; Catulli et al., 2017; Catulli,et al., n.d.; Catulli & Reed, 2017; Hazen et al., 2016; Jiménez-Parra et al., 2014; Khor & Hazen, 2016; Matsumoto et al., 2016; Piscicelli et al., 2015; Rexfelt & Hiort af Ornäs, 2009; Van Weelden et al., 2016). Most of them focus on the individual, while few studies deal with the role of societal or system-level factors (Briceno & Stagl, 2006; Mont, 2004; Mylan, 2015; Petersen & Riisberg, 2017; Santamaria et al., 2016)

- The third set of questions examines how the design and development process of PSS and remanufacturing could address the consumer or user to gain acceptance. For PSS, these questions are addressed by Knot & Luiten, (2006), Mont & Plepys, (2003), Rexfelt & Hiort af Ornäs (2009), Santamaria et al., (2016), and Stacey & Tether (2015). In the case of remanufacturing, only Mugge et al., (2017) and Van Weelden et al., (2016) explore what strategies or incentives are needed to improve acceptance of refurbished products as a type of remanufactured ones.

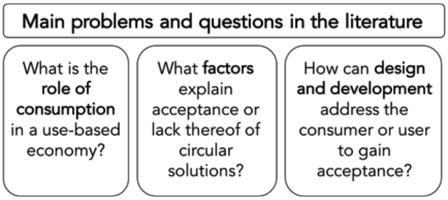

Figure 2. Problems addressed by the literature.

Fields and theoretical approaches

To answer these questions, researchers have used theoretical approaches from psychology, sociology and anthropology, mainly. Psychology provides the theoretical instruments for most authors: Briceno & Stagl (2006) use the needs framework presented by Cruz et al., (2009) to explore how PSS satisfy human needs or not. Baxter et al., (2015) use it to address ownership and object attachment in a circular context. Other authors dealing with both, PSS and remanufacturing use the Theory of Planned Behaviour (TPB) (Abbey et al., 2015; Armstrong et al., 2015; Hazen et al., 2012; Khor & Hazen, 2016; Michaud & Llerena, 2011; Piscicelli et al., 2015; Rexfelt & Hiort af Ornäs, 2009; Schotman & Ludden, 2014; Shih & Chou, 2011; Van Weelden et al., 2016). Catulli & Reed (2017) explore Personal Construct Psychology and Ertz et al. (2017) appeal to Cognitive Involvement Theory to explain why people engage in Goods Multiple Lives Practices (GMLP).

Using a more systemic perspective authors such as Catulli et al. (2017), Mylan, (2015), Petersen & Riisberg (2017), Piscicelli et al. (2015) and Santamaria et al., (2016), obtain their theoretical background from different sociological theories. Catulli et al. (2017) draw on Consumer Culture Theory to explore how PSSs fit in consumer culture values and perspectives. Mylan (2015) and Piscicelli et al. (2016) use Practice Theory as a framework to explain the potential for PSS diffusion. Petersen & Riisberg (2017) examine how a particular PSS interacts with a wider network of human and non-human actors using Latour's Actor Network Theory. Santamaria et al. (2016) analyse how semiotics and cultural studies could contribute to the understanding of contextual factors that could affect acceptance, adoption and diffusion of PSS. Authors dealing with remanufacturing questions do not use sociological theories in their research, as their studies are usually more grounded in engineering disciplines.

Finally, Bardhi & Eckhardt (2012) use a more anthropological approach to understanding how the concept of ownership in an access based economy would affect acceptance by individuals. Hazen et al., (2016) venture away from the remanufacturing tradition and explore ideas from Human Geography to explain the interaction between different factors such as price, quality, economic incentives and regulation.

Methods and tools used
Studies used both quantitative and qualitative methods for data collection. PSS literature employs qualitative approaches and tools, mainly focus groups and interviews (Armstrong et al., 2016; Bardhi & Eckhardt, 2012; Besch, 2005; Catulli, 2012; Catulli et al., 2013; Dewberry et al., 2013; Ertz et al., 2017; Mylan, 2015; Piscicelli et al., 2016; Rexfelt & Hiort af Ornäs, 2009a). Less used but still important in this literature stream are surveys conducted to collect quantitative data (Armstrong et al., 2016; Briceno & Stagl, 2006; Catulli & Reed, 2017; Ertz et al., 2017; Knot & Luiten, 2000; Piscicelli et al., 2015; Shih & Chou, 2011). Other qualitative methods used were nonparticipant observation (Bardhi & Eckhardt, 2012; Petersen & Riisberg, 2017), structured interviews (Catulli & Reed, 2017), and wardrobe audits (Petersen & Riisberg, 2017).

Literature dealing with remanufactured products had a more quantitative approach to data collection, using experimental settings (Abbey et al., 2017; Abbey et al., 2015a; Abbey et al., 2015; Jiménez-Parra et al., 2014; Michaud & Llerena, 2011) or surveys (Hazen et al., 2016; Matsumoto et al., 2016; Mugge et al., 2017). Only one study used qualitative methods, namely semi-structured interviews (Van Weelden et al., 2016).

Key issues
The most prominent issue investigated by the literature was barriers for acceptance. They refer mainly to negative perceptions of remanufactured products and PSS, values (environmental and cultural) and their influence on adopting a PSS or a remanufactured product (more details presented in Table 1. Other factors being explored include beliefs (Abbey et al., 2015a; Abbey et al., 2015; Mugge et al., 2017; Van Weelden et al., 2016), attitudes (Hazen et al., 2016), and norms, both social and personal (Bardhi & Eckhardt, 2012; Khor & Hazen, 2016; Matsumoto et al., 2016; Michaud & Llerena, 2011; Mylan, 2015). Positive factors enabling acceptance are not extensively studied in the literature.

Gaps in research
Regarding gaps in research, authors working on remanufacturing issues call for more efforts to understand how external factors such as price, warranties, demographic and cultural factors affect acceptance and adoption of remanufactured products (Abbey et al., 2015; Hazen et al., 2016). They also suggest intrinsic motives need to be further explored (Abbey et al., 2015a). Finally, they advocate for better explanations of the intention-behaviour gap connected to environmental values and remanufactured products (Abbey et al., 2017).

Issues: barriers	Authors
Remanufactured and used products perform worse than new ones	Abbey et al. (2015), Jiménez-Parra et al., (2014), Matsumoto et al. (2016)
Remanufactured and used products ar not hygienic, generating disgust, fear of contagion and contaminated interaction	Abbey et al. (2015a), Bardhi & Eckhardt (2012), Catulli et al. (2013), Baxter et al. (2016).
Risk aversion	Hazen et al. (2012), Rexfelt & Hiort af Ornäs (2009)
Animosity against lack of ownership	Bardhi & Eckhardt, (2012), Catulli et al. (2016)
Unidimensional value offering	Catulli et al. (2013), Dewberry et al. (2013), Stacey & Tether (2015)
Problems to access the offering	Abbey et al., (2015a), Hazen et al. (2016), Khor & Hazen (2016)
The practice is tightly connected to other practices	Mylan (2015)
Inertia, lock-in and path dependency	Santamaria et al. (2016)

Table 1 Barriers for consumer and user acceptance of remanufactured products and PSS.

Another proposed dimension for further research relates to methods and tools for collecting relevant data. Catulli et al. (2016) suggest exploring ethnographic methods to understand PSS better. Additionally, Santamaria et al. (2016) indicate the need for tools to extract data on cultural codes that can be used to design circular offerings better. Finally, Dewberry et al. (2013) suggest that participatory design could be important in developing PSS, given the need for more local and contextualised understandings.

Some authors also suggest more research is required on the type of individuals or groups that are more susceptible to accept this kind of offerings and what is their particular context (Catulli et al., 2013; Mugge et al., 2017). Lastly, the literature invites researchers to explore strategies to improve acceptance from policy, design and communication perspectives (Hazen et al., 2016; Mugge et al., 2017).

A suggested research agenda
Although the work on consumer acceptance of circular solutions such as PSS and remanufacturing has been expanding some work remains to be done. Based on the achievements of existing work on the topic, here we suggest an outline for a research agenda that may contribute to successful interventions in the transition towards a circular economy.

Definitions, questions and problems
- Explore the role of consumption, consumers and users in the circular economy.
- Provide definitions of acceptance in the context of a circular economy.

Influencing Factors
- Further explore factors that have a positive impact on acceptance.

- Empirically explore how different factors relate to others and if there is a hierarchy.
- Interactions between cultural and demographic factors and intrinsic motives like beliefs, values and norms.
- Influence of cultural factors on acceptance.
- Individual characteristics that influence acceptance.

Fields

- Use insights and tools from anthropology and areas such as sociotechnical studies to address the interface between the individual and the collective.

Methods

- Explore the utility of nonparticipant observation and ethnographies to collect data.
- Examine the role of participatory methods to develop PSS and product proposals.

Other aspects

- It is necessary to include other circular economy strategies in this review (e.g. sharing economy, collaborative consumption and product re-use).
- Expanding the review to conference papers could provide a fresh view on what new topics, early stage researchers and established scholars are exploring.

Conclusions

This article aimed at providing a general review of the literature dealing with consumer and user acceptance of two particular circular solutions, PSS and remanufactured products. Based on the findings the paper outlined a research agenda on the topic. Twenty-four articles were reviewed in depth, searching for inputs on six main categories: definitions, problem and research questions, definitions, theoretical background, issues, methods and research gaps. Base on this analysis a set of questions to be addressed was suggested that can work as the seed for a research agenda in the topics of circular economy strategies and consumption.

Acknowledgments

I would like to thank the Circular European Economy Innovative Training Network funded by the EU through the Horizon 2020 Marie Sklodowska-Curie Innovative Training Network Action, as well as our colleague Lucy Chamberlin from the Design Department at NTNU for her bright and timely comments and suggestions on the content and form of this article.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-70

Towards more circular office fit-outs: a socio-technical descriptive framework of office fit-out processes

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Keywords
Circular economy
Office building fit-outs
Interior refurbishment
Recycling
Material flow analysis (MFA)

Abstract
The built environment is the most resource intensive sector of the economy, accounting for a significant share of the extracted materials and the total waste generated. Within the built environment the most recurrent replacements of building materials and components take place during fit-outs, which are the process of installing interior fittings, fixtures and finishes. These materials and components are frequently replaced in non-domestic buildings.

Non-domestic building fit-outs are therefore responsible for a significant consumption of materials and a large source of waste. However, they tend to go unnoticed and unmeasured in the research about sustainable buildings. The present work aims to study this research gap and analyse the potential for fit-outs to become more sustainable. The approach of this project ties in closely to the concept of circular economy, where materials are kept at their most useful state for as long as possible.

This paper provides a socio-technical descriptive framework of fit-out processes in office buildings. This descriptive framework contains a qualitative analysis of the roles and interactions of involved stakeholders regarding the material flow (based on interviews), and a quantitative material flow analysis (MFA) throughout the downstream supply chain (based on a fit-out case study). The mixed methodology used includes on-site observations, cross-examination of the corresponding design specifications or waste reports, and semi-structured interviews with the involved stakeholders.

The aim of this research is to provide a grounded perspective that allows the identification of process and design improvements that support the transition towards more "circular" fit-outs. It is concluded that there are potential areas of improvement as fit-out practices show a predominantly linear tendency both for decision making and material flows.

Introduction

The built environment is the most resource intensive sector of the economy, accounting annually in the European Union for 50% of all extracted materials, 35% of carbon emissions (European Commission, 2011), and 32% of total waste generated, approximately 830 million tonnes (EEA, 2012). Within the built environment the most recurrent replacements of building materials and components take place during fit-outs, which are defined as the process of installing floor, wall and window coverings, partitions, doors, furniture, equipment, and sometimes mechanical and electrical services (Cole and Kernan, 1996; Forsythe, 2010). In offices, these components can be replaced every 3-10 years (Trucker and Treloar, 1994; Roussac et al., 2008; Forsythe and Wilkinson, 2014). In addition, an outgoing tenant may remove the fit-out (de-fit) and the new tenant will reinstall all these fittings, fixtures, and finishes (re-fit). Accordingly, fit-outs account for a significant amount of wasted resources, and associated embodied carbon emissions throughout the lifecycle of a building.

Office building fit-outs tend to go unnoticed and unmeasured in the debate about sustainable buildings (Forsythe and Wilkinson, 2014) but this is beginning to change. Building fit-out certification methods, such as SKA Rating, BREEAM or LEED exist, but have a low uptake and do not fully cover the circular economy concept. Growing environmental concerns and the gradual increase of UK's landfill tax (Seely, 2009) certainly encourages stakeholders to pursue waste recycling instead of landfilling. However, most fit-out waste gets downcycled, since the original materials or components are generally not designed with recycling or reusing in mind (McDonough and Braungart, 1994).

In order to identify key areas of improvement in the fit-out process and in the use and management of resources, it is pertinent to understand key materials used and waste generated, as well as the destinations of waste streams.

This paper analyses fit-out projects within UCL and London, tracing outgoing waste streams and incoming building materials and components. The roles and responsibilities of different stakeholders within the supply chain are analysed in order to assess which actors have the highest impact on components specification and waste management.

The objective of this work is to set out a socio-technical descriptive framework of office fit-outs from a material flow perspective. The aim being to identify potential improvements in the fit-out process and the design of building components, reflecting on the possible benefits for main stakeholders involved and for society as a whole.

Background

Circular economy

The environmental consequences of using the biosphere to dispose of waste are becoming critical, such as climate change, loss of biodiversity and natural capital, land degradation, and air and ocean pollution. So the circular economy is a model proposed to replace the current 'take-make-dispose' attitude and to decouple environmental pressures from economic growth. The four sources of value creation in a circular economy to achieve this decoupling are (EMF, 2013): 1) Minimising material use over a product's lifespan. 2) Maximising the number of consecutive use cycles 3) Diversifying reuse across the value chain and across industries. 4) Using higher quality input materials.

Non-domestic building fit-outs

There is large potential to integrate circular economy characteristics in building fit-outs processes. Buildings can be seen and analysed in different layers, depending on function and replacement rate. Brand (1994) proposes six different layers: Site, Structure, Skin, Services , Space plan and Stuff. These layers have increasing rates of replacement, from the Site being permanent to the Space plan and Stuff being replaced every three years or so. Fit-outs relate to the most frequently replaced layers: Services (sometimes), Space plan and Stuff. Brand (1994) demonstrates that in a 50-year cycle, the changes within a building cost three times more than the original building. Multiple authors state that, the embodied energy of fit-outs eventually outweighs that used to construct the building (Cole and Kernan, 1996; Zabalza et al, 2009).

Non-domestic buildings, represent 26% of the total EU building stock floor area, where 6% of the total are offices and 4% education buildings (Economidou, 2011). Non-domestic buildings may have 30 to 40 fit-outs during their lifecycle, accounting for an estimated 11% of UK construction spending (RICS, 2016).

The Construction Resources and Waste Platform (2009) carried out a study based on fit-out waste data contained in the SMARTWaste tool. Based on four UK office fit-out projects, the average rate of waste generation is reported to be 6.4t per 100m2 of gross internal floor area (GFA).

The Better Building Partnership et al. (2015) used a fit-out case study in Sydney, Australia to record the types and amounts of waste generated. A rate of waste generation of close to 10t per 100m2 of GFA was found, and 63% of this waste was diverted from landfill. The materials that were not able to be recycled were ceiling and carpet tiles, timbers, office furniture, and paint.

The Institute for Sustainable Futures (2014) performed a series of interviews in Sydney to identify the main waste contributors during fit-outs. The same few materials were consistently nominated: plasterboard, ceiling tiles, carpet, packaging, office furniture (particularly workstations) and the resultant MDF (medium-density fibreboard) and particleboard. It is stated that although some issues can be solved systematically, each material stream needs to be tackled specifically.

Hardie et al. (2011) interviewed twenty-three experts in commercial refurbishments in Sydney to find out the average rate of reuse and recycling. They report that building materials and components such as aluminium, structural steel, steel reinforcing bars, bricks, and concrete, are subject to a high level of recycling, however, little recovery is made from the removal of most internal fittings and finishes during the fit-out process.

Methodology

A mixed methodology approach is taken composed of specific methods to answer specific research questions. All research outcomes are then concatenated to provide a socio-technical descriptive framework of the building fit-out process and its material flow.

1) In order to map out the stakeholders within the fit-out supply chain who determine the specification of building components and the management of waste, exploratory interviews were conducted using chain-referral (snowball) sampling. Twelve people related to the fit-out industry were contacted and interviewed. The interview data was cross-checked to lead to an objective interpretation.

2) To describe the function of actors at each stage in the fit-out process and to define the relationships among them (evaluating their impact on the material flow), semi-structured interviews and/or questionnaires were carried out with the stakeholders identified in research objective 1. Three further fit-out experts were interviewed. The key aims in the interviews and questionnaires were to describe the fit-out process in-depth, to identify the roles and interactions of the supply chain actors for each stage, and to define the main drivers and barriers to improved circularity in the fit-out process. The data from interviews and questionnaires was qualitatively analysed to lead to an objective conclusion.

3) In order to define how material flow occurs in fit-out projects, from incoming components to outgoing waste streams, four waste contractors and three managers at recycling facilities were contacted and interviewed. Also,

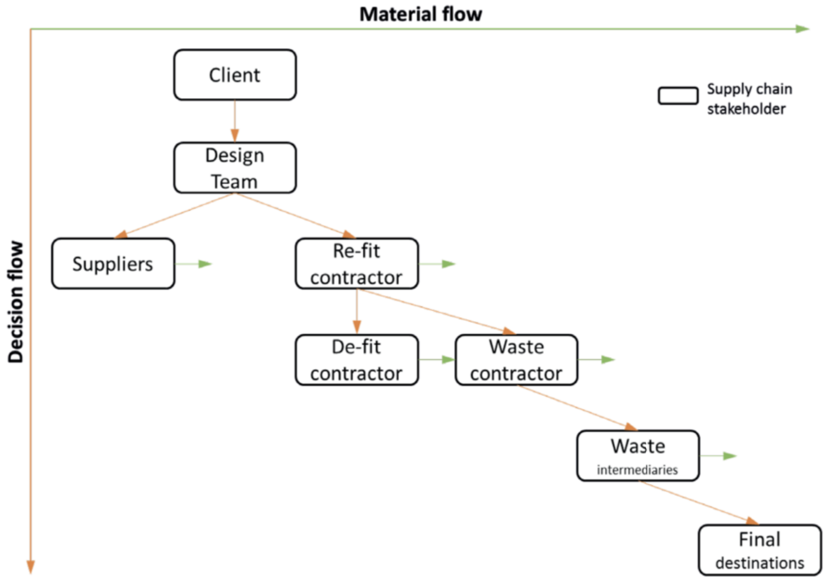

Figure 1. Generic fit-out supply chain stakeholders and structure.

an office building fit-out was selected as a case study to carry out a material flow analysis of the waste streams generated during the project. Material flow analysis was performed using data from stakeholders' reports, such as fit-out specifications, site waste management plans (SWMPs) and Recycling Reports. Also, site observations were carried out during and after fit-out.

Fit-out descriptive framework

Fit-out supply chain structure

Several stakeholders within the fit-out supply chain were interviewed including policy makers and stakeholders collaborating in the design team, as well as fit-out contractors, waste contractors and employees in recycling facilities.

From these interviews, it can be concluded that fit-out processes in the area of study are very similar to each other. Thus, a generic fit-out process is considered and described next.

The Client choses whether to pursue a sustainable fit-out or not and whether to use an assessment method as guideline. The Client also hires the Design Team. The Design Team is usually comprised of an Architect, Project Manager(s), M&E (Mechanical and Electrical) Engineer(s), Quantity Surveyor(s), and sometimes includes a Sustainability Consultant. The Design Team potentially has the highest impact on the decision making within the project, covering decisions such as the specification of building materials and components and the management of waste.

Once the project brief is developed by the Design Team (including project specifications, times and budget), the Project Manager sends out an invitation to tender. Any Fit-out Contractor can then submit a tender, i.e. offer their services to carry out the fit-out works, stating how they would perform the job and how much it would cost. The Fit-out (Re-fit) Contractor who gets the job will be in charge of all the on-site process and they may sub-contract other actors, such as Strip-out (De-fit) Contractor or Waste Contractor. Likewise, the main Fit-out Contractor normally has within their team another Project Manager, M&E Engineer, Quantity Surveyor and a Sustainability Manager.

The assigned Waste Contractor will be in charge of collecting the waste arising from the de-fit and re-fit stages to then take the waste to a transfer site, where it usually gets sorted into different waste streams.

The different waste streams are then sent out to different material recovery facilities (MRFs) or Waste Collectors where they deal with thousands of tonnes of one or several waste streams. The respective Waste Collectors further sort and grade the waste streams for onward delivery, potentially to their respective Final Destinations. These destinations may include recycling within the original industry (closed-loop) or in another industry (cascade), as well as incineration for energy recovery or landfill.

Figure 1 shows the generic structure of the fit-out process. The decision flow is represented in the diagram with a vertical descending orange arrow and the material flow is represented with a horizontal green arrow. It can be appreciated that both the decision and the material flows have a linear tendency.

The Suppliers produce and market the building products, and the Design Team selects from the available offer. The De-fit and Re-fit contractors install and remove the products, respectively. The Waste Contractor collects the waste and sorts it, to then hand over the different waste streams to the corresponding Waste Intermediaries who further sort and grade the waste before sending it to the respective Final Destinations.

During this study, it was found that the Design Team and the Fit-out Contractor(s) generally have negligible knowledge about the Final Destinations of components and materials, whereas the Waste Contractors and the people in charge of the Final Destinations generally have negligible influence on the specification of these components. It can be suggested that the linear tendency of the decision flow is a barrier for the circularity of the material flow, or in other words, a linear decision flow leads to a linear material flow. However, more analysis and case studies are required to support this supposition.

Fit-out materials and components

Table 1 presents a list of the common fit-out materials and components along with the corresponding European Waste Code (EWC), where available. These materials and components are consistently considered in the literature review and in fit-out SWMPs.

Element	EWC
MATERIALS	
Asbestos	17 06 05
Fines (soil)	17 05 04
Glass	17 02 02
Gypsum (incl. plasterboard)	17 08 02
Hardcore	17 01 07
Metals -Ferrous	17 04 05
Metals -Non-ferrous	17 04 01*
Mixed waste	17 09 04
Paint, adhesive, etc.	20 01 27
Paper & Cardboard	20 01 01
Plastics (including packaging)	17 02 03
Textiles	20 01 11
WEEE	20 01 36
Wood (including fibreboard)	17 02 01
COMPONENTS	
Appliances	N/A
Batteries	20 01 33
Carpet	N/A
Electrical socket	N/A
Fire alarm	N/A
Fire extinguisher	N/A
Insulation	17 06 04
Light -Fluorescent tubes	20 01 21
Light -Other	N/A
Office furniture	N/A
Raised access floor tiles	N/A
Suspended ceiling tiles	N/A

Table 1. Common fit-out materials and components (Author generated, 2017).

Element	Weight [t]	Share [%]
Gypsum (plasterboard)	72.59	31.8
Mixed waste	66.25	29.0
Metals	32.84	14.4
Wood (including fibreboard)	25.06	11.0
Glass	13.02	5.7
Hardcore/Soil	11.90	5.2
Paper & Cardboard	6.18	2.7
WEEE	0.32	0.1
Light -Fluorescent tubes	0.30	0.1
TOTAL	228.46	100.0

Table 2. Weight and share for each material stream collected, for the first quarter of 2017 (Waste Contractor's report, 2017).

Fit-out waste generation

A major waste contractor in London was contacted in order to find out the top material streams or waste streams generated during fit-out projects (Table 2). Over 90% of the waste they collect comes from building fit-outs. Figure 2 shows the share or percentage (by weight) for each material stream relative to the overall waste collection, for the first quartile of 2017

Material flow in an office fit-out case study

The fit-out took place in London during 2016, and is considered a best-practice fit-out in the UK. The fit-out gross internal floor area (GFA) is 162m2 and the project value is £60k.

The information presented here was provided (and cross-checked) by the design team, the fit-out contractor and the waste contractor.

Outgoing waste

The total waste generated (considering de-fit and re-fit) is 3.81t, with a landfill diversion rate of 99.5%. The rate of waste generation is 2.35t per 100m2 of GFA, which is 63% lower than UK average (6.4t / 100m2 GFA).

Table 3 shows a breakdown of the waste streams generated during the de-fit stage. The waste during this stage (2.82t) accounts for 74% of the total waste generated.

Table 4 shows the waste stream breakdown for the re-fit stage, which accounts for only 26% of the total waste.

Table 5 presents waste stream breakdown combined for both the de-fit and re-fit stages. For this case study, gypsum (including plasterboard) accounts for the largest share (34.0%), followed by mixed waste (31.9%), wood (17.0%), office furniture (9.9%), and insulation (0.2%).

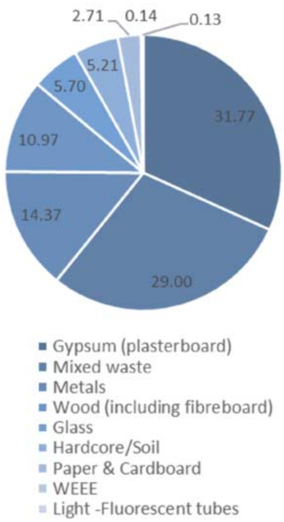

Figure 2. Share (by weight) for each material stream relative to the overall waste collection, for the first quarter of 2017 (Waste Contractor's report, 2017).

De-fit waste			
Element	**Weight [t]**	**Recycled [t]**	**Disposed [t]**
Gypsum	0.96	0.96	0.00
Mixed waste	0.90	0.88	0.02
Wood	0.48	0.48	0.00
Office furniture	0.28	0.28	0.00
Insulation	0.20	0.20	0.00
Total [t]	**2.82**	**2.80**	**0.02**
Percentage [%]	**100**	**99.3**	**0.7**

Table 3. Waste generated during de-fit (fit-out SWMP, 2016).

Re-fit waste			
Element	**Weight [t]**	**Recycled [t]**	**Disposed [t]**
Gypsum	0.72	0.72	0.00
Mixed waste	0.27	0.26	0.01
Total [t]	**0.99**	**0.98**	**0.01**
Percentage [%]	**100**	**99.0**	**1.0**

Table 4. Waste generated during re-fit (fit-out SWMP, 2016).

All waste			
Element	**Weight [t]**	**Recycled [t]**	**Disposed [t]**
Gypsum	1.68	1.68	0.00
Mixed waste	1.17	1.15	0.02
Wood	0.48	0.48	0.00
Office furniture	0.28	0.28	0.00
Insulation	0.20	0.20	0.00
Total [t]	**3.81**	**3.79**	**0.02**
Percentage [%]	**100**	**99.5**	**0.5**

Table 5. Waste generated during de-fit and re-fit (fit-out SWMP, 2016).

Waste stream final destinations

The Fit-out Contractor (and the upstream stakeholders) tend to sub-contract a Waste Contractor that can ensure a high rate of landfill diversion. This is generally driven by environmental reasons whether or not a certification assessment is followed.

Another important reason for landfill diversion is the gradual increase of landfill tax, as handing the waste to a Waste Contractor is normally cheaper than landfilling. The 'gate fee' refers to the price that the Waste Contractor charges per tonne for each waste stream. The gate fee for Mixed waste is generally the highest, so it is advisable for the Fit-out Contractor to segregate waste on-site. In fact, some segregated waste streams are collected free of charge or even paid for (negative gate fee), as is the case for segregated Metals, Plastics, and Paper & Cardboard.

Figure 3 shows the generally linear waste stream among the downstream stakeholders for the office fit-out case study. Note that 15% of gypsum is closed-loop recycled. Although 99% of the waste was diverted from landfill, all material streams diversify into multiple Final Destinations that require a lower grade of material quality.

In this case, Wood is sent to Belgium, mixed Metals generally end up in Spain or Turkey (or other countries depending on the offered price), and Plastics are sent to China. All other Final Destinations are located within the UK.

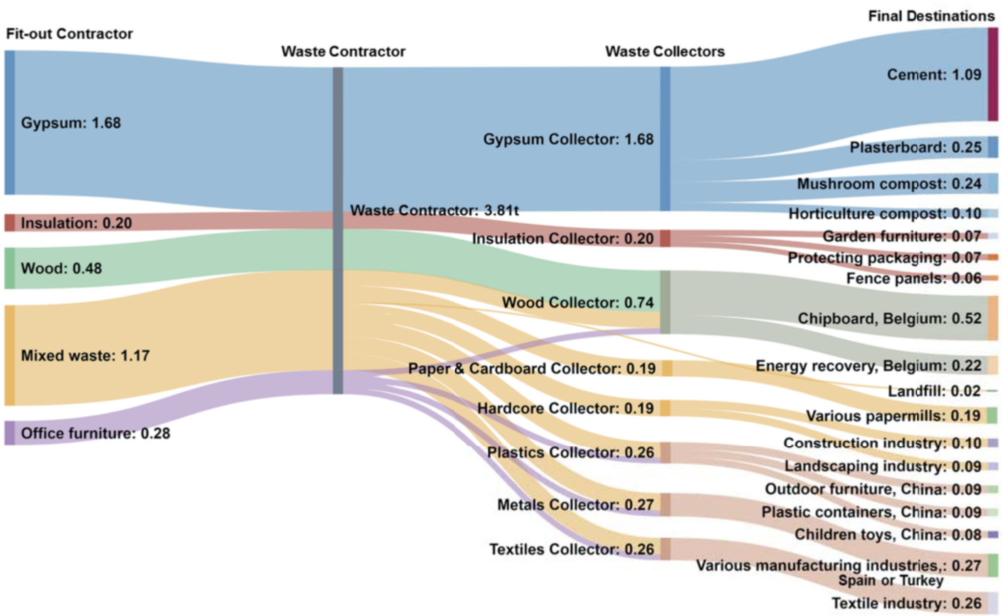

Figure 3. Waste streams flows in tonnes for an office building fit-out.

Conclusions

Given the emerging socio-technical descriptive framework of office fit-outs, it is clear there are several areas that can be improved.

It is found that the office (and non-domestic) fit-out supply chain has a generic structure in which both the decision and material flows have a predominantly linear tendency. The stakeholders in this supply chain with the highest impact on the specification of materials and components and the decisions on waste management are generally the client and the design team.

Currently, good-practice fit-out projects (and the corresponding assessment methods) pursue high recycling percentages for the generated waste streams. However, this study found that the stakeholders in the supply chain are generally unaware of the waste streams' final destinations, i.e. what the different waste streams get recycled into or used for.

In order to be able to design more 'circular' fit-outs, the stakeholders involved in the supply chain should have more effective communication. That is to say, the suppliers and the design team should understand what happens with materials and components at the end-of-life. Accordingly, the actors in charge of the final destinations of these components and materials should provide a systematic feedback to the suppliers and the design team.

In the office fit-out case study, it is found that the rate of waste generation was 2.35 tonnes per 100m2 of gross internal floor area (GFA), which is lower than the UK reported average of 6.4. However, the fit-out project analysed in this paper is considered best-practice. On the other hand, the top wastes generated during this case study were gypsum, mixed waste, and wood, which coincides with the data provided by the interviewed waste contractor.

Further studies on building fit-outs are required in order to confirm the findings presented here, and further investigate the share and final destinations of each waste stream. Likewise, it would be useful to carry out a Life-Cycle Analysis (LCA) for the building components most commonly found in fit-out projects.

Acknowledgments

The authors acknowledge the support and the data provided by the interviewees and the corresponding stakeholders.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-76

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

A double diffusion of innovations: the case of electric automobility product service system

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Keywords
Diffusion of Innovation
Electric Vehicles
Practice Theory
Product Service Systems

Abstract
This paper explores the double diffusion of an electric vehicle Product Service System (PSS). The research is based on a case study of a use orientated PSS run by UK-based e-car club.
The double diffusion involves consumers being confronted with electric vehicles (EV) - a technical innovation, accessed through a car club - a PSS sociotechnical innovation. The paper explores the intertwining of these two innovations.
Using Practice Theory, the paper concentrates on meanings that users associate, or find lacking, in performing automobility through an EV car club. For an EV mobility PSS to diffuse, it is necessary to disassociate it from meanings of poor availability, range anxiety and concern about location of charging facilities and associate it with positive meanings of freedom, thrift, altruism and environmental protection. The offer of additional service through links with mobile phone apps could facilitate diffusion. These meanings appear to have stronger resonance among certain segments of car users than others, which suggest that insights offered by Practice Theory need to be complemented by other research perspectives to explore characteristics of individual users.

Introduction

This paper reports results from an ongoing study into an electric automobility Product Service System (PSS). A PSS is a system of products, services, supporting networks and infrastructure designed to be more resource efficient than traditional business models (Mont, 2002). PSS are often classified (Hockerts 1999, Cook et al. 2006) into three categories:

- ***Product orientated***, where service is added to basic products.
- ***Use orientated,*** when customers access products owned by suppliers, such as e-car club.
- ***Result orientated,*** when consumers acquire results, such as when "thermal comfort" is supplied to customers.

Sustainability is a major challenge to product design and PSS diffusion could improve resource efficiency (Cook, 2014). But PSS suffer from poor uptake (Vezzoli et al., 2015), especially in consumer markets (Catulli, 2012).

Car clubs are organizations which provide members with access to a fleet of shared cars (Shahen & Cohen, 2007) for local trips (Bardhi & Eckhardt, 2012). Examples, such as Zipcar, using conventionally-powered cars, are established in many places (Catulli et al., 2016). However all car clubs together have only 0.4% niche market share of automobility in the EU, high rates of failure and customers' defection (Le Vine et al., 2009). With car ownership is associated with meanings of freedom and independence (Choo & Mokhtarian, 2004), the lack of control allegedly associated with PSS (cf. Tukker's, 2015) may apply to e-car club. Such PSS may also suffer from poor on demand availability (Catulli, 2012).

EVs also present challenges. Although EV uptake rates are now increasing, initially they were lower than expected (Walsh et al., 2014). EVs remain expensive to buy, involve range anxiety (Lane & Potter, 2006) with concerns about recharging (Shepherd et al., 2012). Combining automobility PSS with EVs thus involves social and cultural dynamics shaping diffusion processes of two different innovations. With this automobility PSS, consumers are confronted with a double diffusion of innovations:

1) Electric vehicles (EV) – a technical innovation
2) PSS – a sociotechnical innovation

The paper therefore explores the intertwined diffusions of these two innovations.

Research perspective and methods

Following Mylan (2015), the research adopts Practice Theory (PT) to investigate diffusion of an EV automobility PSS. PT is a cultural theory which analyses social practices to explain how human subjects make and transform the world in which they live through their daily routines (Feldman & Orlikowski, 2011). A social practice is a "routinized type of behaviour which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, "things" and their use, a background knowledge in the form of understanding, know how, states of emotions and motivational knowledge" (Reckwitz, 2002:249), i.e. 'materials', 'competences' and 'practices' (Shove et al., 2012). Importantly, PT focuses on mundane practices, of what people do and feel in their daily routines (Warde, 2005). PT seeks to go beyond consumers' purchasing decisions to explore how consumers integrate materials they use in their routines, as this integration plays a profound role in sustainable consumption (Shove & Walker, 2010). PT's focus on mundane activities can complement the understanding of acquisition offered by other consumer studies approaches.

Mylan (2015) suggests that obduracy of current consumption practices may impede diffusion of PSS. Traditional automobility is obdurate for two reasons:

1) Automobility is tightly linked to conventionally-powered cars
2) Automobility is tightly linked to activities such as shopping and commuting to working.

These two linkages re-enforce the obduracy of traditional mobility

The case study for this paper is the UK-based e-carclub (e-carclub.co.uk, 2015). This car club, which rents out EVs, was established by the National Energy Foundation and Sustainable Venture (e-carclub.co.uk, 2015) and is now owned by Europcar. The methods used to gather data included participant observation and 15 interviews of current, dormant and lapsed e-carclub members.

Findings

Competences, materials and meanings

Competences (the skills and know-how of the practitioners) and materials (physical objects such as tools, hardware and infrastructure) are drawn from the framework used by Shove et al. (2012) to shape the meanings of the focal practice (using the e-carclub for automobility). Meanings, which are the symbols, norms and collective conventions imbued in practices, are important because of their role in motivating consumers to perform practices (cf. Reckwitz, 2002), and so shape PSS diffusion (Mylan, 2015). Therefore, in the following narrative we focus on these meanings and how they interplay with the other elements, as revealed in the responses to interviews and observations made in this research.

Car-based mobility is a practice which drivers perform to meet obligations towards members of their families. For example, drivers use their own cars to take children to school and parents to health care visits.

"….my niece (…) is 17 and she's just about to get her driver's license and in her family there's three kids and two parents but her father doesn't drive and so her mother has to do all the driving. (…) her mother's reasoning is, (…) there would be another adult to take responsibility for driving the other kids around, like to brownies and choir (…), so at the moment it's always Karen and if Kathy had a car then she could also take on some of that responsibility and ease the burden on Karen".

Some participants feel that they need vehicle ownership to meet these obligations reliably. This is particularly true in emergencies. Automobility through e-carclub on the other hand is associated with inflexibility. Mike for example explains that e-carclub would not give enough flexibility in his mobility:

"…if one of them (his children or their friends) says, oh I need to be in school early (…), oh suddenly we've got to jump in the car…"

Participants who have families thus seem not to think the PSS empowers them to fulfil those obligations. They want their own car outside their door. The PSS is seen as unable to support this flexibility. In this respect, automobility with e-carclub is associated with lack of empowerment, as EVs are not always accessible on demand to meet obligations. But another group of e-carclub users thinks differently. For younger people and students, the PSS enables them to drive new cars that they cannot afford to buy. For example, they may not own a car because they mostly travel by bicycle and public transport. For them, unlike in the case of people with families, the PSS may be associated with meanings of empowerment, including to assist relatives in their travel. Guy for example explains that

"….when my mum and dad came for the weekend and I wanted to take them to Stowe (…) there was no public transport so the e-car was ideal".

So the meanings associated with the practice are shaped by practitioners' characteristics and circumstances. Certain mobility segments find positive value in e-car club, whereas others do not and that value can be transient or vary with particular situations.

Although many users of e-carclub find it offers less empowerment and flexibility than owning a car, there are some compensating advantages. It is associated with freedom from responsibilities, e.g. parking, maintenance and taxes, but is also associated with range anxiety and fear of liability for damage incurred during use. Freedom is thus limited by obligation towards the PSS provider. As Mike explains, he does not feel as free in using a PSS EV, as with his own car:

"….we used to throw all stuff in there, wetsuits and things and occasionally we'd even put a boat on the roof and things like that, we had a roof rack, so we usually use our car as a workhorse and (…), messing up your own car

is fine but if you're messing (a rented car), is (…) someone going over the car with a magnifying glass and saying, oh you've scuffed this or that? If it's not my car, I can't sort of treat it in the cavalier fashion".

Another beneficial meaning for users of the EV PSS is that it is strongly associated with environmental protection and also with thriftiness; it is seen as a "hip", "clever" mobility practice. It is also associated with novelty and modernity – partly because it is an EV, but also because of the practice of booking the service using apps. As Caroline explains:

"This looks brilliant, you know, I get my membership, I get my PIN number, I swipe, (…), you know, obviously it's fairly automatic in that there's not that many people around, (…), it's kind of manpower efficient, but (…), what if something goes wrong?"

The last point suggests desire for quality assurance, which could reduce meanings of loss of empowerment.

Finally, for some participants, the focal practice is associated with meanings of health because car ownership encourages them to use their car every day, rather than only occasionally if they use e-carclub. As Jaspreet says:

"…if I do use it on a day to day basis I become lazy, so actually (…) being able to rent a car is much better because it still kind of encourages you to walk around, be fit, but only take a car when you really, really need it".

In short, meanings of environmental protection, novelty and thrift encourage automobility using e-carclub. However, traditional mobility using owned cars is made obdurate by the belief by most participants that owned cars are more reliable for the fulfilment of obligations towards others. Table 1 summarizes the meanings.

Access as part of PSS

Accessing products through a PSS differentiates from traditional product purchase for consumption because of different relationships that consumers have with materials, meanings and competences required.

Meanings that support EV PSS	Meanings averse to EV PSS
Environmental protection	Obligations (to family and friends)
Modernity	Liability for damage
Trendy	Lack of availability (including emergencies)
"Hip"	Lack of control
Thrift	Lack of empowerment
Empowerment (if ownership not affordable)	Lack of flexibility
Freedom (from maintenance, road tax, etc.)	Range anxiety
Control granted by apps for younger drivers	Concerns with recharging
	Lack of independence

Table 1. Meanings associated with EV PSS.

Access, seen as a transaction "that can be market mediated but where no transfer of ownership takes place"(Bardhi and Eckhardt, 2012:1), is a defining element – and a sub-practice in itself. Drivers learn access processes, including booking of the EV through apps on mobile phones. They also need to learn to plug in and unplug EVs as e-carclub drivers are responsible for leaving EVs charged for next users. Learning the practice of access produces anxiety. As Donna explains,

"I was absolutely terrified so my partner just jumped in it, drove it no problem, it took me a while to build up the confidence and I had to go out with him first and drive it on my own somewhere quiet (…), to get the hang of it and then I watched YouTube videos, I mean the instructions were clear but I felt I had to kind of watch YouTube videos first".

Remembering passwords and login names also seems to be a problem for some participants, used as they are to jumping in the car parked on their drive. E-carclub mobility also involves travelling to where EVs are parked, which may involve additional forms of mobility. Practitioners however resist this. They seem strongly against combining different modes of transport, including walking. Felicity for example would need to carry heavy loads to the EV,

"…it would be a real hassle even just walking to the bus stop with this bag of books"

In short, access, as alternative to purchasing products, is key to PSS and it is an integral part of the focal practice. Because of this, PT's lack of focus on consumers' ways to acquire products can be problematic in understanding PSS consumption. Data shows that participants use materials and competences associated with other practices to access EVs. Here we see that materials such as mobile phones and apps, together with competences to use them, migrate into the mobility practice from communication practices (Cf. Shove et al., 2012).

Jaspreet explains, for example, that using mobile phone and apps became an integral part of managing access to EVs, making PSS seem more acceptable,

"Yeah, like booking it from an app, that's definitely a really good idea because a lot of students are lazy so (it) is easy to just quickly go on your phone and just know that you can book it from there, that's definitely good. A lot of students have smart phones or iPhones or like Samsung so if you can just, (…) download the app and every time you need a car, (…), because if you are a member of course you can take the car any time you want, so just being able to directly book it from your phone, then being able to collect it is very easy".

This seems to make younger people, who are more familiar with apps, receptive to practicing automobility through e-car club. To be practical the system needs to be booked via mobile phone apps. Comparing participants' responses it appears that younger ones, such as students, are far readier to adopt access practices if these are supported by ICT.

In summary, access is an integral part of PSS consumption. Whilst PT usefully describes the interplay of meanings, competences and materials involved in practices associated with PSS, a lack of focus on acquisition may limit its ability to contrast access with traditional acquisition. Furthermore, types of consumers differ in their interaction with access. Access seems to be problematic for many practitioners, who do not trust it to provide the necessary reliability and availability of materials. In some cases participants mentioned difficulties in performing access activities. However, access has potential with younger, trend-conscious practitioners. These seem to have the competences required for access and associate it with positive meanings. This highlights the need to research differences between practitioners, for which PT may need to be complemented by other approaches (cf. Shove et al., 2012).

Discussion and conclusions

This research used Mylan's (2015) framework to explore this double diffusion process of two innovations. The findings have shown the presence of tight links of conventional mobility practices to meanings of freedom, independence, access on demand and empowerment. This makes use of owned cars obdurate, impeding PSS diffusion. The double diffusion involved in an e-car club PSS is also associated with a number of negative meanings for EVs, such as range anxiety and concern about location and use of charging facilities. For an EV mobility PSS to diffuse, it is necessary to disassociate it from these meanings and associate it with positive meanings of freedom, thrift, altruism and environmental protection. The offer of additional service through links with mobile phone apps could facilitate diffusion. These meanings appear to have stronger resonance among certain segments of car users than others, suggesting a weakness in PT's implied homogeneity of users. In a nutshell, the issues shaping PSS go beyond lack of control.

Further research is needed to explore different aspects of PSS consumption, in particular access and its similarities and differences from traditional acquisition, and the role of consumers' diverse identities and their relationship with access in shaping PSS diffusion. This may be enabled by complementary consumer studies perspectives that focus on these aspects of consumer behaviour.

Acknowledgments

The Authors would like to thank RADMA for their generous financial support

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-80

Is ownership the issue? The role of responsibility in determining public acceptance of product-services systems

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Keywords
Product-services systems
Access-based consumption
Public perceptions
Ownership
Responsibility

Abstract
Product-service systems (PSS) have been proposed as one approach towards increasing product longevity and achieving a more sustainable, low-carbon economy. Encompassing a range of different strategies - including extended producer responsibility, repair and remanufacturing, product renting and sharing schemes, and pay-per-use services - PSS often include a shift to access-based consumption, where the product is no longer owned by the consumer. We propose that the shift in ownership, and thus the location of responsibility for products, may play a role in public acceptance of these schemes. We conducted a series of four two-day workshops with members of the public (n=51), to explore this issue, using deliberative techniques to explore public perceptions of product-service systems. Two scenarios and materials were presented, describing different forms of PSS with different arrangements for ownership and responsibility for products. Overall, we found that while participants were not explicitly concerned with the lack of ownership of products under these schemes, the redistribution of responsibility that accompanied this was a serious concern. This was often rooted in a lack of trust in businesses, as well as other consumers, and led to a range of conditions being placed on participation in PSS. As such, the successful introduction of product-service systems will only be possible if careful consideration is given, not only to price and affordability, but also to deeply held values pertaining to trust and responsibility.

Introduction

The transition towards a sustainable, low carbon society will require a step-change in the way we produce, consume and dispose of materials and products. This change can only come about if we can identify new ways of designing, using, and delivering products, materials and services, in order to reduce demand and make more efficient use of existing resources. One proposal for encouraging more sustainable consumption is through the development of new business models, known as product-service systems (PSS). Encompassing a range of different strategies, the hope is that these innovative business models will lead to increased product longevity and/or more intensive use of products, thus preventing the need for production and consumption of further products.

Introducing product-service systems

Whilst many definitions have been proposed, PSS can be broadly defined as 'integrated bundles of products and services which aim at creating customer utility and generating value' (Boehm & Thomas, 2013; Tukker, 2015). Three main categories have been defined (Tukker, 2004):

- *Product-oriented services* are similar to current business models. Products are sold with additional services attached; producers take responsibility for products through extended/lifetime warranties, maintenance services, or incentivised return.

- *Use-oriented services* are designed to enable consumers to access products whilst ownership remains with the service provider. This can include individual leasing/renting of products, but also sharing/pooling of products.

- *Results-oriented services* aim to shift consumption from an ownership to a service provision based model. For example citizens pay for services such as lighting or washing, whilst ownership of products and materials remains with the service provider.

Whilst all PSS include both products and services, these categories differ in the extent to which value is based in the tangible product content or the intangible service content.

Ownership and responHsibility in PSS

One key distinction between PSS is the manner and extent to which they embrace access rather than ownership based consumption. For example, whilst product-oriented services maintain traditional forms of ownership, use-oriented services instead provide only temporary access to a product that remains owned by the provider. With result-orientated services, the level of access that is provided is variable and is dependent on payment plans and whether or not the service is available through products placed permanently in the home.

Bardhi & Eckhart (2012) describe how access-based consumption alters the nature of object-self relations and the rules that govern those relationships. From this perspective, ownership is characterised by a strong identification with products and full property rights, whilst access-based consumption reduces these. Crucially, whilst sacrificing certain rights, access-based consumption is also claimed to remove the responsibilities associated with product ownership, suggesting it may liberate consumers and allow for a fluid sense of identity creation irrespective of ownership.

Consumer acceptance of PSS

Despite extensive research, the focus of PSS scholarship has largely focused on the design of PSS and on value creation rather than on how they would be received (Tukker, 2015). Often, assumptions are made regarding the extent to which people are prepared to adopt new forms of provision, especially given the novel relationships that access-based PSS will require consumers to develop with products, businesses and other consumers.

Realising mainstream adoption of PSS would require radical shifts in Government policies and business models. This transition will also be bound up with social norms, values and practices, and as such may raise profound societal challenges. A number of papers have reflected briefly on the consumer acceptability of PSS. Despite often highlighting a general belief that consumers will not easily accept non-ownership based consumption (Mont, 2002; Schrader, 1996; Littig, 2001), there is often the assumption that low entry barriers, due to lower costs than purchasing outright will be enough to encourage consumer uptake (Tukker, 2004).

Only more recently have questions surrounding the role of consumers/users of these services (Vezzoli et al., 2012) been examined in more detail. Focusing primarily on barriers to consumer acceptance and uptake of PSS, the following influences have been identified (based on: Rexfelt & Hiort ad Ornäs, 2009; Antikainen & Lammi, 2016):

- *Price:* including affordability of fixed or monthly costs and perceptions of lifetime costs of products.
- *Product-service specifics:* including perceived quality of PSS, availability and convenience, transaction costs, and safety.
- *Consumer characteristics:* including habits and mindset, willingness to change, risk taking ability, environmental attitudes, relationship with product, and current lifestyle choices.
- *Relationship with company:* including reputation and image of company, and the uncertainties and communication surrounding PSS.

Based on a number of case studies of specific, and usually existing, access based products and services – such as car-pool schemes, product rentals and leasing such as clothing and appliances – research often suggests that generally consumers have a positive response to adopting PSS (despite specific concerns based on the factors listed above). In particular, paying only for what you use, avoiding rapid product obsolescence, seamless provision of needs, and avoiding obligations for product maintenance and repair, are all seen as positive aspects of access rather than ownership based provision (Catulli, 2012).

Research aims

Within this paper we will reflect upon how members of the public are likely to respond to access-based consumption within product-service systems. Rather than focus on one specific business model or product category, as seen in most of the existing literature, our research is novel in exploring the wider concept of PSS. Utilising multiple examples from the two PSS categories (use- and results-oriented services) we will thus be able to explore key areas of public agreement and contestation regarding PSS, explicitly focusing on responsibility and the influence this has perceptions of ownership and access-based consumption.

Methods

A series of deliberative workshops were designed, aiming to elicit public perceptions, values, meanings and emotions surrounding alternative systems of production and consumption. We conducted four two-day workshops: two in Cardiff and two in Bristol, with participants divided into higher and lower income groups in each city. In total, 51 participants were recruited to achieve a diverse (but not representative) sample from a range backgrounds, based on gender, age and economic social grade.

The workshops were framed around the idea of exploring the future of consumption, focusing first on past trends in consumption across society, before asking participants to consider how their patterns of consumption have changed over time. Following this, participants were presented with a series of six scenarios, each of which explored a different aspect of sustainable consumption. These took the form of vignettes, or 'a day in your life' stories, which provided a narrative vision of the future of everyday life, and were accompanied by posters providing further details of products and services available within them.

Here we focus on findings from two of these scenarios, each highlighting a different example of how PSS could reduce demand for material resources through access-based consumption. Whilst the scenarios were not described as such explicitly, each discussed a different category of PSS (Tukker, 2004), including examples of:

1. Use-oriented PSS: product renting and sharing through community based examples such as using a library of things (specific examples of power tools and kitchen appliances), swap shops, repair cafes/hackspaces; corporate examples such as Uber and Airbnb.

2. Results-oriented PSS: pay-per-use services including detailed examples of washing as a service (including installation, detergent, maintenance and remanufacturing for a monthly fee) and transport as a service (following the Riversimple electric car service example (Riversimple, 2016); Kitchen appliances and furniture provision were also discussed.

A large qualitative data set was generated, requiring careful comparative analysis of the data across all workshops. Data was analysed using grounded theory, an interpretive qualitative methodology (Henwood & Pidgeon, 2003). Analytical focus was placed on revealing the substantive ways in which people describe, understand and evaluate the different forms of PSS, and the trade-offs and conditions they are (un)willing to accept under a range of future scenarios.

Findings

Use-oriented services

This scenario explored a range of access-based schemes, including renting, sharing and pooling of products. Responses were generally positive, in part because this scenario was not seen as that different from current lifestyles. For example, many were familiar with (and had used) companies such as Uber and Airbnb, as well as local community schemes to swap and share household items and baby clothes. In addition, these schemes were welcomed as possible solutions to perceived increases in isolation and loneliness in the community.

Whilst participation was seen to be in part driven by practical factors, such as convenience and cost (Rexfelt & Hiort ad Ornäs, 2009; Antikainen & Lammi, 2016), concerns coalesced around a theme of responsibility. The lack of product ownership within these access-based schemes, was not explicitly stated as a concern, despite the clear redefinition of object-self relationships (and the new relationships with others that these would require), perhaps in part because of the functional nature of the products and schemes discussed.

Concerns were raised about the safety and cleanliness of different products, leading to suggestions that certain types of products are inappropriate for sharing (e.g., unclean kitchen appliances, or unsafe electrical appliances). Whilst these themes are clear within previous research, here we found the underlying cause to be the vague and dispersed distribution of responsibility. Linked to this, these schemes required closer relationships with business and the community that were both direct and indirect (e.g., through sharing a product). Concerns were thus raised around trust in others not to damage or steal products, as these schemes would only work if people "don't abuse the system" (Chantal).

As such, there was general agreement that responsibility would need to be clearly allocated, amongst communities, local councils and business as appropriate, in order to properly manage the safety and insurance needs of the scheme:

Arnie: *"I think these things should be centrally owned somehow by like a system or like as an aspect of the council or government or something and then they are sort of serviced. Because they would need to be serviced I think much more regularly…"*

Oscar: *"Yeah. I think you will be going in and then they'll all be faulty…"*

Ralph: *"Perhaps that system is owned by a company and […] everybody pays an annual membership fee, like a fiver or something. And then, like that item as soon it breaks down it's replaced by the company you know."*

Results-oriented services

Perhaps the most radical scenario this focused on pay-per-use services such as paying for washing or driving. Echoing previous research (Bardhi & Eckhart, 2012), some participants did believe this to be a good option to be available to those that want it, commenting that they liked 'the idea of responsibility being on someone else to manage and maintain [products]' (Pete). However, this form of service provision inside the home was still very controversial. Primarily the need to enter into multiple contracts led to strong concerns around the distribution of responsibility within these business models.

As noted by Rexfelt & Hiort ad Ornäs (2009), some participants had trouble understanding pay-per-use services, often relying on examples of hire-purchase cars and mobile phone contracts to extrapolate future relationships. These concerns related to a distrust in business, and particularly contracts, with many feeling that these would be designed with small-print or loop-holes to charge you more. Although participants were aware that services would include full repair and maintenance, they could not foresee a situation in which they were not (financially and legally) responsible for the condition of the product. As such they imagined multiple circumstances through which products were accidentally damaged, believing they would be charged or penalised financially for this:

"I would be worried in this scenario what the catch is going to be because they're always there. I don't care

whether it's your washing machine, your television, once you go into those type of contracts and it's not your own, there is always some sort of penalty that's hid away. […] They're not going to give you a £50,000 car and you return them wreck worth £10,000. Do you understand? " (Ralph)

Here a desire for ownership was often rooted in a desire to maintain clear distribution of responsibilities and thus minimise financial risk.

In addition, and in contrast to the discussion of use-oriented services, participants felt uncomfortable with new object-self relations under this scenario. One concern was around the need to manage daily life differently; for example where restrictive contracts require careful budgeting where use of products was previously unlimited (e.g., only allowed to use the washing machine 5 times a week). In addition, contrasting previous findings (Tukker, 2004), participants also described a sense that they would need to be more, rather than less, careful in protecting the condition of products, stating that this would make them feel unable to relax and enjoy the use of these products:

"I'm responsible to someone else and my actions, in my home, if it becomes my home, my furniture […] If someone comes around and they have a glass of red wine and they drop it on my sofa, ahh, you know. Suddenly I don't want anyone coming around. Because what if they drop it, I'm responsible because it's not mine." (Mia)

With these concerns in mind, a range of conditions were thus placed on these schemes, including the need for appropriate product insurance, as well as fair and flexible contracts.

Conclusions

Advocated to promote sustainable consumption, product-service systems often involve adopting access-based consumption schemes, where ownership of products remains with service providers. The desire for ownership is often cited as a key reason for public dissatisfaction with PSS. As such, our research explored public perceptions of both use- and results-oriented PSS, in relation to a range of different products.

While the intrinsic importance of ownership varied amongst participants, for a range of different reasons the distribution of responsibility played a key role in determining broad perceptions of PSS. This role was varied depending on the scheme in question, with concerns around use-oriented services focusing on cleanliness and safety factors (and the fair distribution of responsibility around these), while those surrounding results-oriented PSS considered the shift in responsibility for products within the home. Interestingly, participants were more inclined to accept use-oriented PSS (which arguably seem the most radical, due to providing the lowest levels of access) over results-oriented PSS which provide sole, in-home product access; perhaps, in part because renting and sharing of products is more similar to current consumption practices, and thus is less of a threat to existing object-self relations.

Whilst these findings refer to public discourses and perceptions, rather than practices or behaviours in relation to specific products, we believe that cultural understandings of ownership will be crucial in understanding the possibilities for any large-scale transition towards sustainable consumption. As such, the successful introduction of product-service systems will only be possible if careful consideration is given, not only to factors such as price and convenience, but also to deeply held values pertaining to trust and responsibility that influence these cultural understandings.

Acknowledgments

This study forms part of the research programme of the Centre for Industrial Energy, Materials and Products (CIE-MAP) supported by an RCUK grant: EPSRC – EP/M008053/1.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-84

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Carative factors to guide design development process for object-owner detachment in enabling an object's longevity

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Keywords
Care practice
Object detachment
Product longevity
Carative design
Lingering attachment

Abstract
During the 20th century the cultural and economic value of products dramatically changed as the availability and affordability of mass-produced, low cost goods increased in the marketplace (Walker, 2006). We buy things that end up never used, we store objects that are never needed, find the extra storage space for the object that doesn't fit in our house. Most of the things we own just sit there gathering dust, eventually to be thrown away although they are still perfectly functional. The exploration of ways to let go of objects has important implications beyond the conventional interpretation of object-user detachment. To care for one's possessions is as much about maintaining and repairing objects to keep as it is about letting objects go to a good home. In this sense, carative factors are a useful way to address ways of object-user detachment and help to promote re-use and repair to sustain and extend product lifespan.
This paper explores how the carative factors can be used to inspire and stimulate designers to explore ideas, and enable new ways to approach problems of attachment and consumption, and drive creative solutions that encourage letting go. A set of characteristic factors are presented in card format, serving as a stimulus toolkit and tested through a workshop and live design projects. The findings, potential benefits of the toolkit and effects on products lifespan will be further discussed.

Introduction

Most people in the wealthy nations of the world are used to buying and consuming countless products, in many cases not taking any action when they are no longer needed, piling up objects in closets and closing them to forget, or otherwise throw them away.

In this climate of consumption, appropriate ways to let go of objects have become less important, and people face difficulty making decisions for further action when the relationship with objects nears its end. Users' lack of knowledge, skill and motivation, and the lack of an after-use system do not foster care practice known to help extend the life or use of particular objects (Gwitt 2015).

Product longevity (Chapman, 2005, 2010; Evans & Cooper, 2010; Tietze & Hansen, 2013; Tukker, 2004) is recognised as one of the strongest strategies to reduce waste and increase positive environmental impacts. Longer lasting products, extending products life span, lifetime optimisation and other systems (e.g. Chapman, 2005, 2010; Evans & Cooper, 2010; Tietze & Hansen, 2013; Tukker, 2004; Van Nes, 2010) attempt to reduce consumption and waste by increasing the durability of the relationship between user and product. Whereas, new ways of collaborative consumption provide significant environmental benefits by decoupling the owner-object relationship, seeking to increase efficiency, reduce waste and mop up the surplus created by over-production and –consumption (Botsman and Rogers, 2011). Despite promising directions of users- objects attachment, additional research is needed to facilitate more widespread adoption of both strategies (Mont, 2008; Tukker 2013). Marchand (2003) explores detachment from possessions as a way to extend the longevity of objects in his paper entitled 'Sustainable User and the World of Objects Design and Consumerism'.

His study revealed that 'by practicing detachment from objects, [people] are more predisposed to accept an object's physical ageing.

Longevity can be also achieved through object-owner detachment, by exploring deeper motivational origins of humans' intrinsic caring behaviour. The practice of care is just as much about maintaining or mending objects for attachment as about peaceful and graceful ways to let things go for projecting hope into shared future (Jones 2013). Discovering and understanding which factors motivate the action to let go of unnecessary objects to increase efficacy is key to address appropriate ways of object-user detachment and help to circulate the material, sustain and extend products lifespans, and eventually instilling care-giving behaviour.

Carative factors and the framework

In order to explore the dimensions of caring for one's possessions, this study borrows and builds on Jean Watson's term *'carative'*, which she coined in her studies of nursing practice as a contrasting concept to *'curative'*. She proposes *'10 carative factors'* in the caring process that may help a patient attain (or maintain) health or die a peaceful death (Watson, 1985, p.7).

In this study, we propose a set of carative factors that might apply to objects, based on Watson's 10 factors, and on Blustein's four different forms of care (Blustein, 1991; Shaw, 2015), namely *affection, responsibility, commitment and benevolence* (Figure 1). Different levels of attribution of care entwined, thus work together to enable care-giving behaviour.

A series of interviews and online surveys was conducted with 10 interviewees and 65 survey participants, including discussion of possession and attachment of objects. The participants were selected from Royal College of Art, Canary Wharf College parent's association and Open door church community. Emerging themes were categorised under these four themes, and developed into a set of stimuli for a toolkit (Figure 1).

47 influential factors found during the initial research have provided direct impact on to create original carative factors inspirational cards for the design processes. The aim of the toolkit is to allow designers to explore ideas through provocative and inspirational questions, to enable different ways to approach the design challenges and drive creative solutions for letting go of objects. The toolkit was distributed to designers to be tested for their own projects, and through an interdisciplinary creative workshop. The aim of the workshop and the design studies are twofold: to provide a critical research environment so it enables form and examine the carative factors and the original design to be produced; to develop a design methodological process to produce case-specific design knowledge to address concept of letting things go.

The Workshop: Pass the objects

The workshop was held at the Royal College of Art involving 6 participants for idea generation and discussion. The workshop participants were recruited via online advertisement in collaboration with Royal College of Art Students Union. Participants were asked to bring examples of 'unnecessary' objects.

During the session, the participants grouped into pairs and generated design concepts using carative factors inspirational cards, focusing on the ideas of relinquishing things for the purpose of sharing (Figure 2). This also enabled them to review the benefit of the toolkit. 24 design concepts were generated using this toolkit and the concepts are summarised according to 4 motives of carative factors framework (Table 1).

Group 1 selected an unopened ink cartridge to explore ideas around. The ink cartridge was kept at home because it is new and unused although the original printer was given away. The owner felt uncomfortable throwing the cartridge away due to the environmental concern, but couldn't find the appropriate owner. Fifteen concepts

Figure 1. Carative factors and the framework.

were generated around this object, Responsibility and commitment were dominant carative factors.

Furniture ranked high among the objects that people keep with uncertain future plan. Although participants did not bring in this object to workshop, group 2 was interested to explore ideas around furniture. It was suggested size, weight and ways to disassemble influence owner to build burden of responsibility, as a result they tend to keep unnecessary furniture until moving houses (defra 2008). Ten concepts have been generated through the cards.

Group 3 chose unneeded shoes. It was kept at home because it was unhygienic to give away and psychological obsolescence. The group produced one solid concept by exploring four themes.

Finding

Group 1 mainly focused instilling **responsibility** or **commitment** among owners. None of concepts were generated through carative factors of affection. Affection is the loving form of care; people are naturally inclined to give care; owner's affective relationships with the objects are more important (Kirschen 2001). In this case, the owner had low level of affection towards ink cartridge, therefore group 1 had difficulty generating ideas in this theme. However, benevolence towards a recipient was a strong inspirational factor, seeking to enable community based circulation of resources.

Group 2 developed ideas on each of the four themes. Although burden of responsibility might be regarded as the main reason for keeping furniture, all three other factors were also used to generate the concepts. According to this group, obstacles to detachment for furniture owners may vary according to their personal experiences, and responsibility is not the only factor to consider but all of four themes are relevant.

Group 3 interestingly produced one solid idea by using 4 themes together. Although, each theme of cards was given out at a different time, they built upon the one idea by using all four themes.

Design studies

Two designers were given the toolkit to use in their own design projects.

Designer 1 created a design brief to deal with the problem of unwanted clothing waste, addressing the question of how the design could be improved to help owners enable a shared use of unnecessary clothes and elevate the objects' efficacy. By applying the inspirational carative factors cards during the idea generation process (Figure3), one strong and solid concept was created. Eleven carative factors influenced the design development process by crossing over the four themes. The factors of the cards used are *reward, community, pick up, descriptive norm, reciprocity, matching values, embedded personal story, engaged story, reassurance, share story and re-creation.*

Figure 2. Workshop idea generation session using carative factors.

Figure 3. Designer 1 is exploring the carative factors inspirational cards.

Figure 4. The concept generated by designer 1.

The output of the design idea was a story- telling based, peer-to–peer, online and off-line platform where people can donate and purchase second-hand clothes, and in doing so, receiving points or credits. The platform also offers design tutorials or workshops on upcycling skills and techniques to enable people to repair, adapt and customise their purchased clothes. Later the recreated clothing can be exhibited at the gallery or re-sold (Figure 4).

	Chosen object	4-motive of cataive themes and selected factors		Design concepts
Group 1	Ink cartridge	Affection		-None
		Responsibility	- Community - Pick up - Reward - Social role play	- Online ink swap platform. - Pick up and deliver services. - Printers talk to each other's to find other owners who are in need for certain colours of cartridge. - Ink party host by local ink ambassadors to meet and swap.
			- Reward	- Reward point scheme to build the reputation and get reward. - Send the unneeded cartridge to shops and reward donors with printed photos.
			- Threatening Constraint	- Getting a fine. - System that ink cartridge is scanned when it is manufactured and can't be disposed of through recycling bin to restrict owners' behaviours. - Make consumer humiliated by the action of disposal, neighbor puts the stickers on his/ her door 'I don't know how to reuse'. - Talking cartridge when it is binned 'Don't throw me' or 'Let me out'.
		Commitment	- Patriotic	- Add 'Made in new castle' on the objects to make prude of local objects.
			- Reminder	- Phone Application; Library of everything you own and remind to let go.
			- Reciprocity	- Return to manufacture and get deposit back.
			- Plan ahead	- When the contract ends, cartridge stops working and can be given to someone else.
		Benevolence	- Appreciation - Benefit to others	- Donate to school and school sends photos to donor of how pupils are using it.
Group 2	Chair	Affection	- Reassurance - Secure and trustable - Knowing progress Suggestion	- Platform for passing down furniture: Services based platform for people in need. People who are looking for a chair upload pictures and their stories and the donor makes decision to give away. Send the chair to a new owner and get feedback.
			- Reassurance - Share story - What a surprise - Knowing progress	- Swap website: Upload the chair with stories and pictures and receive a story of use or alternative things as rewards.
		Responsibility	- Pick up services - Ease-of–disassembly	- Unneeded chair pick up services. - Donate dissembled chair and make something new with other people's donations.
		Commitment	- Patriotic - Reminder - Plan ahead - Knowing result	- Penalty policy if thrown away. - Sharing purchase with other consumers and use chair for certain amount of time and pass it to other people. - Let people know that sharing the furniture with others will induce sense of national pride.
		Benevolence	- Positive self-images - Benefits to others - Appreciation - Re-creation	- Pop up shops to donate and make something new. - System to give feedback to receivers, such as sending photos or sharing happy memories.
Group 3	Shoes	Affection Responsibility Commitment Benevolence	- Reassurance - Embedded personal story - Feedback - Assessment - Ease-of- disassembly - Reward - Anti-function	-Shoes community-based application. An interactive tool to match donor and receivers through their requirements. Both parties up load their stories and the system finds the matching donors and receivers. Share the story of how to take care. Set the time of use and if not pass it to others then punishment.

Table 1. Ideas generated by workshop participants.

Designer 2 explored the problem of unneeded pharmaceutical products left to accumulate in the home, either forgotten, or kept 'just in case' even if they may have expired.

Prompted by the carative factors cards, of *reminders; secure and trustable home; better use; reward,* the resulting concepts was a smartphone application to manage pharmaceutical products, linked with unique scanning codes which are printed on the packaging. The app helps users manage their medicines, gives notice of expiry dates, provide information on how and where to dispose the pharmaceutical waste and its packaging and offer services to request a pharmaceutical waste disposal bag (Figure 5).

Findings

Designers in these trials preferred to use cards in combination, by mixing the themes. They found it was

Figure 5. The concept generated by designer 2.

easy to use and understandable without a facilitator, however they took some time to digest the contents, partly because of the amount of explanatory text, and to understand the meaning of each theme in the framework.

However, overall the designers reported that the toolkit was beneficial for their design process. The toolkit enabled openness to new design ideas according to participant 1. Participant 3 strongly engaged with the issues and design methodologies, and would like to adopt the original and transferable methodology developed through this study for future projects.

Most of concepts generated focused on ways to pass objects to new recipients or manufacturers, which would have a positive effect on object's longevity.

Conclusions

This exploratory study has described how the carative factors allow designers to explore ideas and drive creative solutions for letting go of unwanted objects in order to elevate the efficacy of products. The designed toolkit, consist of motivational factors are adopted and validated through designers' live projects and the workshop. The potential benefits of using toolkit on designers' idea development process were established and the positive effects on object's lifespan were demonstrated.

It should be noted; however, the study was based on limited samples. Moreover, the actual impacts on environment have not taken into account.

Nevertheless, these limitation, this study has demonstrated that introducing the notion of carative factors has potential as a design method for extending the lifespan of objects by enabling object-owner's detachment of unneeded objects and allowing the material to circulate.

Following on from this study, future research will attempt to re-contextualise carative factors under easy and accessible themes. Further case studies will be conducted for testing and validation of the toolkit. This study will contribute to the growing field of emotional design and sharing economy and provide design approaches for new sustainable design knowledge.

Acknowledgments

The authors would like to thank workshop participants. Also thanks to Xian Chen for sharing her work and contribution to this project.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-89

Pilling in knitwear: a clothing longevity problem beyond design

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Keywords
Clothing longevity
Sustainable supply chains
Design for durability
Sustainable fashion
Sustainable production
Testing for durability

Abstract
The environmental impact of clothing could be reduced by extending garment lifetimes, and many clothing retailers are now exploring design for longevity as a sustainable approach. In order for products to meet durable design standards consistently, global supply chain processes must be managed and controlled to avoid quality problems and early product failure. This paper uses a single case study to explore the challenges of meeting specified durable product standards in production by tracing and observing the identification and resolution of a quality issue affecting the durability of luxury knitwear. The research demonstrates that new tests and processes could enable durable products to be produced more consistently, but also identifies the obstacles and limitations to implementing these enhanced procedures. The paper proposes that effective production management of durable clothing may be more difficult within global supply chains where differences in business culture, operational practice and knowledge exist between companies. Supply chain models that emphasise shared values, knowledge and information exchange, trust and collaboration are considered as the most effective in delivering sustainable products. It concludes by identifying a range of conflicting priorities between commercial and sustainable practice that must be addressed to achieve consistency in durable clothing production, and makes recommendations for industry and future research.

Introduction
Some 80% of the environmental impact of clothing is established at the design stage (Defra, 2011), therefore New Product Development (NPD) has a significant impact on determining the sustainability of clothing products. Research suggests that extending average clothing usage by three months could reduce its environmental footprint by 5-10% (WRAP, 2012), and clothing longevity has become a key area of focus for sustainable design (Cooper et al., 2013; Gwilt, 2014). Research in this field tends to focus on describing approaches to design for longevity, and on prescribing the benefits. However, there is a lack of research into the challenges of managing the quality and consistency of longer lasting products during production within global supply chains that are often complex and fragmented (Oxborrow and Claxton, 2016).

This paper discusses research undertaken during a project supported by Defra to investigate the issues affecting design for clothing longevity. It considers one specific case to explore the challenges of meeting product standards specified at the NPD stage during the manufacturing process, and investigates issues related to process control that can impact the durability and longevity of clothing.

Literature Review
Clothing retailers and suppliers acknowledge that poor durability leads to high product return rates which are costly and damage their reputation for quality (Cooper et al., 2013). Design for clothing longevity is now widely discussed as a sustainable approach, focusing on the extension of garment lifetimes by improving durability and reducing the potential for product failure (Cooper et al., 2013; Gwilt, 2014; Laitala, Boks and Klepp, 2015). In order to achieve this, those involved in design and NPD processes should be empowered to develop and specify materials, garment fit and manufacturing methods that lead to longer lasting products.

Garments must be approved as meeting the design specification before manufacturing can proceed, and should then be produced to a consistent quality level. The clothing industry follows routine quality assurance procedures which include the setting of clear garment performance standards and undertaking voluntary testing during production to assure the consistency and quality of materials and processes at each stage of the supply chain. The frequency of and responsibility for testing can vary according to the product type, the supply chain model and the retailer's quality standards (Keiser and Garner, 2012). However, some garments regularly fail tests, leading retailers to take risks with product quality due to commercial pressures, meaning that problems are not always addressed (Oxborrow and Claxton, 2016). Design for clothing longevity or durability may require companies to adopt a more considered and rigorous approach to product specification; however, testing regimes designed to quality assure, measure and control compliance to durable design standards can add complexity, cost and time to NPD and production processes (Cooper et al., 2013). Therefore, testing of both materials and finished garments for longer life is an obstacle.

Many clothing retailers encounter a further level of complexity in managing sustainable design and NPD processes which are more in-depth, integrated and multi-disciplinary (Oxborrow and Claxton, 2016); organisational values and a system thinking approach should enable all perspectives to be addressed collectively (Hong et al., 2009) and empower those responsible for NPD to act effectively. Effective engagement and management of the supply chain also plays a critical role in enabling clothing retailers to deliver sustainable products. Gam et al.'s sustainable clothing design model C2CAD (2008) focuses on collaboration where inputs are selected, tested and valued for cost and potential environmental impact; supplier networks are engaged in information sharing to address issues with materials; and production efficiencies and quality are considered. Curwen et al. (2012) identify five principles of sustainable clothing design: a clear company mandate, shared values within the supply chain, effective knowledge gathering and sharing, cross-functional organisation and supply chain simplification. However, design for clothing longevity research is prescriptive regarding what should be achieved, but lacks the practical detail of how this could be realised that appears in models such as those of Gam et al. (2008) and Curwen et al. (2012).

Global sourcing affords clothing retailers the opportunity to reduce costs, but speed to market is reduced, putting pressure on NPD teams to shorten design lead times. It also fragments the clothing industry clusters previously able to acquire and share fashion and technical knowledge (Aage and Belussi, 2008) and also results in poor transparency, data reliability and influence over upstream suppliers (Rauer and Kaufmann, 2015). Globalised firms attempting to achieve sustainable outcomes need to address their product-service mix, governance structures, commercial objectives, and agency within the NPD process (Bostrom et al., 2015); smaller companies may find this easier to achieve where there is more control and visibility of the end to end supply chain (Caniato et al., 2012).

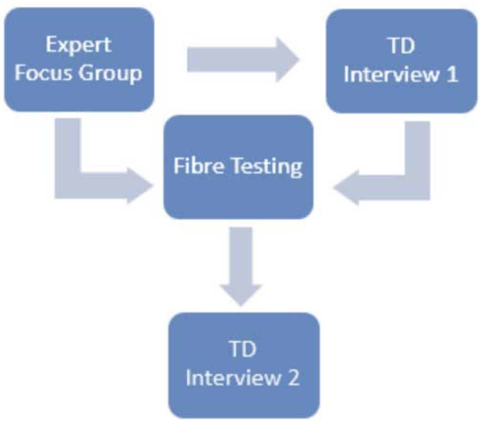

Figure 1. Research Process

This paper goes on to explore the barriers, including technical limitations, conflicting priorities, and organisational influences that hinder the adoption of design and supply of longer lasting clothing. It then discusses ways in which the commercial, technical and design limitations of reducing the environmental impact of clothing through extending its useful life can be mitigated.

Methodology

The research followed a single case study approach to investigate a quality problem affecting garment durability, leading to customer returns. Case studies are considered an appropriate strategy when 'the focus is on a contemporary phenomenon within some real-life context' (Yin, 2003:1). The company is a small luxury knitwear brand selling in high-end retail markets in the UK and China, with the company head office based in the UK, and in-house manufacturing in China. The supply chain is vertically integrated from the fibre processing stage through to the finished garment, however yarn dyeing and spinning are outsourced to an external contractor. Pilling is a key factor limiting the durability of knitted products and can result in significant customer dissatisfaction (Cooper et al., 2013). The case company had received an unusually high number of customer complaints and garment returns for pilling during the Autumn / Winter 2014-15 season, and wished to investigate the cause.

The research took place between July 2015 and April 2016. A mixed methods approach was utilised, including a technical expert focus group, semi-structured interviews with the UK based technical director (TD), and exploratory testing of upstream materials (see figure 1).

The focus group included experts in textile testing, knitwear production and textile finishing. The discussion resulted in the identification of strategies for reducing the risk of pilling during the NPD and manufacturing processes under the broad headings of 'Technical Product Development' and 'Testing and Monitoring'. Discussion of these with the TD resulted in a hypothesis that the likely cause of the excessive pilling was a higher proportion of short cashmere fibres being present in the yarn. The TD faced resistance to carrying out any extra tests on the fibre from the outsourced dyeing and spinning processes as this was seen as a criticism of individual workers, managers and the external contractor. The focus group findings and first TD interview provided a rationale for carrying out additional independent testing of these fibres in order to assess whether quality levels were being maintained. A second interview with the TD discussed the implications of the test results and how the findings were used to inform changes in management and control of the outsourced processes.

Research Results

Expert Focus Group and 1st TD Interview

Cashmere fibre quality is controlled by specifying the mean diameter and length of the fibre measured in the raw white (undyed) state. In-house tests demonstrated that the raw white fibre met the specification at the point where it was sent to the external contractor. As fibre quality was not normally tested during the dyeing and spinning processes, a series of extra tests were carried out at an accredited textile testing laboratory to assess whether damage was occurring at the external contractor. Figure 2 demonstrates the in-house and outsourced processes from fibre to finished spun yarn, and identifies the existing and additional testing points.

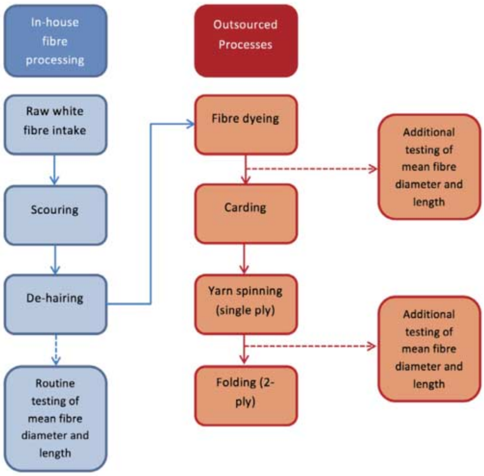

Figure 2. Yarn spinning process: in-house and outsourced processes with existing and additional testing points

Fibre Testing

Samples taken from the same raw white cashmere fibre batches as the Autumn / Winter 2014-15 production were tested for average length and diameter to corroborate the case company's in-house results. In addition, the same tests were carried out on two colours at different stages of the outsourced yarn production process: after the dyeing stage and after spinning. Figure 3 shows the fibre and yarn samples that were tested.

Figure 3. Bags of fibre and cones of yarn observed during the testing process

	Test: Single fibre length BSISO6989 method				
	Mean Fibre Length (mm)	% Fibres < 20mm	% Fibres < 30mm	% Fibres < 40mm	% Fibres < 50mm
Raw white fibre	**43**	**21.1**	**36.5**	**50.3**	**62.1**
Pink dyed fibre	39.4	21.7	35.1	52.8	70.7
Pink dyed yarn	29.4	37.3	57.3	73.5	84.8
Raw white fibre	**43**	**21.1**	**36.5**	**50.3**	**62.1**
Black dyed fibre	41.5	25.6	40.2	49.5	62.3
Black dyed yarn	28.5	44.2	63.5	76.3	84.7

Figure 4. Fibre test results

The test results shown in figure 4 demonstrate that the mean fibre diameter remains consistent during the dyeing and spinning processes when compared to the raw white fibre. The mean fibre length of the raw white fibre is 43mm, with 21% under 20mm. After dyeing, the mean fibre length of both shades has reduced slightly, but is within commercial tolerance. However, the mean fibre length within the finished yarn has been significantly shortened: the pink has reduced to 29.4mm and the black to 28.5mm. The proportion of short fibres below 20mm in length has also increased substantially at this stage. The results indicate that the fibres are relatively unchanged after dyeing, but have been damaged after this, either during the outsourced carding or spinning stages, both of which are mechanical processes causing friction.

2nd TD Interview

The TD visited China in January 2016 to discuss the test results with the external contractor and to review the dyeing and yarn spinning production processes. Three possible causes of fibre damage were found. Firstly, fibres were being excessively dried out at the end of the dyeing process; secondly, the dyed fibres were not sufficiently humidified in preparation for carding and spinning; and thirdly, the lubrication oil applied before carding and spinning was not suitable for a protein fibre. In each case, the increased dryness and brittleness caused would make it difficult for the fibre to withstand the friction of these processes. The external contractor agreed to make the necessary improvements to process control and implemented additional testing of the mean fibre length after the carding and spinning stages to monitor fibre quality. The TD reported that the pilling issue for the Autumn / Winter 2016-17 season was resolved by taking these measures, and pilling resistance tests carried out on finished garments from production showed significant improvement.

Discussion

The research aimed to investigate the challenges of managing the quality and consistency of longer lasting products during the production process. A robust NPD process was demonstrated, where fibre specifications were used to achieve the required level of quality and durability as advised by Cooper et al.'s best practice advice on design for longevity (2013). In addition, appropriate voluntary testing described by Keiser and Garner (2012) had been undertaken within the in-house manufacturing processes to monitor consistency. This proved effective in assuring quality at the raw white fibre stage, but once the product passed to the external contractor for dyeing and spinning, it was apparent that weak process management had caused the fibre to become damaged. It is possible that the UK team's remoteness from the supply chain, especially the outsourced processes, led to a lack of influence and poor transparency of issues that might arise. According to Rauer and Kaufmann (2015), this is a common problem within globalised and fragmented supply chains.

It could be argued that had the additional testing stage undertaken to ascertain the cause of the excessive pilling been a routine activity, the issue would have been identified earlier. However, this would have added cost and time into the production process, which is seen as an obstacle within the industry (Cooper et al., 2013). It would have been more productive to follow Gam et al.'s sustainable clothing design model C2CAD (2008) or Curwen et al.'s five key principles of sustainable design (2012), both of which emphasise the importance of information sharing within supplier networks to address issues with materials, and prioritise production efficiencies and quality. A collaborative approach is seen as being most effective to investigate problems, as well as knowledge sharing to achieve solutions. In practice, the TD was unable to overcome initial resistance to investigating the pilling issue and the case company's in-house team in China appeared reluctant to engage with the external contractor to investigate the problem: the reason for this is unclear, but could point to variations in business culture, management and values between different companies and global locations within the supply chain, cited by Curwen et al. (2012) as one of the five key principles that need to be addressed for effective sustainable design and production. The case company would benefit from reviewing their governance systems, ensuring that management structures and roles are defined effectively to allow those with appropriate knowledge and skills to contribute to the achievement of sustainable outcomes as advised by Bostrom et al. (2015).

Caniato et al. (2012) suggest that smaller companies with less complex supply chains are better able to address problems arising in the production process; however, the research demonstrates that although the case company was able to control NPD and in-house manufacturing processes, the outsourced processes were very difficult to influence and manage. According to Aage and Belussi (2008), such issues may be exacerbated in larger, more complex globalised supply chains as clothing industry clusters have become more fragmented; language barriers and differences in business culture, management practices and technical knowledge can limit the ability to acquire, share and apply knowledge effectively.

Conclusion

The investigation successfully explored the challenges of achieving consistent standards in production for clothing that has been designed to be durable. The results demonstrated that product durability had been compromised due to weak management of production processes. Although the supply chain was simple in structure, the company had little control and influence over the outsourced processes and were only able to resolve it by undertaking additional independent testing of materials. Differences in business culture and operational practice between the UK based NPD team, the Chinese in-house manufacturer and the external contractor resulted in resistance to investigating the problem; this perhaps indicates a lack of shared values, knowledge sharing and collaboration which are seen by some experts as key principles of sustainable design and production.

This single case study model offered the opportunity for the researchers to trace and observe one company's approach to durable clothing NPD and production, enabling the development of hypotheses about the causal mechanisms involved (Bennett and Checkel, 2012). However, the limitations of single case study research include the lack of generalisability and external validation of results (Yin, 2003). There is considerable variation within the industry in terms of product types, retail models and supply chain networks, meaning that it is difficult to make generalised recommendations. However, the findings have been used to inform the development of a toolkit intended to assist clothing retailers to resolve issues that affect product durability during production. The case study is used to demonstrate the value of tracing a product's supply chain and identifying processes, quality assurance systems and management structures at each point in order to support the investigation of quality issues.

The research is based on a single brand and its high-value knitwear supply chain. While it demonstrates that new tests and processes could enable durable products to be produced more consistently, it also identifies the obstacles and limitations to implementing these enhanced procedures. Further research could explore similar issues in additional cases to uncover opportunities to reduce early product failure.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-94

New product development and testing strategies for clothing longevity: an overview of a UK research study

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Keywords
Sustainable clothing
Garment durability
Supply chains
Product testing
Consumer behaviour

Abstract
Many garments have short life-spans, contributing to excessive carbon emissions, water consumption and waste. This paper reports on a research project which aimed to identify expectations of clothing longevity, examine the NPD process within the supply chain and identify opportunities for change, evaluate the potential for innovative technologies and improved product testing, and explore business practices aimed at more sustainable approaches to NPD. The paper provides an overview of the two-year project, presenting key findings from data collection that included interviews with 31 industry practitioners, three consumer focus groups, three industry and consumer round tables, an expert workshop, and four pilot actions undertaken with UK clothing retailers to evaluate key issues. The research identified and explored themes relating to NPD that could enable increased garment lifetimes, which were consolidated into six areas: the adoption of advanced textile processes and finishing techniques, action to overcome constraints on appropriate product testing, the potential for retailers to influence consumer behaviour, a loss of technical expertise and lack of multi-disciplinary collaboration, failure to embed good practice early in the NPD process, and evidence to encourage retailers and brands to adopt new business models. Industry and government policy recommendations were proposed to improve knowledge-sharing, strengthen the business case and influence consumer behaviour, while further research may be needed on the adoption of new garment and textile technologies, the business case and the global context of the clothing industry.

Introduction

The short life-span of many items of clothing is problematic, contributing to excessive carbon emissions, water consumption (notably in cotton production) and waste (WRAP, 2017). Our past research in this area (WRAP, 2012; Cooper et al., 2013; Cooper et al., 2014) has suggested that among the many factors that determine the longevity of garments are new product development (NPD) processes and associated behaviours across the supply chain.

This paper reports on a research project funded by Defra (the Department for Food, Environment and Rural Affairs) which aimed to identify expectations of clothing longevity, examine the NPD process within the supply chain and identify opportunities for change, evaluate the potential for innovative technologies and improved product testing, and explore business practices aimed at more sustainable behaviour within NPD. This consolidated approach was considered necessary to understand how to overcome the complex barriers to increased clothing longevity. An overview of the findings is presented below; future papers will analyse specific research themes and present the primary data in more detail than is possible here.

The recommendations presented are intended to address technical and commercial limitations and facilitate a more pro-active approach to design for longevity. While it is evident that, in principle, garments can be made to last longer, how the necessary change should be co-ordinated across the supply chain and commercialised, and by whom, is less clear. The issues are embedded in a context in which cost and aesthetics dominate design decisions. Conflicting priorities are persistent and systemic, and contribute to business strategies that often appear resistant to increased longevity.

State of Knowledge

A literature review confirmed that current knowledge on clothing longevity has latterly seen significant growth, notably in the UK and Scandinavia, but remains limited in scale. Previous research in the field has addressed the technical durability of garments (Annis, 2012; Cooper et al., 2015) and, specifically garment testing and wearer trials (Annis, 2012; Cooper et al., 2014), consumer perspectives (Fisher et al., 2008; Fletcher, 2012; WRAP, 2012) and emotional durability (Niinimaki and Armstrong, 2013), design strategies (Niinimäki and Hassi 2011; Cooper et al., 2013), retail and brand responses to extending clothing lifetimes (Goworek et al., 2012), supply chain and critical path issues (Abecassis-Moedas, 2006; Caniato et al., 2012; Curwen et al., 2012) and business model innovation (Buttle et al., 2013; Armstrong et al., 2015).

In key areas relevant to the project, however, such as brand perspectives on sustainability (Miller and Merrilees, 2013) and green NPD (Gmelin and Seuring, 2014), the clothing sector has received relatively little attention. Similarly, despite recent advances (WRAP, 2012, 2017; Kaitala and Boks, 2012; Laitala, 2014; McLaren et al., 2015), current understanding of how consumers maintain and retain garments is inadequate.

Research Methods

Drawing upon action research (Reason and Bradbury, 2001) the methodology was structured around PDSA (plan-do-study-act) cycles (Lodgaard et al., 2013 cf. Langley et al., 2009) as a means of reviewing the potential to change current systems and business practices. A qualitative approach was adopted and data collection comprised interviews with 31 industry practitioners, four consumer focus groups (totaling 29 participants), three expert round tables (on testing, pilling and consumer behaviour) and a workshop attended by 22 academic specialists. The data from this phase, undertaken between March 2014 and December 2015, was subjected to (manual) content analysis.

Four pilot actions were subsequently undertaken with UK clothing retailers to evaluate issues raising concerns: (i) durability testing to support a clothing lifetime guarantee marketing campaign, (ii) a review of customers' views on clothing longevity to understand how retailers can influence consumer behaviour, (iii) development of a testing regime for colour fastness representative of consumer laundering practices, and (iv) investigation of a quality problem in the supply chain to identify upstream causes of garment failure. These utilised a range of methods, including product tests, an online consumer survey, and interviews. Finally, a tool kit was developed as a resource to generate discussion and ideas within NPD teams, aimed at overcoming commercial and technical barriers to the design and production of longer lasting clothes.

Key Findings

It is clearly technically possible to produce garments that last longer than the current norm. The research confirmed this and added to extant knowledge by identifying and exploring themes relating to NPD that could enable increased garment lifetimes. These are consolidated below into six areas: (i) the adoption of advanced textile processes and finishing techniques that could enhance product longevity, (ii) time, cost and technical constraints on the type and effectiveness of product testing carried out during the NPD process, (iii) the impact that retailers could have by influencing consumer behaviour and enhancing their approach to user-centred design and clarity in garment care labelling, (iv) the loss of technical skills and knowledge within retail NPD teams and across the supply chain and the need to enhance multi-disciplinary collaboration in order to promote better design practices, (v) A failure to embed good practice early in the NPD process and, finally, (vi) a continuing lack of evidence to encourage retailers and brands to pilot and adopt new business models that would support clothing longevity. Key findings from the data follow.

The adoption of advanced textile processes and finishing techniques

Textile and yarn finishes and garment production techniques that could support increased longevity are available: these include anti-pill finishes, treatments that can reduce wash frequency requirement, and fused seams, hems and buttons that enhance garment durability. Not all are readily accepted by buyers and consumers in the UK, however, in part because the underlying technical complexity gives variable results and this, combined with cost, time and market limitations, constrains their use. Lack of collaboration between various actors within the supply chain means that these issues are unresolved, while their impact on product cycles, aesthetics, cost and the environment are inadequately understood. Technical innovations could increase garment longevity, including improvements in laundry and care products and fabric finishes that support durability or reduce the need to wash, dry and iron garments. New communication tools, including RFID and traceability systems, apps and social media could improve co-ordination and knowledge-sharing across the supply chain and the quality, clarity and consistency of information provided to consumers. Scope exists for new technologies to be used in product testing processes and for new tests to be developed.

Time, cost and technical constraints on product testing carried out during NPD

Extended product tests and wearer trials for durability are not routinely carried out. Obstacles include substantial resource implications and critical path pressures. Standard tests only assess fitness for purpose early in the garment lifetime, and there is variation across the industry in the interpretation of test results and pass criteria. New or revised tests are needed that represent consumer behaviour and prolonged clothing usage while meeting commercial needs. Establishing new tests is a complex task: there is a need to develop suitable metrics and objective measurement techniques and to ensure consistency of application and relevance to real-life consumer behaviour. Historic data may be used to inform future garment ranges, although it may have limitations.

The impact of retailers on consumer behaviour, user-centred design and care labelling

Retailers and brands could do much more to encourage consumers to care, repair and reuse clothes, thereby prolonging lifetimes. They could, for example, adopt user-centred design as a means to develop products that consumers want to use for longer. Emotional attachment is an under-explored aspect of clothing longevity. Care instructions and labelling could be standardised and simplified, providing clearer and better guidance that would enable consumers to make informed decisions about garment care. In particular care instructions could be standardised across garment and fabric types and labelling could be made easier to read. Care instructions may need to be modified to take account of prevailing behaviour rather than expect consumers to change unilaterally.

The loss of technical skills and knowledge within retail NPD teams and across the supply chain and the need to enhance multi-disciplinary collaboration

There is a lack of NPD knowledge and skills within some retail and brand teams and across the supply chain. The problem is exacerbated by globalisation of production and, in some cases, an absence of trusting buyer-supplier relationships and confidence in the valuable knowledge and experience that suppliers can provide. Improvement is needed in skills training and in the acquisition and retention of technically skilled staff; more specifically, practical training, problem-solving and experiential learning and CPD is needed within the retail sector. There is a need to acknowledge the value of technologists' skills and experience, recognise the wealth of technical knowledge within manufacturing, and create opportunities for knowledge exchange. Developing systems and applied technologies to capture historical knowledge could improve decision-making.

A failure to embed good practice early in the NPD process

Design decisions early in the NPD process have an impact on clothing durability, as do the materials and processes deployed along the supply chain at the fibre, yarn, fabric, finishing and garment production stages. Responsibility for design is not always clear, while opportunities exist to embed better working practices that identify potential problems at an earlier stage in the NPD process. Retailers and brands should adopt WRAP's Clothing Longevity Protocol checklist and ensure that materials, components and garments have appropriate durability.

A lack of evidence to encourage retailers and brands to adopt new business models

The major constraint to designing and producing longer lasting clothing is the challenge that it poses to established commercial interests. Business model innovations are needed to provide viable ways to commercialise and scale-up production of longer lasting garments, but there are persistent doubts over the commercial viability of such alternatives to the current norm. Concern about cost, in particular, is an inhibitor to change.

Policy Recommendations

The research findings suggested various policy recommendations for industry and government, which may be summarised as follows. First, there is a need for direct, short-term initiatives that promote the longevity agenda within business and consumer contexts. Scope exists to improve promotional messages for different target groups and to use marketing, celebrity endorsement, social media and new technologies more effectively to engage consumers.

Second, resources and infrastructure are required to support education, training, knowledge-sharing and collaboration within and between organisations in the supply chain. This could enable the exchange of knowledge across the sector and between clothing and other sectors. Intervention to influence how consumers buy, care for and dispose of clothing could help to overcome potential conflict with commercial interests. Third, support for commercialisation of the business case through the adoption of new technologies, processes and product testing is needed in the form of longer, proof of concept trials, while further work is needed to increase understanding of users, alongside the business case. Finally, either industry support or legislation is needed to improve the clarity and reduce the complexity of garment labelling. Measures are needed to encourage retailers and brands to take more responsibility for discarded products within the circular economy.

Further Research

The project uncovered various areas that merit further research, notably the potential for adopting new technologies, the business case for increased clothing longevity and the global context. First, given a rapidly changing technology landscape, there is a need to increase understanding of garment and textile technology and the potential benefits of adopting a range of new technologies suited to the design and production of longer lasting clothes. For example, new finishes and treatments exist that could lengthen garment life but research is needed to understand their sustainability impacts, design and aesthetic implications, and the business case.

Second, there is a need to develop conceptual models and extend the short pilot actions undertaken in this project into wider scale demonstrator projects that implement and evaluate change over a prolonged period in a commercial context. The objective would be to establish the business case, assess the environmental impacts and develop strategies to resolve any trade-offs between commercial, consumer and sustainability requirements.

Third, NPD needs to be explored within an international context in order to understand potentially important cultural and behavioural issues; this would reveal the transferability (or otherwise) of past UK and Scandinavian research findings. Extending the research is important because of the global context of the supply chain, the power of global brands and the ever-increasing importance of international markets.

Summary

This research project set out to resolve some key questions faced by industry concerning how to increase clothing longevity. In exploring how existing NPD processes and assocated behaviour impact on current supply chain performance, it was evident that cost is a dominant factor. Design decisions are predicated upon cost, with time a key secondary concern in some markets (notably fast fashion). There are, however, signs of increasing attempts in NPD to address product longevity, often to support brand values or demonstrate competitive value.

A range of technological innovations could be incorporated into the NPD process to address issues such as the lack of reliable data on materials performance (e.g. pilling caused by short fibre composition in yarns). Obstacles include a lack of priority placed on clothing longevity, uncertainty regarding the overall benefits for certain products and markets and, in some cases, cost.

Innovations in the testing process could be adopted to improve garment durability but these, too, face limitations, not least the requirement for a commercial case to be made before the complex and resource-intensive process of establishing and accrediting new test methods can be undertaken. Clarification of existing test protocols and standards is more readily achievable.

Better co-ordination of NPD initiatives throughout the supply chain could support the communications, knowledge and skills necessary to design and produce longer lasting garments. Such initiatives need to be inclusive across multi-functional teams (commercial, design and technical) and applied across the supply chain (including fibre, yarn and materials supply). Their effectiveness will be contingent on improved governance structures that enable more effective utilisation of skills and knowledge and a more clearly articulated commercial case.

Finally, effective solutions require recognition of shared responsibility between suppliers, retailers, brands and consumers. Consumers' decisions concerning clothing care and disposal could be positively influenced by relatively straightforward developments in communication such as improved labelling. Enhancing emotional durability, enticing consumers to keep clothing in active use for longer, is more complex and will require more considered design and marketing approaches.

Acknowledgments

This research was undertaken with financial support from the Department for Environment, Food and Rural Affairs (Defra), project reference EV0553: 'Strategies to improve design and testing for clothing longevity.'

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-98

Dimensions of sustainable behaviour in a circular economy context

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Keywords
Design for Sustainable Behaviour
Circular Economy
Dimensions of Behaviour Change
Design principles

Abstract
Although Design for Sustainable Behaviour research has seen increasing attention over the last decade, limited attention has been directed towards behaviours relevant for a circular economy. To investigate this shortcoming, this paper collected empirical examples that reflect where these two research fields meet. The result of this analysis is presented as a grid consisting of nine dimensions of behaviour change (control, obtrusiveness, timing, exposure, meaning, importance, direction, encouragement and empathy) and four goals for circular economy (maintenance, reuse, refurbishment and recycling). The collection of behaviour change principles shows that examples for almost all combinations exist, with least being identified for refurbishment and most for recycling. This insight does not only give an indication on where attention has been directed previously, but also suggests areas where there may be a need for further development of behaviour principles. The overview of examples of behaviour changing principles related to circular economy may also foster inspiration among practitioners both within Design for Sustainable Behaviour and circular economy.

Introduction

The rapidly developing field of Design for Sustainable Behaviour (DfSB) is an example of a transdisciplinary enquiry and aims to investigate, at various levels, how to influence the sustainability impact of consumers' activities. This is done by studying their behaviours and practices, developed over time and in space. A couple of dozen case studies have been reported on so far in the literature (Daae and Boks, 2015), and almost without exception these focus on interaction with (new) products, such as choice of preferred washing machine programs (McCalley and Midden, 2002), switching off electrical appliances (Rodriguez and Boks, 2005), socially sustainable mobile phone use (Lilley, 2007), behaviour related to leaving the door of a refrigerator open too long (Elias, 2011), and sustainable use of wood stoves (Daae and Boks, 2016). These studies used a variety of user-centered research methods, such as diaries, interviews, surveys and video observation, and generally conclude with suggestions for product-oriented design interventions. DfSB literature has proposed a number of behavioural dimensions (Daae and Boks, 2014), strategies for design intervention (e.g. Lilley, 2009, Scott et al., 2012), and inspiration tools (Lockton et al., 2010, Daae and Boks, 2017) that may assist designers in finding solutions towards sustainable behaviour.

Behavioural challenges related to circular economy typically include maintenance, refurbishment, reuse and recycling behaviour (Ellen MacArthur Foundation, 2012, van Weelden et al, 2015, Piscicelli and Ludden, 2016), but may also include other behaviours such as purchase or sharing behaviour (Tukker, 2013, Ellen MacArthur Foundation, 2012). According to our observations, there has not yet been much attention in DfSB literature for applying tools and methods to behavioural challenges specifically related to fostering a circular economy. Most case studies in the DfSB literature (many of which are mentioned in Daae and Boks (2015)) address behaviour related to energy, water, food or product efficiency, or in other words, to 'using less'. The card deck tool "Design with Intent" presents 101 strategies for how designers may be able to influence behaviour using different 'lenses', each accompanied by an example. Only one of the examples (a waste bin) presents an example that can be directly related to a circular theme.

There may be several reasons for this lack of attention. These types of behaviour may be seen as principally a yes or no decision (i.e. there are no increments as there are with using less), and therefore less interesting from an academic perspective. DfSB researchers may also avoid purchase or disposal behaviour because they have a preference for focusing on the interaction between the user and the use phase – which covers the core functionality of the product, and usually its main environmental impact. Themes related to design for a circular economy, such as design for reparability, upgradability, disassembly, remanufacturing, recycling etc. have been researched extensively in more traditional Design for Sustainability literature, but these fields have typically had a limited focus on the use phase (Boks & McAloone, 2009), and even less on user behaviour. There is also a lack of consensus on the exact meaning and differentiation of these circular economy terms, with for instance refurbishment commonly being confused with remanufacturing, and recycling used as a 'catch-all' description that may imply reuse, repair, up and down-cycling and other activities, depending on the context.

Research questions and methodology

The above considerations provide the context for this paper, as they made us wonder to what extent DfSB principles are used in a circular economy context. One of our goals is to do a preliminary investigation on how insight from DfSB research may contribute to improved design for circular economy. We make this concrete by addressing the following research questions:

- Can we, in contradiction to our findings from reviewing DfSB literature, find good examples of design strategies that have addressed behavioural components related to circular economy challenges?
- Does a search for such examples provide us with insights on how often DfSB strategies are applied in certain contexts, and which strategies may be more or less useful to apply?
- Can we, based on these findings, draw conclusions, formulate hypotheses, and/or recommend further work related to the potential of addressing circular economy challenges with DfSB approaches?

In order to address these questions, we refer to the Dimensions of Behaviour Change. These consist of 9 main dimension categories (and 55 sub-dimensions) identified in Daae and Boks (2014). Here, the following dimensions were proposed as distinct categories of how designers may influence behaviour: Control, Obtrusiveness, Encouragement, Meaning, Direction, Empathy, Importance, Timing and Exposure. These dimensions were the result of extensive workshops with both design professionals and students in Norway and the Netherlands, and are an operationalization of elements in the CADM (Comprehensive Action Determination Model) (Klöckner and Blöbaum, 2010), which contributed to the theoretical foundation of the Dimensions of Behaviour Change. The model explains how behaviour is a result of automaticity (what habits the user has), norms and values (what the user thinks is right or wrong), intentional processes (what the user wants), subjectivity (what the user thinks he or she can or cannot do), social factors (how others influence the user) and situational contexts (how surroundings influence the user). Table 1 further explains the dimensions.

Results and analysis

To structure our discussion of the four circular economy goals (maintenance/repair, reuse, refurbishment and recycling) in the context of the nine Dimensions of Behaviour Change, we first created a grid in which we placed examples of behavioural principles for each of them (see Figure 1). We acknowledge that to some extent, this was a random process, but we saw no other way to collect data that would represent a more systematic coverage of examples that may exist. We have attempted to reduce the randomness by having three researchers explore their surroundings and the internet, each of them using their own approach and knowledge of 'circular' products and services. Open areas of the grid do not imply that there are no examples to fill these gaps, but merely that we did not find them in our investigations. This suggests that these areas probably represent less common applications of behavioural principles in a circular economy context.

Control	How much control the user has over the behaviour can vary from complete control to no control. If the user has much control, designers can only expect the user to behave the desired way if this is in line with their intentions. Having more control is often easier to accept for users, but will generally require more attention, and willingness to pay that amount of attention.
Obtrusiveness	How obtrusive a design is will affect how likely it is that the user will become aware of it, but it will also affect how likely it is that the user accepts it. Sometimes the immediate attention of the user is required, whereas in other contexts the user must not be disturbed.
Encouragement	When attempting to making people change their behaviour, designers can focus on which behaviour to avoid, or rather on which way to behave, or perhaps present alternative ways of behaving – all with various degrees of encouragement.
Meaning	Sometimes people behave a certain way because they think it is the right way to behave, or because they are afraid of the consequences of behaving differently. Sometimes people might do something just because it is enjoyable or fun, or emotional in some other way.
Direction	The more the user will agree with the way the designer tries to make him or her behave, the more likely it is that they are willing to make an effort or even sacrifice to behave that way.
Empathy	Whether people focus on themselves or on others and what others might think of them depends both on who they are, what they think is important, and on the situation they are in.
Importance	How important someone considers certain behaviour, or the consequences thereof, to be, will affect how much effort the user is willing to put into it. It will also affect to what extent they will accept design solutions that take away the possibility to control their own behaviour.
Timing	Whether users encounter behaviour principles before, during or after the behaviour will affect how they are affected by them. Sometimes the context or the users disqualify some options because the users are unwilling to pay attention, or because the context does not allow them to be interrupted.
Exposure	Users have different needs, and exhibit different levels of acceptance, depending on how often they interact with a product. Something might work if the user encounters it rarely, but lose its effect or become annoying if the user encounters it every day.

Table 1. Dimensions of Behaviour Change.

Maintenance and repair strategies

Finding examples related to maintenance and repair is fairly easy. The Fairphone enables the user to replace broken parts on the phone and thus prolong the lifespan of the phone itself, which is an example of a control strategy. Car dashboards indicate with an obtrusive warning when a car is due for a maintenance overhaul. The Norrøna flagship store in Oslo has a service centre, where you can get your clothes fixed if you were looking for new, creating perfect timing. In many convenient locations (such as train stations), we are still exposed to shops that repair our old shoes. Patek Philippe Watches market their products with the slogan "You never actually own a Patek Philippe. You merely look after it for the next generation", providing meaning. Public advertisements point out the importance of repairing your products. Shops fixing broken glass on cell phones provide a service in the same direction as the user probably wants. On the web, there are multiple videos of how to fix things, providing encouragement to users. The Restart project organises social gatherings where you meet others and help each other repair electronics and household items. This can be regarded as an empathy strategy.

Figure 1. Grid of DfSB strategies related to CE,

Reuse strategies

Similarly, it was relatively easy to find examples of design focused on people's participation in reuse. Filippa K has second hand clothing stores in some of their shops, giving users control by enabling them to buy used clothes. Royal Dutch Shell give users the option to use their own favourite cups instead of giving away new cups when they enter a coffee subscription, timing it with the moment when they subscribe. Second hand clothes stores have collection points spread out in many cities, exposing people to the concept of giving away the clothes they do not need. Finn.no, a major Norwegian online second hand store, published an estimate they had done of the reduced global warming impact their business had resulted in, giving meaning to it. Off-brand printer ink retailers often reuse original empty cartridges when they sell their products, providing a product in the direction people want. In some trains, there is a collection point where people are encouraged to leave newspapers for reuse. There are multiple apps and communities enabling members to help and share things and services, appealing to people's empathy.

Refurbishment strategies

Refurbishment strategies that make use of the various dimensions of behaviour change were less easy to find. We also noted a thin line between refurbishment and reuse.

A Swedish ketchup producer gives away sports caps that enable the user to repurpose empty ketchup bottles as water bottles. We would characterise this as a control strategy. Patagonia offers to refurbish worn Patagonia garments and marks them with a label, advertising for the concept in an un-obtrusive way. Freitag informs customers that the material in their product comes from truck-covers and thus gives meaning to them. "Sofa gutta" refurbishes old high-quality couches and resells them. This is in line with many people's demand and thus categorized as direction. Urban Upholstery refurbishes old furniture, leaving the frame exposed in order to encourage future refurbishment. In Japan, it is considered culturally valuable to repair something that is broken. People even use valuable materials such as gold in repairs and make them obvious; an example of using empathy.

Recycling strategies

We found it easiest to identify examples of use of behaviour change strategies in the context of recycling strategies, with all dimensions represented. This was not surprising as recycling behaviour has received a lot of attention in the behaviour literature (e.g. Thomas & Sharp, 2013; Klöckner & Oppedal, 2011; Schultz, Oskamp, & Mainieri, 1995).

Information on milk cartons that they can be recycled with plastic caps makes it easier for the users and provides them with control over their actions. Max, a Swedish burger chain has so many recycling fractions in their restaurant that it promotes recycling in an obtrusive way for the consumers. Firms such as HP provide return packaging for used toner cartridges upon purchase of new ones, an example of good timing. People are increasingly confronted with waste bins that provide the option for separating paper, bottles and general waste, which makes it more likely that they will participate in recycling behaviours. Municipalities that systematically offer such waste bins could be said to apply an exposure strategy. The Fun Theory concept of "bottle bank arcade" makes it fun to recycle and is thus a meaning strategy. Garbage trucks in Oslo have "value transport" printed on them to remind people of the importance of recycling. Many cell-phone companies offer trade-in options of old cell phones. As this is in line with many customers' wishes (to have a new phone and a discount), it is a direction strategy. Information about what recycling fraction it is encourages people to recycle packaging. Keep America Beautiful ensures that recyclable bottles address users in the first person, with the words "I want to be a bench. Recycle me", an example of an empathy strategy.

Conclusions

Space restrictions for this paper do not allow us to discuss more examples or go into detail about the way knowledge from behavioural psychology is applied in practice. We do see that the majority of behaviour change dimensions can be found in 'real life' examples for most of the four circular economy goals, and in some instances, these examples could fulfil two or more of the dimensions (e.g. timing and exposure for the repair shops). However, we found it more difficult to find examples for refurbishment strategies, which may be because refurbishment is not a widespread offering in business-to-consumer markets (Mugge et al, 2017). Moreover, it is worth noting that the behaviours actually required of consumers are often not 'refurbishment' or 'recycling' exactly (these processes normally are done by companies), but more 'return', 'sort' or 'separate', and therefore in a future study it may be necessary to adapt the circular economy goals accordingly. The circular model of leasing or sharing as a replacement for ownership is another goal for future exploration, and a focus on the growing Product Service Systems (PSS) and access-based consumption (e.g. Bardhi and Eckhardt, 2012) literature would provide a basis for this.

Given more space, it would be advantageous to examine a few of the examples referred to here in greater detail, focusing more closely on the language and means of communication with consumers, and the values and intentions of the companies. There is also scope to develop the table in Figure 1 into a tool for practitioners to use in designing new communications for circular economy behaviours.

Many of the examples found may not be the result of extensive research on how users can best be influenced, but rather happenstance or the result of ideas to solve immediate problems. An adaptation of DfSB methods to the circular economy context may prove advantageous to the efficiency and adaptation of circular economy efforts. This may be especially relevant for more tricky or large scale circular economy value propositions that are further away from the user's daily life, such as buying reused clothes or electronics.

The overview created by this study will hopefully inspire practitioners to apply behavioural principles in the context of circular economy and may contribute to increased attention to the large opportunities formed by the meeting point of the two fields.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-102

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

The circular pathfinder: development and evaluation of a practice-based tool for selecting circular design strategies

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Keywords
Circular product design
Circular design strategies

Abstract
The Circular Pathfinder tool, which provides guidance to companies looking for appropriate circular design strategies, was developed based on OEM (original equipment manufacturer) case studies. Ease of use was one of the main requirements during development of the tool, resulting in a software-based guide that asks a maximum of ten product-related questions, after which it gives a recommendation for one or more specific circular design strategies. The advantage of a practice-based tool is that the practical relevance is, in all likelihood, high. The disadvantage, however, is the lack of scientific validation. This paper presents a literature review of the decision variables and heuristics of the Circular Pathfinder, with the aim to uncover any discrepancies between practice and literature. The main finding is that the focus on practical usefulness of the tool has led to excessive reduction of the complexity inherent in strategic circular design decisions. Recommendations for improving the Circular Pathfinder tool are given.

Introduction

In this paper, we analyse the Circular Pathfinder tool, which provides guidance to companies looking for appropriate circular design strategies. This software tool guides its users through a maximum of ten product-related questions and, depending on the answers, provides recommendations for specific circular design strategies (e.g. refurbishment or recycling), product examples for each of the strategies and appropriate design tools (see Figure 1 for a screenshot of the tool).

Current tool development in the field of circular and sustainable design is usually research-driven: a tool is developed based on a literature review and validated with industry or with a hypothetical case (for instance de Aguiar et al. (2017). Subsequent adoption of methods and tools in practice is acknowledged as being problematic (Daalhuizen and Schaub (2011). One of main the reasons mentioned in the literature is the misalignment between the tools and the designers' requirements for tools (Lofthouse, 2006). In contrast, the development of the Circular Pathfinder tool was industry-driven. The advantage of this approach is that the practical relevance of such a tool is likely higher. The disadvantage, however, is the lack of scientific validation – which this paper aims to address.

The purpose of this paper is therefore to do a post-evaluation and scientific validation of the tool's underlying decision variables and practical heuristics. This is done by comparing these variables and heuristics against the literature, in order to uncover conformities and discrepancies, leading to recommendations for improving the Circular Pathfinder from a scientific perspective.

Background: development of the Pathfinder Tool

The Circular Pathfinder was developed for the European FP7 ResCoM project, which is aimed at developing industry pilots and support tools to assist the transition to circular business models and product designs. The tool was developed by a product design and research agency (IDEAL&CO) as an easy-to-use 'meta-tool' for the design, R&D and innovation departments of OEMs (Original Equipment Manufacturers).

A practice-based approach was taken in the design of the tool, tracing the pathways taken by a range of OEM companies (including the ResCoM partners Bugaboo, Tedrive, Gorenje and Loewe) in their implementation of circular business and design strategies (IDEAL&CO Explore & DUT, 2016). For all cases, the retrospective question was asked which contextual, product-related factors could be used to discern the different circular pathways implemented by the OEMs.

Six key product decision variables were identified that appeared to influence the chosen circular pathways in these cases:

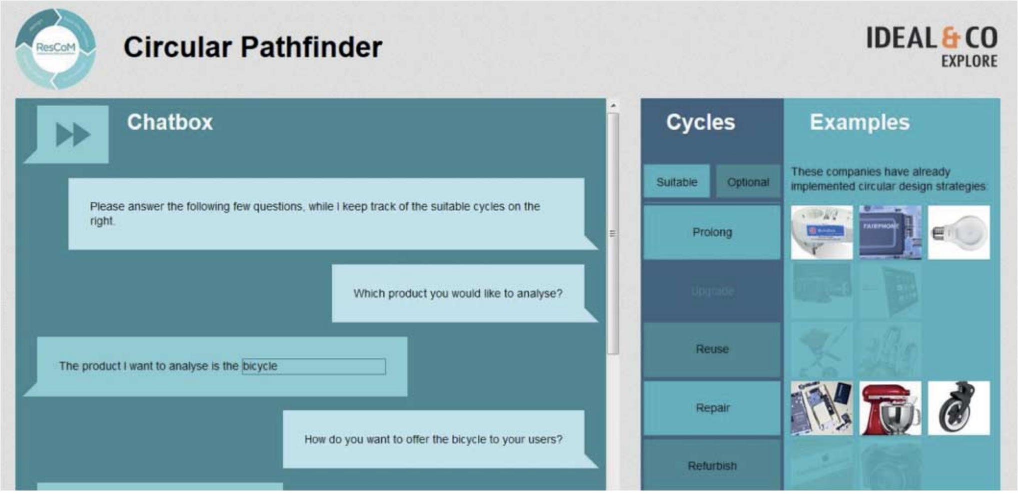

Figure 1. Screenshot of the Circular Pathfinder tool.

1. Whether the parts or materials of the product could -in principle- be collected.
2. The reason for discarding the product.
3. Whether the product could be used again after the first use cycle (as a whole).
4. Whether parts of the product are still useful to the company when the product is replaced or discarded.
5. Whether users are interested to acquire the used product (in good condition).
6. Whether users demand a warranty to assure that the used product works well.

These variables were transformed into a concise set of practical heuristics, e.g.: “Upgrade IF discarded because outdated” (figure 2), and accompanying questions, e.g.: “How long do people use the product and why do they stop using it?” (see figure 2). Based on the answers, the tool suggests one or more suitable and/or optional circular design strategies by, for example, saying “Design for upgrading is a relevant design strategy when the product becomes outdated and is discarded while it is still functional”. In total, there are eight recommendable strategies: design for durability, upgradeability, reuse, repairability, refurbishment, remanufacturing, recycling, and bio-cycling (biodegrading).

The Circular Pathfinder has so far been applied to approximately 40 cases, and used with companies directly or indirectly involved in the ResCoM project.

Scope of the tool

- The tool is based on best-practices of durables (e.g. office furniture) and products that combine durables and consumables (e.g. washing machines and reusable beer bottles). This excludes ‘pure’ consumables such as food.
- During the development of the tool it was discovered that the revenue model (i.e. sale/ lease/ charge per use) frames the circular pathways and options that are available: users may answers questions differently depending on the revenue model. Consequently, an additional question is asked at the start of the tool concerning the (desired) revenue model, and users are invited to revisit their choice.
- The pathfinder’s premise is that factors that can be influenced by the manufacturer’s operations (e.g. product design) do not hold back the potential of a circular pathway. Instead, they are the challenges to overcome if the pathway is perused.

Method and Approach

In order to scientifically validate the Pathfinder, the following approach was used. At first, we tried to find evidence in literature for the heuristics (see figure 2), such as:

“Reuse IF people are interested in paying for a used product AND product life ≥ 2x use life AND people do not usually demand warranty”.

Finding support in literature for such (compounded) heuristics is difficult. Literature does describe variables relevant to circular pathways. However, their interplay is not described in the same type of logical statements. We thus decided to focus on the decision variables underlying the heuristics. The reasoning is as follows: if support for the consequences of these variables on the suitability of circular pathways can be found, it becomes more likely that a combination of variables (that form a heuristic) is also supported. For each of the six variables a (succinct) literature review was carried out, using relevant variable-related search terms and snowballing.

Results: validation of variables

Each of the six variables mentioned in the background section are clarified with a concise review of relevant literature.

1. Collectibility of parts/materials

Materials or parts that wear away or that are consumed (for instance detergents) may be practically impossible to collect for reuse or recycling. An example of a product that wears away is a car tyre, leading to dissipation of rubber and rubber compounds into the environment. According to Ciacci et al. (2015), "Dissipation of elements is caused by scattering and dispersion into the environment at concentrations that prevent any form of recovery". They argue that this can inhibit reuse and recycling strategies. Ciacci et al. (2015) propose to use restrictive measures (i.e. bans), better product/process design and the development of substitute materials in order to reduce dissipation. The cradle to cradle approach by McDonough and Braungart (2010) advocates the use of (non-toxic) biodegradable materials which would make dissipation less harmful for the environment. This is in line with the Circular Pathfinder's suggested design strategy.

For the materials and parts that could be collected, the Pathfinder tool suggests recycling as a relevant strategy. Literature suggests that there are still considerable barriers for recycling, because of "insufficient collection infrastructures and poor collection efficiencies" and the fact that "consumer recycling awareness can hamper the potential for recycling" (Tanskanen, 2013). Although there are best-practice examples of companies that have successfully tackled the recycling of their products (de Pauw, 2015), ensuring product recyclability through design is still in its infancy (Lifset & Lindhqvist, 2008), as are innovative take-back systems (Atasu et al., 2010)

2. Reason for discarding the product

To determine which pathway is potentially relevant, the Circular pathfinder distinguishes four main reasons why a product is discarded: Because it broke down, degraded visually, became outdated, or because the user no longer needs it. These reasons show a clear overlap with literature on product obsolescence. Academics for instance distinguish between functional obsolescence (a product breaks down), aesthetic obsolescence (a product becomes outmoded, or no longer visually attractive), technological obsolescence (a product becomes technically outdated, for instance a video player), and obsolescence of desirability (user no longer needs or wants the product) (Bartels et al., 2012; Burns, 2010). The literature also discerns different approaches to resolve product obsolescence. Den Hollander et al. (2017) present design strategies for preventing, postponing and reversing obsolescence, such as design for repair and maintenance, which can be used for product design in a circular economy.

Nevertheless, research has also suggested that product replacement decisions are determined by a complex range of factors that include design, technological change, the cost of repair and availability of parts, household affluence, residual resale values, aesthetic and functional quality, fashion, advertising, and social pressure (Cooper, 2004). The way this variable is used in the Pathfinder may therefore be too one-dimensional, as the real reason a consumer discards the product may be more complex.

3. Reusability of the product

This variable addresses the possibility for the product to be used again after first use, and is related to the product's functional life span. In other words: can the product be used again without functional failure? This question refers to the product's durability and reliability. Reliability is defined as "The probability that a product manufactured to a given design will operate throughout a specified period without experiencing a chargeable failure, when maintained in accordance with the manufacturer's instructions." (Moss, 1985). Reliability is closely linked to maintenance, which needs to happen regularly in order to keep a product in good working condition. From an OEM's perspective, having highly reliable, long-lasting products can be profitable because downstream activities, including after-sales service and sales of spare parts for maintenance and repair, may "represent ten to 30 times the annual dollar volume of the underlying product sales." (Wise & Baumgartner, 1999). Strategies to extend the life of a durable, high-quality (and reliable) product may therefore be worthwhile due to indirect profits from the sales of spare parts both during the first and following use cycles.

4. (Re)usability of parts

In the tool this variable is a key factor in the heuristic for remanufacturing. When there is still a market for the product, parts that are usable in a next generation or can replace broken parts in the field are suggested for remanufacturing. Hatcher et al. (2013) state as a general rule that "the product must be durable (able to withstand multiple lifecycles) and contain high value parts (worth investing in). Also, there must be market demand for the remanufactured products." However, Goodall et al. (2014) state that asides from market demand, "a supply of used cores" (i.e. products) is necessary. With regard to these used product cores being returned they highlight three uncertainties, namely their state or physical condition, the design and physical structure (e.g. presence of upgrades or modifications), and the unknown timings and quantities of product returns. This is exemplified by Atasu et al. (2008) who argue that the main bottlenecks can be found in product return acquisition and remarketing processes. The additional factors these authors pinpoint may indicate the current Pathfinder heuristic does not address enough factors.

5. Interest in used products

This variable addresses people's interest to acquire a used, or second-hand, product. Guiot and Roux (2010) distinguish ethical, economic and hedonic motivations for consumers to engage in second-hand shopping, noticing that these motivations are "extensively interwoven". From an OEM perspective, the current size of many second-hand markets force OEMs to form strategies to respond to it (Oraiopoulos et al., 2012). According to Oraiopoulos, a positive example is set by "IBM and Hewlett Packard, [who] create high resale values for their used equipment by facilitating the resale process and secondary use (e.g., charging small relicensing fees, offering maintenance and

Figure 2. Heuristics underlying the tool.

inspection).” They remark: “Such a proactive, and in a sense cooperative, relationship with third-party brokers and refurbishers, however, is not a standard policy among all … OEMs.” Fearing cannibalization of new product sales, some OEMs attempt to actively eliminate second-hand markets. It follows that some companies may not wish to support second-hand markets and for whom this Pathfinder advice would be less useful. Furthermore, interest in acquiring used products may not automatically translate in willingness to pay (WTP) (Hazen et al., 2012; van Weelden et al., 2016).

6. Demand for warranty on reused products

The Pathfinder uses consumer demand for warranty as indicator of the potential for refurbishment or remanufacture, in contrast to reuse (second hand products) where users tend to feel little need to receive a (formal) warranty. In cases where users are concerned about the performance and durability of second-hand products, “The warranties play an important role in reassuring the buyer.” (Saidi-Mehrabad et al., 2010) This is particularly the case for products such as household electronic appliances with high perceived risk (regarding health and safety, durability and likelihood of malfunction) (Guiot & Roux, 2010). van Weelden et al. (2016) found warranty and service “to be major determinants of the perceived risk-benefit balance when considering a refurbished mobile phone.” The tentative conclusion that can be drawn from this short review is that in the case of perceived ‘high-risk’ products, warranties are appreciated by consumers, with little distinction being made between second-hand or refurbished products. This is in contradiction to the Pathfinder heuristic.

Discussion & Conclusion

This article has given a concise literature review to validate the variables used in the pathfinder. The review has highlighted a number of areas in which the pathfinder could be improved.

The variables and heuristics underpinning the tool are somewhat one-dimensional. While the developers deliberately chose to reduce the complexity present in circular design decision-making processes in order to create a practical tool, this does create some drawbacks. For example, the pathfinder has more attention for bio-cycles than techno-cycles, while currently this can be unfeasible for companies, and dissipation can be addressed with other strategies than biodegradability (Ciacci et al., 2015). Another example is that the reasons for discarding products are often more complex and intertwined than the pathfinder suggests. Likewise, whether a part can be reused is only one of the factors influencing the remanufacturability of products according to literature. As such, literature seems to indicate that the set of variables considered by the pathfinder is incomplete, and therefore the pathfinders heuristics may not have enough validity to provide companies with an accurate recommendation about which circular design strategies to follow.

An additional area of improvement is the use of terminology, both from a scientific, and a business point of view.

From a scientific point of view the use of circular economy terminology can be confusing. This is not a concern limited to the pathfinder but is also very much present in literature itself (den Hollander et al., 2017). Terminology such as repurpose, refurbish, remanufacture, recondition, and reuse are often used interchangeably, while some have distinctly different meanings. Likewise, the ambiguity surrounding recycling, bio-cycling, biodegradation, consumables, dissipation, and the distinction between collection and recovery therein can lead to confusion when filling in the pathfinder. The pathfinder does provide descriptions of terminology, but nonetheless the clarification of definitions (e.g. providing common synonyms) and attuning of terminology with literature could be improved.

While this approach may clarify terminology from a scientific point of view, this may not necessarily simplify the tool for OEMs who are the target of the tool. Here perhaps, incorporating more economic language and clear metrics may be beneficial. Examples of this are willingness to pay instead of consumer need/interest, residual value or revenue/profit from after sales service, instead of product lifetimes. This could improve the precision of the questions and the outcomes of the tool.

Acknowledgements

This work has been conducted as part of the ResCoM project that has received funding from the European Union’s FP7 (seventh Framework Program) for research, technological development and demonstration under grant agreement No 603843.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-108

Developing scenarios for product longevity and sufficiency

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Keywords
Sufficiency
Product durability
Repair
Re-distributed manufacturing

Abstract
This paper explores the narrative of peoples' relationships with products as a window on understanding the types of innovation that may inform a culture of sufficiency. The work forms part of the 'Business as Unusual: Designing Products with Consumers in the Loop' [BaU] project, funded as part of the UK EPSRC-ESRC RECODE network (RECODE, 2016) that aims to explore the potential of re-distributed manufacturing (RdM) in a context of sustainability. This element of the project employed interviews, mapping and workshops as methods to investigate the relationship between people and products across the product lifecycle. A focus on product longevity and specifically the people-product interactions is captured in conversations around product maintenance and repair. In exploring ideas of 'broken' we found different characteristics of, and motivations for, repair. Mapping these and other product-people interactions across the product lifecycle indicated where current activity is, who owns such activity (i.e. organisation or individual) and where gaps in interactions occur. These issues were explored further in a workshop which grouped participants to look at products from the perspective of one of four scenarios; each scenario represented either short or long product lifespans and different types of people engagement in the design process. The findings help give shape to new scenarios for designing sufficiency-based social models of material flows.

Introduction

This paper reports on work undertaken as part of a UK EPSRC funded project that explored how redistributed manufacturing (RdM) has the potential to disrupt the way we produce and consume products across the lifecycle through engaging users in local modes of sustainable production. In response to such disruption the research explored new business scenarios to promote resource sufficiency through exploring the engagement of people with their products across different product lives.

It is proposed that new, localised structures of design and manufacturing can enable large reductions in resource consumption by limiting waste in a supply chain (e.g. reducing transport distances) and through addressing the flows of resources at critical times in the lifecycle of products. Design and manufacturing strategies that extend product life offer one of many approaches that can reduce post-production resource flow. Such strategies may also promote more localised manufacturing, greater levels of bespoke mass customisation and the structural facilitation of closing different resource loops. The closing of resource loops across product lifecycles theoretically promotes increased resource efficiency and an increased utility of resources, thereby increasing the sustainability of production and consumption activities (Ellen MacArthur Foundation, 2013). An opportunity for such strategies is to not only create new systems of production and consumption, but also to challenge the paradigm of persistent growth implicit in current patterns of industrial production and consumption. The idea of questioning growth confronts 'business as usual' practices head on and as such remains on the margins of the debate. It is however, an important part of the debate.

At one level strategies for greater resource utility sit happily in a context of efficiency: making what we do today ever more efficient and resourceful (Ehrenfeld, 2008). This focuses on reducing current environmental impacts of manufacturing and pursuing current goals of productiveness. An efficiency response to this moderates business as usual modes of operation without a change to overall production goals, to attune and respond to resource scarcity through technological responses that can include for example, circular economy frameworks, environmental technologies and waste reduction initiatives. However, many argue that efficiency alone will not deliver sustainable outcomes (Ehrenfeld 2008, Princen 2005, Cooper 2005, Jackson 2009). Predominately this is because efficiency-based decision making does not take the long view.

Connecting sufficiency and product durability

A radical transformation in patterns of production and consumption is required to respond to eco-services decline as a result of increasing resource depletion, climate change, increases in global population and growing requirements for excessive resource consumption. In contrast to efficiency, strategies driven by a sufficiency rationale challenge the fundamental goals of maximum productivity and growth. (Princen 2005) argues that sufficiency presents a different rationality to the one that dominates advanced industrial and post-industrial societies that emphasise the efficient and the judicial (and in production terms, the linear and the lean). A sufficiency rationale recognises the complexities and dynamics of natural systems and the imperative of promoting an ecological integrity that can protect the eco-services on which all economic transactions rely (Princen 2005, pp25-26). Sufficiency equals resource security that equals sustainability. This is long-term thinking.

This analysis suggests that shifts in thinking are required to counter high levels of material consumption while maintaining levels of productivity conducive to supporting a society's economic, social and ecological wellbeing. The premise of this research is that a shift to a more durable product culture will provide environmental benefits (Braithwaite et al 2015, Bakker et al 2014). However such a shift will not only require technological and system changes such as those proposed by the theory and practice of circular economies (efficiency-oriented), but also a much greater understanding of, and engagement with the people to address issues of demand. The paper links concepts of product durability, repair and adaptation to redistributed manufacturing to create greater potential for dispersed 'making'. It proposes that through extending material utility using local making knowledge and services, there is a potential to deliver a sufficiency-led product culture.

Methodology

The paper reports on three objectives of the BaU project: to map consumer interventions across the lifecycle of products; to explore people-product relationships in product repair; and to envision more sustainable scenarios of product development in RdM contexts. Meeting these objectives required the application of different methodologies.

A literature review was undertaken to explore consumer interventions across the product lifecycle. Within Customer Relationship Management (CRM), consumer touchpoints (Dahan et al, 2010) are a well-established tool for mapping and understanding the interactions between a brand and its customers (Hogan et al 2005, Martin et al 2011, Baxendale et al 2015). Building on the theory of customer journey maps, the project employed the mapping of consumer intervention points to visualise the opportunities for the consumer to intervene in, and modify, the intended or expected product lifecycle. The project used current literature to map points of intervention in a customer journey throughout the entire product lifecycle, from product specification, design and manufacture, through promotion, sale and use, to repair, re-sale and disposal. A key aim of this mapping exercise was to explore new opportunities for people-product interactions to support sustainable production and consumption in RdM contexts.

The second phase of the project explored product repair as a means to investigate peoples' interactions with their products in use. This study included semi-structured interviews that were carried out between May and July 2016. A survey of relevant literature was also completed prior to interviews to establish key interview themes and to help populate the customer journey map (Saca, 2016). A key purpose of the interviews was to understand what constitutes brokenness and repair and to find out how people engage in the repair process and to further understand the role of more localised product interventions (e.g. maintenance and making) in slowing resource loops. In total 41 interviews were completed: 10 were visitors to the Farnham Repair Cafe and the Guildford Repair Cafe; 16 were volunteers at those Repair Cafes or members of other Makerspaces (The Restart Project, Men in Sheds); and 15 were members of the general public.

In the final stage of research new scenarios for business ('Business as Unusual' BaU) were developed. Here scenario planning is used to visualise the key assertions of the BaU project – that manufacturing is localised, people are involved in the design of their products, and overall resource use is low. Based on these three founding concepts, two critical uncertainties were identified: product longevity (the length of product life) and consumer design drivers (the nature of consumer interactions and the types of consumer data). Four different scenarios formed the basis of a workshop activity exploring different product lifecycles and customer interventions. Note the BaU project also researched fast moving consumable goods and the use of large consumer data sets; while the work is not core to the scope of this paper, it does inform the development of the scenarios.

Engaging people in the product lifecycle

The customer intervention map

A literature review identified the relevant phases of a customer journey across the lifecycle in order to create a Consumer Intervention Map (CIM). In common with existing CJM models, the CIM depicts the customer journey space at increasing levels of detail. Based on the literature the map was populated with 'active' touchpoints where consumers directly and intentionally intervene to alter the brand's intended, or expected, customer journey model. Passive touchpoints (for example magazine advertising or sales staff interactions) that do not involve consumer intervention were excluded. The identified touchpoints were mapped to their appropriate phases in the product lifecycle (Figure 1) using a system of colour coding to identify different stages of the lifecycle and diferent colour tones and positioning to indicate the different drivers of intervention. The inner circle

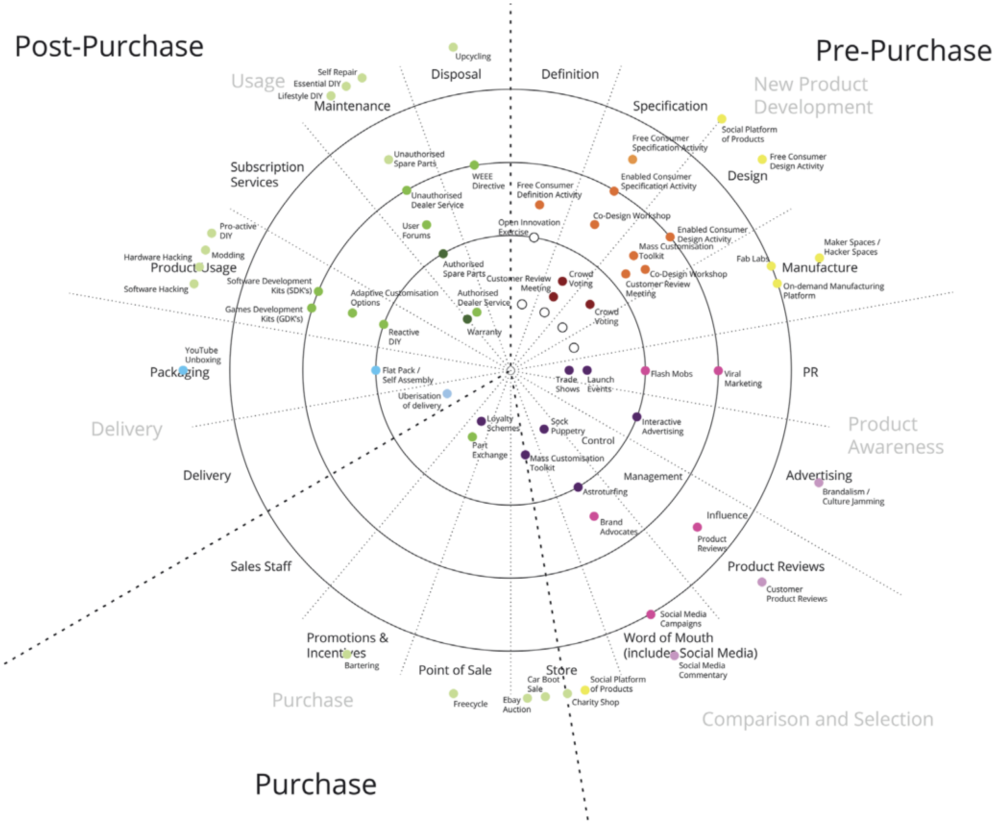

Figure 1. Consumer intervention map populated across the lifecycle (source: CIM, 2016).

represents touchpoints driven and 'owned' by the product/brand organisation; moving to the outside of the circle or beyond its boundaries, represents less control from the organisation and a move to independent initiatives by individuals or communities (e.g. hacking a product to create new functionality is a people-product intervention outside the circle). The CIM was used to plot the different product journeys that resulted from exploring the BaU scenarios in the later workshop activities.

Product repair

The primary focus for this part of the project was the activities found in repair cafes. A total of 26 interviews with volunteer repairers and people bringing products for repair were undertaken. A brief overview of repair cafe respondents' motivations and barriers to repair is presented in Table 1. Perceptions of brokenness varied but most respondents referred to a loss of function or a decline in the performance of the product that no longer meets the expectations of the user. Poor product performance was similarly highlighted in a study undertaken by Nottingham University (Salvia et al, 2015). Which found that vacuum cleaners were replaced due to a decline in the performance of the product, and specifically the reduced power of the vacuum suction: a problem that can be easily remedied by cleaning or replacing the filters. Instead, many owners chose to dispose of the product and purchase a new one. Comments made by repair cafe interviewees highlighted issues of product care and maintenance, such as a lack of maintenance know-how, an inability to take newer products apart (e.g. glued components) and expectations that products today don't last that long. Heiskanen (1996) states that people replace products because of technical failure, dissatisfaction or a change in their needs. Similarly, Granberg (1997) and Cooper (2004) present different types of obsolescence that reflect a complex set of relationships between people, their products, technological trends, and the economic and cultural contexts of product use. The very different relationships people have with their products are also evident in repair café conversations. People report a decline in product performance as a primary factor to dispose of a product. A lack of maintenance and general care across product-life are also key reasons why product functionality decreases below acceptable levels and people seek alternative solutions. A lack of product knowledge and lack of technical information about the product and its spare parts can also play an important role in this decision-making process. Similar points have been reported in earlier literature (e.g. Gwilt et al, 2015 and Salvia et al 2015) The relationships people have with their product also matter. Sometimes it's an emotional connection (Chapman, 2005) - a gift from someone special; a product passed down through the family; a

Motivations and barriers to product repair			
When is a product considered to be broken?	**What makes something worth repairing?**	**Why don't you repair it yourself?**	**What are the main barriers for repair?**
- When it doesn't work as it used to - When it no longer can do what it was bought for - When the main function doesn't work anymore - When it is no longer convenient to use - When it stops working or doesn't work well - When the quality and performance decreases	- A product with emotional attachment that you want to keep - A familiarity with the product and technology - Better to repair than replace with a product you don't understand. - Cheaper to repair than replace - Cheap products are not worth paying repair for	- Lack of knowledge - Lack of time - The inconvenience of repair - The ease of buying a new product - Not owning the right tools - Concerns about voiding the warranty - Concerns that product won't work anymore - Lack of creativity to do repair - Lack of skill	- Lack of access to spare parts - Obsolete components - Lack of knowledge about the spare parts required - Products are not designed for longevity or repair -Products designed for manufacture, not disassembly - Difficult to open products to repair them - Products not looked after, are seen as disposable

Table 1. Repair cafe participants' views on product repair (Saca, 2016).

comfortable chair; a favourite dress. Other times the attachment is more pragmatic. One elderly lady explained how she much preferred trying to fix her products (she'd brought a number to the cafe already) because she was familiar with how the product worked and what all the buttons do (or the ones she needed to know about), and she didn't want to consider having to think about all that again with a new product using new technology.

Community based repair initiatives alongside on-line IFixit instructions and Makerspaces have provided a new type of platform for people to make different decisions about extending their product's life using local making contexts. Not only do such repair initiatives contribute to waste reduction and product longevity, they also provide places for people to socialize, share and learn new skills (Kohtala 2015; Prendeville et al 2016).

Interventions during product use provide opportunities to transform the worn into the useful, the old into an adapted new. It is this potential for extending the utility of material resources that offers the potential to disrupt business as usual practices. This is not new – thrift, for example, is a historical norm. What is emerging as a challenge is how resource resilience can be promoted through strategies of redistributed making.

Business scenarios for product longevity and sufficiency

Customers' product needs may be met in entirely new ways through creating hybrid models of co-design and production between customers, local makerspaces and manufacturers, where new product experiences and communities can be connected and informed (Sanders 2008). Longer lasting products coupled with a culture of repair provide an interesting backdrop for proposing new business scenarios. New configurations between circular business models and design strategies will not only extend product life but also reframe the role of the product in different modes of consumption (Moreno et al, 2016). Bocken et al (2016) identify new business models that shift a "dominant business model logic" to a circular economy mode.

Similarly, this exploratory study identified two critical elements in considering a shift in the production paradigm. One focused on the nature of engagement with people across the lifecycle, from very engaged (people-led activity) to people inspired (data driven input). The other addressed the timeline of a product's lifecycle from short-life to long-life. . Four conceptual business scenarios reflecting structural change in relationships between production and consumption emerged and were explored with expert participants at a workshop (BaU, 2016). Two of these scenarios focused on product longevity and the engagement of people at different scales. Figure 2 shows the core factors of both durability scenarios. These explore who designs (consumers or experts); the need for technological developments; the scale of data required for consumer engagement; and the scale of the organisation.

For example, in the scenario, Engaging Endurables (Long Life Cycle + Customer Led Design), durable products with long life cycles are crafted and exchanged in localised systems. They are designed by individual customers who work with the makers to customise their purchases. Technology development facilitates consumer engagement and co-design, and builds local networks of makers and maintainers. Local businesses work with end users through apps, service provision, and physical exchange and repair points. In the scenario, Democratic Durables (Long Life Cycle + Customer Inspired Design),

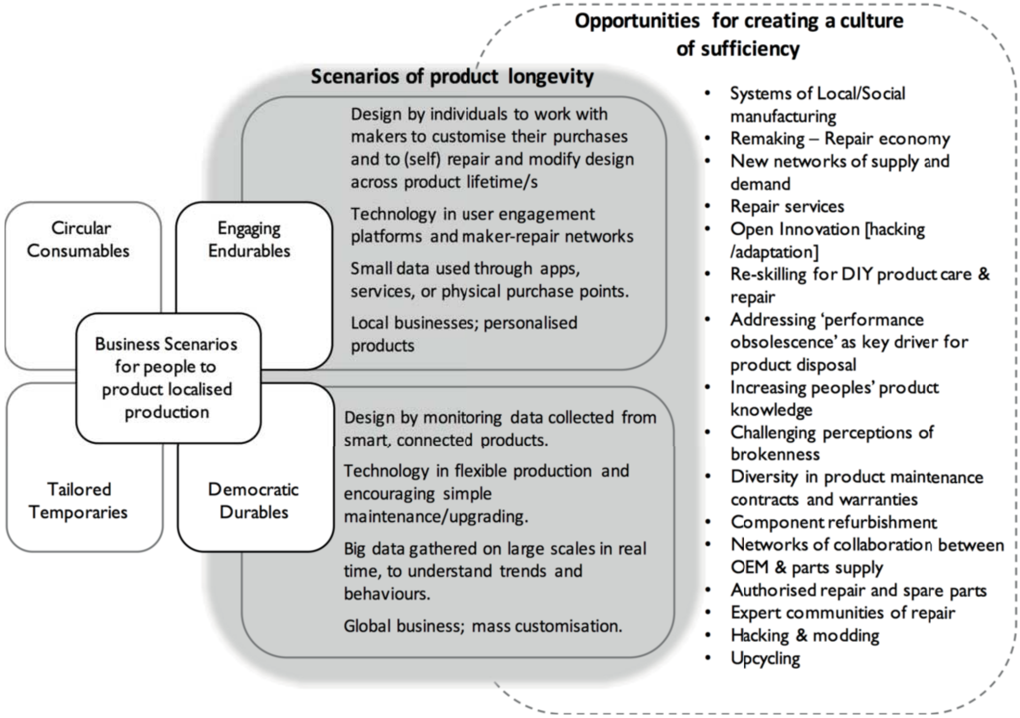

Figure 2. Business as Unusual scenarios with a focus on product longevity.

connected products with extended life cycles are produced, maintained and exchanged in a localised system. They are designed by monitoring lifecycle data collected from products in use. Technology development is focused on delivering flexible systems of supply, assembly, maintenance and upgrade. Large companies gather big-data in real time to understand trends and behaviours, and translate these into targeted offerings working with localised branches and assembly centres. New product-people interactions across the product lifecycle help shape new modes of consumption. Longer-lasting products for example, explore ways in which different people-product interventions can recalibrate peoples' views of resource use, product adaptability and their value. Figure 2 also links durability scenarios to opportunities for structural change to enable a slowing of resource flows in product life, in part achieved through the adoption of modes of redistributed making and consuming.

Conclusions

Reframing ideas of disposability and linear product flow is critical in current contexts where efficiency-oriented drivers have proved ineffective at creating sustainable business outcomes. Product obsolescence, in its many forms, can only be successfully addressed if a greater emphasis is placed on business strategies of sufficiency alongside those already addressing efficiency. This exploratory research suggests that developing a better understanding of the opportunities and challenges posed by long-life products, alongside the potential of different people-product interactions in product life, will support evolving cultures of sufficiency and the creation of new systems of sustainable production and consumption that enhance the lifespan of material utility. Individual motivations for this may be driven by economic necessity but also may be influenced by the areas highlighted in this study, such as a familiarity with the technology or functionality of a product, an emotional attachment to a product or a desire to learn new skills. The viability for distributed making and product life extension is also determined by the presence of new infrastructures, services and skills to support repair and adaptation. There are opportunities for RdM strategies to establish a capacity for different collaborations between OEMs, the suppliers of parts, local fixers and makers and end users in creating sufficiency-based social models of material flows.

Acknowledgments

We would like to thank the UK funders, EPSRC ESRC, of Grant (EP/M017567/1): 'RECODE Network on Redistributed Manufacture, Consumer Goods and Big Data'. We would also like to thank all the participants, and volunteers of the Repair Cafes in Farnham and in Guildford, The Restart Project in London, the Men in Sheds based in Milton Keynes, and all the interviewees who gave freely of their time to discuss their stories of repair. We would also like to thank the participants of workshops that have helped us explore each of the BaU scenarios.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-114

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Transforming and prolonging design lifespans: design education cases for sustainability

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Keywords
Design for sustainability
Design education
Personalization
Open design

Abstract
This paper aims to present an approach focusing on design education for sustainability through providing two exemplary cases from third-year industrial design projects. The main themes explored in these projects involve personalization via design transformation, adaption and upgrading during design, use and post-use phases. The first project developed and facilitated at Carleton University, the School of Industrial Design mainly addresses the key theme of transformation of LED lighting from indoors to outdoors during use phase for the adaptation of design solutions for diverse tasks (e.g. mood to therapy lighting, task to outdoor lighting etc.). Second educational project developed and facilitated at METU Department of Industrial Design, aims to develop design solutions for open kitchen platform enabling transformation and upgrading during design, use and post-use phases. For each case, users are considered as active participants in the design process. The first project was undertaken individually whereas for the second one, the design students worked in teams due to the complexity of the project scope and objectives. This paper outlines the main intentions, phases and outcomes of these educational projects through providing insights and suggestions from design educators' perspective. The illustrative student projects demonstrate some of the key principles and considerations being aimed throughout the phases of the projects. This paper also provides some future directions that can be implemented in further researches and educational projects.

Introduction

The core principles of design for sustainability can be viable through critically and constructively evaluating and reflecting on diverse approaches. As one of these inspirational thoughts for design research and education, evolving and adaptable design solutions at the local scale can empower users as active participants in the process of design and product personalization (Mugge et al., 2005) tailored to local needs, preferences and tastes via enabling local skills and knowledge, and post-use services including repair, reuse and upgrading (Walker, 2011). To achieve this, designers needs to rethink design in systems-thinking scale, and provide alternative solutions integrating various scales and approaches of production, spanning batch or mass production, craft, do-it-yourself and open design.

Environmental and social implications of existing products

To address sustainability considerations (Oğur et al. 2015) in design process, design educators can help design students rethink existing solutions, and explore design experiences rather than solely focusing on redesigning products. Particularly for established product categories such as household appliances, lighting, etc., current products appear to be disconnected, product parts cannot be replaced and upgraded effectively for personalization and post-use as the result of automation and standardization of production, and not effectively involving people in design processes. This, in turn, results in the externalization of environmental and social impacts of material sourcing, extraction and processing, production, assembly and transportation processes in this predominantly globally-tailored system. The current patterns of production and consumption do not mainly aim to involve people in the process of personalization for tailoring design solutions to their needs and preferences, and for post-use such as repair and upgrading. This close system eventually feeds into excessive consumption patterns and rapid disposal of products (Cooper, 2012).

Design education in a complex world

Design education would be the first step to make this change, challenge the narrow vision of existing patterns, and enable and encourage students for different directions. Changing designers' understandings about design through addressing sustainability considerations needs to start at the very early stages of design education. Challenging existing norms and understandings about design is a complex and perplexing task, as many design schools and existing design practices lean towards conventional design processes and solutions. Although in our current state of environmental issues, such as degradation of resources, pollution, water scarcity and climate change, the current practices are very slow to adapt, and there might be several challenges as design educators have to meet many requirements such as teaching objectives and outcomes which are in many cases very established, and can be hard to change considering the mainstream practices, strategies and priorities tailored to mass-production and consumption patterns.

Design adopting new approaches – systems thinking and rethinking design

Via facing these current challenges in design education and practice, design and the process of designing can be the key to alter our way of perceiving design in terms of providing alternatives en-route to change. Adaptable and evolving design solutions enabling part replacement easily, effectively and engagingly can be incorporated as one of the main design considerations in design education projects. In that thinking, the students can be encouraged to design a system of components and/or parts rather than aiming towards making incremental changes on existing product categories via redesign. That systems thinking approach could eliminate repetitive or duplicate components (e.g. motor, heating elements, circuitry, etc.) which can be quite apparent in household appliances and electronics. This reconfiguration and reconnection of the components in terms of how they relate to each other via systems thinking can be adopted in design education projects rather than bounded by a closed-system approach which limits the nature of design solutions to "products" and "interfaces". This new approach strengthens and extends the current role of designer which would turn it into the facilitators of change (Fuad-Luke, 2009). This new position embraces users as active participants of design process from design adaptation to upgrade, from design to post-use phases. Although the established terms appear to separate these stages (i.e. design, use, production, post-use), in this new systems-thinking approach all of them are intertwined. Evolving, transformable, adaptable design solutions would consider all these stages concurrently. Users as active participants can adapt this system of components, while replacing each part in case of breakdown, wear and tear, technological or aesthetic obsolescence.

There are several examples of open design approaches where new generation designers provide many alternative directions on how the systems-thinking approach can be adopted such as open design solutions by "OS Water Boiler" by Jesse Howard and "I love OS" project by Thomas Billas based on Open Structures modular design grid (openstructures.com, n.d.), flexibility and interchangeability of parts for repair and adaptation in Hacking Households project (sepic.cc/Hacking-Households-1, n.d.), and essentials (electrical components) and additives (mainly 3D printed) coming together in Open E-components project (cargocollective.com/open_ecomponents, n.d.). Introducing these new approaches as part of the design ideation and development of alternative solutions can be very inspiring for reinstating and reaffirming these, and make them more relevant and applicable to design thinking and education.

Design education projects

Design education for sustainability with a particular emphasis on extending product lifespans has been incorporated into educational projects in various ways. The ones exemplified below mainly address the themes of design transformation, adaptation and upgrading for personalization. To achieve that main themes, potential solution directions were explored such as part replacement, interchangeability to elongate the lifespan of products.

This paper intends to present alternative directions and strategies that can be valuable for design educators and researchers. The design education projects aim to help the design students understand how these main themes can be potentially interpreted and reflected on design solutions. Learning through designing and reflecting is a natural part of design process. In these projects, the role of users is also defined more actively through a more participatory approach. For each case, the design students are highly involved in field research through user observations and interviews to have a better understanding of user needs, preferences and perceptions, and through concept prototyping to get feedback on their design ideas.

The examples of design education projects involve the areas of LED lighting design and small household products, focusing on the approaches of transformation and open design for sustainability that have many opportunities for effectively and creatively involving people in design, production, use and post-use phases. Design experiences that engage users in maintaining, adapting and personalizing designs can be realized in various ways. To do so, design project briefs and how educators develop project phases appear to have invaluable implications for revisiting and developing learning process and project outcomes.

Case1: Transformation of LED lighting from indoor to outdoor environment

In one of the lighting design projects undertaken in Fall 2016, the third-year design students developed diverse design solutions for LED lighting that can be transformed from indoor to outdoor as well as outdoor to indoor. In that educational project, various design tools and considerations were incorporated into the studio course including transformation for personalization as well as post-use aspects such as maintenance, repair and upgrading. Rather than designing an everyday lighting, the students dealt with a more complex problem of transformation and adaptation, which helped them develop diverse scenarios for indoor/outdoor activities and tasks (e.g. camping, hiking, skiing, walking, studying, sleeping, relaxing, etc. for mood, therapy, task, emergency lighting etc.). Personalization and post-use as design considerations helped the design students being critical

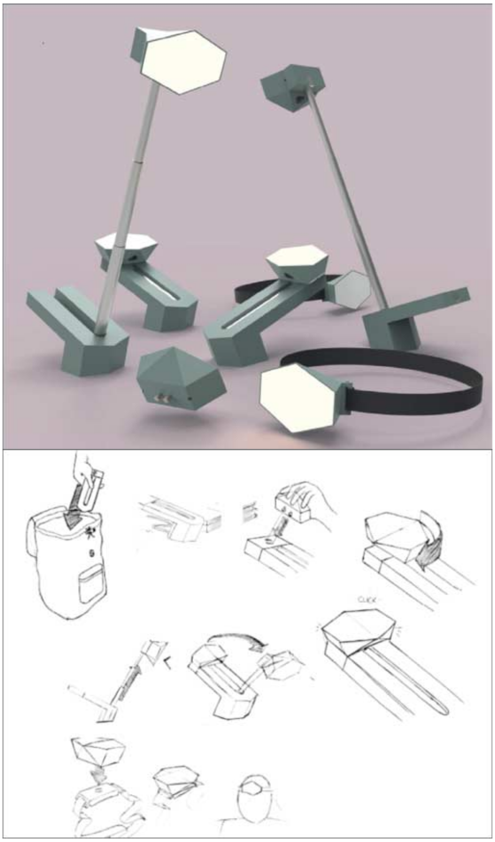

Figure 1. Facet LED lighting design and use sketches by Kaamil Ajmeri. © Carleton University.

about the main lighting components, and how these would be brought together by the users, so that design solutions could be adapted for diverse activities, tasks and situations. Through utilizing simple and applicable design connection detail (i.e. attachable and detachable), the approach of "product family" was also rethought within the context of this design solution, namely Facet (Figure 1). The design of the connection detail appears to be an integral part of the design process through which the student reflects on the various applications of it for developing task oriented different components of that product family. Facet lighting design proposes a family of LED lighting products designed for those with active lifestyles and small spaces. Facet can adapt to suit various tasks via making transformation easy and effective for users.

Case 2: Design solutions for flexible cooking platforms in kitchen environment adopting open design principles

The second example is from an earlier design education project undertaken in Spring 2015 through which open design approach (Tooze et al., 2014) was taken into consideration for developing solutions via rethinking small kitchen appliances. In that project, rather than redesigning existing small household products, the students were encouraged to think in terms of assembly, arrangement and adaptation of parts or components for enhancing food preparation experience (e.g. preparing hot drinks, cooking, warming, baking, grilling, toasting, etc.).

Similarly, but for this case even more apparently, the design student teams had to revisit their conventional understanding of "what a product is". In that case, the "product" itself turned into a system of components enabling part replacement for maintaining, repairing, aesthetically and technically adapting or upgrading, etc. Part accessibility, user engagement and localization are the key ingredients of this design education project inspired by open design and personalization approaches to transform the nature of design solutions for sustainability.

The main purpose of this project is to develop a flexible, open-source cooking platform, supporting diverse food preparation, making and serving scenarios in which users as participants are actively and creatively involved in design assembly, adaptation, maintenance, repair and upgrade. The design solutions aimed towards demonstrating at least three diverse cooking scenarios, while potentially enabling a wide range of cooking types. Making products technologically more accessible and understandable and open to people intervention, so that:

- People can maintain and replace parts properly for repair and upgrading.
- People can become more active participants of the design process, thus adapt and personalize these solutions considering their needs and preferences (e.g. for different cooking practices).
- As active participants, they can share their skills and knowledge through online cooking platforms.
- Through systems thinking approach (enabling interchangeability) repetitive parts can be eliminated, various scales of production can be brought together, which in turn empowers other production types such as craft/bath production, and new flexible technologies and the related local skills and knowledge.

Design solution presented here (Figure 2 and Figure 3) has main components including heating base, structural elements, hangers and connectors through which basic setup can be adapted based on user needs. Other components such as coffee/tea brewer, kitchen timer, bain-marie, steamer, etc. can be attached to the main structure for different configurations.

Assembly and disassembly details are significant in bringing together the structural components with heating elements, structural ones with adaptable components for different practices such as cooking, brewing, etc. and heating components with the additional or accessorial ones. Height adjustability, component configuration,

Figure 2. OpenKitchen design project features, Spring 2015 by Gülnihal Karaca, Dhafan Ridharizan and Kaan Yaşa. © METU.

Figure 3. OpenKitchen use scenario, Spring 2015 by Gülnihal Karaca, Dhafan Ridharizan and Kaan Yaşa. © METU.

adding new accessories via 3d printing, storing and cleaning, replacing components with others for repair and upgrading are the main features of transformation and adaptation in this open kitchen platform.

In comparison to open design examples, in design education projects the student teams seek for a mutual understanding and language (or set of open design rules) that can be applied to the transformation of components which appears to be the key step to bring together various parts in diverse ways. This can be a common grid, the standardization of connection details for ease of attachment/detachment as well as flexibility of connection details for incorporating diverse components (craft-produced parts, readily available parts, electrical parts, etc.) For instance, to attach a readily available part/accessory with the structural components, an adaptable connection detail via 3D printing can be produced for enabling this flexibility. Another noteworthy outcome of this project is about raising questions considering the changing roles of designers, users, producers in that open design approach for sustainability. The boundaries between these roles, as well between design phases become more blurred and interrelated. This needs to be discussed and redefined through proposing new design solutions derived from systems thinking.

Insights into further design directions for design education for open design and sustainability

Design education has the power to challenge our current preconceptions about design. The two examples in this paper aim to demonstrate what new and inspiring approaches such as personalization and open design may imply for design process and outcomes as well as for sustainability.

The process of discussing and incorporating these approaches also holds many challenges. The terms such as transformation and adaptation for diverse tasks and needs coupled with systems thinking in the second project help us rethink the nature of design in line with sustainable design considerations.

Particularly for open design approach, there a few exploratory design examples, and that area of focus is newly emerging. To make these examples more feasible, more researches and explorations are needed. The main teaching goal for these projects is to introduce the design students with these new understandings, help them more critical about their discipline. Currently, industrial design is one of the most changing one among other disciplines. There are pros and cons for that, since considering these rapid changes, we as design educators and design researchers, may not have enough time to reflect on the design education projects and processes, make a thorough assessment and apply necessary changes. At the same time, rethinking design curriculum based on these pressing environmental, social and cultural issues for design is another imperative task. That shift requires raising more questions on the role and priorities of new graduates who may be struggling to find their own paths. In line with these changes, these are also exciting times to explore and demonstrate new alternative directions to take.

Considering all the imperative environmental and social issues that we face currently, design researchers, design educators and students, and designers become more critical about how we design products. To make these alternative ways of thinking about design and sustainability more prevalent, acceptable and applicable, design solutions should engagingly involve people (i.e. users as active participants) in the design process. Through exploring and adopting this in design education projects, new generation designers will be able to find alternative paths to effectively address sustainability issues for transforming and prolonging design lifespans.

Acknowledgments

I would like to take my colleagues in the third-year design studio, Harun Kaygan, Fatma Korkut, Mustafa Hasdoğan, Ahmet Burak Aktaş, Özümcan Demir, Mert Kulaksız at METU, and my colleague WonJoon Chung at Carleton University for the development and facilitation of these educational projects, also my students, from METU and Carleton University who contributed to these projects.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-120

Clothing fit and sizing for women can be improved to increase the lifespan and durability by including the bust cup size as a new independent measurement

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Keywords
Close fitting garments
Experimental pattern cutting
Bust cup grading
New sizing system.

Abstract
The inability of many consumers to find good fit in mass-produced clothing has long been recognized as a major problem in providing quality apparel products to consumers (Labat, 2007). Howarton and Lee (2010) state that fit is one of the first things that individuals consider in evaluating a garment, it is also the number one customer complaint and reason for clothing returns. The ultimate goal of manufacturers and retailers of clothing, is to provide clothing for the whole range of their target market that consistently fits well to increase customer satisfaction, and ultimately sales (Apeagyei, 2013). Pisut and Connell (2007) estimated that 80 percent of garments produced using current standards would not fit consumers. Their respondents were asked to evaluate the fit of garments at specific body locations, and to identify where garments were tight, of those reporting fit problems in specific areas, tightness was the predominant fit problem at the bust, 79.4 percent.
The development of new methods of identifying and categorizing body shapes, and new paradigms for sizing systems, can create changes in the methods of production and distribution of clothing that rival the shift from custom-made clothing to ready-made clothing in the early twentieth century (Ashdown, 2014). This study develops a pattern cutting construction methodology with bust cup size integration, producing an optimised sizing system, which can improve the fit of women's upper body clothing. If clothing fitted the three dimensions of the female form, consumers would be encouraged to buy to last, and not buy for the season or the occasion.

Introduction

Apparel fit is dependent upon accurate body measurements and an understanding of the target customer's size and shape. Gribbin (2014) states that fit, proper fit, is not about size or measurements; it's all about shape. Perfect fit for people has always been a target for design of clothing. However, given the complexity of human body shapes, finding a cost-effective method to provide quality fit in apparel continues to be a challenge for this industry (Wagner et al. 2007). Ashdown and O'Connell (2006) claim that fit dissatisfaction could be related to measurement variations among the same sizes made by different manufacturers, with good fit requiring a proportional balance between body and garment, and can only be reliably achieved with appropriate development and implementation of sizing systems, effective patternmaking, and quality manufacturing. Gribbin (2014) believes that there are two key factors behind why so many consumers complain about not finding clothes that fit their body shape, one is that the core body shape that most brands start with, represents a very small percentage of the real people who make up their target customer demographic. Product developers have included consistency of sizing and fit among their list of concerns in the product development area, as brands and retailers have increasingly adopted global, multi-vendor sourcing strategies and have, in many cases, outsourced the pattern development process (King, 2014).

Retailers sizing, grading increments, and available size ranges of clothing were investigated for this research, to see how the high street retailers conform to sizing standards, and grading practices. An experiment was conducted on three retailers, comparing the sizing of fitted garments to their published size charts. Available bra sizes were also investigated from 35 retailers, to gain an understanding of clothing sizes and bra sizes available on the high street. Bye et al (2008) analysed the width of the bust dart, remaining the same from size to size, because the areas that shape the dart at its widest and narrowest ends grow in proportion to each other when graded. However, White and Scurr (2012) observe that UK women now purchase a D cup bra or larger.

Pattern cutting experiments were conducted to create women's top body garments with bust cup size integration, creating sizes within sizes. Data was collected from a survey on fit and satisfaction of clothing, for women who wear bigger than a B cup bra to analyse the difficulties they have finding clothing to fit their bust size. A pilot of 14 women tested the improved pattern creation by participating in a wearer trial of a panel line fitted dress. Improving the fit of clothing, by creating upper body garments which conform to a woman's three-dimensional form, can improve the lifespan and durability of the clothing, creating made to fit, made to last.

Clothing sizes

The UK National Sizing Survey (Size UK, 2003) identified a shift in body shapes, and an inconsistency in retail sizing. An investigation of 47 high street retailers was undertaken to analyse the sizing of garments (from retailer's websites). The results showed a significant difference in measurements for clothing all labelled a UK10, shown in table 1. Table 2 shows there are no consistencies in how clothing is made larger (graded). The retailer's analysis shows the inconsistency highlighted by Size UK is a problem that still exists today.

In January 2017 two items of clothing were purchased from three retailers to cross analyse the sizing, and grading. They were purchased in stores in Hong Kong, SAR. A pattern was taken from the garments, with girth measurements recorded. The bust line measurement was taken as 2.5cm under armhole. The garments would have had ease of movement added into the pattern. Dove (2013) shows minimal ease of movement is 4cm

	Average Size	Smallest Size	Largest Size	Difference Smallest to Largest
Small - UK10 - US6				
Bust	86.5	80	92	12
Waist	68.4	62.5	75	12.5
Hip	93	87.5	102	14.5
Medium - UK12 - US8				
Bust	91.4	88	94.5	6.5
Waist	73.2	67.5	80	12.5
Hip	97.9	92.5	106	13.5
Large - UK14 - US10				
Bust	96.8	92	100.5	8.5
Waist	78.6	73.75	87.5	13.75
Hip	103.2	97.5	106.75	9.25

Table 1. Retailer's analysis of clothing sizes (data downloaded from online websites in June 2015)

Grading Analysis - Small to Medium - Medium to Large						
	S - M GRADE			M - L GRADE		
	Bust	Waist	Hip	Bust	Waist	Hip
Average	4.7	4.7	4.9	5.4	5.4	5.3
Lowest	2.5	2.5	2.5	2.5	2.5	2.5
Highest	10	10	10	10	12.5	10

Table 2. Retailer's analysis of grading of clothing sizes (data downloaded from online websites in June 2015)

bust, 2cm waist and 4cm hip. Table 3 shows the original garment measurements, with reduction of ease, with a cross comparison to the sizing displayed on the websites. Woven upper body clothing predominantly had a semi fit, often with no bust shaping. In Zara a fitted shirt, with a loose waistline, back darts, and no bust dart, H&M and Marks and Spencer's there were no fitted shirts in stock, a fitted woven dress was purchased in both retailers. The differences recorded between the advertised sizing, and the garments were significant, as shown below.

An investigation of 45 retailers sizing codes was conducted in June 2017; data collected from retailers' online websites, as shown in table 4. Sizing codes ranged from numerical 000 to 28, and XXS to XXL, with the largest size range from one retailer covering 20 sizes. What does a size "00" mean? From the consumer's point of view, the result is confusion, dissatisfaction, waste of time and high product returns and exchanges (Faust and Carrier, 2010). Bye et al., (2008) believe that the standard practice of mass-production is to create a range of sizes by increasing and decreasing from a sample size garment that fits the sample size model. A range of 20 sizes would cover approximately 100cm girth growth, based on an average of a 5cm grade per size. However, the human body does not grow proportionally, as suggested in size charts that guide grading practices. Current size charts do not accurately reflect body measurements across sizes or changes in body shape. As a result, grading practices contribute to fit problems. Bye et al., (2008) believe that the sample size should be the base size for no more than two sizes up or down. The optimum fit model for sizes 6-14 is a size 10.

Within the last decade technology in intimate apparel has evolved with cup padding, seam free bonding and the design of bra cups, which creates lift and shape. For women with a small bust size, padding can increase confidence and self-esteem, and enable them to show a full bust line. White and Scurr (2012) observe that body sizes have changed substantially since the introduction of

	Pattern	Minus ease of movement	Retailers online size	Difference
H&M dress (34) 98% polyester, 2% elastane				
Bust	75cm	71cm	84cm	- 13cm
Waist	64cm	62cm	68cm	- 6cm
Hip	88cm	84cm	92cm	- 8cm
Zara Shirt (S) 100% cotton				
Bust	90cm	86cm	86.5cm	+ 0.5cm
Waist	82cm	80cm	69cm	+ 11cm
Hip	96cm	92cm	96.5cm	- 4.5cm
M&S Dress (UK10) 95/5 Polyester elastane				
Bust	91cm	87cm	84.7cm	+ 2.3cm
Waist	77cm	75cm	68cm	+ 7cm
Hip	95cm	91cm	92.5cm	- 1.5cm

Table 3. Cross comparison of three high street retailers garment pattern and published sizes

Retailers Sizing Data collected June 2017 at 45 retailers	Size range of dresses		
	Smallest	Largest	Range
Adidas	2XS	2XL	7
All Saints	2	14	7
Abercrombie Fitch	XS	XL	5
American Eagle	XXS	XXL	13
Aquascutum	6	18	7
Asda	8	24	9
Asos	4	18	8
Bcbg	XXS	L	7
Burberry	XS	XL	5
Calvin Klein	XS	L	5
Coast	6	20	8
Debenhams	8	22	8
Dorothy Perkins	4	28	13
Forever 21	XS	XL	5
French Connection	6	16	6
Gap	XXS	XL	7
H&M	8	20	7
Jaeger	6	20	8
Jane Norman	8	18	6
J Crew	000	16	11
John Lewis	4	28	20
Juicy Couture	0	12	7
Karen Millen	6	16	6
Lacoste	4	14	6
Levis	2XS	XL	6
Lk Bennett	6	18	7
Mango	6	14	5
M&S	8	24	9
Miss Selfridge	4	16	7
Monsoon	6	22	9
New Look	6	20	8
Next	4	26	12
Nicole Fahri	8	16	5
Nike	XS	XL	5
Oasis	6	18	6
Paul And Joe	34	44	10
Phase Eight	6	20	8
Ralph Lauren	4	26	12
Reiss	4	14	6
Topshop	4	18	8
Uniclo	XXS	XL	6
Urban Outfitters	6	12	4
Wallis	8	20	7
Warehouse	6	18	7
Zara	XS	XL	5

Table 4. 45 retailers sizing ranges (data downloaded from online websites in June 2017)

the alphabet bra, with many UK women now purchasing a D cup bra or larger. An investigation into available bra sizes was conducted in June 2017, from 35 retailers' online websites, the chart below shows that all retailers cover sizes up to a D cup, with many offering larger sizes up to a J cup. If production caters for demand, this shows many women have, as White and Scurr found, bigger than a D cup bust size.

In November 2015, a survey was launched online to determine consumer satisfaction over high street sizing in relation to their bra cup size. The survey received 116 responses, 41 complete, with 34 women confirming their

Retailers Sizing Data collected June 2017 35 retailers	Bra Sizes	
	Smallest	Largest
Adidas	A	DD
Agent Provocateur	A	E
American Eagle	A	DDD
Anne Summers	A	DD
Asda	A	G
Asos	A	HH
Bouxavenue	A	D
Bravissimo	DD	L
Calvin Klein	A	DD
Curvy Kate	D	JJ
Debenhams	A	G
Dkny	A	DD
Elle Macpherson	B	E
Fantasie	DD	G
Figleaves	AA	K
Forever 21	A	D
Freya	DD	H
H&M	A	D
Heidi Klum	A	DD
John Lewis	AA	J
Juicy Couture	A	C
Knickerbox	A	DD
La Sensa	A	D
Mango	B	C
Matalan	B	DD
M&S	A	G
New Look	B	F
Next	A	DD
Nike	A	E
Stella Macartney	B	E
Topshop	A	E
Triumph	AA	J
Ultimo	A	DD
Uniclo	XS	L
Urban Outfitters	A	D

Table 5. Retailer's bra size ranges (data downloaded from online websites in June 2017)

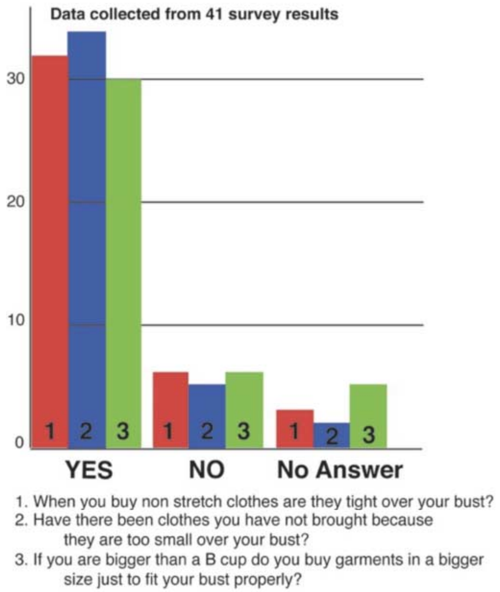


Figure 1. Survey results on bra sizing and fit (https://myacs.polyu.edu.hk/utils/mysurvey/index.php/838438/lang-en.)

body measurements. Three questions relating to bra size and fit were analysed in figure 1.

Figure 2 shows the cluster of women's under and over bust sizes. The red diagonal dotted line shows the high street sizing of apparel where the over bust is an average of 10cm larger than the under bust, with black dots representing the women's under and over bust measurements. Green dots have been applied over the top to represent cup sizes from B to E. Based on the high street sizing of a B cup model; the cup sizes are vertically up from the dotted red line. The blue bold line shows an example of an F cup woman, size 10 and size 14, where the increase in cup measurement meets the high street sizing (red dotted line) 2.5 sizes up. Resulting in a size 10-body frame woman with an F cup bust having to wear between a UK size 14 and 16 in fitted apparel.

Product development of clothing begins with a prototype being fitted to a human fit model, or dress form, explains Faust and Carrier (2010). Grading is the process used by clothing manufacturers to produce patterns for a garment in the full range of sizes. Most grading sources use identical horizontal components for front and back grade rules, with the assumption being tied to simplified grading systems, maintains Schofield and Labat (2005). Cooklin (1990) recommended a front increase that is greater than the back at the bust level, distributing 62.5% of the total increase of the bust across the front. Clothing developed from total girth measurements does not consider the bust cup size, with the front and back bust line the same measurement. By adding in the bust cup size into the standard sizing system model would view the bust line as a front and back measurement, where the front bodyline at the bust could be increased for cup sizes. Bye et al (2008)

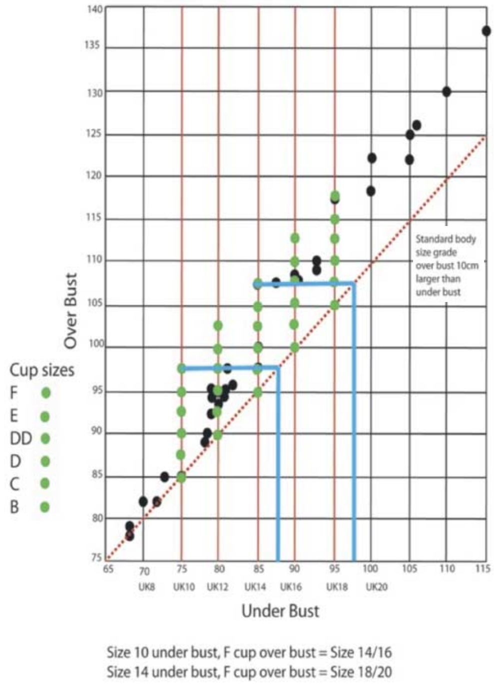


Figure 2. Under and over bust cup measurements with approximate bra cup sizes (https://myacs.polyu.edu.hk/utils/mysurvey/index.php/838438/lang-en).

analysed the width of the bust dart, remaining the same from size to size, because the areas that shape the dart at its widest and narrowest ends grow in proportion to each other when graded.

An experiment was performed to create a bodice block with the front bust line larger than the back to accommodate the B cup bra size. The British Standards (BSI) size small measurements are - 83cm bust, 67cm waist and 91cm hipline. A size small bust cup is a 34B, with a bust measurement of 85cm over bust, and 73.75cm under bust. B cup (over bust) bust being 11.25cm larger than under bust measurement. A base size sample was developed with an 85cm over bust measurement to accommodate the B cup bra over bust, with a 74cm under bust measurement, respecting the BSI 67cm waist and 91cm hip measurements.

Bust plus ease of movement 85cm+4cm = 89cm. 89cm divided into the front and back measurements. B cup size is 11cm. Therefore, the back bust line would be 89cm minus 11cm = 78cm. Half for the back is 39cm. The front bust line would be the half, 39cm plus the 11cm B cup size = 50cm

Waist plus ease of movement 67cm+2cm = 69cm
Hipline plus ease of movement 91cm+4cm= 95cm

A dress form was used to create a panel line dress with bust cup sizing. Measurements were taken and recorded, with additional measurements recorded with a B and a D cup bra placed on the form. The dress form was taped for key girth and height dimensions. Table 6 shows the bust measurements, which were recorded, noting the increases of the bra, 3cm for a B cup bra and 6cm for the D cup bra.

A pattern was constructed from the dress form wearing the D cup bra shown in figure 4, where the bust dart created at the shoulder was 10cm in width, and the side front side seam swung outwards to accommodate the D cup girth. A panel line dress was made with a V neckline from the block. The bust fitted the form with ease of movement. The front armhole appeared to be a good fit when the dress form arms were inserted, with a shapely waist fit and the hip with 4cm ease of movement.

A front bodice plan was created with the bust cup grading, shown only to the waistline, as this bust cup grading method does not affect under the waist position. The bust dart is estimated at 2cm growth per cup size. The bodice plan is shown in figure 5.

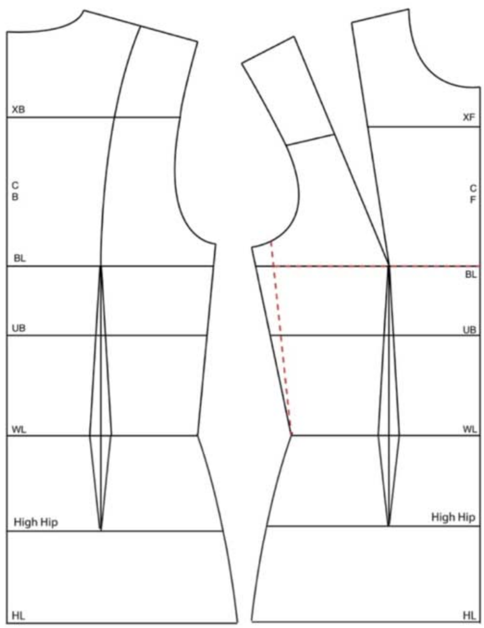
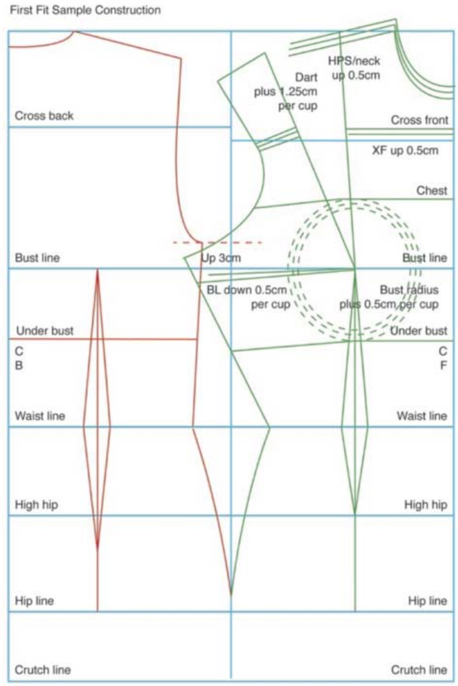


Figure 3 shows the base grade block with the bust line larger at the front (created by Tanya Dove).

	Dress form	B Cup	D cup
Bust girth	93	96	99
FRONT Bust girth. Side to side	51.5	54.5	57.5
BACK Bust girth. Side to side	41.5	41.5	41.5
Bust width between nipples	20	21	23
Under-bust girth (Under radius)	79	79	79
Neck shoulder point to breast point (HPS to BL F)	28	28.5	29.5

Table 6. Dress form with bra measurements.

A preliminary study was performed on a small selection of women to test if bust cup size integration improved the fit of clothing. The sample covered a wide range of age, body size and bust size. The preliminary study was conducted using manual methods of collecting body measurements from the participants. The over bust measurement



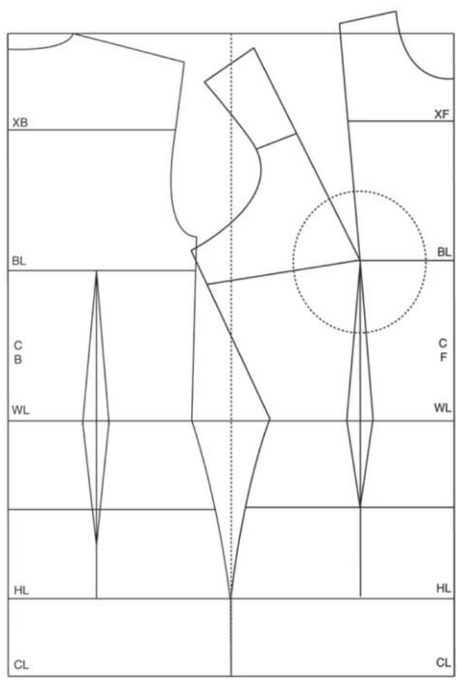


Figure 4. Block pattern of dress form with a D cup bust size (created by Tanya Dove).

was taken in two parts, front body and back body to determine the bust volume size, and consequent bust cup size. Participants figure shape, height and body size was analysed, with estimated clothes and bra sizes based on a 5cm grade. The smallest body size was an estimated UK10, the largest a size 24. Bra sizes ranged from C cup to E.

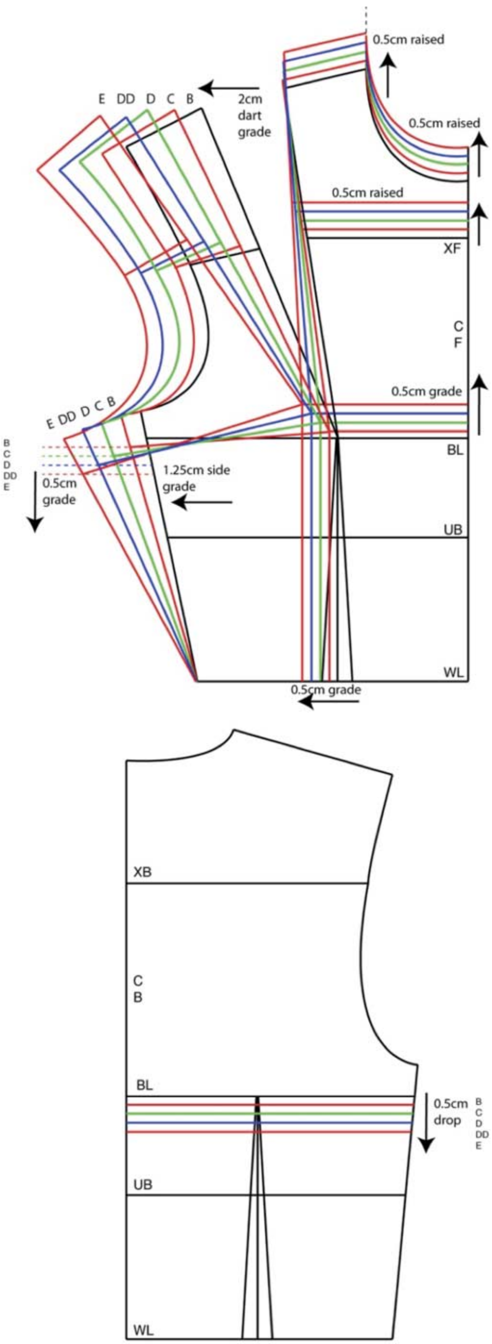


Figure 5. Bust cup grading plan (created by Tanya Dove).

Made to measure pattern blocks were made for the participants using the base size developed and the bust cup formula to increase cup sizes. A panel line sleeveless dress was made for each participant, who all completed a wearer trial and a post fit questionnaire. All participants liked the way the dress fitted them, scoring 4 or 5 out of 5 on the scale. The two E cup women commented that they felt the bust line was still a little tight for their fit preference. The grade as shown in figure 4 had 2.5cm girth at the bust line per cup size, and an increase of 2cm dart width per size. From a technical capacity, the evaluation of this preliminary test was successful, with most participants liking the fit, feeling it was an improvement in the bust area, with the majority of participants saying they would wear the dress in the future. Most of these women do not wear dresses, partially due to being unable to find dresses to fit their body shape, but also their own personal taste and style.

The technical experiments show that sizing of clothing could be improved by bust cup integration in clothing, creating a new sizing system. Communication of fit and sizing are critical to the development of an effective sizing system, developing a labelling system that successfully matches the best size in the range that fits a customer according to Ashdown (2014). Chun (2007) believes that when key dimensions are listed on the size label, women consumers can find their garment sizes easily by comparing their body measurements and the key dimensions listed on the size label. Developing this sizing system would create cup sizes within sizes, shown in figure 6.

For each of the core sizes there would be a range of cup sizes. As mentioned by Faust and Carrier (2010) manufacturers should be familiar with their target consumer's size, and by slicing the market in market segments or niches could develop clothing, which better fits the consumer. Labelling this sizing system analyses the three current systems – UK 10,12,14, or size small

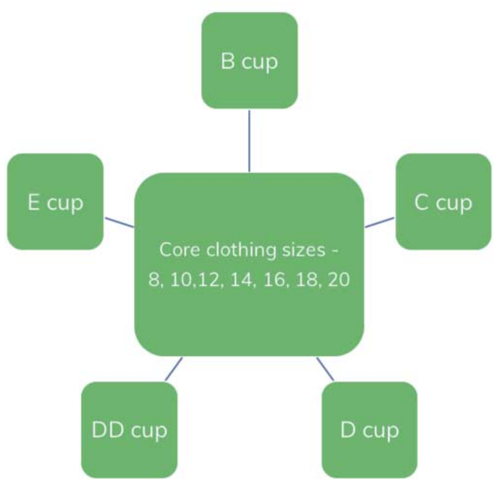


Figure 6. Cup sizes within sizes.

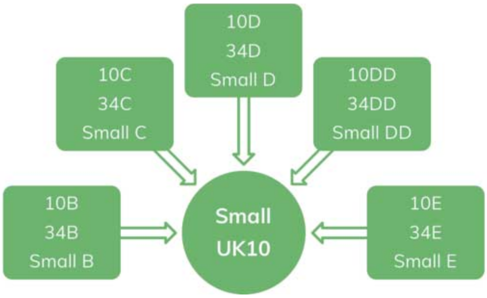


Figure 7. Labelling system.

medium and large, with the European sizing of 34, 36. All of these labelling systems could have the alphabetical cup size quoted to enable consumers to recognise their clothing size by their bust cup size, shown in figure 7.

Conclusion

The preliminary findings in this research have shown an inconsistency in retailers sizing and grading of clothing. Retailers believe they cater for their customers in their sizing, yet clothing returns and bad fit are commonplace. In a disposable economy, where discount outlets and bargain prices are constantly being sought, it could be argued that people do not want to pay a higher price for clothing that either doesn't fit their body form, or is not made to last. White and Scurr (2012) observed UK women now purchasing a D cup bra or larger, and with 28 out of 35 bra retailers stocking larger than a D cup bra. The cluster analysis of women's under and over bust sizes showed a size 10-body frame woman with an F cup bust would have to purchase clothing up to three sizes larger, just to fit her bust size. The objective of this research is to add bust cup sizes into a clothing sizing system to better represent the three-dimensional contours of a woman's body. This has a marketing angle, of 'made to fit, made to last'. Where retailers could develop size specific ranges for their customers, using quality fabrics and workmanship, creating a sustainable product and increasing the products lifespan. Global access to anthropometric data, virtual try-ons and mass customisation are all developments in the industry, however, they are based on existing pattern cutting methods of creating clothing. Developing an improved pattern cutting methodology for women's clothing can improve customer's satisfaction, and the subsequent fit. Consumers would be able to purchase clothing made to their upper body dimensions, with the outcome of this being less consumption and quick purchases, and more sustainably brought clothing, which has an increased product lifespan. Further research is currently being carried out in this area of bust cup size integration.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-127

Playing for time: seven practice-led workshop tools for making design decisions to extend the life of fashion textile materials and products

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Keywords
Fashion textile design
Longevity
Workshop tools
Creative outcomes
Playfulness

Abstract
Since 2011, the authors have been developing creative and playful sustainable design workshop tools to understand, develop and share knowledge and ideas with other designers. These tools originated through practice-led research methods, involving prototyping, to explore and consolidate research theories. By translating design strategies into both realised artefacts and tools for engaging others through design, the authors have continuously transformed practice and theory in the field. More recently the theory has become focused on the starting point of 'circular models for design', in particular, designing for lifecycle speeds. This paper discusses some of the tools used for exploring 'product longevity' and 'circular', resulting in further insights for future design, including the current understanding of 'longevity' as both a product and a material consideration, with two seemingly opposed strategies. The authors research groups' primary methodological approach is through designing and making textile/fashion artifacts to generate new theory; in order to share this approach and support others outside of the group to use making as a key research method they often design and facilitate workshops and create tools, which are then shared via the project website. In this paper tools developed specifically to design to extend the life of a fashion textile product are discussed and the creative outcomes generated are presented. The playful tools generated playful ideas and by reflecting via field notes on these industry workshop outputs the authors here offer a set of tools to support designing sustainable and circular textiles for long life.

Introduction

This paper presents seven design tools developed to support fashion textile designers make decisions around materials and product that potentially extend the life of the garment. The assumption was that the use of playful tools and the co-creation of new design concepts in workshop sessions can lead to new understanding and insights about longevity and fashion textile design.

Methods

In this project work the authors further developed their methods to align closely with two practice-based design research frameworks for sustainability - Walker (2013) and Goldsworthy (2012). They comprise three similar stages – *thinking/theorizing; designing/making;* and *reflecting/sharing*. Both frameworks are based on the solo researcher designing and creating textile artifacts and focus on the iterative and experimental aspects of working with materials, form and process; as well as the intimate relationship between thinking, making and writing (Earley et al., 2016:35-37). For this paper, the tools that were designed by the authors enabled designers from a range of backgrounds - who were participants in workshops – to create a design concept on paper for a product with an extended life. The seven tools have been analysed by the authors through field notes and photographs taken at the time. The insights from each tool have been drawn into summary form highlight the contribution each one makes to longevity design for fashion textiles as product or material.

Phase 1 'Baseline' Tools

During the project period 2011-2015 we explored tools which contextualised our research into 'sustainable design' and provided 'enabling tools' for ideation and design action in a commercial environment. These enabling tools were used to redesign existing fashion textile products.

Author 1's playing cards (Figure 1) were used to encourage participants to think holistically about sustainable design, before focusing on approaches that would lead to the greatest improvements when assessed using the Higgs Index (Sustainable Apparel Coalition, 2012). The cards were introduced to participants through a talk from Author1, and through watching short animations created for each of the ten approaches (Textiles Environment Design, 2013). Then a series of tasks were set within

Figure 1. Tool 1 - Author 1's design strategy cards.

the workshop format which challenged the participants to think of a design decision, based on the card played to them, that would lead to a product with a lower environmental impact.

The process began with the original garment being recorded through an object analysis process on to the left-hand side of the Redesign Worksheet (Figure 2). This allowed the participants to create a baseline for the product, which in some cases was used to also generate a score using the Higg Index (Sustainable Apparel Coalition 2012). The redesign ideas were recorded on the right-hand side of the Redesign Worksheet.

The Checklist (Figure 3) enabled participants to double check that their changes had not created problems for later – like chemicals that are hard to recycle, for example. They can score the product improvements for themselves.

These are <u>baseline tools</u> that build the designer's

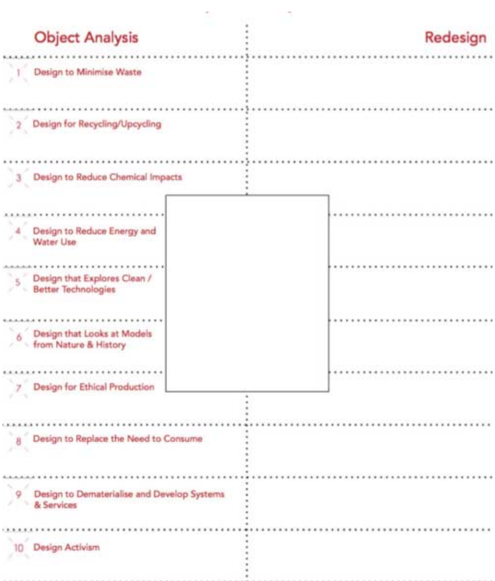

Figure 2. Tool 2 - The Redesign Worksheet (Earley, 2013)

Figure 3. Tool 3 - The Checklist (Earley, 2013).

understanding about making design decisions and choices by separating them out; and then understanding the impact created when making different decisions. In this phase of the research it was noted that the 'circular' recycling redesign concepts all resulted in the biggest score change. This then lead the authors to understand that tools were needed to explore the contexts around design for recycling in more detail - in particular material and product speeds.

Phase 1 Creative Outputs

The phase 1 workshops generated over 60 redesign concepts over an 18-month period. All concepts pursued material or product longevity – the idea of 'short life' was not considered as an option by participants as the worksheets being used specifically asked them to build in extended life thinking.

Figure 4. 'Family Jeans' a pair of denim jeans designed to

last a lifetime, using low impact textile considerations and biodegradable materials to bury at the end of life (Earley et al., 2016:81).

Figure 5. 'Mono-material Dress' working with the latest recycling technology to reprocess the minimal-waste, mono-material polyester garment (Earley et al., 2016:82).

Figure 6. 'Wool Blazer' a long wear and multiple-owner garment with low wash credentials, using recycled material and a design that will allow longevity and 'passing on' (Earley et al., 2016:83).

Figure 7. 'Cable Jumper' connects strategies for local low impact and ethical manufacture with mending and rental services, it requires low wash and has possibilities for mono materiality with the reuse of the yarns in another garment, or within the garment itself (Earley et al., 2016:84).

Phase 2 'Lifecycle Speed' Tools

These tools ultimately reflected our developing personal practice, which in phase 1 culminated in prototypes and exhibition (Earley & Goldsworthy, 2014). The insight was that several design paths lead to 'longevity' including the unsurprising emphasis on 'product longevity' and 'extended use through multiple users'; but more surprisingly design concepts which focused on seemingly 'short life' products with a circular materials model which resulted in an equally long-term use of resources - albeit through multiple product reincarnations. As we moved into phase two we developed tools which reflected this departure in our thinking around designing circular products.

The framework for Phase 2 had moved from 'sustainable design' to a more focused 'circular design' strategy. This in turn focused our tools into Life Cycle Thinking (LCT) aids. One of the first challenges was to express 'speeds' relating to circularity with a 'whole lifecycle approach'. Several tools were developed to aid design ideation of short-life and long-life textile products. After a review of existing 'slow design' strategies (Goldsworthy et al., 2017) it became clear that the discourse around 'speeds' often related only to the production and use phases. The following workshops have been designed to interrogate and question this assumption in order to find insights based on a whole-cycle view.

The purpose of these tools was often to express a complex set of scientific insights into a form which could quickly communicate starting points for design briefs. They continue to develop through every testing and iteration, and revealed several contradictions and complex relationships between each stage of the lifecycle.

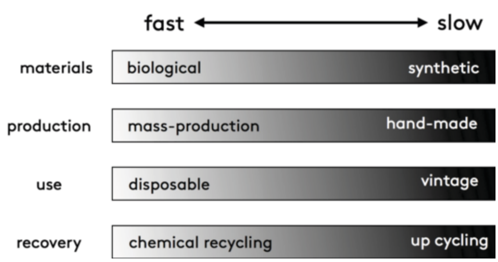

Figure 8. Tool 4 - Lifecycle Sliders was a framework for assessing 'longevity' and 'speeds' with a lifecycle perspective (Goldsworthy, 2017: S1964).

The Lifecycle Sliders were used initially with a group of emerging designers at UAL. The Masters students were asked to research and analyse a selection of textile products according to the lifecycle stages along the sliders. Each plotting was completed in discussion with the whole group so that insights could be shared.

- Insights resulting from the workshop included; discussion around raw material speeds which concluded that renewable annual crops such as cotton were in fact 'fast' compared to the oil based synthetic which take thousands of years to form.

- That recycled synthetics (such as recovered PET) could be considered 'fast' as the conversion process was much shorter and less impactful than the same PET made from virgin raw materials.

Figure 9. Emerging Designers Workshop. The Lifecycle Sliders were used as a teaching and brainstorming tool with current MA students at UAL, Dec 2016.

These tools were developed further for use in a series of workshops which were designed and took place in three cities, using four typologies from phase 1 LCA research (Roos et al., 2015) – a polyester shirt, an outdoor jacket, a t-shirt and some jeans. 24 redesigned concepts were created over a four-month period with 56 industry stakeholders, resulting in insights around both fast garment and slow garments.

The workshop aimed to challenge participants on their understanding of the circular textiles economy, through exploring its application in the fashion industry and learning what industry leaders are doing, before using their experience to redesign products around different lifecycle timeframes – from fast to slow. The day included using author 1's Design Strategy Cards with a focus on the product typology card selected by each group. After this the facilitators gave a slide talk about the notion of fast, and intentionally speeding up a product's lifecycle.

A task was then given which was based on each group selecting a Speeding Ticket, which gave them a specific time frame to aim for. After sharing insights around this fast product, another slide talk gave a perspective about slowing down the circular lifecycle. Groups then selected a second Speeding Ticket which gave them the slow pace to aim for, and the design ideas were then shared for a final time.

Figure 10. Tool 5 - Speedcycle was developed as a tool to express the complex relationships between different parts of the lifecycle and present a 'cost per use' model used by environmental scientists to designers (Goldsworthy, 2017).

Lifecycle representations rarely communicate any proportionality in speed or timeframes. When trying to design within a specific context this becomes problematic and misses vital elements for consideration. If represented in models which do try to communicate a different set of journeys relating to speed you can immediately see the tensions which shift which each story. 'Speed' can be translated in very different ways if related to different parts of the life-cycle and often a product can therefore have multiple and often counter-intuitive mixes of speeds within a single product.

Figure 11. Tool 6 - The Speedometer was designed as a worksheet based on the speedometer of a car, to help teams of participants to work create products for both fast and slow cycles (Earley, 2017).

Figure 12. Tool 7 - The Speeding Tickets were a set of briefing cards issued to teams in order to provide them with a target speed (Earley, 2017).

Phase 2 Creative Outputs

During four workshops in three countries with 56 participants, 24 new design concepts were created. This section highlights three that explored longevity for: a pair of denim jeans; an outdoor jacket for children; and a polyester bridesmaid dress. The use of the tools through half day and whole day workshops lead to concepts which demonstrated a high level of creativity in terms of material innovation, garment cut and construction, service design and the overall narrative (Earley, 2017: 2654-2655).

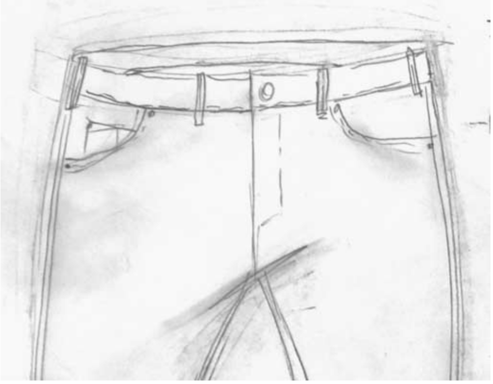

Figure 13. 'Slow Jeans for Men Who Toil' - a pair of jeans that focused exclusively on the historical context of the oldest denim jeans in the world which are 137 years old; encouraging longevity ambitions through reinventing traditional local processing and construction and a highly developed narrative platform to engage users.

Figure 14. 'Jigsaw Jacket' was a garment with detachable and interchangeable (disassembly) parts, based on a kid's poncho shape. Made from recycled polyester this a monomaterial jacket grows as you wear it and users can order component parts. The user was imagined to be a kid's nursery school which subscribed to this jacket through a service provider.

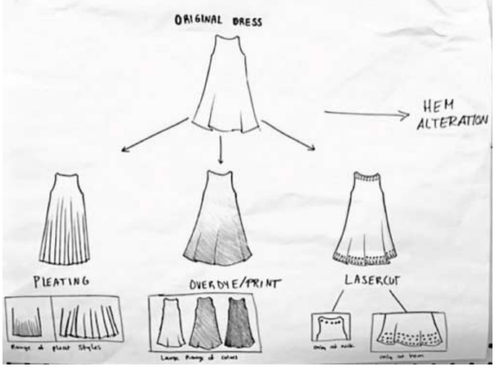

Figure 15. 'Maid-Make Dress' is a high-end bridesmaid dress that builds on emotional durability potential and becomes a bespoke special occasion item. The dress is connected to a service that transforms the garment after the wedding – giving the user two more 'looks' for special occasion wear before cascading down the market levels and final end-of-life processing takes place.

In this next section, we summarise each of the tool types in terms of how they were used to make decisions about a fashion textile material or product during the design specification stage.

Baseline Tools

1 - The Strategy Cards

Cards 1-5 aided the designer in making choices towards more durable materials; with card number 2 being the used to consider 'circular' materials that remain in use indefinitely through being reprocessed.

Cards 6-10 supported aspects of the product in terms of durability achieved through traditional, historic approaches; provenance (quality & ethical considerations); service design to support long use; design activism to message habit change.

2 - The Redesign Sheet

This tool helped the designers identify what the current material was comprised of, and gave them worksheet space to propose material attributes that may lead to extended life.

This tool also helped the designer identify what the current desired fashion product is comprised of beyond the material (cut, sew, trims, etc.), and gave them worksheet space to propose product attributes that may lead to extended life.

3 - The Checklist

This tool enabled the designer to check that the redesigned material would meet a particular set of requirements – for example, had the change made to the material to achieve longevity (a coating, for example) lead to the material being harder to recycle or reprocess?

This tool also enabled the designer to check that the redesigned product would meet another particular set of requirements – had the change made to the product to achieve longevity (a reinforced area made from a different fibre type) lead to it being harder to recycle or reprocess?

Lifecycle Speed Tools

4 - The Lifecycle Sliders

This tool initially served as a framework to guide thinking about a product journey in terms of speeds at different points of the lifecycle. It enabled in depth conversations about raw materials, their 'renewal timeframes', the various processes needed for each material in production alongside scenarios relating to the use and recovery phase. By visually mapping in this way participants were able to see where more appropriate choices might be substituted and where there were obvious mismatches. For example, a very high impact, slow material like polyester being used in short life, low quality fashion products.

5 - The Speedcycle

This visualisation of the lifecycle with proportionate representation facilitated understanding of the interrelatedness between cycle stages and impacts. It was designed to illustrate the environmental science standard of 'cost per wear' and was effective in modeling the impacts of short vs long life across the cycle. In future iterations, there may be benefits in including 'scale' of cycle as a further comparative dimension.

6 The Speedometer

This tool enabled the designer to understand the current speed of the material and product, by drawing upon their existing knowledge of garments they know well through personal ownership and use. The tool gave them insight into how the length of ownership versus number of uses can work in making a design decision.

7 – The Speeding Tickets

Once a baseline for current material and product speed had been established the Speeding Tickets were used to set the designer the challenge of designing to extend material and product life by a specific number of months or years. This tool lead to new insights about how design decisions change according to precise timeframes.

Next Steps

During 2017-2018 we will continue to develop design concepts and playful tools for design practitioners to employ in their own design process through a focused project with the designers in one Swedish fashion company, exploring the concepts of material and product longevity through 'design workshops' alongside the development of 'design research artefacts' which further express the theory. Tools and analysis methods will be further honed during this process with the intention of producing 'longevity guidelines for design' at the end of the project in 2018.

Acknowledgments

The Mistra Future Fashion Programme.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-133

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

On the meaningfulness of data in product design for lifetime optimization

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Keywords
Planned obsolescence
Product design
Maintenance
IoT
Data

Abstract
Planned obsolescence is generally considered as a negative business strategy that induces replacement needs and affects attachment dynamics, as opposed to the goal of elongating product lifetime. At the present, however, an early replacement of long-lasting products is preferred in at least two cases which can be addressed during the design stage i.e. when the cost of maintaining is higher than product benefits and when there are environmental reasons to replace obsolete products. Furthermore, designing meaningful products that help the user in his/her daily activities, while addressing environmental issues, could help affecting attachment even in standardized and utilitarian products, such as home appliances. In this study, the holistic view and the management of the complexity of Systemic Design, combined with the use of the IoT technologies are proposed using the refrigerator as a case study. Acquiring information is considered as a tool for product innovation; the data is divided into (i) static data, related to the product and (ii) dynamic data, which derive from the context of use and interaction with users. The latter can be acquired by investigating the object's daily use and environment, with data acquisition through quantitative tools (sensors) and qualitative ones (feedback, questionnaires, interviews). IoT and data retrieval open a variety of possibilities in monitoring, accessing more precise knowledge of products and households useful for design purposes. This paper seeks to demonstrate how IoT can support and trigger a design transition towards more durable products and components, by focusing on sustainability and simplifying people's lives in daily actions.

Introduction
Planned obsolescence is a well-established business strategy whereby the product is designed to lose value rapidly (Agrawal et al. 2016; The Economist, 2009; Aladeojebi, 2013). It generally occurs indeed when manufacturers deliberately accelerate product lifecycle by introducing new features or technological improvements and by stimulating fashion changes (Mugge et al. 2005) which in turn negatively affects the experienced attachment to the currently owned product and induces replacement need. Both object obsolescence and replacement could be fostered when the product shows a deteriorated appearance or an aesthetic wear, e.g. when objects could not return to their original appearance even after cleaning. The aesthetic diminishes (shiny surfaces become dull) and the product goes out of fashion, (Byrnes, 2010). As Papanek (1985) claimed, product obsolescence occurs both aesthetically and technically. We could also add functionally. Technological obsolescence is dictated by manufacturers and occurs when new products make the previous ones incompatible. At any time, indeed, the manufacturer of connected objects may decide to stop running its product, e.g. ceasing the updates and making it obsolete in no time. It may also happen that the object experiences a decline in performances. In this case, the object is felt as outdated by a specific target, but it can still be seen as satisfying by other users. Industrial product design should be challenged and reconsidered to address environmental sustainability issues, such as elongating life spans of products, developing products adaptable to local and regional resources and conditions, and enabling product maintenance, repair, upgrading, etc. (Bakırlıoğlu and Doğan, 2012). However, these three aspects of obsolescence would be even more challenging if placed into new dynamics and new sustainable business models.

Two issues can be addressed in the early design stage, for which designers are called to anticipate and avoid their occurrences.

Cost of maintaining higher than product benefits
It occurs when the cost for maintaining is higher than product benefits or even unsuitable compared to buying a new product. In this case, we are considering products whose pieces are out of production, the failure of essential

parts such as the engine for the car or parts designed to be non-replaceable. Designers should, therefore, anticipate this undesirable effect, by designing products that can always be updated, disassembled, repaired and maintained. Moreover, in addition to the product, both designer and companies should envision the spare parts network and consider services related to the upgrading operations. We should necessarily avoid and delay the replacement of a product when it still works and the user still wants to use it.

Environmental reasons to replace obsolete products

While planned obsolescence is generally considered a negative strategy, in the specific case of durable goods (e.g main appliances, vehicles, heating systems) extending the product lifetime is not always a sustainable choice. Replacement of obsolete products could be motivated by environmental reasons and could be subsidized by tax incentives to speed up the removal of such products from the economy, pushing the consumer to replace his old devices in favor of more sustainable or less harmful ones. As Mugge et al. (2005) suggested, a sensible evaluation of the environmental desirability of early replacement compared to extending product longevity can be performed evaluating the interrelations among three parameters: (i) the initial environmental impact of the replacement product, (ii) the possible improvement of energy efficiency, (iii) the expected usage time. Once again, the designer can do his job by anticipating and doing research before making design decisions, considering the harmfulness of the materials and gases involved. Upgradability and the choice of a modular design could allow the replacement of a technologically obsolete part, preserving the operation of the product.

Research focus: home appliances

We look specifically at everyday objects, in which an interaction between people and technology is expected. At present for products with a relatively high energy-efficient improvement, early replacement is preferred over product longevity (Mugge et al., 2005). Home appliances are addressed in this paper as a case study example of criticalities listed above, adding to these also disassembly issues because, although the volume of this e-waste in people's perception is overestimated, it still accounts for about 2% of the landfill space (Zimring and Rathje, 2012). Appliances have a recovery rate of 57% (Center for Sustainable Systems, 2016) as they are mainly made of metals, however, cannot establish what happens to the 43% non-recyclable part. Another aspect to consider is that home appliances are considered as utilitarian, standardised products, unable to trigger attachment dynamics (Mugge et al., 2005), whose purchase occurs almost exclusively for functional reasons. However, since appliances are a means to do a task faster or easier, there is room for improving performances and useful life in the early design stage. The user, indeed, seems to want them to last longer, avoiding wasting money in their early replacement unless specified conditions change. The need for bigger appliances or house remodelling and renovation are among the primary replacement reasons, together with the demand for new features, while the replacement of a worn-out appliances remains the most common purchase motivation (Mintel, 2016). Considering these long-lasting products, there is room to address the replacement motivations combining them with an extension of the useful life, providing services and maintenance for the products. This scenario could radically change by introducing new strategies and business models such as strategies to reduce product ownership through sharing, remanufacturing activities and so forth. Another strategy can be combined with the previous ones to address the same issue, i.e. extending useful life by redesigning meaningful and high-value products. For example, when a product provides a more efficient and personalized service, the consumer is expected to develop new relationships with it and disposal may be delayed.

Methodology

We defined a methodology (Figure 1) to address the lack of perceived benefits in connected appliances (Accenture Interactive, 2015; Gfk, 2016), by shifting the focus from "technology push" solutions, to "need pull" ones. We hypothesized that the current lack of data and experiments to understand the actual use of appliances leads to lost sight of the original aim of them (Fiore et al, 2017), i.e. help the user and simplify daily user operations (Berg, 1994). Thus, we started from the broad research question "how to define a more sustainable home system?" by choosing to focus on the refrigerator. This appliance resulted from a multi-criteria decision process (Fiore et al., 2016), which included the level of interaction with the user and the environmental impact of the product. The refrigerator, though, seems to be an appropriate starting point also as it is the only appliance directly involved in the food waste, cooking and preparation operations and tasks, as well as being the only stand-alone appliance, connected to electricity but not to the water network.

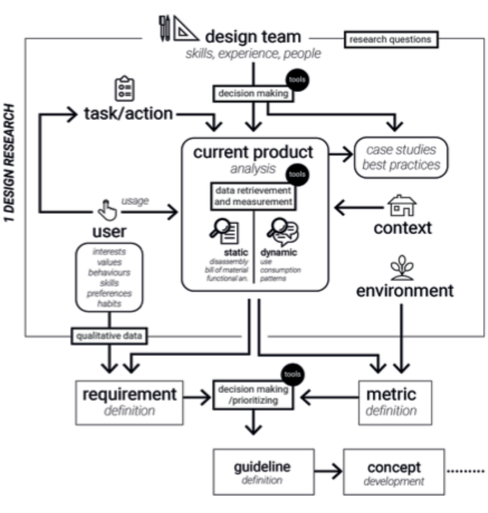

Figure 1. Methodology

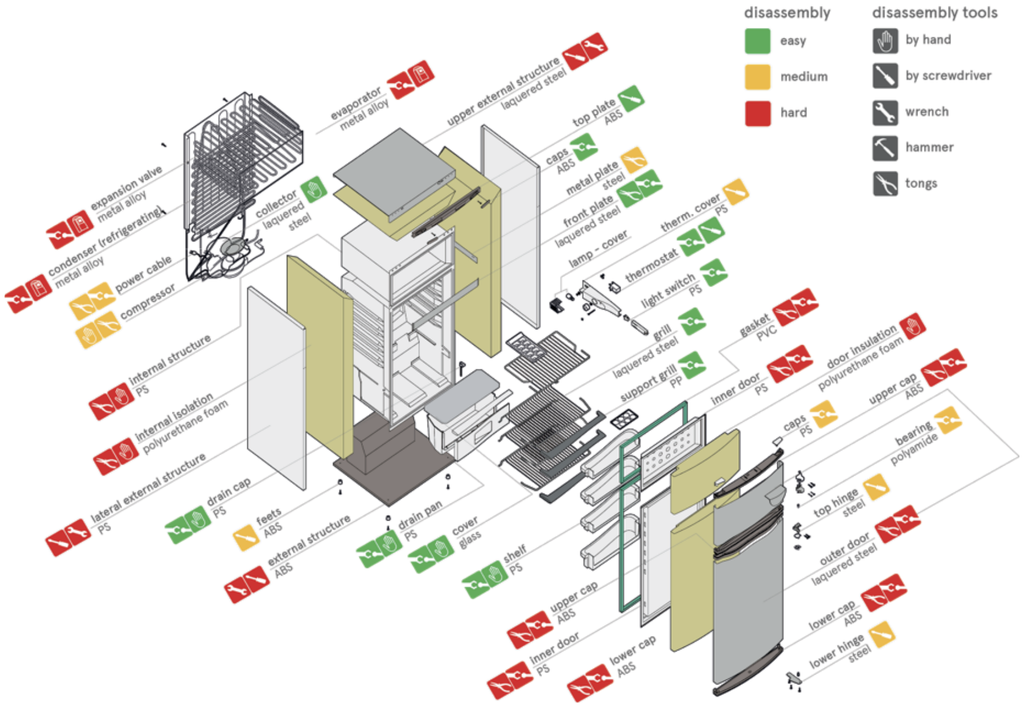

Figure 2. An example of a product (a refrigerator) broken-down into its individual components.

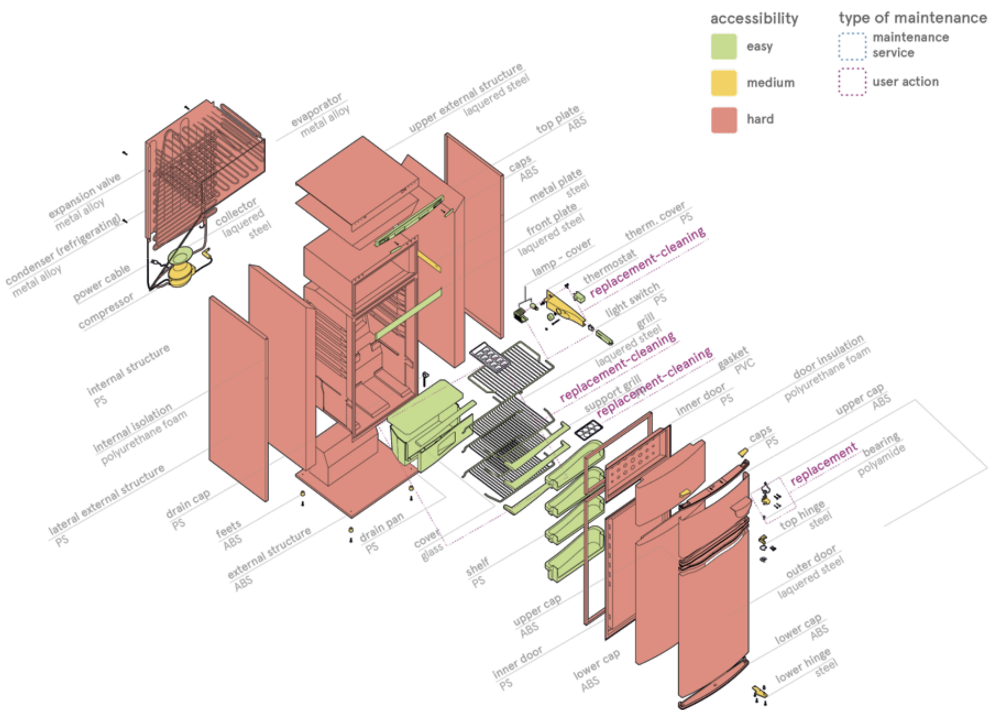

Figure 3. Maintenance.

We need to step back and identify which operations the householder should perform and then detect which actions are involved. In this case, the main task we identified is *"storing food at the right temperature to fulfil the expected duration"*. From there, all the other actions such as the door opening derive directly from the design choices that someone in the past has made, namely the decision that the solution should be a refrigerator. Therefore, considering and focus only on that object prevents the designer from questioning on whether the refrigerator is really needed and 'the growing role of refrigeration in today's Western food system' (Kuijer and Bekker, 2015), not considering other agents of change and assuming the availability of that appliance. For that reason, we decided to group into the section 'case studies and best practices' high and low-tech solutions that have been given to conservation in general. In parallel, we analysed current refrigerators and we looked for a feasible solution to address the task now. Since the refrigerator object has already been defined, we jump into the product analysis to understand the room for intervention for designers.

Data Retrieval

What was immediately clear to us was the non-privileged designer's point of view, which does not have the complete overview about the object to design and would require certain data to design, which are currently not available. We can divide the missing information about current products into static data and dynamic ones.

Static Data

Static data comprehend the technical material, such as drawing and model for studying current shapes and dimensions, bill of materials (BOM) to understand how many different materials are involved, the related weights, questioning why designers chose that material (i.e. are there any physical- functional- performance reasons behind the choice?). We also include disassembly or product dissection (Figure 2), in which the product is broken down into its components, understanding the ease of performing the disassembly and the tool needed. The same analysis made on disassembly can be maintained on maintenance (Figure 3) by considering the ease of access for each part.

Eventually, the functional analysis (Figure 4) allows providing alternatives for each functional group of the current product, understanding which parts are required to perform specific functions, which parts depend on the design solution chosen.

This is a method for a reverse engineering capable of extracting information from a physical object. It could be thus performed on every worn-out object to deconstruct it and understand its functioning through the analysis of its parts, having the possibility to disassemble, measure and observe it. This tool should help designers to question, understand, reconsider each part or group of parts and their function individually.

Dynamic Data

Using the refrigerator as a case study, we implement our methodology through a pilot experiment, highlighting the need for dynamic data related to the real use of refrigerator, i.e. the object in relation to the user. We instrumented two refrigerators over a week with sensors to detect light, energy consumption, inside temperature, humidity and noise, external coil heat dispersion. We assumed power consumption as a reflection of the refrigerator's activity and the light as a reflection of user interaction (Figure 5),

Figure 5. Assumptions.

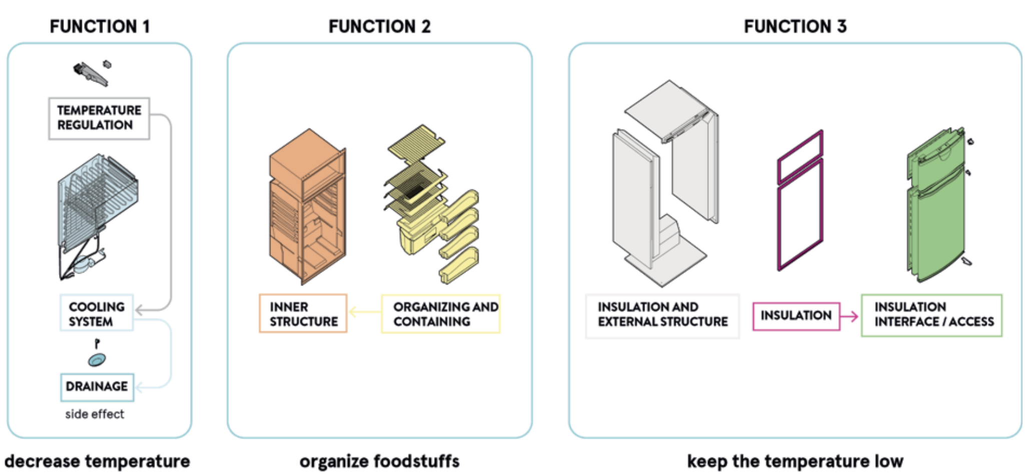

Figure 4. Functional analysis.

we combine these two indicators with the other variables and eventually we reflected on the data to extract design insights (Fiore and Bourgeois, 2017).

From an in-depth analysis of data broader conclusions are drawn, specifically on the potential benefits of using IoT indicators to detect different situations directly related to the use or object-specific data. The Internet of things (IoT) could help indeed to collect missing information about both the object and its use, to address critical aspects in the design stage thus extending products' lifetime. Below we discuss how the knowledge gained from data and the potential of IoT could become valuable intelligence and can be leveraged in the design stage. IoT data represents a whole new class of information: quantifiable knowledge about the operation and performance of products (Henne, 2015) during the use phase.

Diagnostic, predictive maintenance and user alert

During the first experiment, we detected that energy patterns are highly recognizable, being characterized by activity and inactivity alternate phases. The first conclusion is that with the aid of IoT learning system the refrigerator could alert the user when it experiences energy anomalies, preventing cooling failure, noise and water leaking, up to prevent the refrigerator breaks (Fiore and Bourgeois, 2017). The designer can consider the fridge as a unit, but also investigate group of components or a single part. The design team could consider just one indicator for understanding one aspect of the product or analyse multiple/aggregate indicators to understand and detect more complex dynamics, correlations and patterns. This could be the case of the following three examples considering (i) functional groups (fig. 4), (ii) essential components or (iii) parts that are subject to wear. The first case is a system of parts grouped by a specific function, the second are those parts whose breakup will compromise the whole product functioning, eventually leading to replace it. Some relevant parameters should be defined and verified by measuring them through ad hoc experiments on these components, providing a more precise knowledge about the system. For this reason, both criteria definition and thresholds setting are important decision-making steps. The third case is represented by parts subjected to wear, which can also be monitored with ad hoc experiments, to make their recovery suitable for a second valuable use of components or materials. Data about the real use of a product can be collected for a short time, with an object instrumented for the experiment. Then the R&D or design team could make projections over time of the expected use to determine when the object should be replaced or updated to obtain the maximum value from it. This stage would require analytics to measure and combine data inputs over time (Henne, 2015). Monitoring some parameters of the refrigerator as a form of predictive maintenance could also affect new business models (PTC Inc., 2015) and value-added services throughout the lifecycle, being particularly relevant for the circular economy.

Ongoing Research

Currently, most of the IoT development for everyday applications relies on a technology-push, connecting things and collecting data with a limited use of the information and a poor experience. In the home context, Mennicken and Huang (2012) highlight that smart technologies are those fitting householders' routines, avoiding unnecessary work. We identify five potential steps to extend everyday objects' lifetime by using IoT technologies:

Detect: collecting the information related to the goal to achieve, through means balancing benefits and constraints.
Control: adapting product operation to the specific use or context.
Predict: anticipating and preventing breakdown based on pattern of use.
Communicate: contextual awareness about the potential risks (and reason), providing advice to improve the product lifetime.
Share: product use and operation can be shared and aggregated to detect more complex correlation and patterns of use leading to product breakdown.

These steps must be tested during the next months with a pilot study planned on a larger number of dwellings, using a platform of communication with the user.

Conclusions

This paper seeks to demonstrate how IoT can support and trigger a design transition towards more durable products and components. The proposed strategy is suitable for both current product-centred economy and a future service-centred one. It provides some guidelines and directions for future studies that want to address the extension of the life cycle, based on predictive maintenance while promoting an efficient use of products. IoT and the data collected open a variety of possibilities in monitoring, accessing more precise knowledge of goods and households, useful for design purposes. Many smart interventions can be done on appliances before talking about connected products, pointing out the difference between 'smart' and 'connected'. Among them detect failures in advance, notify, inform, communicate are only a few possibilities and it raises the need for learning systems able to recognise patterns, together with a platform on which to share and communicate directly with the user. Introducing the flow of information in the design process is important to reach the overview on products. Moreover, every designer could question the product in different ways, according to the heterogeneity of the working team. On the one hand, this data collection can lead to improve current products and their maintenance (proactive monitoring, remote control, predictive maintenance), introducing services (meaningful information to the user, interaction with other connected things such as the supermarket card, predictive food shopping). On the other and it could lead to develop new products more focused on sustainability, simplifying people's lives in daily actions.

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*Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)*

DOI: 10.3233/978-1-61499-820-4-139

Strategies for food longevity

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Keywords
Design for sustainability
Emerging initiatives
Food
Product longevity
TransitionS

Abstract
Although food has been circular by nature, the current food supply chain has turned into an unfortunate linear system. The challenges of transitioning towards a sustainable food eco-system requires radical changes and new perspectives, where things are done differently. Starting with related work in the field of design for product longevity, the current work explores the role of design in developing food systems on eco-systemic level that work as efficient as possible, and create a world without waste. Eight local initiatives in Rotterdam have been studied. From the lessons learned, nine strategies were formulated. Although these strategies seem to work well and are promising starting points for innovation, it remains difficult to build sustainable business models around these strategies that can be scaled and sustained. Initiatives oftentimes keep struggling with the current system and finding the proper scale for their business. It can be concluded that design promises to play an important role in accelerating this transition towards a circular and future-proof food system.

Introduction

The way our modern society has developed into a world of unlimited growth has no future; we would need 1.6 earths to keep supporting humanity (Global Footprint Network, 2016). One of the big societal challenges is creating a food system that will fit the human needs within the planet's possibilities. Such a food system will need a "fundamental transformation" (World Economic Forum, 2017). Obviously, food wastage is a problem, but also the way food is consumed is a big challenge. In fact, only 24% of the impact that consumers have on the environment, is directly visible, which makes it difficult for consumers to make more deliberate choices (Porcelijn, 2016). These challenges demand new ways of innovation – a shift in thinking, doing, and organising (Mulder, 2014); we can no longer only optimise current systems, but we need to let go of existing paradigms and actively look for radical alternatives that support the transition towards a more sustainable future.

Being aware of the need to radically change the existing food system, more and more initiatives are emerging that let people take greater control and responsibility of their own lives. These emerging initiatives are, for example, experimenting with sustainable lifestyles and disruptive businesses aiming to demonstrate how society can be radically changed (Rotmans, 2014). Oftentimes, these initiatives have a pragmatic character and start with fulfilling local needs by offering products and/or services to the local community. As their ultimate goal is to change current systems, they usually depend on the government, either for permission or support (Igalla & Van Meerkamp, 2015). Even though, emerging initiatives are lauded by many of their users and stakeholders, the question remains whether these initiatives can and will have a long-lasting impact (Igalla & Van Meerkamp, 2017).

In the current work, we explore the value of design in sustaining emerging initiatives and their impact on societal change, and focus on the city of Rotterdam. Rotterdam is a city where many initiatives are emerging to make the city resilient for the future. There is a culture open to change. Moreover, Rotterdam has open space and has a municipality willing to support these initiatives (Mulder, 2015; Fast co-exist, 2016). Particularly, we focus on initiatives across the food chain that challenge and improve the food system on a local scale. In the related work, design approaches in the context of product longevity and sustainable transitions are described and the role of food in this context is explained. Thereafter, the method is presented, and results are discussed. To conclude, the nine lessons learned from these food initiatives will be discussed, and what this means for the role of design.

Related work

In an elaborate investigation on the challenges of waste, RSA (2013, 2016) discusses various opportunities of a circular economy through the lens of design. Figure 1 shows the resulting four design models.

Design for product longevity is at the heart of the proposed design strategies. This strategy refers to designing products in such a way that materials and energy going

Figure 1. The four circular design models (retrieved from RSA, 2013).

into a product, are used to a maximum. In other words, products are designed to last, and after product use they can be passed on to another user (RSA, 2013). Figure 1 also shows that this design strategy is the loop that is closest to the user, and therefore most preferred in circular economy thinking (Charter & Keiller, 2014; RSA, 2016). When this is not possible or relevant, one can move on to the next loop (RSA, 2016).

Creating products that fit in a circular model involves many strategic decisions, e.g., choosing product life scenarios and business models (Bakker, Wang, Huisman, & Den Hollander, 2013). Differently put, not only functional aspects are important, but also the emotional, aesthetic, and financial aspects of the design. However, in keeping with Porter and Kramer (2011) companies should not only profit from a product, but they should also look at how to create 'shared value', which means creating not only economical value for the company, but also a societal value.

Towards food longevity

After all, in terms of product longevity, it might seem strange to define food as a product. Food is not produced for (long-term) usage, but to consume. As a matter of fact, food is circular by nature, and already part of a circular ecosystem; it grows, it is eaten, and then the waste is returned to the ecosystem, but in practice the food supply chain is linear instead.

About one third of the edible parts of food is being wasted globally (Gustavsson, Cederberg, Sonesson, Otterdijk, & Meybeck, 2011). Even worse, a lot of that does not end up in the system anymore, but on a landfill, which is a huge waste of energy and resources. Hence, it is necessary to design the food system in such a way that the materials and energy going into producing the food are used as efficient as possible. Such a change from product longevity to food longevity, however, requires a transformation on system-level, and requires collaboration between multiple stakeholders, from both within and outside the traditional food system players (World Economic Forum, 2017).

The current work, therefore, deliberately refers to *food longevity* instead of product longevity, and explores the role of design in developing food systems on eco-systemic level that work as efficient as possible, and creating a world without waste; also, referred to as the blue economy (Pauli, 2017).

Case study

As said before initiatives located in Rotterdam are subject of the current study to illustrate the welcomed transition. Eight initiatives were selected on their unique perspective and positioning along the food supply chain: from production to consumption and waste management (Figure 2). Seven of them are an entrepreneurship/start-up, and one is a platform-based organisation. A combination of desk-research (articles in newspapers and magazines) and in-depth semi-structured interviews (with Rechtstreex and Happy Shrimp) has been used to study their strategies to change the food system and how their initial ambitions and values might have changed along their growth process. To evaluate the research findings regarding their validity, these were sent to the initiatives to check whether they can relate to the results and give them the possibility to give feedback. Next, findings were analysed to distil lessons learned, which were clustered. The nine resulting strategies are described in the results section. The eight initiatives participating in the current study are briefly introduced below.

Rotterzwam is a company located in the former swimming pool 'Tropicana' in Rotterdam. Being part of the city farming movement, they collect coffee grounds (the residue of coffee) from local companies and grow mushrooms on it. After two to four harvests of mushrooms the coffee grounds have become very fertile and can be used as a fertilizer on farming grounds. This is in keeping with one of the ideas developed by Pauli (2017) to establish a blue economy. By combining different ecosystems (coffee beans and mushrooms) a new system arises with (almost) no waste. Next to this, they sell a DIY mushroom grow kit, give workshops, and spread their knowledge open-source through webinars.

Rechtstreex offers a platform to local farmers (within 50 kilometres from Rotterdam) to sell their products directly to consumers. Consumers can order online and collect their food at a weekly pop-up store, run by local employees of Rechtstreex, in their own neighbourhood. Farmers get a fair price for their products.

Rotterdamse oogst is a bimonthly market where products from local farmers are sold. Farmers get a fair price for their products. Moreover, they organise many educational activities for children and adults. This is often combined with musical performances or public lectures.

Kromkommer 'rescues' vegetables that are being discarded because of their looks (e.g., oddly shaped or not the right

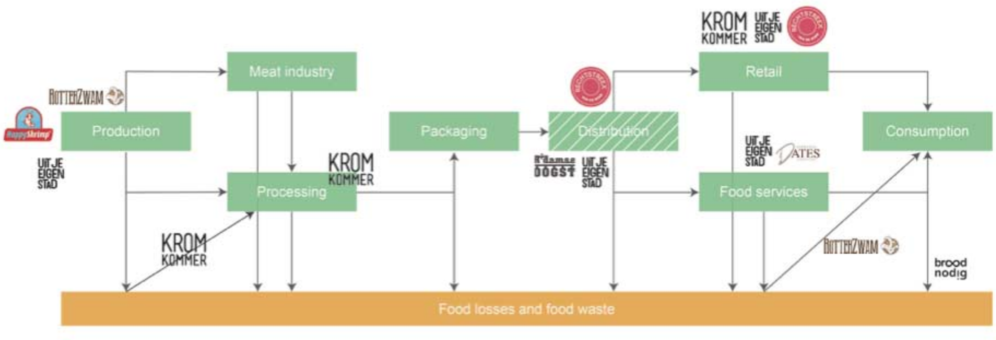

Figure 2. Linear food production chain with local initiatives.

size). From these vegetables, they make veg(etari)an soups, which they sell through other initiatives such as Rechtstreex and Uit Je Eigen Stad as well as through some super markets and concept stores.

Happy shrimp was one of the first initiatives, and unfortunately went bankrupt after a few years. They produced biological tropical shrimps and used waste streams of a nearby power plant. Although the concept worked well, the start-up phase took too long, and returns on investments were not received in time.

Broodnodig collects the stale bread in different neighbourhoods in Rotterdam, and uses this to produce biogas. Stale bread is a big problem in Rotterdam, because it is often thrown away on the streets, which causes rat plagues.

Uit je eigen stad is a true city farming initiative. They sell products from their own farm, on a self-initiated market and mini stores, and use these products in two restaurants that they run.

Espresso Dates is a breakfast- and lunchroom, which uses mainly local products, combined with some Moroccan influences and super food. Most of the food they sell is produced in the neighbourhood. Many different people get together here, because it is at the intersection of different neighbourhoods; from the more expensive ones to social housing.

Results

From the lessons learned, nine different strategies for food longevity were defined (see Table 1).

The first strategy, as shown in Table 1, is the upcycling of food waste, which refers to trying to turn food waste into a more valuable product than it was before. To illustrate, Kromkommer turns vegetables and fruits, that usually get thrown away, into soups.

A related strategy is using waste streams from other systems, as input for the production process. The Happy Shrimp farm for example used the waste streams of a nearby power plant as a heat source for their shrimps.

Another strategy is promoting vegetarian/vegan food. Plant-based food often has less impact on the environment than meat.

Local production is oftentimes used as a strategy to make the distribution channels as short as possible. The rationale is that food usually travels large distances before it ends on your plate, which generates a lot of unnecessary CO_2 pollution. The current initiatives demonstrate that food can be produced locally as well.

To produce locally, some initiatives make efficient and innovative use of city space. Vacant buildings are re-used for city farming: a former swimming pool turned into a mushroom production facility, and a harbour building turned into a shrimp facility.

By shortening the distribution channels more transparency is created for the consumers. Transparency is another strategy used by the initiatives to show the origin of food. It connects farmers and consumers, and enables buying directly from a farmer. This also creates more possibilities to offer the farmer a fair price. A shorter production chain leaves a bigger percentage for the farmer. At the same time, consumers seem to be willing to pay more, when they know where their money is going. Rechtstreex is, for example, very transparent about the fact that the farmer receives 57 cents per euro.

Creating a (more) local food system, largely depends on the community that uses the system. Therefore, enhancing (more) social cohesion is an important strategy. Points of sale are often located on a place that is important to the community. Moreover, the initiatives organise many events to involve the community.

Lastly, *education* in which initiatives share their knowledge and ideas acquired overtime is another important part of their business strategy. It not only inspires more people to have an impact, it also appears a welcome source of income.

Discussion and conclusions

The nine strategies described above, seem to be promising starting points for innovating the food system towards a more sustainable and circular system. In general, the initiatives are quite effective to change the way we look at food, by producing locally or more sustainable, creating transparency or awareness around food, and by minimizing or reusing waste.

Most initiatives use a combination of different strategies, combined with a form of tutoring and inspiring others. Interestingly, the initiatives start with a societal need or problem to solve, and while doing this, they also try to find economic value in their ideas. This shows that they often create shared value (Porter & Kramer, 2011) the other way around. Especially the funding in initial years are crucial for the initiatives. Oftentimes, the initiatives are partly funded by crowdfunding, which stresses the value that the products and services have for society.

Although evidence was found that sustainable business models are built around these nine strategies, this is not straightforward. Initiatives frequently indicate how they were struggling to survive. Yet, the biggest struggle bottom-up initiatives encounter, seems to be the current system. Most of the consumers are not (yet) ready to change their behaviour. Comfort and ease are found in the old system, where big supermarkets are the major players. This makes it challenging for local initiatives to stay close to (and propagate) their original values when they are gaining popularity or when they are not getting known by a bigger audience. For customers on the other hand, it is difficult to see which companies are truly transparent and honest, and which are not.

How can initiatives be scaled and sustained to become profitable, while keeping locality as a core strength? Rotterzwam demonstrated a successful scaling strategy by encouraging others in their network to start the same initiative in other cities around the world. However, Rechtstreex, experienced that scaling up by replicating in Utrecht and Eindhoven was not a promising strategy. Consequently, they are focusing again on growing their market and network locally, in Rotterdam. Surprisingly, initiatives also influenced the major players positively. For example, Albert Heijn, one of the largest supermarkets, started their own 'Buitenbeentjes' (i.e., oddballs) fruits and vegetables line in 2015, a food longevity strategy that already has been promoted by the initiative Kromkommer in 2012 (Engelen, 2016).

It can be concluded that best practices on a small and local scale, can be adopted by large, traditional players in the system. However, transitioning the entire food system towards a circular system has a long way to go. It requires an approach where food is seen in a broader perspective. Interestingly, the broadening role of design, which crosses traditional boundaries (Brown & Wyatt, 2010; Diehl & Christiaans, 2015; Calabretta, Gemser, & Karpen, 2016), offers great opportunities to accelerate this transition (Transition Design Symposium, 2016).

Acknowledgments

We would like to thank Gilbert Curtessi (Happy Shrimp) and Rachelle Eerhart (Rechtstreex) for their time, their rich insights and thinking along with us. Moreover, we would like to thank, Mark Slegers (Rotterzwam) and Lisa Verbruggen (Kromkommer).

	Type of Business	Strategies								
Initiatives		Upcycling of food waste	Reuse of waste streams	Vegetarian (or vegan)	Local production	Efficient use of city space: city farming	Transparency in food chain	Fair price for farmers	Social cohesion in communities	Education
Rotterzwam	Entrepreneurship	✓		✓	✓	✓				✓
Rechtstreex	Entrepreneurship				✓		✓	✓	✓	
Rotterdamse Oogst	Platform				✓		✓	✓	✓	✓
Kromkommer	Entrepreneurship	✓		✓				✓		✓
Happy Shrimp	Entrepreneurship		✓		✓	✓				
Broodnodig	Entrepreneurship	✓								✓
Uit Je Eigen Stad	Entrepreneurship		✓			✓				✓
Espresso Dates	Entrepreneurship				✓				✓	

Table 1. The initiatives and nine resulting strategies.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-144

Consumer perspectives on product lifetimes: a national study of lifetime satisfaction and purchasing factors

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Keywords
Circular economy
Consumer goods
Lifespan labelling
Product lifetimes
Throwaway society

Abstract
The extension of product lifetimes of consumer goods has the potential to encourage sustainable consumption, reduce carbon emissions and facilitate a transition to a circular economy. However, current understandings of consumer perspectives on product lifetimes are limited. This paper presents the findings of the first national study of consumer satisfaction with product lifetimes across an exhaustive range of consumer durables. The research was undertaken in the United Kingdom where consumer satisfaction and purchasing factors were studied across eighteen product categories. These product categories were devised from academic and market research undertaken at Nottingham Trent University. In total, 2,207 participants completed the survey and the sample profile was similar to the United Kingdom's population with respect to age and gender. The results indicate that consumers appear generally satisfied with the lifetimes of their products and suggest that efforts to extend product lifetimes should focus on developing business and policy options. However, participants also emphasised that longevity, reliability and guarantee length were important factors in their purchasing decisions. Consumer interest in these factors could indicate that lifetime labelling and the promotion of longer guarantees by manufacturers and retailers may offer pathways to reduce energy and material consumption associated with short-lived products, facilitating movement towards a low carbon circular economy.

Introduction

Materially-rich lifestyles across the world exert ever-increasing demands on the planet (Trentmann, 2016). Global improvements in standards of living are driving spiralling consumer demand for products (Wilk, 1998). In the United Kingdom (UK), the design, production, distribution, use and disposal of these products account for a significant proportion of energy and material demand (Norman et al., 2016; Salvia et al., 2016). These products embody carbon (Allwood & Cullen, 2012), and their decreasing lifetimes characterised by the 'throwaway society' (Cooper, 2004, 2010b), represents a significant challenge to meeting carbon reduction targets (IPCC, 2014) and attaining a circular economy (Montalvo, Peck, & Rietveld, 2016).

Encouraging consumers to purchase longer-lasting products could abate the "churn" (Cox, Griffith, Giorgi, & King, 2013, 27) of consumer goods, and would minimise environmental impacts (ERM, 2011). Previous research has asserted that consumers are interested in how long products last (ERM, 2011; Knight, King, Herren, & Cox, 2013). However, consumers have also shown limited concern for the environmental impacts of discarded products (Cox et al., 2013), while continually expecting innovation and psychologically linking products to their identity and success (Cox et al., 2013; Wieser, Tröger, & Hübner, 2015).

Research into consumer satisfaction and expectations of product lifetimes is an emerging field of enquiry. While product categories that include electrical and electronic equipment (EEE) (CTA, 2014; Cooper, 2004; Echegaray, 2016; Knight et al., 2013; Oguchi et al., 2016; Tasaki, Terazono, & Moriguchi, 2004; Wilhelm, Yankov, & Magee, 2011) and clothing (Langley, Durkacz, & Tanase, 2013a, 2013b) have been extensively studied, other products, such as carpets and boilers, have rarely been evaluated (Cox et al., 2013; Wieser et al., 2015).

This paper reports the findings of the first nationwide survey of consumer satisfaction with current product lifetimes, which was undertaken across eighteen product categories and conducted in the UK in February 2017. The paper outlines the formulation of the product categories, the design of the consumer survey and describes the data analysis undertaken. The research findings are summarised, with the degree of consumer satisfaction with product lifetimes and the importance of reliability and longevity in comparison to other purchasing factors are examined. Finally, the role of consumers, businesses and government in facilitating the choice of longer-lasting products is examined, and the contribution they can make to reducing the environmental impacts of products and achieving a circular economy is explored.

Methods

Product categories

An evaluation of the United Nations' Statistics Division's (UNSD, 1999) Classification of Individual Consumption According to Purpose (COICOP) and Mintel Academic market research database (e.g. Carroll, 2017) identified over 400 products that could be classified as durable goods. Durable goods are defined as products "that may be used repeatedly or continuously over a period of more than a year" (UN, EC, OECD, IMF & World Bank, 2009, p. 184). Owing to time and cost constraints, it was not considered feasible to conduct a national survey of consumer satisfaction with product lifetimes at the product level. Consequently, a product categorisation scheme was developed using COICOP, Mintel reports and previous consumer studies of product lifetimes (e.g. Cooper, 2004; Cox et al., 2013; Wieser et al., 2015) (see Gnanapragasam, Oguchi, Cole, & Cooper, 2017, this volume). These eighteen product categories were designed to be representative of the entire range of consumer durables, thus achieving a comprehensive consumer survey (Dillman, Smyth, & Christian, 2014).

Consumer survey

An online survey was designed to assess consumer satisfaction with product lifetimes across these eighteen categories. The questionnaire included items on purchasing factors and satisfaction with product lifetimes (e.g. Knight et al., 2013) (see Figure 2 in the appendix). In addition, demographic information, such as gender and age, was also collected. Each participant answered questions on up to nine of the eighteen product categories to minimise potential survey fatigue and non-response (Dillman et al., 2014).

Likert items were used to assess consumer satisfaction with product lifetimes. A Likert scale (ranging from 'very dissatisfied' to 'very satisfied') was utilised to assess consumer lifetime satisfaction with the eighteen product categories. As each of the product categories encompassed a range of products, it was not possible for participants to estimate lifetime expectations in years. A Likert-type scale (ranging from 'not at all important' to 'extremely important') was used to gauge the level of importance that participants assigned to the following purchasing factors: Appearance, brand, guarantee length, longevity, price and reliability. The importance of reliability as a purchasing factor was studied for bicycles, cars, electronic goods, jewellery, clocks and watches, large kitchen appliances, power tools for the home and garden, small household appliances, and space heating and cooling products because, unlike other categories, these products contain complex electrical, electronic or mechanical parts.

Sampling strategy

As suggested by Bryman (2008) and Robson (2011), extensive pilot testing was undertaken with participants from different backgrounds to ensure the questionnaire was readily understood. Participant recruitment was conducted by a market research company (JRA Research) who recruited from an opt-in consumer panel to meet age and gender quotas derived from the UK population. The sample characteristics deviated from the UK population by no more than 3.58% for gender and 5.35% for age (see Tables 2 and 3 in the appendix). The data presented in this paper is unweighted, as with the exception of one characteristic (participants aged 18-24), the sample characteristics remained within 5% of the UK population, which is an acceptable standard in the discipline of market research (Sarstedt & Mooi, 2011). In addition, weighting has not been implemented by recent studies into consumer expectations of product lifetimes (Hennies & Stamminger, 2016; Wieser et al., 2015).

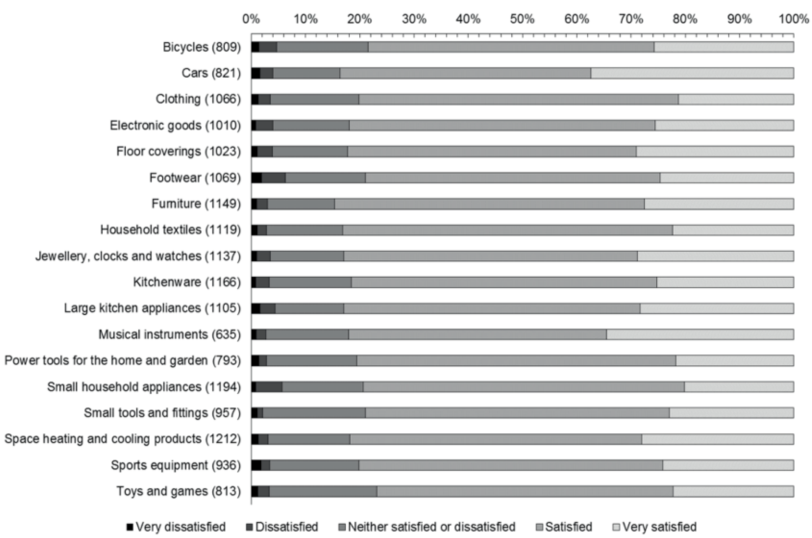

Figure 1. Consumer satisfaction with product categories.

Data analysis

The data for levels of satisfaction and purchasing factors were prepared for analysis by excluding responses where participants had stated that they could not answer the question. The findings were tabulated a compound percentage bar chart was produced to facilitate visual comparison of consumer satisfaction data across the eighteen product categories. Purchasing factors were assigned a numerical value (i.e. from 1 for 'not at all important' to 5 for 'extremely important') and the median scores were calculated.

Results

Study coverage

In total, 2,207 participants completed the consumer survey. Response rates for each product category ranged between 635 (for musical instruments) to 1,212 (for space heating and cooling products).

Consumer satisfaction

Figure 1 depicts levels of satisfaction with lifetimes across eighteen product categories. Overall, the majority of the respondents in this study indicated that they were satisfied with the lifetimes of their durable goods. When 'very satisfied' and 'satisfied' were aggregated, all product categories illustrated high satisfaction levels, ranging from 77% satisfaction for toys and games to 85% satisfaction for furniture. In contrast, only a small proportion of respondents indicated that they were 'dissatisfied' or 'very dissatisfied' with product lifetimes. Aggregating these responses, participants who reported dissatisfaction with product lifetimes ranged from 2% for small tools and fittings to 6% for both footwear and small household appliances.

The product category with the highest proportion of respondents who were 'very satisfied' was cars (37%), followed by musical instruments (34%). In contrast, the product category which showed the lowest proportion of respondents who were 'very satisfied' was clothing (21%). The product category with the highest proportion of respondents indicating that they were 'dissatisfied' was small household appliances (5%). In contrast, the lowest proportion of respondents indicated that they were 'dissatisfied' with both power tools and small tools (1%). Very few respondents stated they were 'very dissatisfied' with product lifetimes: 2% recorded that they were 'very dissatisfied' with the lifetimes of footwear, large kitchen appliances, cars and sports equipment. Across all other product categories, only 1% of respondents were 'very dissatisfied'.

Purchasing factors

The median values for purchasing factors were calculated across the eighteen product categories to determine their relative importance (Table 1). The results illustrate that reliability was an 'extremely important' purchasing factor in the categories in which it was studied. Longevity was 'extremely important' for furniture, floor coverings, large kitchen appliances, power tools, cars, electronic goods, and space heating and cooling products. For the remaining eleven categories, longevity was considered to be 'very important'. Price was identified as 'very important' for all product categories apart from cars, for which it was 'extremely important'. Guarantee length was considered 'very important' for eleven product categories and 'moderately important' for seven product categories. Brand was identified as 'moderately important' for all categories with the exception of cars and electronic goods, for which it was 'very important'. Finally, the results for appearance show the most variability across the product categories. For clothing, furniture, floor coverings, household textiles, kitchenware and jewellery, it was identified as 'extremely important'. For the remaining twelve product categories, appearance was considered 'very important' for six and 'moderately important' for the other six.

Discussion

Study coverage

This study provides the first example of a national survey of consumer satisfaction with product lifetimes across

	Appearance	Brand	Guarantee	Longevity	Price	Reliability
Bicycles	Very	Moderately	Very	Very	Very	Extremely
Cars	Very	Very	Very	Extremely	Extremely	Extremely
Clothing	Extremely	Moderately	Moderately	Very	Very	
Electronic goods	Moderately	Very	Very	Extremely	Very	Extremely
Floor coverings	Extremely	Moderately	Very	Extremely	Very	
Footwear	Very	Moderately	Moderately	Very	Very	
Furniture	Extremely	Moderately	Very	Extremely	Very	
Household textiles	Extremely	Moderately	Moderately	Very	Very	
Jewellery, clocks and watches	Extremely	Moderately	Very	Very	Very	Extremely
Kitchenware	Extremely	Moderately	Moderately	Very	Very	
Large kitchen appliances	Very	Moderately	Very	Extremely	Very	Extremely
Musical instruments	Very	Moderately	Very	Very	Very	
Power tools for the home and garden	Moderately	Moderately	Very	Extremely	Very	Extremely
Small household appliances	Moderately	Moderately	Very	Very	Very	Extremely
Small tools and fittings	Moderately	Moderately	Moderately	Very	Very	
Space heating and cooling products	Moderately	Moderately	Very	Extremely	Very	Extremely
Sports equipment	Very	Moderately	Moderately	Very	Very	
Toys and games	Moderately	Moderately	Moderately	Very	Very	

Table 1. Importance of purchasing factors.

the complete range of durable goods. Responses were received from 2,207 individuals across the UK and the sample characteristics broadly match that of the UK population aged 18 and above (ONS, 2016) (see Tables 2 and 3 in the appendix). The similarity of this sample to the UK population indicates that this study is representative, this follows previous research conducted by Skelton and Allwood (2017) and Wieser et al. (2015). Additionally, the response rates in each product category for this research compare favourably to those in recent research into consumer expectations of product lifetimes (e.g. Hennies & Stamminger, 2016; Wieser et al., 2015) and are comparable to those achieved in a recent study of regretted consumption (Skelton & Allwood, 2017).

Consumer satisfaction

Consumer levels of satisfaction were found to be uniformly high across the eighteen product categories under investigation. These findings contrast with that of Cooper and Mayers (2000) in which almost 45% of participants asserted that most EEE did not last as long as they would like it to. The findings of this research were similar to that of a recent study conducted on EEE in the UK by Knight et al. (2013) which found the majority of participants to be mostly satisfied with how long their products lasted. This may indicate that there has been a temporal trend of increasing satisfaction with product lifetimes which parallels the decline in consumer expectations of product lifetimes in the UK (Gnanapragasam et al., 2017, this volume).

If most consumers are generally satisfied with product lifetimes, as this study would indicate, then future efforts towards "slowing resource loops" (Bakker, Wang, Huisman, & den Hollander, 2014, p. 309) and achieving a circular economy through the proliferation of longer lasting products should, perhaps, focus on the business case (e.g. Bocken, Short, Rana, & Evans, 2014), public policy (Cooper, 2010a; Ervine, 2010) and environmental arguments (ERM, 2011; Norman et al., 2016), instead of consumer concern. Additional qualitative research could serve to deepen our understanding of consumer satisfaction with current product lifetimes, perhaps deciphering why today's consumers are satisfied with lifetimes of products even while some are, arguably, in decline.

Purchasing factors

While dissatisfaction with product lifetimes was not evident, this study found that consumers placed comparatively greater importance on reliability and longevity in comparison to the other four purchasing factors surveyed, including price, across all eighteen product categories (Table 1). Previously, it has been suggested that product lifetime information should be clearly communicated to consumers so that they can make informed purchasing decisions (Cooper & Christer, 2010; Knight et al., 2013; Montalvo et al., 2016). Strategies such as lifetime labelling have been positively received by consumers across a range of products (SIRCOME, University of South Brittany, & University of South Bohemia, 2016). Lifetime labelling could enable consumers to consider information on product lifetimes into account when making purchasing decisions. Additionally, consumers considered guarantee length to be a 'very important' purchasing factor for the majority of product categories. This indicates that the introduction and effective communication of longer lifetime guarantees by manufacturers and retailers may entice consumers to purchase longer-lasting products (Cooper & Christer, 2010; Knight et al., 2013). In summary, both lifetime labelling and the provision of longer guarantees could encourage greater uptake of longer-lasting products, helping to slow and reduce material demand and enact the circular economy at the product level (Bakker et al., 2014).

Conclusions

This paper reported the findings of the first national study of consumer satisfaction with product lifetimes across the entire range of consumer durables. The study found that overall, UK participants appear satisfied with the lifetimes of their durable goods. It also revealed that consumers consider reliability, longevity and guarantee length to be comparatively important factors when making purchasing decisions. While it appears that consumers may be satisfied with arguably declining product lifetimes (Gnanapragasam et al., 2017, this volume), the importance consumers place on longevity, durability and guarantee length may foster opportunities for the development of lifetime labelling and the provision of longer guarantees for durable goods. The findings of this study indicate that government, manufacturers and retailers may be best-positioned to encourage the uptake of longer-lasting products, reducing consumption (Cooper, 2005), driving efforts towards a circular economy (Montalvo et al., 2016) and enabling carbon emissions reduction targets to be met (Salvia et al., 2016).

Acknowledgments

This project was financially supported by the UK's Engineering and Physical Sciences Research Council's Centre for Industrial Energy, Materials and Products (grant reference EP/N022645/1). The authors would like to thank Dr Angela Roberts for providing detailed comments on drafts of this paper.

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Appendix

A. In general, how important are the following when you are buying [product category]?

a) How the product looks, b) brand, c) How long the product will last, d) How reliable the product will be, e) Length of guarantee provided, f) price.

1 Not at all important, 2 slightly important, 3 moderately important, 4 very important, 5 extremely important, 6 do not know/ cannot say.

B. In general, how satisfied or dissatisfied have you been with how long your [product category] lasted?

1 Very dissatisfied, 2 dissatisfied, 3 neither satisfied or dissatisfied, 4 satisfied, 5 very satisfied, 6 do not know/ cannot say.

Figure 2. Survey questions.

	UK population (%)	Survey sample (%)
Female	51.26	47.68
Male	48.74	52.32

Table 2. Gender profile of sample.

	UK population (%)	Survey sample (%)
18 – 24	11.45	16.80
25 – 44	33.50	28.84
45 – 64	32.43	36.24
65 – 74	12.35	12.40
75+	10.27	5.72

Table 3. Age profile of sample.

Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-149

Conditional garment design for longevity

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Keywords
Clothing design
Longevity
Modular
Incremental
Design strategy

Abstract

In the clothing sector, approaches to design for longevity can provide the "…single largest opportunity to reduce the carbon, water and waste footprints of the clothing in the UK" (WRAP, 2013a). Although an emphasis lies on slowing consumption, the types of design-led approaches that can be used to achieve this goal are considerably varied yet sparingly used by the mainstream fashion industry. In light of the growth of a circular economy, the challenge facing the fashion industry is to adapt the existing product design and development model and explore a fashion system where other, more diverse design approaches can prosper. Thus, this paper attempts to contribute to this debate and further highlight factors that need to be considered by fashion companies when developing garments designed for longevity.

Through a range of novel design principles/methods, underpinning modularity and incremental garment design/construction in this paper we demonstrate how designers may begin to envisage garments as items designed for longevity. The experimental work carried out here is part of a larger initiative, Re:Textile in Sweden (Retextile, 2017). In the experiments conducted we demonstrate the power of various garment design conditions intended to synthesize a change towards garment longevity. Together with highlights of the key processes and basic design principles underpinning these design-led approaches, the experimental work also specifies how and where they contribute in achieving the aims of designing in a circular economy. The findings also highlight the opportunities for improving the redesignability of the garment in its active use life as set by the original design conditions laid in light of design for longevity.

Introduction

In the fashion industry, garments are developed for a variety of markets, for consumers with specific requirements, needs, and values. The characteristics of garments developed for these markets differ greatly; their aesthetic, material and production characteristics are selected to suit a given function, purpose and price point. High street fashion garments are primarily designed for aesthetic appeal and are frequently constructed from inexpensive materials that keep the items affordable and (easily) replaceable, while at the same time demand shorter lead time to market. Once purchased, all garments go through a cycle of wearing, laundering, storing, and perhaps repair and alteration, before a final disposal (Bras-Klapwijk and Knot, 2001). Typically, at the point of disposal many consumers believe that garments have no further purpose or use value, and so items are often placed in a waste bin (WRAP, 2012).

Of the 350,000 tonnes of discarded clothing that is sent to UK landfills each year (WRAP 2012), much of this waste could be reduced if designers employed strategies to extend the life of garments and support consumers to engage with maintenance practices. In many cases the lifetime for clothing can be extended from 3 to 5 years if designers consider longevity factors during the design process used to develop fashion products (Claxton et al. 2015). It is commonly understood that the decisions made during the garment design process are known to potentially lengthen or shorten the lifetime of the product during its use. If poor quality materials and inexpensive construction processes are employed, then the physical durability of a garment is compromised. At the same time aesthetic design decisions can make a garment appear 'outdated' when new seasonal trends emerge (Walker 2006). Moreover, some design decisions can confuse consumers because they confront preconceived ideas about the relationship between price and brand: one where the durability of a garment is seen to correlate with a high price and brand (Gwilt et al., 2015).

In maximizing garment longevity, 'durability' could be considered in terms of both its physical and empathetic qualities. However, this point needs to be considered in relation to the context of use, and consumer behavior. Typically, consumers are satisfied if a garment retains its function during use, and they are unconcerned whether the item should last for any longer than this (Cox et al., 2013). To designers there is then a significant opportunity; to not only extend the physical life of garments for as long as possible to keep materials in circulation, but also to change the perceptions and expectations that consumers have towards clothing lifetimes.

Considering design for longevity

For designers in the fashion industry it is possible to reduce textile waste if strategies are employed to ensure garments are 'fit for purpose', desirable to consumers and developed for longevity (Claxton et al., 2015). Through a circular economy lens it is apparent that a wide variety of design-led approaches can be used in new product development to achieve this goal. Moreover, in considering the extension of the life expectancy of garments we propose that designing for longevity could be a mechanism for increasing the active use period and thus delaying the disposal of garments. However, design for longevity in terms of clothing products can be explored from different perspectives.

WRAP (2013a), Laitala, Boks and Klepp (2015) and others argue that the disposal of clothing can be delayed, "…through improved design, consequently increasing the active use period." In ensuring that garments have a long and active life it is necessary to consider the development of clothing products in relation to their empathetic and aesthetic qualities alongside effective physical and technical attributes (Laitala, Boks and Klepp 2015). At the same time the meaning of the term design goes beyond the direct creation of clothing in production, to include the creation of services or systems that sit in consumption (Laitala, Boks and Klepp 2015).

Traditionally the mainstream fashion industry has not exploited the opportunity to manufacture highly durable garments or to provide/support maintenance initiatives. In part this began with the rise in popularity of mass manufactured, ready-to-wear clothing in the 1940s/50s, when fashion became accessible and affordable for consumers. Prior to these new garments were either constructed within the home or custom-made by local tailors or dressmakers (Tarrant 1996) and consumers understood the construction process and valued the resources and inputs required to produce a garment. This appreciation extended through to garment maintenance where in the home consumers routinely repaired, altered and remanufactured garments. In contemporary society, it seems that fashion consumers are predominantly situated outside of the industrial system, often unaware of the methods and materials used to produce garments or approaches to maintain garment lifetimes. Simultaneously fashion producers are still largely comprised of a variety of profit driven businesses, which operate a traditional production model dependent on a seasonal cycle of producing, selling and discarding large quantities of clothing to meet economic returns.

In a circular economy, the fashion industry has the opportunity to influence a change in consumer behavior whilst employing different models for business. According to WRAP (2013a) one approach would be for brands and producers to see longevity integrated within the company strategy, which would provide a clear aim for teams involved with product development during manufacturing and retail.

Existing approaches

If the fashion system was viewed through the lens of 'designing garments and designing supporting services and systems', there are, according to WRAP (2013a) and Laitala, Boks and Klepp (2015), several factors to consider when designing for garment longevity. Notably these areas include:

- Considering the role of design and production in addressing design aesthetics; size and fit concerns; and providing greater durability.
- Supporting consumers through communication and after sales services.

Significantly, in moving towards designing garments for a longer life it may be possible to foreground 'longevity' as a valuable clothing attribute. Disposable garments may then become undesirable; however, this will require, "... a cultural shift, driven by consumer re-education, corresponding marketing promotion and, perhaps, new business models" (WRAP 2013a). There have been a number of initiatives advocated by NGOs and campaign groups, and products developed by brands and fashion companies that demonstrate how design for longevity can be considered and applied in the fashion industry.

The Welsh clothing company, Howies, developed the 'Hand-Me-Down' collection with the intention of creating products with longer lifetimes. During product development the design process involved identifing and correcting the potential weak points that arise in a garment during use. The garments, which were created to last for ten years, were then manufactured using high quality materials and durable construction methods, and the company offered to repair or replace damaged components arising from wear and tear. In 2014 Tom Cridland began his sustainable fashion brand with an aim to develop products supported with a thirty year guarantee. Cridland's range of T-shirts, jackets and trousers for the menswear market are intentionally aesthetically classic, not unlike the products found in the Howies Hand-Me-Down collection. Both brands strived to ensure the physical durability of a garment through select materials and construction methods, but in both cases the opportunity to improve consumer attitudes and practices towards garment maintenance has been missed. This is where campaign groups have been highly active. The 'Love Your Clothes' campaign founded by the NGO Waste and Resources Action Programme (WRAP), UK was developed to influence behavioural change amongst consumers. With the support of industry and academic partners the web resource provides consumers with advice on garment care and repair, remanufacturing methods, and recycling / reuse ideas. Notably the campaign encourages consumers to get involved by posting quick tips, video clips, and blog posts. But it is apparent that there is an ongoing disconnection between 'producers' and 'consumers' although efforts to bridge this divide are emerging. Swedish brand, Nudie jeans, is commited to providing both a product and a service for its consumers. Through the Nudie Jeans Repair shops jeans can be purchased as new, repaired for free, resold as second-hand, or donated to the store for recycling (Nudie Jeans n.d.). At the same time, through the blog the brand encourages consumers to get involved by posting images of loved-yet-damaged garments, or by learning specific care techniques. These approaches signpost the ways in which brands can reach-out and connect with their consumers.

Whilst the examples discussed demonstrate how designers and users can engage with and promote design for longevity, implementation of these types of approaches across the sector remains small. Working in line with design for longevity, in this paper we explore the notion that fashion designers and consumers can visualize fashion garments as living products, which are designed to evolve, transform and grow for a long life.

Demonstrative case

Although design for longevity can be achieved in many ways, it is a combination of the design-led approaches that helps extend the lifetime of a garment. Using appropriate and considered materials and construction techniques in the garment, manufacturing plays an important role in enhancing durability through use. We, in this study, categorized these approaches into two primary design conditions.

1. Modular garment design: refers to the development of a range of detachable parts for fashion garments that can facilitate replacement, repair or even adaptation, by creating novel attachment system. Such modularity can be devised in the method of construction by making the garment components (sleeves, front and back panels, collars and cuffs, etc.) detachable either manually or via automatic separation technologies. More creative forms of modularization can be achieved by making the garment ornamentation, embroideries, and silhouettes modular, i.e. can be easily separated from the garment. Advanced technologies, such as laser-cutting, ultrasonic bonding, 3D printing etc. can be used to enable such garment modularity.

2. Incremental garment design: in terms of designing for longevity informs designers to consider the key attributes or micro design elements, such as garment form, features, garment proportion, color and print, themed references, and genres in fashion (Seivewright, 2007), to be incrementally updated leading to garment life extension. Here it could be suggested that in terms of design for longevity it is important to reflect on the key attributes in terms of the contribution to extending the lifetime of the garment. The garment without these incremental design features is ready-to-wear but with low user appeal for its long life.

To demonstrate these two principle design conditions, an experimental work was conducted under the scope of a regional initiative in west Sweden called Re:Textile aimed at creating structures for circular flows in the fashion apparel industry through concrete projects to investigate the commercial viability of re-design practices.

Experiment 1 – Based on modular design/construction, reusable modules was used in different systems - a kind of qualitative semi-manufacture, enabling re-contextualization and a long and varied product life. Re:Textile created a modular fashion - clothing parts that can be added to and subtracted to create various kinds of garments, such as dresses, tops, skirts, with sleeves, without sleeves etc. The collection is based on interconnected modules, flexible in design, fit and construction and consisting of 18 scarves, designed into 5 different types of garments (Figure 1). Further the collection is made out of mono-material - 100% polyester, including stitching and thus possible to recycle at fiber level.

Based upon a standard estimation of production cost in Sweden of SEK 7 per minute and a mark-up factor of 4.5 for the potential price tag, the retail prices of the above products were calculated to be SEK 308, 416, 677, 735 and 758 respectively.

Experiment 2 – Based on the aspects of incremental design, examples of the existing products, or with some small alternations, is shown in Figure 2. The pant from a sustainable brand is made of a blend of polyester (20%), polyamide (70%) and Elastan (10%) and is reinforced with 100% Kevlar while the shoe cleaning area is 100% Polyester. It has therefore very limited recycling potential; however, the interesting part of this pant is its incremental features on the basis of its functionality. By changing pockets, several different functions can be added or removed as the user may wish. Similarly, the incremental design principle adopted in constructing the backpack incorporates loops for adding or removing functionality depending on activity.

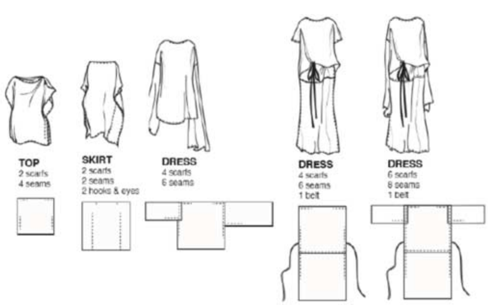

Figure 1. Modular design-led construction principle ©Re:Textile

Figure 2. Incremental design-led construction principle ©Re:Textile

	Principle	Contribution towards Design for Longevity
Modular	• Made of easily separable modules. • Preferred mono-material composition of each module	• Addresses both redesign (multi-purposing) and recycling requirements
Incremental (if Blends)	• Includes micro-design elements that can be incrementally updated	• Addresses multi-functionality. • Must be combined with modularity and mono-materiality to additionally improve recycling potential

Figure 3. Design conditions for longevity.

The calculations in the examples are based on estimates of production costs, put in relation to the original price tag, using the generally accepted mark-up model. The production cost is approximately 20% of the original price tag. The garments in the examples are manufactured in the Baltic countries, so a minute price of SEK 2 per minute is used. The retail price of the pants is SEK 2300.

Analysis and concluding remarks

The paper attempts to outline some of the ways in which fashion brands and designers can envisage garments designed for longevity. Through experimental work that focused on two specific design-led approaches – modular garment design, and incremental garment design, the paper highlights how garment design conditions can be employed to meet the aims of designing in a circular economy. The findings highlight the opportunities for improving the redesignability of the garment in its active use life as set by the original design conditions laid in light of design for longevity (Figure 3).

Design for longevity is often reported to increase garment costs by up to 5% for some products and add up to 2 weeks to garment lead times, thus confirming suggestions that improving garment construction to last for longer could increase costs (WRAP, 2013b). Given this lack of financial incentive for design for longevity, redefining the feasibility for design for longevity in terms of the power of the garment design process based upon certain radical product design conditions (mentioned in Figure 3) to synthesize a longer lifespan of the garment is critical. With modular garment design, it is possible to make garment parts detachable, which can be easily undertaken by the consumer before returning the components (at end-of-use) in separate bins. This will simplify the sorting process (thus lowering the average sorting cost by 50% from ~4 to ~2 SEK/kg). Further this will increase the fraction of redesignable garments rather than being sold "as they are". Incremental design potential will provide higher possibilities for value addition through re:coupling activities, e.g. cut, add, wash, stitch, or print. So, the redesignable fraction can substantially increase along with its yield. Basic requirement however is high design for durability (pilling resistance, color fastness and dimensional stability of the garment). Thus, whilst we have highlighted some of the challenges that need to be addressed when employing specific design-led approaches, we also show that brands have the opportunity to promote the value of 'longevity' in terms of commercial viability.

Acknowledgments

The research has been partly conducted under the funding from Re:Textile, an extended regional research initiative taken by Västra Götaland Region (Region of West Sweden). The authors would like to thank the funding agency for the financial support.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-154

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Design framework for emotionally durable products and services

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Keywords
Emotional durability
Product longevity
User experience
Design methods
Lighting

Abstract
The lighting industry is currently undergoing a systems shift; a bulb, once a consumable, is now a long-life object. However, is this how these products are regarded by consumers—as durable, potentially long-term companions within the home? Or insignificant items easily discarded, without thought? Moreover, with developments within lighting technology these products are able to provide more advanced, enhanced illumination experiences, yet this in turn has resulted in a more technologically complex object, a factor that producers and consumers must be mindful of when considering the lifespan of a product. Emotion and meaning-driven sustainability research offer a vehicle in which to explore these issues within design and the product development process. This paper presents an 'Emotionally Durable Design Framework' developed over the past 18 months in partnership with Philips Lighting. It defines and reveals which strategies are the most crucial when looking to extend both the emotional and physical lifetime of a given product. Our analysis relates nine themes to 38 specific strategies for Emotional Durability, and we conclude by showcasing three lighting concepts, developed using the framework which were exhibited at the University of Brighton and at Philips Lighting Headquarters in Eindhoven.

Introduction

The most recent revision of The Waste Electrical and Electronic Equipment Directive (WEEE) (European Parliament, 2012) has set minimum targets for category 5 (lighting) for 2018 onwards with: 75% to be recovered and 55% prepared for re-use & recycle, prompting designers and researchers in both academia and industry to re-evaluate their approach to New Product Development (NPD) and consider methods related to durability and service innovation. Although, with the recent development of WIFI connected LED's, lighting producers have an opportunity to go 'beyond illumination' to explore a more experience driven design practice to not only enrich and enhance user experience but provide sustainable low energy solutions as well.

'Emotionally Durable Design', (EDD) a theory developed by Chapman (2005 & 2008), offers an opportunity in which to investigate this thinking within NPD. As an approach to design, it examines and articulates the unspoken emotional experiences that occur between products and consumers to reduce consumption and waste of natural resources by fostering more durable, resilient relation-ships with the designed object. The goal is to create products that inspire and delight, promote connection, meaningful interaction and reflection, which endure and evolve with the user over time. Concerned with the tightest and most resource efficient loops of the Circular Economy, Emotional Durability encourages the extension of both the physical and psychological lifetime of the product; providing the greatest opportunity to extract the maximum value during use.

This paper outlines activities from the first 18 months on-going doctoral research partnership between Philips Lighting and University of Brighton; exploring the application of EDD and the design methods to assist in the transition towards a more Circular Economy.

Methodology and Literature Review

The research was developed through a systematic literature and methodology review in conjunction with semi-structured interviews with Philips experts, sustainability professionals and leading academics.

The key theories and principles from Emotion Centered Design and Sustainable Design literature were identified; and along with the rich anecdotal material of both Chapman's (2005) text and his refined PhD 6-point experiential framework (2008) integrated and analysed in relation to:

- ***Product Attachment*** - Mugge, (2007); Mugge, Schifferstein & Schoormans, (2010); Schifferstein & Zwartkruis-Pelgrim, (2008); Page, (2014); Maclachlan (2011)
- ***Slow Design*** - Grosse-Hering, (2012)
- ***Emotional Durability*** - Lacey, (2009); Van Krieken, (2011); Tokaya, (2013); Padro, (2014)

- ***Product Replacement*** - Van Nes, (2003)
- ***Circular Design*** - Bakker et al. (2014)
- ***Ensoulment*** - Jung et al. (2011)
- ***Symbolic Meaning*** - Casais, Mugge, & Desmet, (2016)

Key findings

From the theories presented, those that also consider a sustainability and emotion driven perspective, like Emotional Durability, are Slow design and Product Attachment and both have significant elements of shared ideology. Slow Design highlighting the importance of temporality in consumption and use, while Product Attachment determines that objects that evoke memories support self-identity and promote enjoyable, pleasurable experiences tend to result in users to keeping these objects for longer. However, is important to be mindful that attachment is a facet of Emotional Durability but not the overall objective of the theory. We would argue that users are in a constant state of negotiation with the object, shifting from detachment to attachment and back again. The goal of Emotionally Durability is to create healthy, emotionally rich, rewarding relationships with objects, so if it breaks we will fix it, care for it and at the end of its life, which is the natural progression of all things, it might transform or be disposed of with care, dignity, and responsibility.

Table 1 below, briefly consolidates the central theories found from the literature showing how they assimilated to make up the foundation of the framework.

Developing the Framework

The principles identified in Table 1 were consolidated and distilled into 'Concept Cards'. These were refined through Concept mapping (Martin & Hannington 2012; p.38) in combination with Affinity Diagramming (p.12) to map, cluster and categorize the theory. (Figure 1&2)

This resulted in the framework being developed at two levels: thematic and strategy; refined over 8 months using an iterative practice-based process but ultimately guided by these two central research questions:

- What are the meaningful, emotion driven engagements that exist in the user product interaction journey?
- How can we use this insight to design things that people want to keep for longer?

Figure 1 & 2. Early iterations of concept mapping.

Chapman (2005)	Create immersive rich sensory experiences Ageing Gracefully	Cherishability Consume meaning not matter	Document the Narrative Gift giving Layers of narrative	Keep it moving Consider multiple product lifetimes Material life	Avoid cheap tricks Environment as a user - (mindfulness) Look beyond the symptoms Encourage empathy to keep an open dialogue				Design for dependency Strike a balance - don't create over demanding objects	People use objects to project what group they belong	Relinquish Control Mirrors and projectors of core values	Mind of it's own Provoke a response Design systems that are entirely intuitive	Fuzzy Interactions Inherent Feedback Feed Forward Consider Shades Of Grey	Poetic potential See beyond the physical Don't over script the interaction Pace - time the discovery	
Mugge (2007)			Memories							Group Affiliation	Self-Identity			Pleasure	
Chapman (2008)	Surface	Attachment	Narratives									Consciousness	Fiction		Detachment
Schifferstein & Zwartkruis-Pelgrim (2008)			Memories		Utility and Reliability					Group Affiliation	Support self identity	Enjoyment			
Lacey (2009)		Uniqueness			Integrity										
Mugge, Schifferstein & Schoormans (2010)	Superior Appearance													Superior Utility	
Van Kreiken (2011)	Sensory Engagement Age gracefully		Metaphor to Old Producrs	Evolve Through Use						Share the experience	Co-creation personalisation	Mimic Human Action	Inherent Feedbak Fuzzy interactions Respond to environment	Keep the magic alive/ Surprise Leave room for interpretation	
Van Kreiken (2012)			Evoke Memories					Rewarding			Adapt to user identity	Animacy	Involvement Stimulate - intrigue		
Maclachlan (2011)	Sensory Design		Memories and Longevity								Self-expression	Personality		Pleasure	
Jung et al. (2011)			Intimacy accumulated by association over time					Investment of effort to learn and control functionality		Implicit values created to the patterns of collections of artefacts					
Grosse-Hering (2012)				Evolve	Reflect	Expand	Reveal	Engage	Ritual	Participate					
Tokaya (2013)											Character, Light effect Sensory input luminary design		Change the product person interaction		
Padro (2014)	Analogousness		Uniqueness (+Evolution) Meaningfulness (Uniqueness +value)												
Page (2014)			Memories: Nostalgia					Usability						Pleasure	
Haines-Gadd et al. (2017)	Materiality		Narratives	Evolve		Integrity			Relationships		Identity	Consciousness	Conversations	Imagination	

Table 1.

Testing and refining the framework

Early iterations of the framework were presented and tested through seven generative workshops in Brighton, Oxford, London and Eindhoven with 44 participants from both industry and academia within NPD conducted to investigate these main points of re-search:

- ***Validate:*** the concepts developed by Chapman (2005 & 2008) and the ex-tension of the framework there of
- ***Gather data:*** Stories and insights from participants regarding 'cherished objects'
- ***Educate and Communicate:*** the theory of Emotional Durability

Explored using these methods (Martin & Hannington, 2012) narrative based enquiry (p.68), presentations, concept sorting (p.26) and design charrette (p.58).

Workshops 1-7

Narrative Based Enquiry

For the first exercise participants were asked to bring an item or an image of an item they cherished (Figure 3). This was applied to show, firstly that it is natural for people to have objects they are emotionally connected to, and secondly to gather data on objects that have been loved and kept. It was likely that the notion of Emotional Durability would be unfamiliar to the participants, therefore we were constructing data based on 'cherishability' (Chapman, 2005. p.75), looking to uncover underlying emotional triggers that build this principle into products. Chapman (2005) originally referenced Philips Design, (1996) as inspiration for the term, using it as an example of how these ideas were present within industry. This provides a unique opportunity, allowing the study to bring previously embedded, understood ideas back into the mindset of the organization in new ways. Other phrases were considered: emotionally connected, attached, treasured, possession, however it was decided to utilize a term more indicative of the original theory, which is not as potentially polarizing as 'attached'.

Concept Sorting

The participants were asked to explore the themes and categorise which related most to their objects. (Figure 4) This was used as a method for classification but also a mechanism for assimilating the theory in minds of the participants creating the conditions for active learning, (Sims, 2006) encouraging the participants to assess the theory in relation to their own object.

Figure 3. Oxford participants relaying the stories of their cherished object.

Figure 4. Themes identified and categorised by a participant as relating to their object.

Design Charrette

The participants were asked to choose one or two themes and create a proposal for an EDD light. This gave them an opportunity to synthesize the theory presented and discussed thus far and engage with the strategies and themes in a more meaningful way, while allowing the researchers to better understand how the framework could be integrated into design.

Results from the workshop 1-7

At the close of each workshop a facilitated discussion took place where participants were asked to reflect on these questions:

- Did the framework influence the way you thought about designing the object? Was it helpful or a hindrance to the design process?

- Do you feel you have a better understanding of Emotional Durability? Would you or could see this framework being used in another context?

All feedback, thoughts and reflections from the participants were captured and the 36 stories that were collected and categorized uncovered any limitations and new insights which were then fed back into the framework for further refinement.

An Emotional Durable Design Framework

This process of testing, refinement and reflection resulted in the creation of an Emotionally Durable Design Framework consisting of 9 themes: Narratives, Integrity, Identity, Evolve, Materiality, Relationships, Imagination, Conversations, and Consciousness; with a further 38 strategies that support the creation or evaluation of an Emotionally Durable product. This final iteration was consolidated into the Table 2 and designed into a set of cards. (Figure 6) The theme cards are the larger triangles shown in Figure 5; they are double sided and offer the reader a more detailed description of what the themes embody.

Figure 6 showcases the framework in full; the smaller triangles are the design strategies, which are which are single sided and contain a short description.

Workshop 8

The final revision was used to direct a design workshop with 45 BSc Product Design students at the University of Brighton to further test and improve the process but also generate Emotionally Durable light concept prototypes to be exhibited at University of Brighton and Philips Lighting in Eindhoven.

The students were split into 9 teams, one theme per team and given 2.5 hours to design a new light proposal. (Figure 7) Each team was given a design pack of materials which included:

	Narratives	Evolve	Integrity	Relationships	Identity	Consciousness	Conversations	Imagination	Materiality
THEMES are about...	Markers In Time Links To Family & Friends Nostalgia & Metaphors Provenance	Multiple Product Lifetimes Adaptability & Upgradability Transformation Transcendence Beyond Function	Durability, Reliability & Longevity Repairability & Maintenance Honesty, Authenticity, & Transparency Mindfulness & Reflection	Active Rewarding Participation Admiration & Appreciation Sense Of Mastery	Self-Expression & Identity Markers Group Affiliation Product Personality	Animacy & Anthropomorphism Kami - Spirit In Everything	Inherent Feedback Feed-Forward Interactions Fuzzy Interactions	Continued Engagement & Unexpected Interactions Enjoyment & Pleasure	Objects That Can Mature Multi Sensory Experience Wabi Sabi
STRATEGIES that support the themes...	Consider Gift Giving *Chapman (2005 & 2008); Belk (2007, 2010)* Use Artefacts With Existing Stories Create A Sense Of Nostalgia *Desmet & Hekkert (2007) Van Hinte, E. (1997) Van Kreiken (2010)* Create Multi-Layered Stories *Chapman (2005)* Capture A Moment	Design for Multiple Users *Chapman (2005)* Show Progression *Chapman (2005) Casais, Mugge & Desmet (2015)* Design For Variability & Modularity *Van Nes (2003)* How Can It Transform *Chapman (2005)*	Be Authentic & Honest *Chapman (2005 & 2008)* Ensure Quality, Durability & Reliability *Marchand (2003); Van Kreiken (2011); van Nes (2003); Bakker et al. (2014)* Promote Reflection of Use Chapman (2005 & 2008); Grosse-Hering (2012) Think Open & Transparent Mann (2016) User Can Tend To, Fix Or Maintain The Product *Chapomn (2005); Van kreiken (2010); Bakker et al (2014)* Use Time & Eco Appropriate Materials *Chapman (2016) McDonough & Braungart ,(2002) Ellen Macarthur Foundation (2013) Bakker et al (2014)*	Create Participation With Creative Activities *Chapman (2005); Van krieken (2011); Grosse-Hering (2012) Norton (2012) Padro (2014) Humfreys & Grayson (2008)* Create A feeling Of Control *Casais, Mugge, Desmet (2015)* Create A Ritual Or Habit *Grosse-Hering (2012); Eyal & Hoover (2014)*	Think Customisation & Personalisation *Mugge (2007), Maclachlan (2011)* Give The Product Personality *Govers & Schoormans (2005) Desmet (2007)* Promote Connection & Community *Padró (2014) Mugge (2007) Schifferstein & Zwartkruis-Pelgrim (2008)* Promote Self Discovery	Create Unexpected Interactions Tokaya, p78 (2013) Design for Animacy *Van Kreken (2011) Tokaya (2013) Padro (2014) Lasseter (2001)* Mimic Human Behaviour *Tokaya (2013) Padro (2014)*	Create Feedback & Response *Chapman (2005) Van Kreiken (2010) Jordon (2000)* Consider Degrees of Response *Chapman (2005, P81) Van Krieken (2010) Mullaney (2010)* Make it Respond to its Environment *Mullaney (2010)* Communicate Intention Philips Expert, 19; Norman (2004) Labour Leads To Love *Chapman (2005) Norton, Mochon & Ariely (2012)*	Create Surprise Effect *Ludden (2008)* Leave Room For Ambiguity *Van Kreiken (2011) Chapman (2005)* Build Anticipation *Chapman (2005) Nicolas, Aurisicchio, Desmet (2014) Hassenzahl (2013)* Create A Little Magic *Chapman (2005)*	Think Ageing Gracefully *Chapman (2005 & 2008); Van Hinte, 1997; Bridgens, et al. (2015) Pye, D. (1968); Rognoli & Karana (2014); Van Kreiken (2011)* Engage The Senses *Van Kreiken (2010) Ludden (2008) Mullaney (2010) Desemet* Celebrate Imperfection *Garcia (2015) Walkup (2009)* Make It Unique *Lacey (2009) Padró (2014)*

Table 2. All themes and strategies consolidated and referenced further demonstrating the theoretical foundation of the framework.

(a) Description of theme
(b) Examples of the themes and what they embody

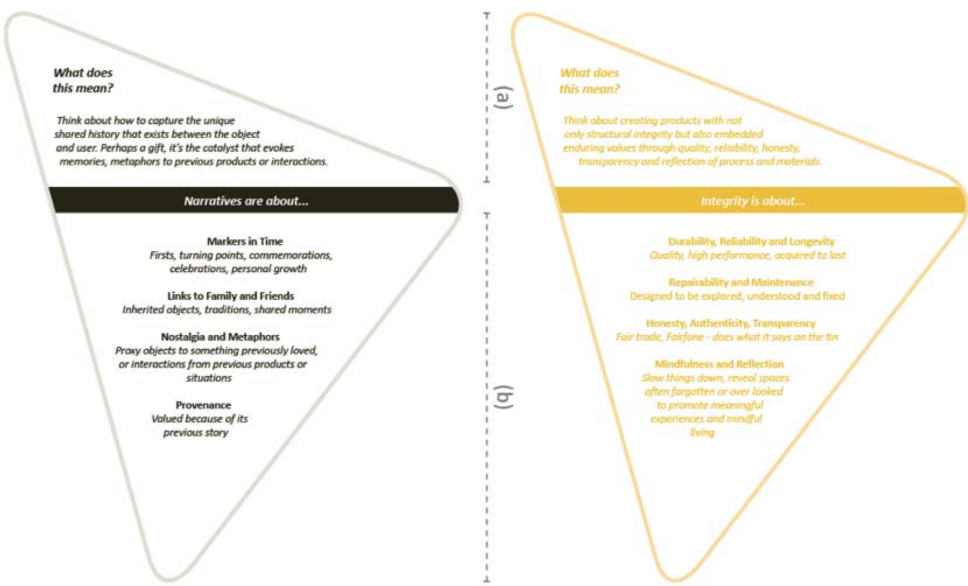

Figure 5. The reverse side of theme cards

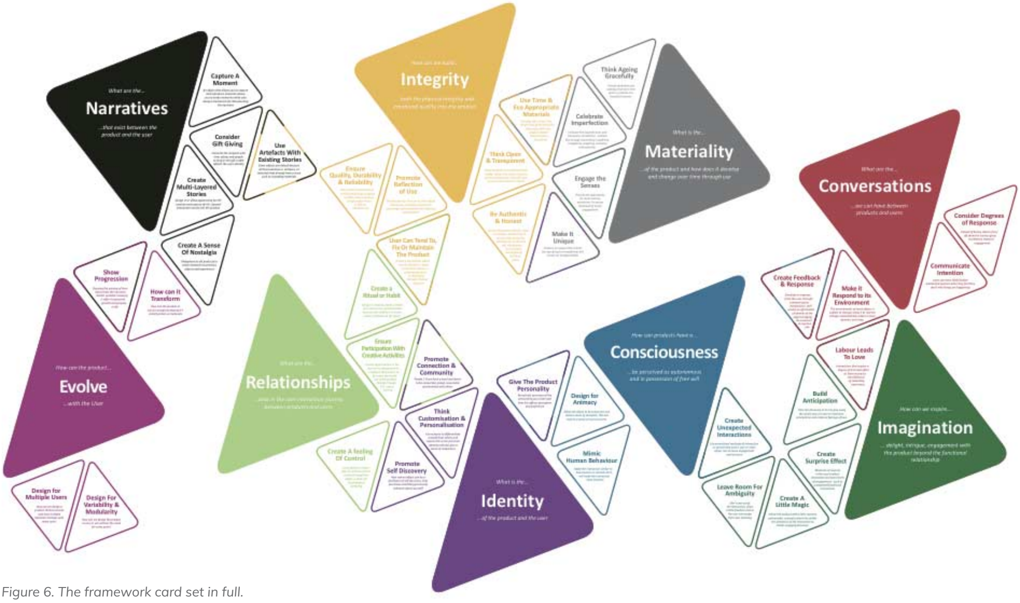

Figure 6. The framework card set in full.

- One copy of framework - 9 themes, 38 strategies and EDD map with design checklist
- One persona - Couple moving in together, Renovators, Students

At the close of the day the teams were asked to present the concepts they created in an 'elevator style pitch' to the Philips experts and academic team who acting as 'Judges' of the challenge. Three concepts were chosen and underwent a further round of product development, conducted by the participants over several weeks in their own time. The three teams produced rapid prototyped models which were presented with display boards and were exhibited from 27th Feb-March 10th at the University of Brighton. The exhibition will also take place in Eindhoven Philips lighting headquarters later in the year. (Figure 8-10)

Results and Discussion

Reflection on Framework Development

The procedure for delivering the framework proved to be a successful process, and although only conducted in the context of Lighting design, the exercises and presentations could easily be implemented with other types of NPD or service innovation.

Reflection on the Framework for Design

As Workshop 8 shows, it is possible to incorporate immediately at the front-end innovation stage and used for Brainstorming - either individually or in teams to create emotionally durable products or services. The feedback from participants showed the framework quick to understand and several of the students took on elements of the theory and integrated into their final year projects. The set of cards that used to present the framework is not our intended final outcome, but is just one example of the many different innovation and creativity tools that could be created. We are currently exploring how they might compliment or 'plug-in' with other existing tools. As our aim is to create a process that can continue to adapt and

Figure 7. Students using the framework.

Figure 8. Paleo, inspired by CONVERSATIONS. Retains heat and radiates a warm glow. Sensors emit a brighter light as hands draw close encouraging interaction which in turn wears down the surface over time creating a unique and personalised light silhouette in your home.

change over time as well, as to ensure it is also Emotionally Durable.

Reflection on the EDD Designs Produced

Analysis of the concepts revealed two Important points for reflection:

- The concepts at this stage mainly attempt to mitigate issues surrounding the psychological extension of the object, but do not address the physical extension directly.

- Will these design strategies used in the concepts actually encourage people to use and/or keep these lights for longer?

Addressing the first, perhaps a challenge to be tackled in development, but it does ask a larger question of the framework of whether it adequately incorporates 'sustainability' or Circular thinking in its execution.
This led to a further reflection which revealed that all the strategies fell into two categories: Those that meet ONLY the psychological extension and those that do BOTH.

Strategies that address BOTH:

- Use Artefacts with Existing Stories
- Use Time & Eco Appropriate Materials
- User Can Tend To, Fix or Maintain The Product
- Ensure Quality, Durability & Reliability
- Think Open & Transparent
- Promote Reflection of Use
- Show Progression
- Design for Multiple Users
- Design For Variability & Modularity
- How Can It Transform
- Ensure Participation With Creative Activities
- Labour Leads To Love
- Celebrate Imperfection
- Think Ageing Gracefully

The strategies that do both we propose provide the greatest an opportunity for the product to be 'Emotionally Durable' and should be considered first. However, the remaining strategies should not be dismissed as they complement those described above, providing the rich, experiential fabric of the interaction.
The next steps for framework are to further test and explore the strategies and themes to uncover which might be more applicable to lighting concepts and Product Service Innovation.

Future Work and Limitations

To address the second point of reflection, research in this field has mainly been conducted retrospectively, asking these questions of objects that have already been kept, loved, cherished but few have been conducted using it as a driver for design; Tokaya, (2013) and Van Krieken, (2011) conducted user studies, but over a short time period with prototyped concepts. Further research is currently being conducted to examine whether these strategies can encourage users to keep objects for longer, explored through extreme use cases. However, long term research from design, development to user testing would be the next ideal step for the theory of Emotional Durable Design to be further realised.

Conclusions

These findings further support and build upon the work concluded by (Chapman, 2008; Schifferstein & Zwartkruis-Pelgrim, 2008; Mugge, 2007; Van Krieken, 2011; Van Nes & Cramer 2005). But what is different about this framework is its ability to comprehensively encapsulate and consolidate both the sustainability and emotion centered perspective at a design concept level. The 9 themes along with the 38 strategies provide an extensive guide for designers to inspire and identify what makes an Emotionally Durable product. Furthermore, the process and findings further validate the theory of Emotional Durability by demonstrating that the key principles outlined by Chapman, (2005) are present within objects that are kept and cared for but that these drivers can also be translated into actionable design directions.

Figure 9. Home-li, inspired by CONSCIOUSNESS. An interactive light board that helps house mates and family members to communicate through light and colour. Once the key fob is removed the light slowly fades away indicating the passing of time.

Figure 10 - Lumi, inspired by EVOLVE. A modular lighting system that helps you to build memories by capturing images from your phone to create a bespoke collage of light that changes and grows with you.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-161

The circular economy fashion communication canvas

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Keywords
Fashion
Textiles
Upcycling
Sustainability
Communication
Circular Economy
Marketing

Abstract

Current design thinking focuses on incremental improvements to a linear system in which products are designed, produced and eventually disposed of. This continued consumption has resulted in over 1 million tonnes of discarded clothing and textiles entering into landfill each year in the UK alone. The effect of this high volume of waste is not only the loss of embodied energy and value, as re-useable items are disposed of, but continued environmental degradation through greenhouse gas emissions, toxic pollution and rapidly declining landfill space. As much as 70% of textile waste in the UK is sent to landfill or incineration from municipal waste collections. Whilst consumers are increasingly aware of the consequences of continued consumption, there is limited understanding of how to act more responsibly. Online sources of communication mean that although more information is available than ever before, confusion over terminology and the authenticity of messages can lead to in-action on the part of all stakeholders.

In order to investigate these problems key points at each stage in the fashion and textiles cycle were analysed using an exploratory sequential mixed methods approach combining case studies, semi-structured interviews and a consumer survey. Brands and designers working to create change by offering more conscientious product choices are struggling to connect with mainstream fashion consumers, hindered by a lack of industry acceptance and media coverage. Barriers to scaling up circular economy fashion strategies include a lack of market knowledge relating to consumers and the most effective promotional and retail strategies. These findings present significant evidence to guide the development of an effective fashion communication strategy for a circular economy.

Academic implications of the research include the identification of additional insights needed to establish more effective methods to communicate the economic, social and environmental benefits of textile reuse, recycling and upcycling to consumers and the fashion industry, leading to further research and contributions to knowledge. Practical implications include key contributions to the development of an operational framework to integrate circular economy fashion strategies into mainstream production and retailing. Originality lies in determining the existing practices already employed in this sector of the fashion industry and examining their effectiveness against the mainstream, in order to more effectively communicate to the benefits of sustainable, circular consumption in an industry which has so far thrived on linear consumption, novelty and obsolescence. In this way, marketing strategies can be developed for circular economy fashion which emphasise longevity, product lifetime optimisation, new forms of consumption and user experiences in a circular economy. The circular economy communication canvas serves a purpose to facilitate positive decision making for all stakeholders.

Introduction and Background

The fashion industry represents a vibrant multi-billion dollar global industry with international job opportunities at multiple levels. The industry faces significant challenges relating to environmental protection, workforce ethics and new technology, bringing a changing perspective to employment and current practices. (Jeffrey & Evans, 2011). It is stated that 'The fashion industry with its complex supply chains has, in several well publicised cases, been shown to be wanting in its treatment of workers, and much work is needed to rectify endemic practices' (Black & Anderson, 2010). Nordas (2004) acknowledges that the clothing and textiles supply chain can be seen as a number of discrete activities, but highlights that it is increasingly organised as an integrated production network, from the sourcing of raw materials via design and production to distribution and marketing. From an examination of supply chain management theories by Hines (2005), we can conclude that a supply chain can be viewed as an interconnected network of organisations and business functions, including retail buyers and suppliers. Each part works to integrate the flow of materials and information towards providing the products and services demanded by consumers. Jeffrey and Evans (2011) describe how the global supply chain is in a constant state of flux, and encompasses existing key players, along with emerging markets.

Farrer (2011) also illustrates the complexity of existing fashion supply chains, commencing with fibre processing, through textile manufacture, garment assembly, distribution, sales and eventual disposal. The challenge is to alter this model to include sustainable practice but also maintain profitability. Processes in the flow could in fact be more localised, but are usually global, and the use phase and disposal are seen as end points, rather than stages in a cycle. A sustainable fashion system is one which reduces negative triple bottom line impacts to the environment, society and economy (Elkington, 2004). The organisation of production in terms of materials use has increasingly come under scrutiny (Livesey & Thompson, 2013). The 'take-make-use-dispose' linear economic model has been called into question in terms of resource efficiency and negative effects along the material chain. A key concept which has been put forward to mitigate the risks associated with this linear model is the circular economy. In the UK WRAP (2010) has outlined a set of actions which relate to the sustainability of clothing and textiles in the circular economy. Through the Sustainable Clothing Action Plan (SCAP), WRAP's main actions to reduce the waste, water and carbon footprints of clothing include research into lower impact fibres, design for longevity and lower impact, supply chain efficiency and consumer information on use phase, garment care practices and recycling.

Solomon and Rabolt (2004) describe how fashion communication is often visual or non-verbal, and can include impersonal sources such as the media (magazines and websites) and personal sources such as friends and family, or people encountered on the street. Communication comprises of the sender, message, channel, receiver and feedback to the sender. In terms of fashion communication this can take the form of more formalised marketing messages, which must consider; who the message is for, how the message should be constructed, what it is about, where the message will be transmitted, why it is relevant to the targeted consumers and when should it be delivered (Moore, 2012; Solomon & Rabolt, 2004). Schneider (2014) highlights that communicating sustainability to mainstream consumers who care more about product design and personal benefits must take a different approach than strategies to communicate with those habitually choosing to purchase ethical fashion. Mainstream fashion consumers often exhibit little concern for responsible consumption choices, as unlike food, unethical garment choices are not perceived to have detrimental health effects (Chan & Wong, 2012). Consumers actively seek out low cost fashion, as price is a major determinant in purchase decisions (Joergens, 2006; Pookulangara & Shephard, 2013). Mainstream consumers are reported to be driven by fun, simplicity, achievability, visibility, success, social status and esteem, as well as rewards and recognition. They follow fashion and trends, embrace consumption and always seek the best solution to improve their lives. To appeal to these customers, sustainable fashion brands must be aware of these influences and how they can be incorporated into a successful communication strategy (Schneider, 2014).

The aim of communication in circular economy fashion is to create more conscientious consumption patterns, moving away from high turnover retail models which put unreasonable pressure on manufacturers to cut corners and overlook worker safety (Sharma & Hall, 2010). Conscientious consumption operates within a sustainable fashion system, and is defined by attitudes and behaviours driven by reducing triple bottom line impacts which result from buying, use, maintenance and disposal of products. Key practices include seeking sustainable alternatives, low impact care options and responsible divestment of unwanted items (Eder-Hansen et al., 2012). Goworek et al. (2012) assert that there is a 'values-action' gap between consumers expressed intentions of ethically motivated purchasing and the translation into actual behaviour. Consumers require information to be broadcast in a clear, coherent and appealing manner, to inform decisions on sustainable fashion purchasing. However, media messages often focus on negative environmental impacts rather than positive developments in sustainable fashion practice, and the breadth and variety of media sources can present conflicting and in-authentic messages which result in confusion and consumer scepticism (Gam & Banning, 2011; Ha-Brookshire & Norum, 2011; Sheth, Sethia, & Srinivas, 2010; Zane, Irwin, & Reczek, 2015). Consumer perceptions within the context of sustainable fashion have been widely researched, yet current research lacks an understanding of how organisations that are producing sustainable fashion not only communicate their message to their audience, but also analyse how their consumers perceive their messages. This research addresses this gap by investigating how sustainable fashion brands understand their consumers' perceptions of sustainable fashion.

Methodology

In order to investigate these problems key points at each stage in the fashion and textiles cycle were analysed using an exploratory sequential mixed methods approach combining case studies, semi-structured interviews and a consumer survey. The practices of those collecting, sorting and grading post-consumer textiles, and those working within circular economy fashion to maximise the reuse and revaluation of such materials through their design practice, were analysed through semi-structured interviews, structured observation and process mapping. An online survey questionnaire evaluated how current consumer attitudes and behaviours would impact upon a circular economy fashion system, assessing how demographic categories define the way individuals view their own practice as consumers, users and eventual disposers. Primary data collection was conducted in four phases using an exploratory sequential mixed method design, in which initial qualitative data collection and analysis informed subsequent quantitative data collection and analysis. (Creswell, 2014). In Research Phase 1, a review of literature on textile collection and fashion upcycling highlighted the interconnected nature of a closed-loop system and identified areas worthy of further investigation regarding processing, design practice and communication. Following the review of literature in Research Phase 1; textile collection and circular economy fashion case studies were conducted on Research Phases 2 and 3. Analysis of the qualitative data from Research Phases 1, 2 and 3 informed the quantitative data collection in the consumer survey of Phase 4. In Research Phase 5, findings and analysis contributed to the formation of a communication strategy for circular economy fashion.

To analyse the current practices of post-consumer textile collectors, three case studies of exemplifying textile collection firms were carried out during Research Phase 2. Semi-structured interviews with key informants from the waste textile management industry, structured observation and process modelling further documented sorting and grading activities and key themes within the industry. To analyse the current practice in circular economy fashion design and communication strategies during Research Phase 3, eight ethical fashion brands and five expert stakeholders were identified as individual cases for this stage of the research. Semi-structured interviews identified how the brands currently communicated their ethos to their consumers, what information it was important to know about consumers and areas in which they felt more understanding was needed. Expert stakeholders additionally informed the research by providing a range of insights into the current issues faced by the ethical fashion industry. Where applicable, designers also gave insights into their employment of a circular economy fashion design process and how this related to their communication strategy.

To evaluate how consumer attitudes and behaviours impact on a sustainable fashion system, qualitative insights from informants in Research Phases 2 and 3 of the study established gaps in stakeholders' consumer knowledge and indicated which lines of inquiry to pursue through quantitative investigation, in line with the exploratory sequential mixed method approach utilised. Along with critical areas highlighted through literature this further contributed to the development of a survey questionnaire during Phase 4. Areas of focus were fashion shopping behaviour; garment use and divestment; fashion influences and information; outlook on fashion consumption and ethics. A sample of consumers with an interest in fashion shopping was made available through internet based social networks and the survey was distributed through online snowball sampling. To develop an effective fashion communication strategy for a circular economy, data derived from Research Phases 1, 2, 3 and 4 (literature review, case studies, interviews and consumer survey) were synthesised and analysed in order develop a circular economy fashion communication canvas, outlining the necessary requirements to effectively connect with consumers regarding sustainable fashion consumption and behaviour change.

Results and Analysis

Empirical evidence from the textile collection case studies, key informant interviews and consumer survey, plus key insights from literature regarding fashion communication, the circular economy and sustainable fashion were synthesised to establish an effective communication strategy for circular economy fashion. Thematic analysis revealed eight key elements deemed necessary for effective fashion communication and circular economy best practice which would facilitate positive decision making for all stakeholders, as shown in Figure 1. The Circular Economy Fashion Communication Canvas (Han, Henninger, Apeagyei, & Tyler, 2017).

Market research

Many small and micro enterprises in circular economy fashion investigated lacked the financial resources necessary for commercial market research, creating a limiting factor at this crucial stage. In order to bypass

THE CIRCULAR ECONOMY FASHION COMMUNICATION CANVAS	
MARKET RESEARCH Industry trends, competitor analysis, current issues in industry, market research	**TARGET AUDIENCE** Clear consumer profile (e.g. age, occupation, income, interests)
COHERENT VALUES Core values must be clearly communicated and followed through across the supply chain	**VISUALLY ENGAGING** Use of creative, short, unique text, images and symbols
CLEAR MESSAGE What is the brand ethos? Key values? Key attributes?	**MULTICHANNEL** Reaching a wide audience by combining online and offline channels
COMPELLING PRODUCTS Unique pieces that attract consumers to buy into the slow-fashion movement	**FEEDBACK LOOPS** Creating feedback loops, which incorporate suggestions from stakeholders across the supply chain

Figure 1. The Circular Economy Fashion Communication Canvas - Adapted from Han, Henninger, Apeagyei, & Tyler (2017)

this barrier, collaborating with larger organisations and academic institutions allows brands to access market intelligence and strategic planning resources to gather more information about their target audience, creating open and effective communication and assisting positive developments into the industry as a whole.

Target audience

Identification of a clear customer profile in terms of age, preferences, lifestyle choices and motivations will enable those working within circular economy fashion and textiles to target their communications to the right people. In order to appeal to younger individuals it will be necessary for circular fashion to be integrated and adopted alongside mainstream and high street fashion, both online and in stores.

Clear message

A clear message communicates the company ethos and the key values and attributes this embodies. Blanco-Velo et al. (2010) have shown that consumer understanding of ethical fashion messages is often hindered by overlapping and contradictory messages and statements. Circular economy fashion brands need to communicate a clear, authentic message about their supply chain transparency to ensure trust, participation and loyalty.

Multichannel

Multichannel message has the advantage of reaching a wide audience by combining online and offline channels. Survey respondents indicated preferences for online channels such as websites and social media, print media such as newspapers and magazines and through social interaction, either online through social networks, or in person such as shopping with friends or talking with friends and family.

Coherent values

For companies and brands operating within circular economy fashion, core values must be clearly communicated and followed through across the supply chain. Results of the consumer survey indicated that consumers expect ethical choices to be made on their behalf by the retailers and brands they buy from. These actions and values must always be clearly communicated in circular economy fashion to keep all individuals involved and engaged.

Visually engaging

Circular economy fashion messages should ideally be short, creative and image led with unique text, images and symbols. Brands and designers interviewed created design led, fashion forward garments, modelled in styled images and product shots. Connecting with consumers through aesthetics is vitally important in order to create a platform on which to engage individuals on the sustainable credentials and human stories regarding garment workers and the fashion industry, however this must be supported by the ability for brands to create well researched and targeted communications.

Compelling products

Circular economy fashion often benefits from a design led approach which creates unique pieces that attract consumers to buy into the slow-fashion movement. Fashion design informants expressed that establishing attractive designs would enable sales, followed by consumer understanding of the terms, care practices and provenance related to sustainable fashion offerings and that this in turn would add to the confidence of customers in making further purchases. Circular economy fashion must create compelling products that are able to compete with the style and design, as well the prices of the high street.

Feedback loops

Feedback loops enable communication messages to travel both ways between all stakeholders operating in circular economy fashion system, from brands and companies to individuals and consumers. Results indicated that social media presented opportunities for feedback from consumers, allowing individuals to express opinions and reactions towards new products, traceability, production information and the message communicated. Feedback loops in the form of in-store or postal take back schemes for unwanted items present an additional way for consumers to participate in good practice, and by offering full circularity to consumers, brands are able to communicate a commitment to diverting waste. Circular economy fashion should make use of each opportunity to offer greater circularity in fashion and textiles, through physical and virtual feedback loops relating to products, information and social interaction in order to stay up to date with and fully understand the needs of all stakeholders.

Conclusions

For effective communication, messages should be under-pinned by relevant market research to identify the intended audience and most effective forms of transmission. Short, creative messages, delivered through a wide variety of media, often using highly engaging visual or non-verbal forms target the predetermined audience. In mainstream and value fashion, promotional messages encourage hyper-consumption through a high turnover of new product lines. For sustainable and circular economy fashion, a paradoxical challenge arises in conveying a message, which aims to reduce consumption impacts and change consumer behaviour, yet also sell more products at the right price for the target market.

Results and analysis established communication as an essential moderator regarding sustainable behaviours and practice. Therefore, an effective communication strategy for circular economy fashion and textiles was developed to detail the essential elements for engaging stakeholders in collaborative best practice. To facilitate positive decision making the strategy for communication requires relevant market research to identify the target audience. A clear, multi-channel message should be communicated to the identified audience, with visual appeal and a compelling value proposition backed up by coherent values. Feedback loops for two-way dialogue between each part of the circular fashion and textiles system are necessary to facilitate clarity, understanding and engagement between stakeholders.

Circular economy fashion communication aims to nurture relationships between consumers and producers and encourage responsible consumption choices which make use of products designed with long-lasting value and enduring style. Personal creativity is emphasised, in which non-purchase related lifestyle choices offer greater versatility, inventiveness and personalisation through practices such as mending, customising and swapping. It is in this departure of intended outcomes where mainstream strategies and those of the circular economy deviate. The operation of circular economy fashion is carried out with lower TBL impact, but this must still be combined with a message of compelling presentation of well-designed and desirable products. Information about company supply chains, ethics, and sustainability ethos must be communicated in a clear and coherent manner as an integral part of each brands' communication strategy, in a way which connects and is relevant to consumers.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-166

Sustainability Cards: design for longevity

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Keywords
Product Longevity
Design Cards
Sustainability
Fashion Design Practice
Industry collaboration

Abstract
Product longevity is considered widely as a relevant strategic approach, amongst many, within the field of sustainability. Yet, how to design for increased product lifetime may not be so obvious for practitioners. The complexity of the surrounding issues can constitute a barrier for designers and companies, in terms of adopting and implementing the approach in the design process. This paper explores whether, and possibly how, the 'design card' format (i.e. method card or alike), can be a way to support dissemination, application and communication of knowledge related to the notion of product longevity for designers and other stakeholders in the design process. The paper is based on a developmental project carried out in the Autumn 2017, within a larger research and collaboration project between raw fur manufacturer Kopenhagen Fur and Design School Kolding investigating sustainability perspectives. The paper describes the development of a deck of sustainability cards aiming for product longevity and presents the final deck. Furthermore, the paper contributes with insights on how designers may apply design cards in the design process and how this practice can further sustainable considerations and strategies in terms of product longevity. As the paper builds on a single case study and is situated within a single discipline (fashion and apparel), the outcome should be considered as tentative indications of future potential.

Introduction

To design for product longevity seems an obvious place to start, if we are to reduce our use of resources and further a more sustainable production and consumption. Yet, the question of how to design for increased product lifetime may not be entirely clear for the uninitiated, as the manifold terms and strategies can seem overwhelming and difficult to penetrate. Furthermore, it has been found, that multiple competences must be developed; normative, interpersonal, systemic, anticipatory and strategic, in order to understand and work with the concept of sustainability (Wiek et al. 2011). The sheer complexity can pose a strong barrier, in terms of designers' engagement, for those without formal training on sustainability. The deck of design approach cards presented in this paper are intended as a navigation tool to inspire designers and other actors in the design process to work with longevity as a sustainable strategy. They have been developed specifically with the aim to influence and extend product lifetime in order to reduce environmental impact. The question we investigate is how the development and application of design cards might, or might not, further designers' understanding of - and ability to design for - extended product lifetime?

Background

The background for this paper is a research project carried out between raw fur supplier and auction house Kopenhagen Fur (DK) and Design School Kolding (DK) between August 2014 and March 2016 (Skjold et al. 2016). The study comprised four different research perspective on fur and sustainability: cultural heritage, material processes, design approaches and user practices. A main finding of the project, across perspectives, is the long-lasting quality of the fur material, which potentially could be developed strategically through design thinking in relation to sustainability. As a consequence, a present follow-on project, conducted with two fashion designers August – December 2016, looked at ways to approach sustainability through the perspective of product lifetime in design practice and if and how design method cards in particular could be a useful tool for designers and organisations.

We will in the following clarify the theoretical foundation, on which the cards are build and describe the methodology involved in prototyping, testing, evaluating and adjusting the deck. Thereafter we present the resulting cards and emerging findings. Lastly, we offer some reflections on the process and outcome. As this paper builds on a single case and that both participants are fashion designers, any outcome must be viewed as tentative, in terms of generalizability.

Theoretical Framework

We have employed a three-fold theoretical base in the research and development of the cards. In order to understand, on a meta-level, how enhanced product lifetime is situated within the larger theoretical field of design and sustainability, we draw specifically on an evolutionary framework (Ceschin & Gaziulusoy, 2016). The framework offers an overview of the development taking place between 1990-2010 regarding ways in which sustainability is perceived and approached. The development is characterized by an increased understanding of the many complex and interacting issues that must be taken into consideration, in order to obtain a real and lasting impact from an initial focus on the product level, to a product service system level, then a spatio-social level, and finally a socio-technical level (Ibid.: 144). Enhanced product lifetime can bear relevance at all levels, but considering the general scope of designer influence, perhaps in particular at the product and product service systems levels.

Furthermore, the framework builds on two dimensions that describe issues on a technology-people scale and an insular-systemic scale. The framework is thereby in line with former and present developments within this domain as proposed by Bhamra and Lofthouse (2007), Keitsch (2015), Lilley (2009), Manzini (1989, 1995, 2015), Vezzoli and Manzini (2008), Vezzoli et al. (2014) among many others.

Secondly, we have grounded the work in literature that specifically addresses extended/optimized lifetime and product longevity broadly (Bakker, den Hollander, van Hinte, & Zijlstra, 2014; Cooper, 2010), as well as the emotional, (Chapman, 2009; Fletcher, 2016) functional (Clark, 2008; Gwilt, 2015; Niinimäki, 2013) and technical domains (Callister, 2006; Hatch, 1993), with product and garment design in mind.

Lastly, to sustain our choice of the card format, we lean on knowledge on methods use (Badke-Schaub et al., 2011; Roozenburg & Eekels, 1995; van Boeijen et al. 2013) and on the practice of using cards in the context of design processes in and with organisations (IDEO, 2003; Laboratory for Sustainability, 2015). The participating designers will be faced with new situations and challenges. In our institution, we have a long experience with using training cards, such as inspirational, methods or process cards, as tools to promote active learning in non-routine situations. Here they have shown to help making things concrete and outline relevant topics (Friis & Gelting, 2014, 2016). Furthermore, 'game pieces' can speed up the process and create common ground when working in teams (Hornecker, 2014).

Methodology

The overall project was carried out as two intertwined strands. On the one hand, two fashion designers were employed to develop fur designs from design briefs centered on product longevity. Parallel in time, we, the authors, developed the deck of cards in a process that played out in four stages.

During August 2016, a prototype deck of cards was developed, by merging recommendations on how to drive fur product longevity through design (Skjold et al., 2016), with existing knowledge obtained in the literature presented above. This work was carried out in an iterative process of mapping, grouping, visualizing and writing the content (see figure 1 and 2).

We presented the cards to the two participant designers primo September 2016 at a bigger project meeting taking place at Design School Kolding (see figure 3). The objective was to introduce the deck, in order for the designers to be able to use it in their design process and communication of ideas. At this initial presentation of the cards, we were able to receive immediate responses and questions to the visual layout and the cards' general 'readability', which furthered our precision regarding the various card elements.

Figure 1. Mapping approaches from existing collections of cards.

Figure 2. Mapping approaches in a Design for Longevity Compass.

Figure 3. Discussing the deck of cards with two designers collaborating with Kopenhagen Fur.

Figure 4. Example of cards in use.

In the third stage from September – November 2016, we followed the two designers collaborating with Kopenhagen Fur, during the design developments (see figure 4). In order to gain insights on how the deck of cards was perceived and possibly adopted, we have engaged in informal conversations and used ethnographic observations (Crouch & Pearce, 2012; Denzin, 2003), as well as conducted semi-structured interviews (Kvale & Brinkman, 2008) during and after design completion. Furthermore, we have presented and received feedback on the prototype deck broadly within the Kopenhagen Fur organisation.

In the final stage, December 2016 – February 2017, we have iteratively adjusted the deck in terms of content and visual structure, in line with participant feedback. Lastly, in order to test the general understanding of the cards on a larger group of people, we have obtained feedback from colleagues, students, external stakeholders and research networks.

The Deck of cards

The final deck comprises 29 cards, each informing on, and describing an approach to product longevity. On one side of the card, there is a visual compass (see figure 5) showing how the individual card links to three overall approaches to design for longevity defined as:

- Technical lifetime i.e. the length of time a product stays in use before it breaks or wears out
- Functional lifetime i.e. the length of time a product stays in use before its functionality no longer meets the user's expectations or needs and
- Emotional lifetime i.e. the length of time a product stays in use before the user stops having any emotional attachment to it.

In combination with the longevity compass, each card, i.e. approach to product longevity, is related to six sub-categories represented by visual icons (see figure 6). To work across the product lifecycle, each card is linked to between one and four categories.

- Material relates to aspects concerning raw materials.
- Production relates to aspects concerning production.
- Transport and Retail relate to logistic and handling aspects.
- Practice and Use relate to aspects in use.
- Recovery relates to the recovery, reuse or recycling of a product in post-use.
- Design and Concept relate to aspects in the design.

The other side of each card presents the user with information on the specific approach, including descriptions of what the approach is about, why it is useful, particular challenges, real life examples, links to other approaches and further reading. A card example is shown in figure 7.

The result represents a concluded first phase aimed at professional design practice in companies and organisations, here specifically designers of fur. The second phase of the project, to be conducted in the spring 2017, has addressed the development of cards for design education.

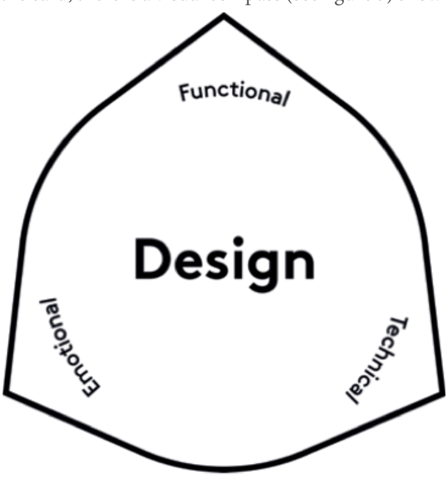

Figure 5. The Design for Longevity Compass.

Figure 6. The six Design for Longevity categories: Material, Production, Transport and Retail, Practice and Use, Recovery, and Design and Concept in relation to a product life cycle.

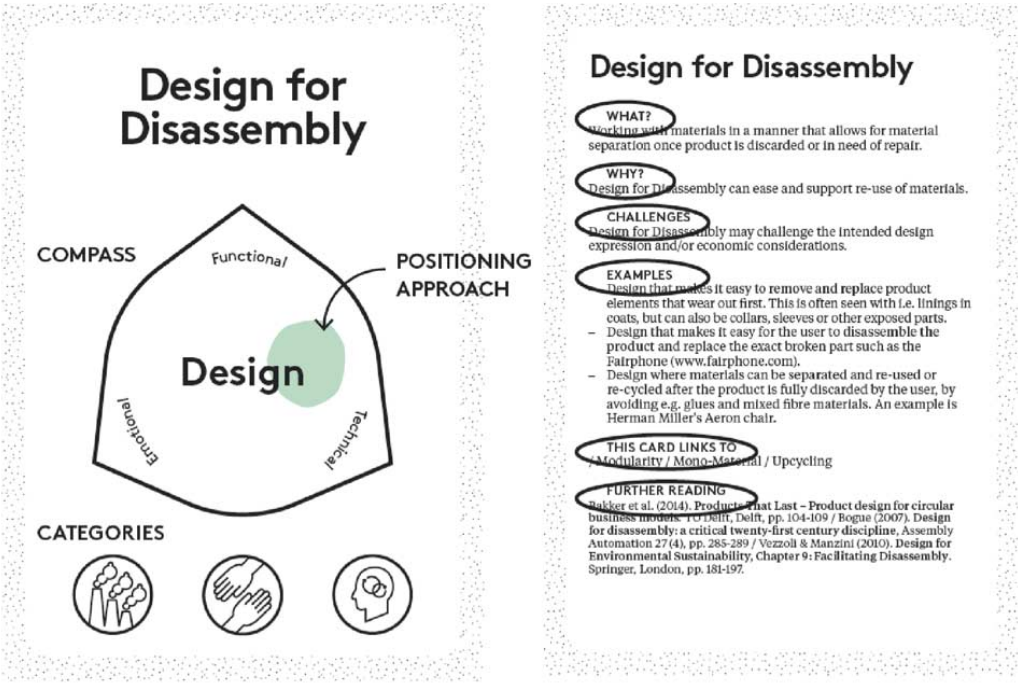

Figure 7. An example of a card for the approach 'Design for Disassembly' with a graphics side (left) and an information side (right).

The cards in use

The two designers came to the project with different backgrounds. Designer A graduated from Design School Kolding in 2010 within menswear, and has since worked in small and medium sized fashion companies in Denmark.

Designer B holds a BA from Central Saint Martins, 2004, and a MA from Royal College of Art, 2007. After working for big international fashion brands, she formed her own company, doing consultancy work.

The designers' initial response to the deck, and the subsequent implementation of the deck in their design processes differed to a high degree. Designer A showed openness towards the deck as a design tool, and engaged from the early stages with the cards as well as she up kept a dialogue with us on their use. Based on her experience, she saw the cards as a useful way for fashion designers, to understand different approaches to product longevity, to identify relevant approaches for specific contexts and to work with them in the design process, both prescriptive and descriptive. She furthermore saw a potential in the deck, as a tool used by design teams and company organisations to further dialogue on sustainability strategies.

Designer B expressed a rather more skeptical point of view towards the deck, which she saw as an unwelcome creative interference – something that would limit her own idea development and creative conceptualization. Therefore, her interaction with the deck throughout the design process was limited. She was also more doubtful of the cards as a means for dialogue in teams and within companies, as dialogue in her experience, does not take place between the different levels in hierarchical structures of fashion brands, where designers are seldom represented at the strategic top level. Yet, what we could observe, was that the cards where used by other participants in the project, to understand how her design embedded approaches to product longevity, and they were in this respect applied as a dialogue tool after all.

With regard to the company, they broadly found that the cards functioned as a way for them to understand themselves, within the organization, and to disseminate to external stakeholders, how the designers had implemented approaches to product longevity in the design process and how the finished designs could be articulated as supporting sustainability through enhanced product lifetime. I.e. the cards became a way to break down some of the complexity surrounding the notion of sustainability by making it more concrete.

These findings are strongly in line with the keynote presentation recently made by Prof. Manzini at the Cumulus Conference in June 2017. Here he argued that in order to work with the complexity of sustainable development, we need to make things tangible by simplifying this complexity, and we need to conduct experiments in semi-safe spaces that can be dispersed to embrace larger groups of actors.

Reflections

The above findings could indicate, that the practice of using cards in a design process, to some extend depends on educational background and previous work experiences. Designer A had been exposed to design cards during her studies, and was therefore familiar with their different use possibilities, whereas designer B had no previous experience with cards as a design process tool. What is also noteworthy, is that designer A had an articulated interest in creating sustainable change in the industry, whereas designer B was introduced to sustainability thinking through the design brief and during the project period. In a way, the two designers seemed to represent the ongoing dichotomized stance towards design methodology i.e. either pro methods, because methods form the basics of how we conduct design, from which improvisation and excellence can spring (e.g. Cross, 2011; Hallnäs, 2009), or contra methods, because they are seen to be to prescriptive, limiting to creativity and projecting a false understanding of design as something that can be done by recipe (e.g. Alexander, 1971; Jones, 1977). Interestingly, the stakeholders surrounding the project within the company, approached the cards from a neutral ground with regard to design traditions, and basically made use of them to dissect what was going on in the designs, from a sustainability perspective.

Conclusions

We have asked how the development and application of design cards might, or might not, further designers' understanding of - and ability to design for - extended product lifetime?

Based on the findings we conclude that the deck of 29 cards can be used in multiple ways by designers when developing design for longevity. Although type and depth of application seems to be influenced by designers' prior experience of using tools such as cards, and hence educational background and tradition, the paper shows that the cards can be a way to inspire the early stages of a design process in brainstorming sessions as well as a frame for developing concepts. Furthermore, they can be a way to mediate knowledge and values in multidisciplinary teams, through discussion of knowledge and values that relate to the specific cards. Lastly, they can be seen as ways to reflect and create analytical awareness of own, as well as other companies' or designers' processes and products.

Further perspectives

As mentioned, the deck is currently in the process of being developed for education and thus a broader understanding of design, where after they will be tested in a teaching context. As for the Kopenhagen Fur, they have decided to use the cards this spring within their fur design course and accompanying design competition, and thus focus the student design brief on product longevity. Moreover, they have produced small video 'explainers' to be put on their website, that clarify the cards and how they can be applied for potentials interested parties. Lastly, the company have chosen to disseminate the cards to their collaboration partners. Hopefully this example can inspire other brands to engage with and apply research in their strategic work with sustainability.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-171

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Circular added value: business model design in the circular economy

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Keywords

Business models
Business model design
Circular economy
Circular business models
Sustainable business models

Abstract

The current linear production and consumption structures, which build upon the intensive use of natural resources and cheap energy, are crucial drivers for the rapid economic development in the last sixty years. Biodiversity loss, climate change, conversion of the planet earth´s surface and resource depletion force researchers, policy-makers, business representatives, and consumers to think about alternative economic approaches and lifestyles. The circular economy concept has recently attracted increased attention from academic, political, and economic institutions. The transformation to an economy characterized by cyclical and cascading usage of natural and physical capital requires disruptive and systemic innovations. On business level, integrated strategies consisting of sufficiency, consistency, and efficiency factors are needed to implement the idea of circularity in the architecture of enterprises. Business developers have to restructure value creation processes, dematerialize value propositions, rethink and demerge global supply chains or consider ecological and social aspects in their cost-benefit analyses. Currently, the most business modeling tools and methods do not consider characteristics that are crucial for designing circular business models. This study is built upon a five-step systematic literature review methodology, which focused on circular economy, conventional as well as circular business model literature. The insights gained from the extensive literature analyses were used to redefine the logic, composition, elements, and potential element attributes of the Business Model Canvas in the context of circular economy.

Introduction

The current production and consumption patterns in the industrialized countries of the Global North as well as in some economically emerging countries have serious impacts on the interrelated ecosystems of planet earth. It is expected that the irreversible changes in ecosystems, triggered by anthropogenic emissions, will crucially influence the global food, water, and energy supply, which increases vulnerability of human beings (WBGU, 2014).

In the last forty years schools of thought such as Biomimicry (Benyus, 2002), Blue Economy (Pauli, 2010), Cradle to Cradle (Braungart & McDonough, 2003) or Performance Economy (Stahel & Reday-Mulvey, 1981) have been developed with the common basic objective to decarbonize and dematerialize economies. The circular economy concept combines the different schools of thought to construct a holistic approach for transforming economic and societal structures. It is an economic system characterized by the cyclical and cascading usage of natural and physical capital that aims to preserve natural resource stocks, while reducing greenhouse gas emissions and harmful pollutants for human health. Circular-oriented economies create new forms of innovative business models in order to enter emerging markets and enhance the competitiveness in current industry sectors (Ellen MacArthur Foundation, 2015). Integrated structures arise with organized networks consisting of collaborative production and consumption, which revolutionize the traditional producer-consumer relationships. Ultimately, the concept of circular economy decouples on the one hand economic progress from consumption of finite natural resources and on the other hand future prosperity from economic growth (Angrick, 2013; Schneidewind & Palzkill, 2012).

The transformation to a circular economy is a complex process involving fundamental changes in current production-consumption-systems. In particular, the company´s logic of creating, offering, and delivering value to one or several stakeholder groups will change substantially (Joustra et al., 2013; Lacy & Rutqvist, 2015). But which value activities of companies will be affected by the transformation to a circular economy? How are circular business models structured and designed? How can the value creation processes of companies be decoupled from the consumption of finite natural resources? Circular business model design methods and instruments provide opportunities for managers and business developers to design and reconstruct the value creation activities of their companies (Joustra et al., 2013; Lewandowski, 2016). They work as manual tools suitable for developing circular business model innovations and assist in integrating ecological, social, and economical factors simultaneously in the key elements of the companies.

Within the fast-growing literature of business models, Osterwalder & Pigneur conceptualized in 2010 a well-established and in practice prevalently used instrument for business model development (Upward & Jones, 2016; Weiner et al., 2010). The so-called Business Model Canvas (BMC) is a strategic management tool for describing, analyzing, designing, and communicating a companies' logic of earning money. It consists of nine interrelated elements that represent the most important aspects of a company (Osterwalder & Pigneur, 2010). However, the BMC builds upon the notion that financial value is the only dimension of value that will be considered and measured in a business model (Joyce & Paquin, 2016). The embedded motivating logic of the BMC is to generate and maximize profits for the enterprise (Upward & Jones, 2016). There is no explicit integration of the ecological and social dimensions of sustainable development as well as circular economy characteristics.

While numerous adaptions have been made to extend the BMC with sustainability and circularity factors (Antikainen & Valkokari, 2016; Dewulf, 2012; Hendriksen et al., 2012; Jonker, 2014; Joyce & Paquin, 2016; Lewandowski, 2016; Mentik, 2014; Upward & Jones, 2016), there is no structured extension of the BMC that integrates ecological, social, and economical sustainability dimensions as well as characteristics of circular business models simultaneously. Therefore, the research purpose was to develop a strategic management tool for designing and visualizing circular business models considering the three dimensions of sustainable development.

Research approach

The study pursued a theoretical-conceptual research approach, which focused on the analyses and critical examination of current conventional and circular business model literature. It builds on a rich body of literature to provide different concepts of sustainability and circularity, analyses of definitions and taxonomies of circular business models, systematic quality assessments of existing reference models for circular business model design on the basis of a detailed criteria set consisting of business model related aspects as well as circularity and sustainability factors. Furthermore, a meta-modeling language for business models has been developed to determine the element relationship structure of the examined reference models. The insights gained from the extensive literature analyses and reference model evaluations formed the basis of the conceptualized holistic circular business model design tool (Figure 1). This paper provides the synthesis about the central construct of circular business model as well as the overall description of the constructed holistic instrument for circular business model development without case example.

The study builds on a five-step systematic literature review methodology, which has been constructed for scientific research in the field of management and organization (Denyer & Tranfield, 2009). The academic databases EconBiz, Google Scholar, LIVIVO, Scopus and WISO were used for the literature search. The following five key assumptions were made to clearly define and to narrow the object of research: First, the business model is a central theoretical construct, more than a vogue expression. Second, business models are considered as a management construct e.g. to enable business transformations, to analyze and design the companies' architecture or to increase the effectiveness of innovations. Third, the literature streams of sustainable business models and

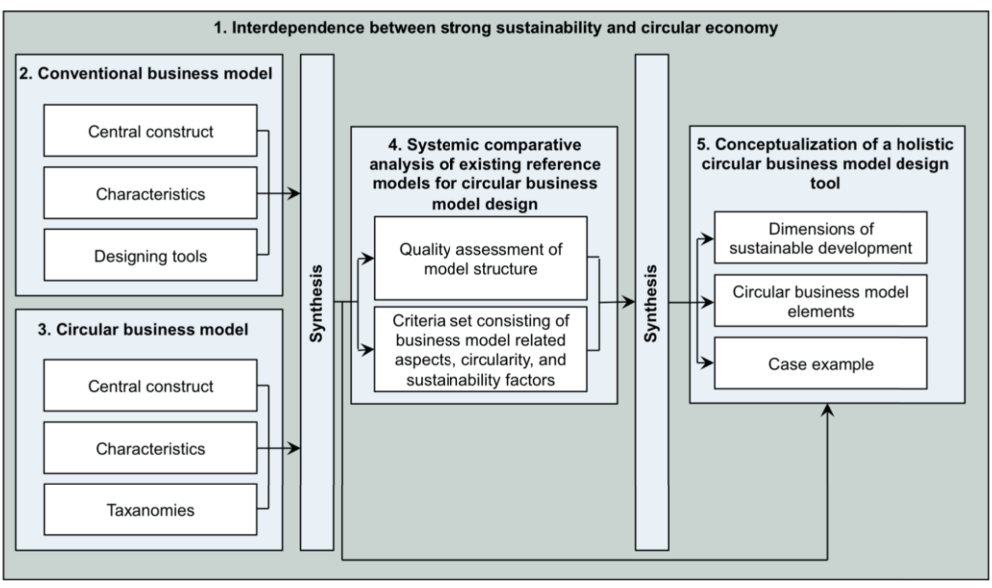

Figure 1. Structure of the study.

circular business models are closely related. Circular business models are regarded as a subcategory of sustainable business models. Fourth, the underlying definition of sustainability refers to the holistic concept of strong sustainability (Jackson 2009; Rogall, 2008; Steurer, 2001; BUND & Misereor, 1997; Daly, 1997). Therefore, circular business activities are perceived as important drivers to achieve the goals of strong sustainability.

From conventional business models to business models for the circular economy

A business model is a simplified and clearly structured representation of the mechanism of how an organization creates, offers, and delivers value to their potential customer segments through the conversion of scarce resources (Osterwalder & Pigneur, 2010; Teece, 2010; Magretta, 2002; Amit & Zott, 2001). It incorporates the most important interdependent components of an enterprise and allows expressing the companies' logic of earning money (Johnson et al., 2008; Skarzynski & Gibson, 2008; Osterwalder, 2004). Hence, the business model describes how the combination of key resources and key capabilities create a value proposition that defines the benefits offered to particular customer segments through a bundle of products and services (Lüdeke-Freund et al., 2016).

In academic literature exists a huge range of different conceptions, which and how many interrelated components and elements form and characterize a business model. Value proposition (value configuration), business infrastructure (key resources, key capabilities, key partners), customer segments (relationships and channels), and profit formula (revenue and cost structure) were the most mentioned business model elements in the reviewed literature (Doleski, 2014; Rusnjak, 2014; Gassmann et al., 2013; Schallmo, 2013; Bieger & Reinhold, 2011; Osterwalder & Pigneur, 2010; Teece, 2010; Johnson et al., 2008; Skarzynski & Gibson, 2008; Osterwalder, 2004). The main objective for business developer is to find a harmonious balance between the above-mentioned elements in order to establish a resilient and robust enterprise.

The different views and approaches in the conventional academic literature about business modeling have to be extended to consider the challenges of resource depletion, destruction of ecosystems, climate change or the increasing social oppression, injustice, and inequality. Instead of concentrating purely on profit maximization and market share extension, circular business model innovations focus on creating value for a broader range of stakeholder while pursuing eco- and social-effective business activities.

The design and interplay of the various business model elements changes fundamentally within a circular economy. Enterprises with circular business models are deeply involved in the product usage phase; they mainly generate revenues through provisioning product-service-systems instead of selling physical products; they offer used, refurbished or remanufactured modular products, which pass several usage cycles in order to grow the number of users that gain benefits from the same (modified) products; they rethink the classical producer-consumer-relationships, value creation activities and value propositions; ecological and social factors complement the overall business culture and philosophy (Bocken et al, 2016; Florin et al., 2015; Lacy & Rutqvist, 2015; Linder & Williander, 2015; Bakker et al., 2014; Tukker, 2004). Table 1 shows the differences between conventional and circular business models.

Based on the gained insights from the systematic literature review and the comparison of several circular business model taxonomies (Bocken et al., 2016; Florin et al. 2015;

	Conventional business models	Circular business models
Focus of value creation	Generating and maximizing financial profits.	Eco- and social-effectively business activities while generating stable financial profits.
Structure of value creation	Supply chains end with the consumers.	Circular supply chains.
Material input	Efficient use of fossil, critical, and finite resources. Use of biodegradable materials.	Absolute reduction in total use of fossil, critical, and finite resources through reuse, refurbishment, remanufacturing and/or recycling. Cascading use of biodegradable materials.
Ownership structure	Product use/consumption requires ownership. Selling products result in loss of control over the different types of invested capital (natural resources, labor etc.).	Access to products and services does not require ownership. Company retains ownership of the provided products.
Producer-consumer relationships	Strong collaboration with direct suppliers and customers in the supply chain. Traditional producer-consumer relationships.	Strong collaboration with all network partners in the circular supply chain. Networks of collaborative production and consumption arise.
Success measurement	Corporate success is measured in financial performance.	Corporate success is measured in balanced ecological, social and financial performance

Table 1. Characteristics of conventional and circular business models (adapted from Kooloos et al., 2016; Hieminga et al., 2015).

Lacy & Rutqvist, 2015; Planing, 2015; Bakker 2014), circular business model can be defined as follows:

A Circular business model describes the rationale of how an organization creates, offers, and delivers value through the structured linkage of various elements while minimizing ecological and social costs in order to achieve the goals of strong sustainability. Only the integration in a circular business network enables organizations to contribute to closing material and product loops.

Over the last decade, tools or rather reference models have been developed that can be used to visualize, analyze, design, and communicate the business model of an enterprise. Reference models are generalized models that represent a specific category of models with basic assumptions (Hars, 1994). One of the most well-known and widely used reference model for business model design in both academics and practice is the Business Model Canvas (BMC) (Upward & Jones, 2016; Weiner et al., 2010). It consists of nine interrelated elements: value proposition, customer segments, customer channels, customer relationships, key activities, key resources, key partners, cost structure, and revenue streams. However, the BMC builds upon the notion that financial profits and costs are the only essential dimension of business activities, which will be considered and measured in enterprises (Joyce & Paquin, 2016; Upward & Jones, 2016). Numerous adaptions have been made to extend the BMC with ecological and social (Joyce et al., 2016; Upward & Jones, 2016; Fichter & Tiemann, 2015; Dewulf, 2012; Doranova et al., 2012; Hendriksen et al., 2012; Bertens & Statema, 2011) as well as circularity aspects (Antikainen & Valkokari, 2016; Lewandowski, 2016; Mentik, 2014). A systematic comparative analysis of the three circular economy BMC extensions, including criteria set consisting of business modeling, sustainability, and circularity principles as well as quality assessment of the model structure, shows that there is lack of structured integration of both sustainability and circular economy characteristics.

C3 Business Model Canvas

The findings of the extensive systematic literature reviews and reference model analyses were used to redefine the logic, structure, elements, and possible element attributes of the BMC in the context of circular economy. The investigations form the basis for the construction of a management instrument for designing, describing, analyzing, and communicating circular business models by taking into account the ecological, social, and economical dimensions of sustainable development (Figure 2).

The name C3 Business Model Canvas (C3BMC) arises from the three pillars of the conceptualized reference

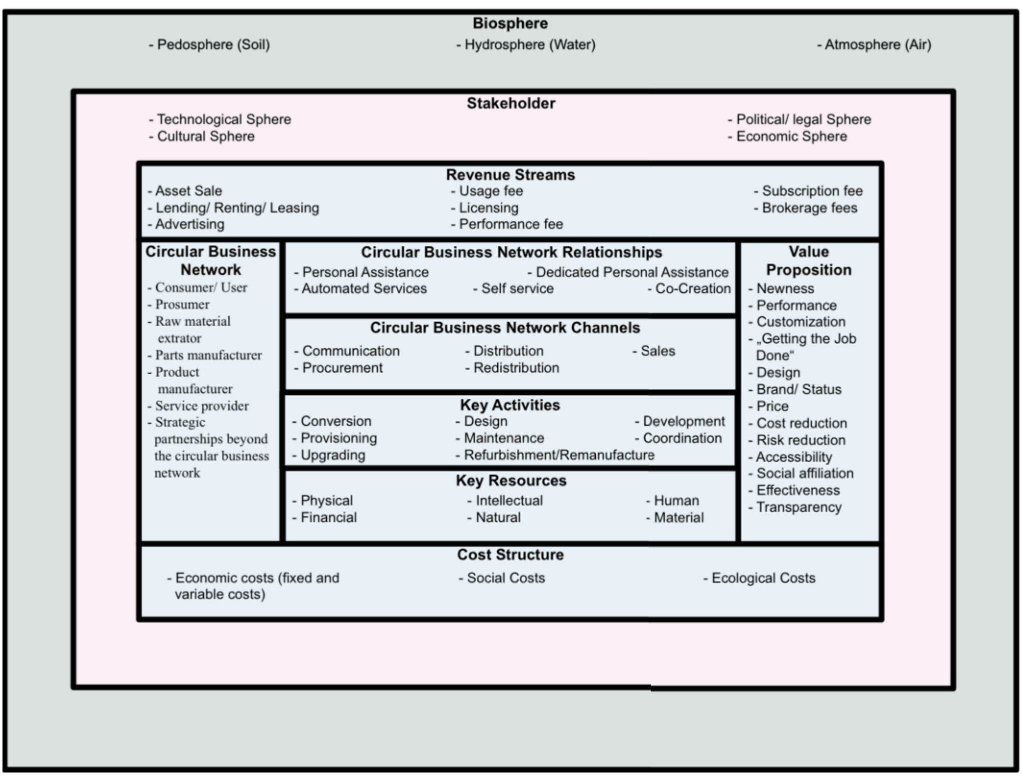

Figure 2. C3 Business Model Canvas

model for circular business model design. The "C" derived from the first letter of the word "circular" that represents the circular economy context. The superscript "3" stands for the three integrated ecological, social, and economic dimensions of sustainable development while the term "Business Model Canvas" refers to the conceptual roots of the reference model. The C3BMC follows the concept of strong sustainability, which means that biological diversity, the regenerative capabilities and resources of nature are essential prerequisites for human life, human development as well as establishing and maintaining social systems. Hence, protection and preservation of nature is the overarching objective of sustainability (Figure 3).

Permanent resource and information exchange processes with its business environment are essential attributes of enterprises. These exchange processes enable organizations to operate in society, to provide services and maintain or increase their market shares. Therefore, the different business environment spheres can be considered as crucial contexts for corporate activities (Rüegg-Stürm, 2002; Freeman & McVea, 2001; Figge & Schaltegger, 2000).

This means, business models need to adapt to changing business environment spheres for ensuring long-term existence of the firm. Hence, it is even more important that users of tools for business model design recognize how the specific business model elements interact with the environment and which stakeholders profoundly influence value creation processes. The consideration of the different habitats (pedosphere, hydrosphere, atmosphere) and social spheres (technological, cultural, political/ legal, economic) illustrates that the interrelated elements of the 'open system' organization are part of a much larger network rather than an independent self-standing entity.

The C3BMC surrounding building block "Biosphere" (ecological dimension) allows the tool user to document direct emissions to soil, water, and air of the drafted circular business model. The building block "Stakeholder" (social dimension) describes the network of various groups who engage in direct and indirect exchange processes with the business model.

The following eight circular business model elements of the C3BMC and their several attributes allow expressing the value creation architecture of circular oriented companies: Circular Business Network, Value Proposition, Circular Business Network Channels, Circular Business Network Relationships, Key Activities, Key Resources, Revenue Streams, and Cost Structure.

Conclusion and future research

The practical work with the C3 Business Model Canvas marks just the beginning of a profound transformation process in existing enterprises. Modifying conventional business models in order to maximize the degree of circularity might require a challenging and resource intensive process of change and adaption. To meet the requirements for a pervasive business, redesign a framework for management practice will be needed, which assists and supports the managers by achieving the pursued transformation. However, this kind of comprehensive approach does not exist in the current scientific discourse about circular business model innovations. A suitable management framework must combine different creativity techniques with analytical

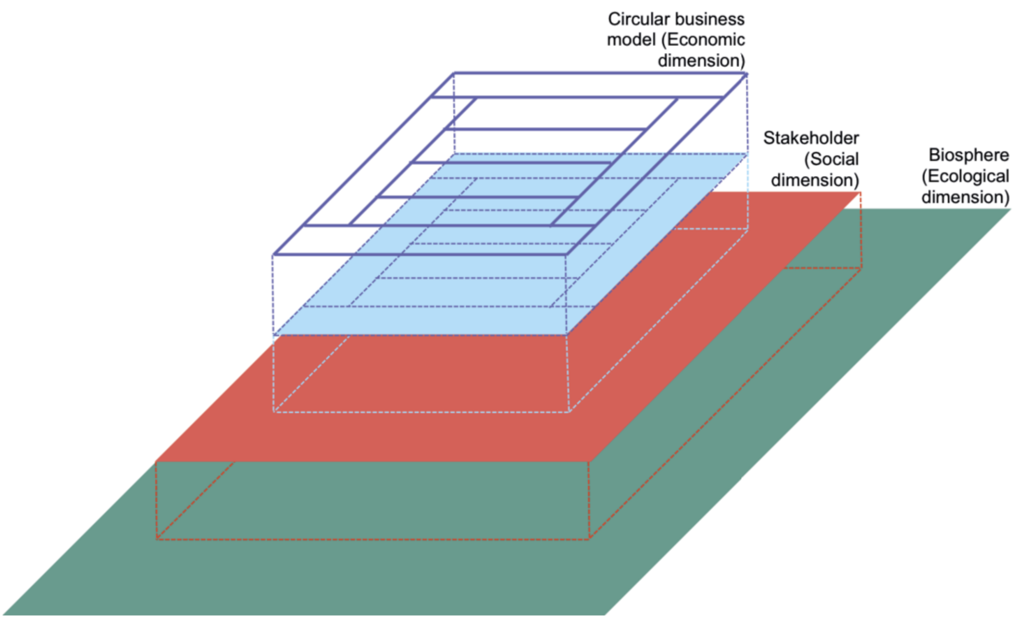

Figure 3. Context of the C3 Business Model Canvas

methods to provide a holistic systemic process to handle the complexity of business model transformations. Longitudinal studies could explore and determine the key phases and challenges of circular business model designing and restructuring progresses.

This study was based on systematic literature review, which implies two major limitations. First, it contains primarily literature related to the overall concept of circular economy. There is a much wider body of literature on sustainable business model innovations, especially literature related to each school of thought underlying the circular economy such as industrial ecology, sharing concepts, collaborative approaches, industrial symbiosis etc. Further research is required to combine, link and integrate these different fields of literature. The second limitation of this study is the lack of empirical evidence. Hence, further research could focus on empirical validation of the applicability of the conceptualized reference model for circular business models in general as well as in different business settings and industries.

The C3BMC presented in this paper contributes to the scientific discourse on circular economy at business level and supports practitioners with a tool to accelerate transformation processes for the achievement of environmental, social, and economic sustainability.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-178

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Sustainable consumption through product longevity: the influence of enhanced product lifetime information on purchasing electrical appliances among German consumers

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Keywords
Choice-based conjoint analysis
Electrical appliances
Product lifetime information
Product longevity
Sustainable consumption

Extended Abstract

Introduction

Sustainable consumption constitutes a key area of research and action for promoting change towards sustainable development (McCormick et al., 2016). According to a widely used definition, sustainable consumption involves "the use of services and related products which respond to basic needs and bring a better quality of life while minimising the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle so as not to jeopardise the needs of further generations" (Norwegian Ministry for the Environment, 1994). In order to reach sustainable consumption in terms of reduced overall resource consumption, changes in not only (energy) efficiency, but also in consumption levels and patterns are necessary. However, so far, strategies concerning the latter such as purchasing and producing fewer goods have received comparatively little support by consumers, businesses and politicians (Lorek and Fuchs, 2013). Correspondingly, the longevity or rather lifetime of products has hardly improved over time, despite its considerable potential in limiting resource depletion, emissions of pollutants and residual waste (Cooper, 2010). Consumers can exert considerable influence on product lifetime across the successive consumption stages of acquisition, use and disposal. Thus, they can already contribute to product longevity by deciding for the longer lasting product at purchase. As an experience attribute, a product's functional durability can, however, be hardly estimated by consumers before purchase (Darby and Karni, 1973; Nelson, 1970). Thus, consumers often have to draw on rather insufficient quality signals such as price or brand (see, e.g., Boyle and Lathrop, 2009; Brucks et al., 2000).

Over the past decades, consumer researchers have extensively examined purchase decisions, especially in the context of sustainable consumption (see, e.g., Thøgersen, 2000; Thøgersen et al., 2012; Thompson et al., 2010). Research on sustainable purchase behaviour incorporating the aspect of product longevity is, however, still in its infancy (Evans and Cooper, 2010). So far, academic and policy-related studies have consistently emphasized the necessity of enhanced product lifetime information for consumers and encouraged future research towards corresponding impact analyses on purchase behaviour (see, e.g., Cox et al., 2013; DEFRA, 2011; Guiltinan, 2009). Accordingly, first studies have examined the influence of such information and found an overall positive impact on the demand for longer lasting products (see, e.g., Braithwaite et al., 2015; EESC, 2016; Wilhelm, 2012). Nevertheless, there is a great need for deeper insights into this research field, specifically because previous studies have hardly considered the various determinants of purchase behaviour within one holistic model. Furthermore, the findings are limited to a few countries (excluding Germany) and product types. In general, sustainable consumption of electrical appliances constitutes an underdeveloped research field which has almost exclusively focused on the aspect of energy efficiency (McDonald et al., 2009; Prothero et al., 2011).

This study addresses several research gaps by developing and empirical testing a conceptual model for purchasing longer lasting electrical appliances in Germany. Hereby, a particular focus is laid on the influence of enhanced product lifetime information. Thus, the research questions are 'What are the determinants of purchasing longer lasting electrical appliances?' and 'How do enhanced product lifetime information influence purchase decisions towards electrical appliances?'

Conceptual Model and Methods

Similar to Nocella et al. (2012), this paper follows an interdisciplinary approach by combining the consumer theory of Lancaster (1966) with Ajzen's (1985) theory of planned behaviour. Lancaster's well-established economic model explains decision-making processes of consumers, also in the context of sustainable markets (see, e.g., Liao et al., 2013; Tabi et al., 2014). The theory claims that consumer preferences are not directed to the goods themselves, but to their attributes (Lancaster, 1966). As one of the most prominent social psychological models in research on sustainable consumption (see, e.g., Joshi and Rahman, 2015; Liobikienė et al., 2016), the theory of planned behaviour considers various psychological factors such as attitudes, social norms and perceived behavioural control (Ajzen, 1985). Based on a combined framework, major determinants of purchasing longer lasting electrical appliances will be identified against the backdrop of relevant literature.

The resulting conceptual model will be tested by using choice-based conjoint analysis, a highly effective multivariate method for measuring consumer preferences for product attributes (Louviere and Hensher, 1983). Thus, the influence of enhanced product lifetime information on consumer preferences for durability and other product attributes such price, brand or energy efficiency can be examined. Compared to traditional conjoint analyses, choice-based conjoint analysis constitutes a more complex, but also a more realistic approach (Rao, 2014). By means of an online questionnaire, discrete choice experiments for different types of electrical appliances such as washing machines and mobile phones will be administered to several population representative samples of German consumers. Additional questions will cover the remaining psychological and socio-demographic factors.

Expected Findings and Conclusions

Overall, the study will help to better understand the main determinants of purchasing longer lasting electrical appliances. In particular, the impact of enhanced product lifetime information, e.g. in the form of an 'expected product lifetime' label, will be estimated. Findings will indicate whether such information strengthen the preference and willingness to pay for durability and, at the same time, weaken preferences and willingness to pay for other product attributes such as brand or energy efficiency. Furthermore, consumers who are willing to buy longer lasting electrical appliances will be identified and characterized. The results will, among others, reveal whether these consumers act according to egoistic motives such as time and money savings or altruistic motives such as environmental concern. Moreover, insights into the role of social pressure and perceived behavioural control will be generated.

With the aim of stimulating demand for longer lasting electrical appliances, marketers and politicians could learn from the study how to promote drivers and reduce barriers of purchasing longer lasting electrical appliances. Marketers could, for instance, improve their durability marketing by offering enhanced product lifetime information. Politicians could introduce mandatory product labelling as well as educational campaigns regarding the sustainability relevance of product longevity.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-181

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

What's hot what's not: the social construction of product obsolescence and its relevance for strategies to increase functionality

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Keywords
Obsolescence
Material culture
Public discourse
Design scenarios

Abstract
"Is it ethical to deny our products what we wish ourselves: A long live?" is one of the major questions the German documentary "Do mixers go to heaven?"[1] from 2016 asks. The star of this documentary is the RG28, a mixer once produced by a former GDR electronic factory, which became famous for its robustness and longevity. The factory didn't survive the Wende in 1989 but the mixers are still available on internet platforms and un junk-shops, some spare parts for the easy-to-repair mixer are still produced. Although it appears as a somewhat pathetic humanization of objects at a first glimpse, it makes an important point: Product lifetimes are more than a property of objects, a rationally calculated number that is inscribed in a product's design. The lifetimes of things made, used and disposed by humans can also be seen as an important characteristic of a given material culture and is rooted in current human-object relationships. This paper discusses both aspects – material culture and human-object relationship – with relation to the highly-contested term obsolescence[2]. Starting with the observation that obsolescence received most public attention in times of crisis, we report results of an analysis of current media discourses. Subsequently we present an alternative praxeological approach to obsolescence than the usual rational choice related explanations. The closing section discusses opportunities to increase a product's "affordance" to be kept alive longer.

Obsolescence as a contested issue

Latest since the term "throw-away society" has been taken up in the second half of the 20th century (Packard 1960) the question of how long consumer goods last and how much waste is produced has been the issue of much debate, particularly driven by an increasing number of consumption- and growth-criticists (O'Brien, Barnett 2013). According to Weber (2014) the public interest in longevity or short-lived products started even earlier and has risen in three waves since the industrial revolution, indicating critical turning points in the history of mass consumption society. First occurring in the interwar period in the USA, obsolescence became an issue again around the first environmental crisis in the 1970s and is coming up another time around 2000 when issues such as toxicity, resource scarcity and digitalisation gained more and more public interest. Particularly since 2011 obsolescence enjoys constant media attention, at least in Germany.

Results of a media analysis

Any sensible analysis of social phenomena particularly socially contested ones like obsolescence need to pay attention to how it is perceived as well as constructed in public discourses. As indicated above obsolescence is not a neutral description for a specific "natural" state of an object. It refers to a process where something is actively discarded, or seen as antiquated and outmoded. Even if an object like an electric device seems to be terminally broken it persists, and might still be useful, and be it only for art[3]. Hence, what is outmoded or not or worth being repaired, upcycled or re-used or not is socially negotiated. One approach to the communicative construction of obsolescence it to investigate media discourses.

A comprehensive search of online archives of German national and regional newspapers revealed over 200 newspaper and online articles that included the term "obsolescence" or "product lifetimes" from the last 30 years. The analysis was guided by the Discourse Analysis

[1] German: "Kommen Rührgeräte in den Himmel", see also www.rg28.de

[2] The paper presents some initial results and concepts of a 5-year transdisciplinary research studying on obsolescence of electronic devices as a challenge for sustainable consumption. It is financed by the German Ministry for Education and Research and started in 2016 (www.challengeobsolescence.info)

[3] See also Baudrillard's notion of the aesthetic transfiguration of materials where "old objects, being obsolete and hence useless, automatically acquire an aestetic aura" (Baudrillard, Turner 2007)

approach (DA). The DA is a qualitative method to examine texts with a focus on how the social world and social meaning is constituted through discourse, it is often used in the analysis of media. In the following we present some first insight into the results of the ongoing analysis.

The online archives sometimes went back to the late 1980ieth but it was an interesting first insight that despite a few random articles a broad media coverage started in 2011. This coincides with the wider release of the "The Light Bulb Conspiracy" from Cosima Dannoritzer, a documentary denouncing planned obsolescence as the core of the modern throw-away society. An analysis of the articles' contents revealed that they mostly dealt with planned obsolescence presenting it as a conscious – and often malicious – decision of producers and product developers to reduce the serviceable life of products[4]. A linear cause-and-effect perspective pointing to the producers prevailed, there were few "systemic views" that reflected obsolescence as an outgrowth of the modern consumer society. The malicious purpose of producers was presented as a certainty, but the evidence mostly consisted of anecdotes. Many articles began with an introduction like "as everybody has already experienced…" presenting cases where products broke down as soon as the warranty had expired. Obsolescence is presented as a kind of regular or normalised experience that almost everybody makes, like bad weather on a holiday. Scientific studies or evidences for a malicious fraud are rarely cited, instead of that the same narratives are regularly reproduced like the story of the Phoebus cartel, a "conspiracy" among major lightbulb producers to control the manufacture and sale of light bulbs in the 1920th and 1930th. Consumers on the other hand are often presented as victims, who should feel tricked or manipulated and are seduced to consume and waste[5]. This clear offender-victim juxtaposition is modified in a few articles where consumers are presented as hungry for trends and insensible for the environmental and ecological impacts of their consumption patterns. Approximately half of the articles reflect on solutions or ways out of the "throw-away"-culture. Almost all of them find that more political regulation is necessary, only a few also mention the responsibility of consumers or broad economic change as possibilities. In recent years, a new narrative evolves around so called repair-cafés and maker spaces. These are presented in a kind of "David-against-Goliath"-story as actors who fight with "a screwdriver against an avalanche of electronic waste"[6].

Implications of media discourses around obsolescence

If we consider print- and online media as a powerful player in public discourses and a significant influence on the perception of citizens, our findings raise some problematic issues. First of all, the clear linear attribution of responsibility and power over the lifetimes of products to product developers and the obvious mistrust against producers can evoke a denial of responsibility among consumers that neither feel responsible nor capable to influence their products' lives. Surveys indicate that consumers often allocate the responsibility for short life-spans to producers and do not question their own practices of usage and disposal (Wieser et al. 2015; European Economic and Social Committee 2016). Even though objects and products seem to be the protagonists of every article they remain passive. Products are presented as objects for projections, that are used – by producers to maximize profit, by consumers to satisfy needs – as some kind of passive plaything. The materiality of consumption and the dynamics of physical human-objects relationship, like the practices of storing, using, caring, adjusting and maintaining as well as the know-how involved in these practices is almost absent in media presentations. Nevertheless, the repair-narratives that come up recently shows that there is a sensibility for this issue. They tell the story of an ongoing emancipation of consumers, of the regaining of know-how about products and their functioning and of a bypass curing the alienation between consumers and their products.

Obsolescence - by choice or by practice?

Current production and consumption patterns in industrialised countries are characterised by an immense growth in personal properties, an increasing equipment of everyday life with electronic gadgets and infinite loops of new product generations (Oetzel 2012, (DESTATIS 2017; Spinney et al. 2012; Brouillat 2015;) 2015), causing tremendous mountains of toxic e-waste on the other side of the coin (UNEP 2011, Chan et al. 2008).

Nevertheless, in times of reflexive modernization (Beck et al. 2003) the fragile material basis of current forms of consumption as well as their tremendous ecological and social costs gain increasing public awareness. In this realm the issue of obsolescence of consumer goods or short-lived electronic devices can be seen as a topic where the problematic preconditions and consequences of modern production and consumption practices intensify and create discomfort. The media analysis and the recent upswing of interest in obsolescence can be seen as emblematic for this discomfort and the way society tries to find a way to deal with it: By searching for scapegoats. The linear perspective and monocausal attribution of responsibility can also be found in other more scientific debates. Here, a central driver for obsolescence is seen in an economic paradigm according to which science and technology is subordinate to economic premises; thus, product life spans are defined by an economic optimum and not by material and technological possibilities (Krajewski 2014; Feldmann, K., Sandborn, P. 2007; Slade 2006, Bodenstein, Leuer 1977, Packard 1960). Although some of these authors adopt a more systemic view than our argument suspects, they have in common that they

[4] *Examples are „Der geplante Defekt", [The planned defect"] Welt, 21.3.2013; https://www.welt.de/print/welt_kompakt/print_wissen/article114625303/Der-geplante-Defekt.html; „Hersteller sorgen mit perfiden Tricks für Umsatz", [Producers create sales with perfidious tricks] Welt online 29.8.2013. (https://www.welt.de/wirtschaft/webwelt/article119505169/Hersteller-sorgen-mit-perfiden-Tricks-fuer-Umsatz.html)*

[5] *An example is „Verführung mit Methode", [Seduction with a method] Der Spiegel Online, 6.10.2011. http://www.spiegel.de/netzwelt/gadgets/apples-design-strategie-verfuehrung-mit-methode-a-790318.html*

[6] *http://www.braunschweiger-zeitung.de/verbraucher/article150790896/Mit-dem-Schraubenzieher-gegen-die-Elektroschrott-Lawine.html*

reconstruct obsolescence as a product of choices – be it by profit-oriented producers, hedonistic consumers, or manipulative engineers – as well as the choice-makers motive to maximize their own benefit.

Without calling the efficacy of economical logics on production and consumption patterns into question we encourage to look beyond such a linear attribution and emphasise a reconstruction of obsolescence as a part of modern material culture.

Obsolescence as a part of material culture

Studies of material culture deal with relationships between people and their things, they emphasize how apparently inanimate things act on people, and are acted upon by people (Woodward 2007). We would argue that a study of obsolescence need to differentiate analytically between practices interacting with objects on the one hand and practices communicating about objects on the other hand. Obsolescence is materially produced when short-lived artefacts are designed, created, appropriated, used, devaluated and disposed of and which can be observed among others in measurable lifetimes or amounts of waste production. But obsolescence is also created in communications qualities of consumer goods, their values and meanings are negotiated. Both aspects are deeply interrelated and form the background for a material culture where short-lived products became a normality. Material culture is inscribed into and reproduced by human-object relationships, therefore they are key to understanding obsolescence.

Science and technology studies (e.g. (Akrich 1992; Hughes 1986), material culture studies (e.g. Miller 2001) and theories of practice (e.g. (Reckwitz 2002, Schatzki 2003, 2009, Shove 2007) are approaches that shed different but somehow converging lights on the dynamics of human-object relationships. They approach consumer goods as "becoming in the course of their lives in the domestic" which are "neither finished nor inviolable forms at the points of production and acquisition, but […] continually evolving, positioned within and affected by an ongoing flow of consumer practice." (Gregson et al., 2009:250). Their study goes beyond the 'objectness' of things, investigating the formative processes through which objects come into being (Rinkinen et al. 2015). Concepts like domestication (Silverstone, Hirsch 1992), affordance (Fisher 2004) or "in-/de-scripting" (Akrich, 1992). consider objects more or less as "fluid" and describe the dynamic interrelatedness of designers, users and the products themselves. In addition, practice theories focus on practical understanding (or know-how, competences) as an integral element of using, maintaining, restoring, fixing and caring for objects. Practical know-how is based on shared understandings, but also emerges in and is formed by everyday interactions.

A different perspective on design for longer lasting products

Taking the perspectives mentioned above as a background, we can ask some questions that go beyond the "homo economicus"-model. Focusing on the communicative production of obsolescence or short-lived products we can ask how the practical meanings of products are produced. Consumer goods often carry "immaterial" meanings like "novelty", "innovation", "desirability" and "distinctiveness". Meanings that do not necessarily connect to their practicability or functionality in terms of consumption needs. For example, Vodafone introduces one of their mobile plans with the questions "Love the buzz of getting a new phone?" and – assuming the answer must naturally be yes – offers: "Get that new phone feeling every 12 months with New Phone Every Year on Vodafone Red+"[7] Consequentially a phone whose role is to generate a "new phone feeling" need not to be designed for lasting long but for looking and feeling new. Of course, a phone still needs to fulfil practical needs like communication. But its meaning goes way beyond practicability and it does not entail or is even impeded by longevity (the longer the products lives the weaker gets the new phone feeling) "Up-to-date" products" (Cox et al. 2013) like smartphones might be exceptional here. But the fact that also "workhorses" (ibid.) like washing machines are replaced when still functional or at least repairable (Cox et al. 2013; Evans, Cooper 2010, Prakash et al., 2016) can be related to a material culture where getting the new is more usual than "maxing" out the old.

A further interesting question relating to the material construction of obsolescence is what the practical understanding of object consists of. How much do producers and consumers know about their products, their technical functioning and ways of maintaining, upgrading, caring for and repairing it? Modern production processes form a complex web of dispersed actions, it grows more and more impossible, even for product developers and producers themselves to have profound knowledge of the technical composition and of all (mal)functions of their devices and to keep track of the global supply chains of their production[8] (Ying Kei Tse et al. 2011, Lehmacher 2015). This systemically produced intransparency is passed on to the consumer added or enforced by a more or less systematic "closure" of products: Many electronic devices can hardly be opened, their "hearts" and "brains" are invisible, their components are assembled in units and can't be reached or replaced component-wise (Prakash et al. 2016) The major slogan of the Repair Manifesto by IFixIt "If you can't fix it you don't own it." assumes that a full appropriation of the whole object is impeded if products stay "black boxes". A little less programmatically spoken we can hypothesize that practical experiences with the materiality of our products and the material foundation of their functional properties

[7] http://www.vodafone.co.nz/red/new-phone-every-year/

[8] Sustainability oriented enterprises like Fairphone and NagerIT make some efforts to increase the transparency of their supply chains but still face many unknowns. The list of suppliers for the Fairphone 2 so far contains almost 100 suppliers https://www.fairphone.com/wp-content/uploads/2017/01/List-of-Suppliers-final-December2016.pdf.

are not at the forefront of human-object-relationships. Practical knowledge relates more to make use of products and not so much on how to exploit them "to the max" by practices of maintenance, care, repair, tinkering, up- or recycling. But how can this "material alienation" between humans and objects be bridged?

Design scenarios to stimulate longer lasting products

Several authors have dealt comprehensively with the question of how to increase product lifetimes and serviceable lives by design (most prominently van Nes, Cramer 2006). Our suggestion is to juxtapose concepts like design for reliability and robustness, reparability or upgradability to our present material culture and its inherent human-object relationships that in different ways produce and built upon obsolescence.

Modular design is often named as the solution for longer lasting products. Thereby "modular" itself does neither automatically lead to a longer-living nor a more environmentally friendly product (e.g. if modular only means "more add-ons", see also Schischke et al. 2016). But our suggestion is, that a sensibly introduced design for reparability or modularity, has the potential to transform the human-object relationship and impact material culture. As an example we focus three modularity scenarios and designs for longer lasting smartphones and reflect some research questions concerning practical understandings and human-object-relationships.

In the *"Fairphone[9]-Scenario"* design concepts build upon the assumption that product lifetime can be increased through repairs. The design is modular to enable the replacement but not the upgrading of components. Even this basic modularity requires higher input material than the usual "compact unit" form which only pays off (from an environmental perspective) if a product is actually used longer and repaired in case of damage. The design of the Fairphone offers different stimuli – like the transparency of physical properties, the invitation "yours to open" and the pre-installed app from IFixIt – that target the user's practical understanding of the product's functioning or at least his or her curiosity. What does it make with users if they can easily look inside their phones, if they are invited and supported to physically "enter" into their devices? Based on our previous reflections we can hypothesize that the affordances in this scenario to get to know the object and to repair if needed enlarges the scope of practical understandings and create a new meaning around maxing out the device.

In addition to reparability the design in the *"PuzzlePhone [10]-Scenario"* seeks to increase the lifetimes by offering a module-wise possibility for upgrades. The phone in this scenario is somehow "future proof" and materially efficient, since devices can be adjusted to changing needs or new technological developments without having to replace the whole device. At the same time the psychological and financial barriers for an upgrade might be lower and modules might be changed much more often than a whole device would be replaced otherwise (so called rebound-effect). At the same time the device can potentially trigger a more profound reflection of users about their practical needs. The three modules of the PuzzlePhone (brain, spine, heart) scenario represent different functional units which further opens up the "black box" and increases the understanding of how things work together inside of a smartphone. A hypothesis is here that in this scenario a more sufficient consumption can be triggered by both: Getting to know better one's own practical needs as well as how they correspond to different functional modules of the device.

The assumptions and questions in the *"Phonebloks[11] -Scenario"* are similar to the previous one but can be pushed a little further. In this case modules are available with a wide range of different functions (screen, cameras, sensors, audio equipment, different kinds of batteries and power chargers, etc.) enabling the creation of a personalized smartphone. Product configuration can be changed constantly which allows the "feeling" of a new device without actually having a new one. From the purchase on this design scenario prompts users to reflect about practical needs, but is flexible enough to react upon changing needs. The possibility of personalization further might deepen the human-object-relationship, users get what they need and no possibly oversized standard package. But also here, rebound-effects are likely and ecological efficiency still needs to be proved. Nevertheless, we can hypothesize that the affordance is high that users realize the complexity and diversity of functions that their small device is offering and might develop a deeper appreciation of it.

The three scenarios correspond to actual cases which are in different phases of realisation: Fairphones do already exist since a while, PuzzlePhone are at least likely to be produced one day, Phonebloks (or Google ARA) are still a fiction. Still, they might represent three possible (maybe also consecutive) steps to bridge materially alienated human-object relationships.

Conclusions

Our paper works with a lot of assumptions that still are somehow sketchy and hypothetical and which are currently further investigated. One of our main observations is that current human-object-relationships in case of modern electronic products are quite ambivalent: Although the relationship is so close that people and electronics almost become hybrids in the course of their everyday practices they live like strangers: A deeper understanding of electronic devices, of their functioning and content as well as their "material needs" in terms of care, maintenance and repair, seems to be inferior and – in view of technological trends towards miniaturisation,

[9] www.fairphone.com

[10] http://www.puzzlephone.com/

[11] *https://phonebloks.com/, see also the now cancelled effort by Google to push this idea further https://atap.google.com/ara/*

automatisation and integration – is very likely to decrease even more. Technological progress might not be reversed, and it would be naïve to suggest that everybody needs to become an electronics expert or to learn fixing conductor plates if obsolescence should be resolved. Our major point and hypothesis is that longer lasting products are an effect of longer lasting relationships between people and their objects and both, the social significance and practical meaning for objects and the practical understanding of objects in relation to their materiality is crucial. We briefly discussed some design options that might be able to evoke these questions as well as appropriate answers. We would argue that easily repairable and modular smartphones for example are more than just innovations in design but require and evoke a transformation of alienated human-object relationships. Nevertheless, innovative product designs that foster longer lasting relationships are just a tiny part of future scenarios for longer lasting products. It still needs to be proved if they have a potential to compete against or even lighten the path dependencies of present economic and socio-technical regimes.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-186

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Object Therapy: critical design and methodologies of human research in transformative repair

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Keywords
Critical design
Transformative repair
Ethnographic research
Publics
Materiality

Abstract
This paper outlines the framework, development, methodologies and objectives of *'Object Therapy'*, a collaborative human research project and participatory exhibition concerning the public perception of broken objects and their transformative repair, which we define as repair that changes an object's appearance, function or perception. The process by which owners of broken objects were interviewed and their possessions collected for distribution to Australian and international, emerging and established artists, designers and other specialists, for response, is described. This methodology is framed as an approach of critical design that connects a community with another, mediated and traced by the researchers, for the purposes of 'constructing publics', a concept developed from John Dewey by Carl DiSalvo and new materialism theorist Jane Bennet. The critical design aspect in this regard corresponds to making public the problems and perception of broken objects – problems of ownership, obsolescence, and lack of options for conventional repair – within a public exhibition presenting alternative, experimental approaches to repair and reuse. The paper argues that the process of commissioning transformative repair processes thereby constructs a public and, via a new materialist approach, reframes human/non-human relations in ways that acknowledge the agency of materiality in social ecologies.

Introduction

The waste and disposal of consumer products presents a serious threat to human sustainability. Since the early 20th century product life cycles have steadily diminished, resulting in increased levels of production and consumption and larger and larger volumes of waste (Slade, 2007: 4–7). Repair is a culturally and industrially established means to diminish waste and return functional objects to service. However, repair industries are in decline. It is known that repair thrives in socio-economic situations of material poverty, but it flounders in advanced economies in which it is cheaper to replace broken products with new products (Kalantidou, 2015: 159). Yet, there is a re-emergent contemporary interest in home and do-it-yourself (DIY) repair in such economies (Tsutsumi, 2015) (Mitchell, 2011). New discoveries are being made by historians and archaeologists regarding the role and significance of repair in history and prehistory (Portell, 2003) (Sennett, 2008), and there is contemporary research into repair as it concerns technical, practical or aesthetic matters (Mitchell, 2011), (Tsutsumi, 2015) (Keulemans, 2015). Furthermore, the broader, extended and embedded role of both repair and maintenance in socio-technological systems has been investigated (Graham & Thrift, 2007) (Housten et al., 2017) (Edgerton, 2011).

However, there are at least two areas of repair that we consider under researched. Firstly, this is the lack of attention given to the experiences and events that occur during and after the moments when an object breaks and its owner or user considers the relative merits of disposal, replacement, or repair, and furthermore a lack of attention to the qualitative and aesthetic experience of encountering objects after they have been repaired. Secondly, we believe that a quite logical, pragmatic focus on functional repair, whether DIY or professional, has neglected the potential role of artists and designers in repair. In particular we are interested in the capacities of artists and designers for 'transformative repair', being repair that changes an object's appearance, function, perception or signification. This definition follows from research on the transformative qualities of the precedent kintsugi, a Japanese ceramic repair practice, that includes, more broadly, the potential capacity of repaired objects to transform an audience or public within a cultural context (Iten, 2008: 18) (Keulemans, 2016: 16).

In this paper we outline the framework, development, methodologies and objectives of *'Object Therapy'*, a collaborative human research project and participatory exhibition concerning the public perception of broken objects and their transformative repair. The process by which owners of broken objects were interviewed and their possessions collected for distribution to Australian and international, emerging and established artists, designers and other specialists, for response, is described. This methodology is framed as an approach of critical design that connects one community – a community of owners – with another, a community of visual artists and designers, mediated and traced by the researchers. It is proposed this process aligns with the concept of 'constructing publics', as developed from the philosopher John Dewey in his 1927 book, "The Public and its Problems". According to Dewey a public is the emergence of a collective of individuals, for the purpose of common action, in respect to a common harm. The concept has more recently been explored by design theorist Carl DiSalvo (2009) regarding critical design and participatory practices. Additionally Matt Malpass argues that a key criterion for critical design is in its capacity to critique and question the dominant technological and industrial ideologies of design and manufacturing practices (Malpass, 2009 & 2017). In *Object Therapy*, the critical design component corresponds to making public the failings of common design and manufacturing practices about their obsolescence and generation of waste; this comprises one aspect of the harm needed to construct a public. The emergence of this public perception and its qualities, via interviews that were provided to designers and artists, affected a participatory process that variably informed their repair and reuse experimentation. The resulting exhibition of transformatively repaired works is therefore proposed as an event-based, material expression of a constructed public comprising owner-participants, designer/artist-repairers and, perhaps more provocatively, the material's capacities of the repaired objects themselves. This inclusion of non-human, material capacities within a bridged public of human actors has been previously proposed by new materialism theorist Jane Bennett (2010). It corresponds with the new materialist concern for uncovering the agential power of non-human objects to better understand their effects and environmental impacts (Bennett, 2010: 95, 100-105). This confluence of critical design theory and new materialism is supported by DiSalvo; in his 2012 book Adversarial Design he notes that the mandate of critical design is complementary to the contemporary formulation of Spinozist-Deleuzian concepts that inform new materialism. DiSalvo sees the practical benefit of this theoretical confluence as bringing about a greater understanding of the political effects of objects and systems, and thereby an expanded role for politics in design that is demanded by critical design (DiSalvo, 2012: 24).

It is a limitation of this paper that we are unable to discuss analysis of individual works in any detail.[1] Rather, this paper discusses the methodological approach and framing, linked to key illustrative examples of works and interview excerpts.

Object Therapy

Object Therapy was developed in partnership between the University of New South Wales, the Australian National University and Hotel Hotel, as part of the latter's Fix and Make cultural program, a series talks, workshops and exhibitions exploring people's relationship to objects.[2] Broken objects were collected via a call for entries, supported by the hotel's public relations, social media, and the Fix and Make community. This was open to anyone who had a broken or damaged object. Around 70 entries were received, and these were assessed (Figure 1) by a criterion for inclusion, so that they:

a. together loosely represented a mixed range of products within contemporary consumer culture without excessive duplication in typology or material,

b. had potential for creative repair (based on the experience of the research investigators as creative professionals engaged in repair practice, and as facilitators or participants of previous repair workshops).

The 30 or so selections included furniture items, ceramics, household appliances, textiles, sentimental objects and, unexpectedly, one human.[3]

The participants were video interviewed by a researcher, then photographed with their objects (Figure 2).

The interview process was designed using a hybrid semi-structured/in-depth interview methodology to facilitate the Reissman model of narrative-based analysis. This

Figure 1. Selection process of the submitted objects.

[1] *We reserve in-depth discussion of individual works for future papers, however an overview can be gleaned from the exhibition catalogue and its curatorial essay in which we distinguish three strands of experimentation: transformative repair, adaptive reuse, and critical objects (Keulemans, Rubenis, Marks 2016). Refer to www.hotel-hotel.com.au/objecttherapy/*

[2] *Fix and Make was a cultural festival that took place in Australia's capital, Canberra, during 2016. It was held in the city suburb of New Acton at Hotel-Hotel, a member of Design Hotels.*

[3] *As previously indicated, we have little space to discuss individual works in this paper, but to satisfy the request of a reviewer we can explain that the human, Peter, was selected and his interview and details forwarded to the Amsterdam-based conceptual designers Thought Collider. Thought Collider considered it inappropriate to apply a repair practice to a person, but in response to Peter's dissatisfaction from a lack of creative and life opportunities, they designed a collaborative research project; an investigation into possibilities for moon habitation. This was enthusiastically embraced by Peter, and a research desk and materials was installed within the exhibition for his public use (Keulemans, et al. 2016).*

Figure 2. Selected Object Therapy participants with their broken objects. Photography by Lee Grant.

interview method involves "less dominating" interview techniques intended to encourage participants to describe their experiences and perceptions through narratives that "reflect and respect their own way of organising meaning" (Reissman, 2001: 695–7). Practically this concerns using semi-structured questions,[4] but allowing interviewees time to free-associate their experiences in-depth in ways that may develop previously non-conscious understandings of their possessions and their relations. In particular, it was hypothesized that the interviews would provide material suitable for a narrative analysis within a new materialist framework, that sought to uncover relations between humans and non-human actors (Bennett, 2010: x). The ways in which such theoretical relations emerged will be discussed towards the end of this paper.

These objects were then distributed to 30 or so designers, artists and other experts, from fields including furniture and homewares design, ceramics, glass art, electronic art, Japanese lacquerware, conceptual design (for the person), material science and a specialist in indigenous art (Figure 3). These were our repairers. They were selected by the curators based on pre-existing and researched knowledge of their capabilities and suitability for the repair of specific objects, but it is important to state only a few of them had any substantial experience with the practice of repair within their field. The brief was focused on the concept of transformative repair or reuse, and was otherwise open. It was expected that the appearance and possibly the function, or signification, of the object would be transformed as part of the repair process. Repairers were also asked to provide an artist statement and complete a survey intended to capture information about the difficulty and cost of the repair, their valuation of their work and any expectations for incorporating repair within their future practice. The analysis of this material is now in process. Its collection was intended to shed light on the viability of transformative repair as a specialist service provided by visual art and design professionals.

After a repair period of approximately two months, the repaired works were collected back at the Fix and Make venue (Hotel Hotel) and shown to their owners on camera during a second interview (Figure 4). Subsequently, works were retained for exhibition, the first of which took place at Hotel Hotel in Canberra on October 14th 2016, accompanied by an online exhibition of interview excerpts. The exhibition has been funded to tour to eight metropolitan and regional venues around Australia from 2017 to 2019.

Publics

In the 2009 paper 'Design and Construction of Publics', Carl Di Salvo notes the relevance of John Dewey's 1927 concept for the constitution of 'publics' to the contemporary practice of design, critical design in particular, and for the design of participatory practices. A public is an emergent concrescence of individuals for the purpose of collective action. Di Salvo notes Dewey's interest in how they are formed, malformed or "thwarted", based on real world "situations, experiences, and materiality of everyday life" (DiSalvo, 2009: 48) Publics should be "broad, inclusive and multiple" so that their political agency was democratically and equitably aligned (DiSalvo, 2009: 48). Publics constitute in response to consequences, threats or harms that affect or impact the lives of their constituent individuals in similar ways, so that it becomes collectively sensible to address and manage those consequences systematically. Nonetheless, publics can be thwarted by the difficulty of individuals to articulate the problems they are experiencing. Dewey notes that such harms are often,

> *felt rather than perceived; they are suffered, but they cannot be said to be known, for they are not, by those who experience them, referred to their origins (Dewey, 1927: Chapter 4) (also Dewey in DiSalvo, 2009: 51)*

[4] *For the list of questions and links to full and excerpted interviews, please see Supporting documentation and links for Object Therapy human research (Keulemans, 2017).*

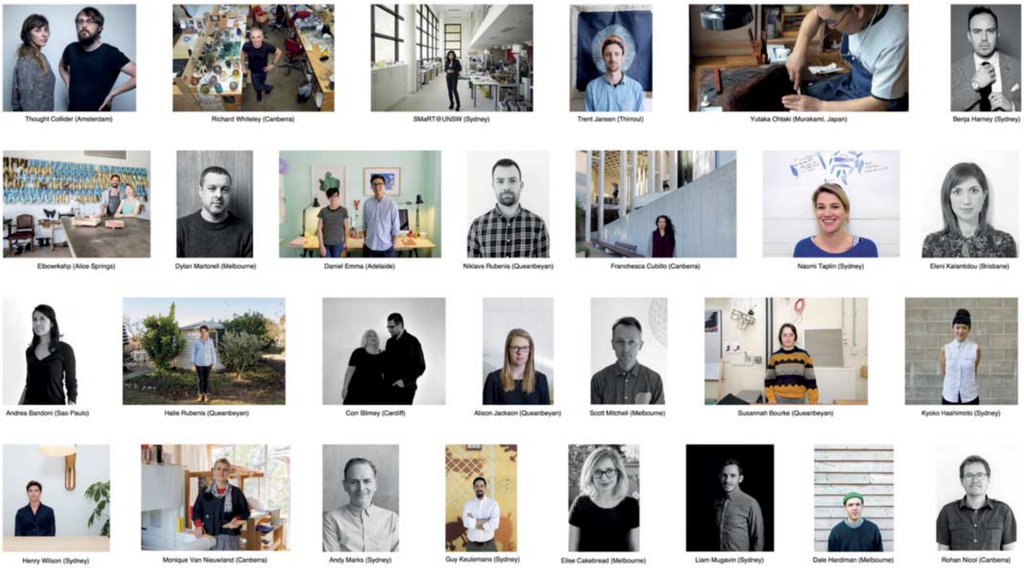

Figure 3. Selected Object Therapy repairers; international, national, emerging and established.

Therefore, Di Salvo proposes that publics must be "prompted" to emerge, and this is a role for design (DiSalvo, 2009:51).

To this extent, *Object Therapy* is framed as a participatory process that prompts a public to emerge through a variety of designed events: a call out for the entries, a selection of objects and their repairers, an exhibition of works and publication in media. These prompts should not be understood to generate a public by themselves. Rather, they co-prompt because they can bind with existing perceptions of harms or threats in the general public. Based on our overview of the interviews we collectively conducted, these perceived harms include:

a. obsolescence, in which objects break while still in use, presenting a perplexity to their owners;

b. waste, the production of which can exert emotional and psychological pressure on owners in the form of guilt, anxiety and the desire to retain broken objects; and

c. a lack of accessible repair possibilities for consumer objects, that typically can be replaced but which may produce guilt, and for sentimental objects, that typically cannot be replaced, frustration or a loss of agency.[5]

It is such conditions of contemporary consumer society (and these are not the only conditions) that co-prompted individuals to offer their possessions and personal details for *Object Therapy*. We note that engagement with such issues is a hallmark of critical design, with similar issues identified in the early work of critical designers Anthony Dunne and Fiona Raby, that they contend are part of the messy and "complicated" experience of consumer products (Dunne and Raby, 2001: 45–7).

There were also prompts and harms that combined to enlisting the contributions of repairers. Firstly, we acknowledge that the marketing presence, status and community reach of the hotel and the Fix and Make community was significant in regard to repairers responding to invitations to contribute. As was the often unstated obligations of professional relationships (which is beyond the scope of this paper). We should note however that there was one obstacle to contribution, in that there was no, or very limited, funding for making and material costs, and furthermore it was made known that the repaired works would be returned to their owners at the end of the exhibition period. This was a consideration

Figure 4. Selected Object Therapy participants with their repaired objects. Photography by Lee Grant.

[5] *Dewey does not refer to these such particular harms in his 1927 book, and such concerns may not have been considered important to him at that point in time, however he references other harms of similar social and economic significance, including alcohol prohibition, railway design, farmer access to fertiliser, the replacement of traditional building technologies with newer materials etc (Dewey, 1927: Chapter 4).*

that was carefully deliberated on the basis that it complemented the participation of owners and the time they gave for research and interview, but it does not fit well with the conventions of commissioning exhibited work from artists and designers. In *Object Therapy*, other than the gains of promotion through exhibition, marketing and media, the repairers had little reward for their time, expertise and costs. Why then participate?

Provisionally, we speculate that repairers feel a need to respond to the same kind of harms that threaten consumers: the problems of obsolescence, the abjection of waste and the loss of repair possibilities. To the fullest extent, these harms also prompt the authors of this paper, as critical designers, curators and cultural actors, in the development of *Object Therapy* and their prior and future projects. It is intended to test this speculation against the repairer survey analysis, in a subsequent paper.

The Extended Publics

Other than constitution of these various publics, we would also like to consider that there is additional publics constituted that are premised on the de-privileging of anthropocentric viewpoints fundamental to new materialist thought. This is public constituted between owner and the objects, and the repair and the object, or more precisely, between these humans and the material capacities of the object. Extending the constitution of a public between human and such non-human actors is conceivable in two or three ways:

- There is a public constituted by object and owner through service and use. The interviews indicate that owners project anthropocentric feelings into their possessions and this motivates their participation in *Object Therapy*. Their concern for the object's material damage, beyond its functional consequence to them, indicates an object-based, albeit projected, emergence of a harm or threat required for the constitution of a public.

- There is a public constituted by repairer and object through the process of repair. Repair statements and post-exhibition panel discussions with repairers indicate that the material capacities of an object suggest possibilities for transformation and guide the repairer to an outcome. This is a hybrid design process, unlike an autonomous act of 'new' creation, in which the material capacities and conditions of the existing damage 'co-act' on the process of the repairer. In this interpretation, material and repairer work together to constitute a public in response to the harm of material damage.

- There is an indirect public constituted by repairer and owner via the object. Although repairers and owners were not in communication with each other within the *Object Therapy* process, the desire of the owner to either communicate or express an emotional connection with the repairer emerged in several works. It was felt by some owners that the quality and style of the repair suggested that the repairer had formed an attachment with the object equal to their own.

Obviously, there is a weakness in the argument that non-human objects can form publics. In what way can an inanimate object experience the condition of a harm or threat required to form a public? It might be asked, for example, what difference does it make for a piece of wood to be chopped up for use within a reconfigured chair, as compared to being ground into fibres for paper making or slowly decomposing within a landfill? Bennet struggles with this requirement, and notes Rancierre's opposition to the notion, but nonetheless asserts that Dewey's original theorisation is open to the possibility (Bennet, 95, 102, 105). We acknowledge the expression of a harm is a consequence of a human projection, paradoxically the kind of human perception de-privileged in new materialist theory. However, that projection is the product of the intense human-object interaction of use, maintenance and/or repair. This is often a careful and close interaction at the level of material. The quality of that interaction is aligned and beneficial to a new materialist analysis.

In conclusion, it should be noted that the construction of viable publics should be evaluated against a capacity to take or compel future collective action (DiSalvo, 2010: 484). This criteria may not yet be fulfilled within the limited scope of *Object Therapy*. Nonetheless, we consider that a potential capacity is evident, insofar that the theorisation of extended publics between human and non-human actors provides a template for the generation of future projects that bring together consumers with designers or artists through the act of transformative repair, as both critique and response to the harms of product obsolescence and waste. A key significance of this approach is that consumer influence on product lifetimes, either passively through preference for buying stronger, better lasting or more reparable products, or actively through political demand for regulation of highly obsolescent or irreparable products, is fostered by the creation of a publics that draw attention to products and their material durabilities and capacity to be repaired or transformed.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-192

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Intelligent disassembly of components from printed circuit boards to enable re-use and more efficient recovery of critical metals

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Keywords
Intelligent disassembly
Recycling
Critical metals
Printed circuit board

Abstract

Based on previous experiences in intelligent disassembly of components from printed circuit boards our goal was to develop an economic solution for reducing the amount of material for the later hydrometallurgical recovery process and to recognize reusable parts on printed circuit boards. Usually the hydrometallurgical recovery process is very time consuming and therefore the recovery rate still relatively low. Therefore, it is beneficial to enrich the content of critical metals in the input fraction by extracting only those components from printed circuit boards that are rich in the target metals (e.g. tantalum, rare earth, platinum group metals).

In addition, there are reusable parts on printed circuit boards which have a high enough resell value on the market. These components must be dismantled, but in a more careful way in order not to destroy the function of the component by thermal or mechanical influences.

One advanced possibility for solving both problems is the adaptation of our semi-automated, flexible disassembly cell for printed circuit boards. This modular cell was developed some years ago for removing re-useable electronic components from old as well as new printed circuit boards. Main modules are a transportation system, a vision system and heating-unsoldering stations.

In this contribution, this new approach will be described from the technological as well as from the economic point of view.

1. Introduction

Electr(on)ic products consist of a high amount of diverse metals. According to a survey of Sullivan, D.E. (2006) e.g. mobile phones have a metal content of 25 % (accumulator and recharger not included), mainly copper (Cu), iron (Fe), nickel (Ni), silver (Ag) and zinc (Zn). Though the absolute amounts of each device regarding the most valuable elements are low (16 g Cu, 0.35 g Ag, 0.0034 g Au, 0.015 g Pd, and 0.00034 g Pt) this adds up to e.g. 0.7 t of platinum based on estimated 2 billion of cell phones in 2015.

Regardless of their low amount in specific electronic components there are some metals which are highly preferred or are even essential for the present technology. The most famous example is tantalum and niobium.

2. Materials and methods

We performed experimental tests on a sample of printed circuit boards (PCBs) that have been manually dismantled from End-of-Life computers. These PCBs were first visually inspected and the mounted components analysed. In a literature search we identified potentially interesting components based on their re-use value as well as on their material composition (percentage of critical metals). These results we used to modify our semi-automated dismantling line – initially developed to disassemble only re-usable and hazardous (for depollution) components to extract components rich in critical metals, but as quick and cheap as possible. We ground the extracted components to a powder with a particle size of less than 2 mm as input to our hydrometallurgical HydroWEEE process.

3. Results and discussion

3.1 State of the art

Currently disassembling for recycling, if it is done anyway, is mainly a manual process. But with the enormous increasing amount of products to be recycled and therefore also to be disassembled, such as computers, printers, telephones and other electronic devices and all sort of household-equipment, it is necessary to automate this aim to increase efficiency. High flexibility and low-cost of disassembly processes will be necessary. The automation potential will be one of the most important productivity factors for this new production process and becomes a new challenge for engineering. The two main goals are:

- Reduce the costs of disassembling for optimizing the recycling processes and;

- Create a humane working environment in disassembly factories.

Due to the particular characteristic and requirements of disassembling tasks, disassembling needs structures and methods for a semi-automated disassembling with both, use of manual and automated (e.g. robotised) workplaces to meet the requirements of a new life cycle strategy.

With an intelligent form of disassembly, it will be possible and economically feasible to extract the re-usable components in a larger amount.

Until now a very high standard in the field of automation and robotics have been reached, but focused mostly on assembly. Few parts of electronic scrap are recycled after disassembling; however, the degree of automation is still very low - only some pilot or demonstration projects are realised mainly in research institutes.

Disassembling, as the first and most important operation in the recycling process, will be a part of the industry with a high rate of expansion. Not only with the increasing trend of de-manufacturing and re-manufacturing there will be a high growth potential.

(Semi-)Automated disassembly
Existing concepts are very inflexible and only developed for a special task or product. "Stiff" automated disassembly in single purpose cells – only for one product (e.g. one type of PC) – cannot be economically feasible today. The number of devices or parts to be collected and concentrated on the place of the disassembly cell is usually too low for a two-shift operation of the cell.

3.2 Semi-automatic disassembly of printed circuit boards

The process can be divided into several steps which are performed successively.

At the beginning, PCBs (printed circuit boards) are dismantled from collected electrical and electronic equipment manually. In this stage, the flexibility of manual operators is used which allows the disassembly of equipment from various sources.

After this manual disassembling procedure, the PCBs with a maximum size of 300x220 mm are fixed on frames with special holding devices and enter the disassembly cell on a conveyor belt. The disassembly cell itself consists of the following stations:

- Vision system
- LASER de-soldering system
- Robot removal station
- Infrared heating removal station
- Stock for de-soldered components

A recognition system with image processing - "Vision System" - identifies re-usable parts and toxic components

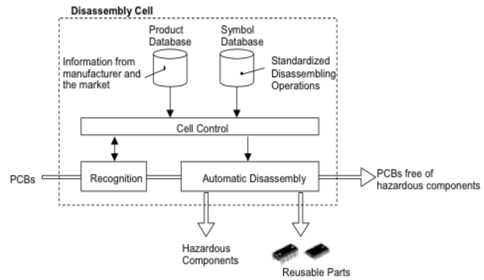

Figure 1. Schematic of the semi-automated disassembly cell for PCBs.

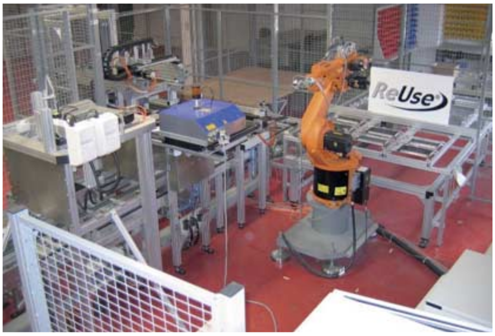

Figure 2. Industrial realization of the disassembly cell.

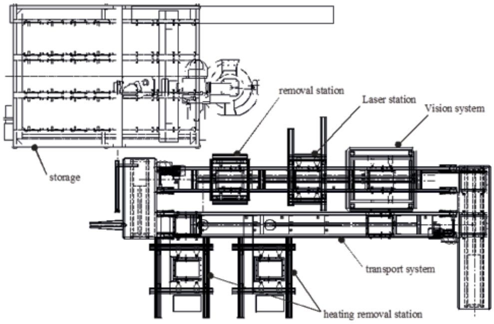

Figure 3. Layout.

on the PCB. This is done by comparing the shape and labels of the parts with a database containing information from manufacturers and information from the re-use market. Beside this the system has to determine the position, size, and the centre of area of the considered component and provide this data as input for the next stations.

To acquire the data, required for a selective disassembly, a high-quality image processing system is necessary. To localise and identify the reusable components on the PCB the vision systems must be able to reach a position in accuracy of 0.1 mm (coordinates, etc.) and recognize the characters on the part by means of Optical Character Recognition (OCR).

Components which are recognised as valuable or potentially hazardous are de-soldered either by Laser or infrared heating and removed using special robotic grippers in the next process step. The combination of a special laser de-soldering technology and special robot

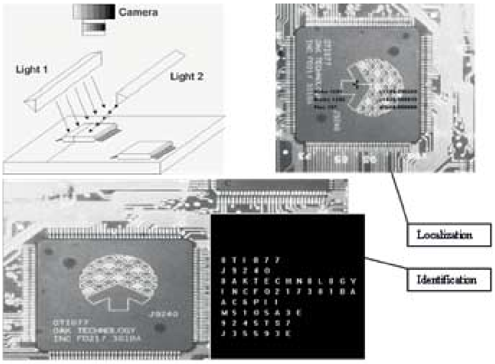

Figure 4. Vision System.

grippers allows us to remove a wide variety of electronic components from the processed PCB. The application of a laser de-soldering process has several advantages compared to conventional techniques (e.g. hot air):

- The temperature of the de-soldering process can be controlled precisely.
- The laser is flexible in view of shape and position of the different components.
- The necessary time for the de-soldering process is very short due to the direct heat transfer.
- The laser beam can be focused on the pins without heating the body of the components.

Summarizing the applied laser technique causes minimal thermal stress for the components, which results in an extended life-time for the re-usable components.

Additionally, the infrared heating appliance unsoldering technology is used to extract components which are not suitable or valuable enough for the laser unsoldering station. By means of the infrared heating station through hole mounted components can be de-soldered (e.g. electrolyte capacitors).

Finally, the disassembly process results in PCBs which are less environmentally relevant and electronic components suitable for re-use.

This system has been operated successfully in industry since 2003.

3.3 The HydroWEEE project

The aim of the research project called HydroWEEE (Innovative Hydrometallurgical Process to recover Metals from WEEE including lamps and batteries) was the recovery of base, precious and critical metals from WEEE residues. Within the HydroWEEE project, different processes for the exploitation of WEEE residues were developed to extract high-purity metals.

In the first research project, a mobile pilot plant with a reactor size of 1 m^3 has been developed that has been and still can be used for process development and optimization. However, in order to really demonstrate the stability, financial credibility and resource-efficiency of our innovative processes an industrial stationary plant as well as a full-scale mobile plant (2-3m^3 reactor) has been necessary. Finally, the previously developed processes of extracting yttrium, indium, lithium, cobalt, zinc, copper, gold, silver, nickel, lead, tin still can be improved even more and new processes to recover additional metals which are still in these fractions (e.g. cerium, platinum, palladium, europium, lanthanum, terbium, …) from WEEE or other sectors (e.g. automotive, …) as well as innovative solutions for the integrated treatment of waste water as well as solid wastes must be developed. The objective of the just finished follow-up project HydroWEEE Demo (2012-2017) has been to build 2 industrial scale, real-life demonstration plants (one stationary and one mobile) in order to test the performance and prove the viability of the processes from an integrated point of view.

These used the WEEE residues for the recovery of Y from fluorescent lamps; Y and Zn from CRTs; Li and Co from Li-ion accumulators; and Cu, Ag, and Au from PCBs. The advantages and novelty of this portable plant include its cost-effectiveness and the use of innovative processes that can be applied anywhere where the plant is based. This last arises from the portable nature of this plant, which allows small enterprises without their own recycling plant, along with the many collection facilities that can now be found in most countries, to take advantage of its transportability.

Especially with printed circuit boards we found that the critical metals are in a too low concentration to make the extraction using hydrometallurgical processes economical.

That was the starting point for us to develop a new cheap technology to extract the components that are rich in critical metals and only use these components - and not the complete, populated printed circuit board - as input material to our HydroWEEE process. With this new idea – combining semi-automated disassembly with the chemical recycling process - we could enrich the content of target metals in our input flow dramatically.

Figure 5. Mobile HydroWEEE Demo plant.

3.4 The RECLAIM project

Based on our previous experience with semi-automatic disassembly lines as well as with hydrometallurgical processing of critical metals our goal in the RECLAIM project has therefore been to develop a new, low-cost dismantling system that selectively disconnects components containing critical metals.

In order to do so, we carried out a literature and internet search on which components contain which materials. Then we started to develop a concept for a much cheaper RECLAIM solution. The main differences between the re-use and RECLAIM lines are:

- Focus shifts from careful removal of components for re-use to a quick and low-cost removal for RECLAIM.
- Only vision system, selective infrared heating, removal and storage for different components (according to material content for further processing) necessary.
- Afterwards no sorting must be necessary .

In order to estimate the necessary investment, we configured a special infrared heating and removal system. Compared to the previous re-use system the recovery system does not contain the laser de-soldering station as well as the disassembly robot.

First discussions with suppliers of such an equipment led to approximate investment costs of 40 -50.000 € net.

After that we had to estimate the disassembly cost per component. The cycle time per boards consists of a time period that the PCB fixture needs to enter and leave the infrared heating and removal station (10 seconds), a period to heat the board before the extraction of components can be started (25 seconds) and finally the time for picking a component from the board and placing it in the right container (5 seconds) which means that we have a fixed time for loading/unloading and heating as well as a variable (depending on the number of components per board). Because of that we analysed 131 printed circuit boards collected locally in Austria and found the following distribution of components per board, see figure 6.

On average 46.85 components were on this sample on one board. But as not all components can be economically extracted, we investigated also the number of extractable components per board, see figure 7.

On average 6.34 components per board are extractable and contain interesting amounts of critical metals.

Concerning the time necessary for heating the infrared module (1000W, 64kWm-2, 900°C, 2-10 µm), you can see in the graphs below that the first heating takes about 2-3 minutes, but as the time between for exchanging the boards is rather short, we assumed that we leave the heating on and only the time necessary for the radiation

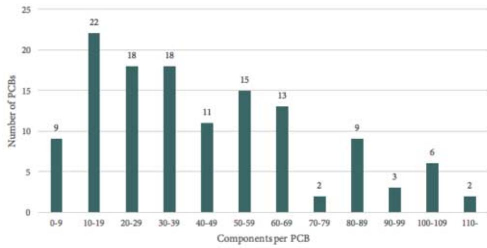

Figure 6. Number of components per PCB.

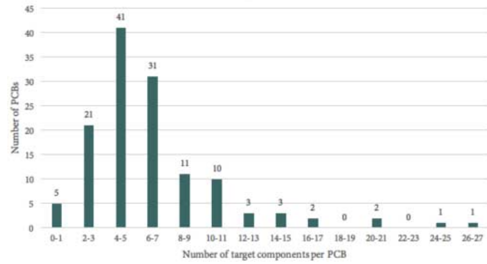

Figure 7. Number of target components per PCB.

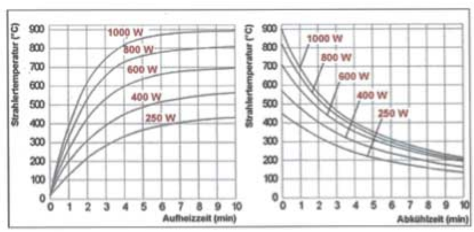

Figure 8. Step responses for heating and cooling of the de-soldering station.

and convection has to be taken into account.

All these results we used as input for the calculation of 2 principle set-ups of RECLAIM disassembly systems:

- Version I: consisting of 1 vision system and 1 infrared heating and removal station with approx. total investment costs of 150.000 € net.
- Version II: consisting of 1 vision system and 2 infrared heating and removal stations with approx. total investment costs of 220.000 € net.

From previous investigations we used as typical costs (including all overheads and indirect costs like maintenance, electricity, …) in recycling companies in Western Europe for 1 hour in a workshop of approximately 60 €.

As a result, we can expect average costs of 0.20 € per component and an annual capacity of 1.1 million targeted components for a Version I system and 0.11 € per component and a capacity of 2.1 million components for a Version II system.

When the focus is put on re-use of components we can expect typical costs of 0.70 € per component for carefully removed components (integrated circuits, memory chips, …) and similar costs as in the RECLAIM lines for the hazardous components.

The optimal economic feasibility will be achieved by combining both lines into one and extracting re-usable, hazardous and components rich in target materials as the fixed time for mounting, transport, clamping, detection, … can be distributed over a larger number of components. And this leads automatically to decreasing costs per disassembled component.

4. Conclusions

The main goal of this paper is to describe a cost oriented way for extracting rare materials and reusable components from electronic scrap.
Based on previous works it consists of a combination of a hydrometallurgical process with semi-automated disassembly lines.
Because the hydrometallurgical process is very time consuming the amount of the input material is dramatically reduced by means of semi-automated disassembly of the interesting components for extracting rare materials as well as reuse.
This allows also a very accurate temperature control for unsoldering of reusable components important for overheating and the remaining life time of the components.
The economy of this method is illustrated by means of tests on several PCBs.
Further work will concentrate to decrease the costs of the lines e.g. by means of advanced control algorithms for reducing the heating time.
In addition, the costs for intelligent disassembly will be benchmarked with manual dismantling in low-income countries.

Finally, the costs for dedicated dismantling will be compared with the revenues from critical metals extracted with the HydroWEEE process in order to check the profitability of this additional step in the recycling chain.
Because of the relatively high additional (functional compared to only material) value of the re-use components we are convinced that a combined re-use and recovery line will be profitable anyway.

5. Acknowledgement

The research leading to these results has received funding from the European Union´s Seventh Framework Program (FP7/2007-2013) under grant agreements 309620 (RECLAIM - Reclamation of Gallium, Indium and Rare-Earth Elements from Photovoltaics, Solid-State Lighting and Electronics Waste) and 308549 (HydroWEEE Demo - Innovative Hydrometallurgical Processes to recover metals from WEEE including lamps and batteries) as well as Horizon 2020 under grant agreement 680604 (sustainablySMART – Sustainable Smart Mobile Devices Lifecycles through Advanced Re-design, Reliability, Re-use and Remanufacturing Technologies).

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-197

Throwaway culture as a status symbol with fashion in India

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Keywords
Throwaway society
Culture
Youth
Status symbol
Sustainability

Abstract

India is a country with people of different cultural background and community. Clothing is treated differently in India. Owing to the significant social meaning held by textiles, clothing used to be rarely discarded. Instead, it used to be frequently recycled for both the domestic and global markets. But with influx of global brands with affordable, machine-made, synthetic clothing and an excess disposable income, buying in excess has become accessible to all.

The research is aimed at establishing an understanding of how consumers dispose of fashion products and how to increase sustainable consumption. In addition to this, two aspects will be analysed:

1. The youth have learnt from society to ignore the value of goods once used, and hence do not possess respect for these products.
2. The people who manage to repair and not replace the product will be treated as misers and financially paralyzed, as new products are equated with status symbols.

This research examines the effects of overconsumption of clothing in India and understanding the growth of the fast fashion industry. It is also aimed at establishing an understanding of how consumers dispose fashion products and what their level of awareness about sustainability is. Research has identified the influences in increased purchase behaviour and the tendency to keep clothing for a shorter time. This is an ongoing research trying to explore and understand the current status of throwaway culture with the youth in India and to propose sustainable solutions.

Introduction

India is a country with people of different cultural backgrounds and communities. Clothing is treated differently in India. Owing to the significant social meaning held by Textiles, clothing used to be rarely discarded. Instead, it used to be frequently recycled for both the domestic and global markets. But with influx of global brands using affordable sewing machines and making synthetic clothing and with an excess of disposable income, buying in excess has become accessible to all.

Cheaper clothing leads to a throwaway culture or a situation where we have wardrobes full of clothes we no longer wear. Fast fashion is a common strategy in fashion retailing that results in tight schedules and short product life cycles. On the other hand, Organic cotton adds value at each stage of the production process, and yields both environmental and social benefits. However, they will also lead to short product lifecycle.

Over the past decade, sustainability and throwaway culture have begun to matter in fashion; companies have realized that affordable and trend-sensitive fashion, while typically highly profitable, also raises ethical issues. This paper has been an attempt to explore the young consumers at a design school, conscious of green values, balance their continual need for ever-newer fashion with their presumed commitment to environmental sustainability.

The research undertaken was aimed at establishing an understanding of consumer's disposal of fashion products and their level of awareness about Sustainability. This research has identified the influences in increased purchase behaviour and the tendency to keep clothing for a shorter time.

When this paper was conceived the author was trying to understand fast fashion and sustainability. The paper is the journey of the author over one year trying to understand sustainability, the trigger being the movie "Unravel", which was an eye opener that about 100,000 tons of discarded clothes travel from Western countries to Panipat in India to be recycled. The first stage was self-analysis and observations of oneself, relatives and with close friends. The observations included, purchase of clothes on occasions, a wardrobe full of clothes with no disposal or disposal once in two years to orphanages or to the poor. These delays were owing to anticipation of that someday "I will become thin and fit into these clothes". This was a pattern seen in the adults. However, the youth wanted to be in trend and would buy cheap clothes online and dispose them off by throwing them away or giving them to their helpers, whom they considered to be poor and needy. While adults would buy for occasions and festivals, the youth would buy trendy clothes, either influenced with peer pressure or influenced by the personality they admired. The adults would buy natural fibre clothing whereas to the youth, cost was the criteria; hence they bought any material other than natural fibres as they are cheap. The adults believed in tailored clothing, whereas the youth believed in picking off the shelf, online or offline. The concept of repair and reuse was missing among the youth, as they would not have the hand skills to do it themselves and if they had to outsource it, this service is expensive. It's much easier to buy a new garment rather than getting it repaired. With these thoughts in mind, the research was commenced.

Throwaway culture and Social understanding of Sustainability

The throw-away society is strongly influenced by consumerism. The term describes a critical view of overconsumption and excessive production of short-lived or disposable items. An important part of the problem with the throwaway society lies in the sociological analysis that pays attention to economic and cultural changes (particularly in the post-war period) relating to levels of affluence, patterns of taste and industrial innovation. Thus, Matthew Gandy (1993: 31) claimed that: 'The post-war period has seen a dramatic increase in the production of waste, reflecting unprecedented global levels of economic activity. The increase in the waste stream can be attributed to a number of factors: rising levels of affluence; cheaper consumer products; the advent of built-in obsolescence and shorter product life-cycles; the proliferation of packaging; changing patterns of taste and consumption; and the demand for convenience products.'

"Sustainability" has many definitions, with the three most common being an activity that can be continued indefinitely without causing harm; doing unto others as you would have them do unto you; and meeting a current generation's needs without compromising those of future generations (Fletcher 2008; Partridge 2011; Report of the World Commission on Environment and Development 1987). Seidman (2007: 58) notes, "Sustainability is about much more than our relationship with the environment; it's about our relationship with ourselves, our communities, and our institutions."

According to HWM Project (2010) the Textile Industry is one of the most polluting industries, not only through production but also through consumption of textile. Majority of Textile waste comes from household sources, generally thrown out as old clothes. The data of metropolitan city Bangalore, collected by BMTC in 2012, shows that maximum waste of 36% is from apparel and 34.4% from fabrics. The graph (Figure: 1) indicates the increased standard of living as with the higher standard of living, luxury for life also increases.

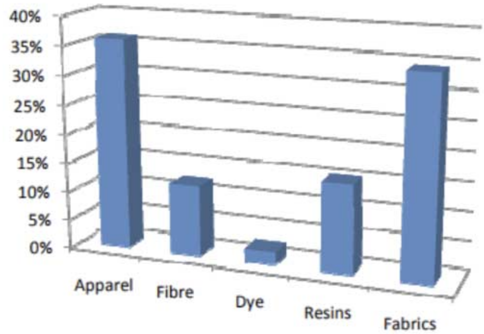

Figure 1. Maximum Fabric Solid Waste from Bangalore. .(Source: Bangalore Metropolitan Transport Corporation, 2012)

The 'culture and economy of consumption,' writes Ferrell (2006:192), 'promotes not only endless acquisition, but the steady disposal of yesterday's purchases by consumers who, awash in their own impatient insatiability, must make room for tomorrow's next round of consumption'. Here, all critiques imply that there is something peculiarly wasteful about contemporary society; that modern consumers are uniquely profligate, ignorant, and disdainful of their consumption behaviour compared to their parents and grandparents. Moreover, the disdain is a feature not only of their specific acts of wasting but has seeped out to become a cultural force in its own right: the callous wastrels of contemporary consumerism have built, so to speak, the callous culture they deserve. However, there remain some basic questions about whether or not the evidence underlying the moral-sociological analysis is sufficient to support the conclusions.

Methodology

This research examines the effects of overconsumption of clothing in India and understanding the growth of the fast fashion industry that has resulted in the increased purchase and production of clothing over recent decades. As an industry built on trends that quickly go in and out of style, fast fashion has resulted in massive amounts of unworn clothing. Consumers either throw away or donate their clothing, each of which results in either environmental or economic challenges. Another area to explore is the post-consumer clothing's donation route.

A combination of qualitative and quantitative methods has been used to undertake this exploratory research. Consumer focus groups and interviews were conducted initially to identify the main themes relating to fashion consumption and disposition. These were followed by a survey administered to young population to ratify the qualitative findings and to ascertain the extent of textile reuse and recycling. This study identifies consumers' lack of understanding of this behavioural aspect and its effect on the environment and suggests ways of addressing the growing problem of textile waste. It further explores the possibilities of making fashion consumption more sustainable. Apart from this, there were two objectives that were analysed:

1. The youth have learnt from society to ignore the value of goods once used, and hence do not possess respect for these products.

2. The people who manage to repair and not replace the product will be treated as misers and financially paralyzed, as new products are equated with status symbols.

This is an ongoing research trying to explore and understand the current status of throwaway culture with the youth in India and to propose sustainable solutions. Due to limitation, the study was carried out in one school of design amongst the design students of various streams and the sample size was limited to 100 out of 250 students of design, which comprised of Knitwear Design and Fashion Communication students. However, unstructured interview questions were administered to youth from several streams other than design. The locale of study was Bengaluru.

Analysis and Findings

The research was aimed at establishing an understanding of the way in which consumers dispose fashion products and also to analyse their level of awareness about sustainability.

The existing literature and fieldwork on this issue and its effects on textile industries in several countries was examined. One of the major impacts of throwaway society in India was throwaway culture. This has seeped into India due to global exposure and the copying of the western culture by the youth of today. The community and neighbourhood feeling have replaced nuclear setups in apartments. The neighbours do not talk to each other; hence there is no feeling of a community. In order to keep our homes clean we dump the waste outside our homes, inconsiderate to the environment. The Father of the Nation, Mahatma Gandhi, perhaps foresaw this as early as in the 1920s and gave this famous quote, "The earth, the air, the land and the water are not an inheritance from our forefathers but on loan from our children. So, we have to hand over to them at least as it was handed over to us." By reviving these messages, we may be able to reach out and protect our environment from creeping into throwaway culture.

The research also focused on how to understand the apparent increase in household waste of apparel and to get a realistic assessment of what lies behind it. There are several possible explanations for the apparent growth rate, one of which demonizes consumers and their throwaway mentality. The simplest explanation for increased amounts of household waste was that there has been an increase in the population over time. Theoretically, if the rate of growth of the population equalled the rate of growth of household waste there would be no per capita increase in the total discards, rather, the increased amount of waste would reflect nothing more than an increased number of people disposing of unwanted items. A second explanation might be that people have become relatively wealthier across the period, either through absolute gains in monetary income or through relative declines in prices of goods. In both cases, increasing amounts of waste might reflect increasing quantities of goods being brought into the house as a consequence of increasing personal wealth. A third explanation might be that there has been no change in population, no significant increase in wealth but changes in disposal practices. In this case, without any increase in material 'inputs,' households have consumed less and less, and discarded more and more, of those materials. If this could be confirmed it would indeed demonstrate that the throwaway mentality really had taken hold. This research has identified that there is increased purchase behaviour and the tendency to keep clothing for a shorter time.

A questionnaire was administered to analyse the above-mentioned objectives. Here are the few findings of the analysis.

Hypotheses:

1. The number of times the youth bought garments was dependent on the family income (Table:1 & Figure: 2). About 57% said once a month and 43% said they buy within six months and both these categories belonged to higher income group (income above 5lakhs a month). On studying a pattern of higher income group, it was found that they purchase on occasions and also when they are bored and a few of them also stated that they buy what's in trend.

2. Their sensitivity towards disposal of old clothes (Figure: 3). Maximum about 40% felt that it should be given to orphanage or poor. However, about 30% felt that they must keep it in the aspiration that someday they will reduce and fit into them. About 69% stated that they dispose their clothes once a year. 86% liked the idea of repair and reuse. The author feels that this could also be as the students of design schools (like NIFT) are exposed to sustainability concepts, as when the same question was asked to the engineering students they responded that they

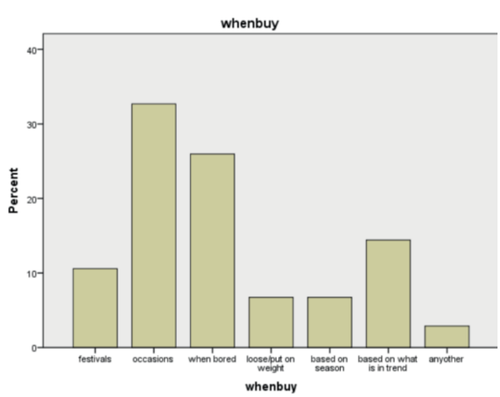

Figure 2. Buying Pattern.

			income								
			>500000	300000-500000	150000-300000	1000000-150000	50000-100000	30000-50000	20000-30000	<20000	Total
times you buy clothes	once a year	Count	0	0	0	0	2	0	0	3	5
		% within times you buy clothes	0.0%	0.0%	0.0%	0.0%	40.0%	0.0%	0.0%	60.0%	100.0%
		% within income	0.0%	0.0%	0.0%	0.0%	10.5%	0.0%	0.0%	75.0%	4.8%
	once in 6 months	Count	6	5	2	2	7	4	2	1	29
		% within times you buy clothes	20.7%	17.2%	6.9%	6.9%	24.1%	13.8%	6.9%	3.4%	100.0%
		% within income	42.9%	18.5%	28.6%	13.3%	36.8%	28.6%	50.0%	25.0%	27.9%
	once a month	Count	8	13	3	10	4	6	2	0	46
		% within times you buy clothes	17.4%	28.3%	6.5%	21.7%	8.7%	13.0%	4.3%	0.0%	100.0%
		% within income	57.1%	48.1%	42.9%	66.7%	21.1%	42.9%	50.0%	0.0%	44.2%
	any other	Count	0	9	2	3	6	4	0	0	24
		% within times you buy clothes	0.0%	37.5%	8.3%	12.5%	25.0%	16.7%	0.0%	0.0%	100.0%
		% within income	0.0%	33.3%	28.6%	20.0%	31.6%	28.6%	0.0%	0.0%	23.1%
Total		Count	14	27	7	15	19	14	4	4	104
		% within times you buy clothes	13.5%	26.0%	6.7%	14.4%	18.3%	13.5%	3.8%	3.8%	100.0%
		% within income	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 1. The number of times the youth bought garments was dependent on the family income

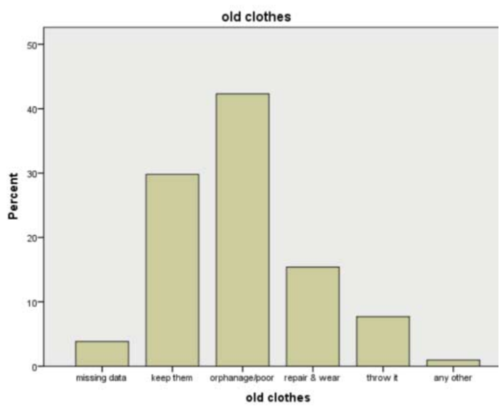

Figure 3. Sensitivity towards disposal of old clothes.

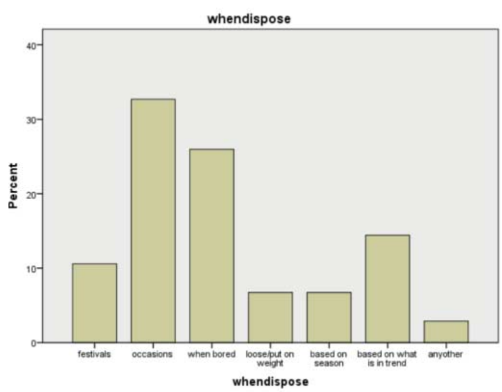

Figure 4. Response towards wanting to buy a recycled garment from their favourite brand.

would just use and throw the garment away once it would fade or become old or go out of fashion. The authors other opinion and observation was that though the students talked about repair and reuse they did not practice the same.

3. When asked if they would want to buy a recycled garment from their favourite brand (Figure: 4) 59% said they would. However, 18% could not commit and another 23% said "no" they would not buy recycled garment. This shows that there is no clear-cut clarity if they would buy recycled garment. When asked the same question to a brand not known to them, it was a clear decline to buy recycled garment from unknown brands. Similarly, for accessories it was a mixed response in favour of purchasing from their favourite brand. In order to understand their knowledge of awareness of the brand's responsibility for disposal of garment, the response was mixed again. 58% said yes and 42% was either not sure or said "no" brands are not responsible.

This shows that the design students have some knowledge but are not very clear about the concept of sustainability therefore directly or indirectly they are a part of throwaway culture. Hence the research objectives have proven to be partially incorrect as there is some amount of awareness of sustainability amongst the youth of design schools but how much they put into practice is questionable. The youth have not totally lost the cultural roots as many of them felt that the people who repaired and reused their garment are either cool or smart. However, for any cultural change to revert will take some time as the awareness drive is in the right direction. However, in non-design schools the awareness campaign has to be taken up seriously.

Conclusion

It can be concluded from this brief foray into twenty-first century patterns of domestic wastage of garment that, serious awareness needs to be created amongst the consumer and the retailer. The lost culture of India needs to be revived of repair and reuse. Sustainability awareness also needs to be simultaneously imparted in schools.

Brands should also be made ethically and socially responsible only then would we see a change. As a society, the youth today must recollect the 'non-throwaway society' of our grandparents' age and not the 'throwaway society' of their parent which saw a huge disposable income due to the influx of IT industry. A man under BPL could also get a BPO job at ten thousand to twenty thousand rupees. Where did this surplus income go? Into fashion and lifestyle as a status symbol! Apart from this, the brands supply garments at a much cheaper rate than the age-old practice of tailor stitched garment in India. Hence the concept of repair and use has been trashed and has been replaced with the concept of use and throw. And lastly everyone wants to be in trend, this has also led to accumulation of garments in the cupboards or throwing away of last season's garments and updating the wardrobe every season. There is tremendous pressure not to repeat garments in the social events. Today's youth is caught in this dilemma.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-202

Use phase of wool apparel: a literature review for improving LCA

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Keywords
Clothing use
Wool
Maintenance
Lifespan
Consumer use phase

Abstract

This paper presents results from a literature review on use phase of clothing with focus on wool. The aim of the review is to study if there is empirical grounding for assuming that the use phase is different for clothes made of different fibres, and if this information could be used in modelling the use phase. We will answer this question based on studies on wool, and see if use of woollen garments gives different environmental impact than use of garments made of other fibres.

The results show significant differences in how garments of different materials are maintained and used. Woollen garments are more likely to be either dry-cleaned or washed by hand than other textiles, and if washed in machine, the temperature is commonly about ten degrees lower than average washing temperature in Europe. Woollen garments are less likely to be dried in a clothes drier. Even the washing frequency differs, as woollen products are used about twice as many days between the washes than similar cotton products. The studies indicated that woollen garments had longer than average lifespans.

We conclude that fibre content contributes to the way consumers take care of and use their clothing, and should be taken into consideration in tools developed for comparing the sustainability of garments of various textile materials.

Introduction

Currently, several tools are in use for rating and comparing the environmental impacts of different textile fibres. These include among others Made-By benchmark (Made-By, 2013), Higg Index Material Sustainability Index Tool developed by SAC (Sustainable Apparel Coalition, 2017), and Defra's report that includes rating of textile fibres based on their environmental impact and social sustainability (Turley et al., 2010). These tools place little or no emphasis on the use phase of apparel. With this article we wish to contribute to discussions on modelling of use phase into such tools and Life Cycle Assessments (LCA) on clothing. Is there empirical grounding for assuming that the use phase is different for clothing made of different fibres, and could this information be used in modelling the use phase? We will answer this question based on studies on wool, and see if wool is used differently than other fibres in such a way that it gives a different environmental impact than other fibres.

Method

We collate previous empirical research on consumers' clothing behaviour and reanalyses existing research data. The study is limited to literature published after 1997, as clothing practices as well as the materials today are likely to differ from those of 20 years ago. Details of the included studies can be found in report by Laitala, Klepp, and Henry (2017), while this method section only lists data that has been analysed specifically for this study and not previously published elsewhere.

One of the main sources is a global wardrobe audit conducted by The Nielsen Company (2012). The study consisted of an online survey of 467 adult respondents (90 minutes) across seven countries: Australia (n= 56), China (n= 104), Italy (n= 51), Japan (n= 52), South Korea (n= 52), UK (n= 52), and USA (n= 100) (The Nielsen Company, 2012). They answered the same questions related to each of the clothing items they owned, including the age of the garments and maintenance practices.

Another source that has been used for acquiring new data for this study is a Norwegian project where a wardrobe audit was conducted on clothing going out of use from 16 households. All 620 garments that went out of use during a half year were registered with disposal reason and lifespan of the disposed items. The study included 35 household members, out of which eight were children, two teenagers, 16 women, and nine men (Laitala, 2014). The material was reanalysed to compare garments made of different fibers.

Results

This section includes a summary of the main findings that are relevant for LCA modelling of clothing use phase.

Maintenance

There are several alternative methods for cleaning clothes. Even though use of washing machines dominates, it is more common to wash laundry by hand in rural areas in developing countries (The Nielsen Company, 2016). Other alternative cleaning methods include washing by hand, airing, steaming, or dry-cleaning.

The results of the global wardrobe audit items show that consumers are more likely to either dry clean or wash wool garments by hand than those made from cotton or synthetics, and that there are differences between the practices of men and women (Table 1). Women reported washing laundry by hand more often, which is also confirmed by other studies (Aalto, 2003; Gwozdz, Netter, Bjartmarz, & Reisch, 2013). In contrast a larger portion of men's clothing is dry cleaned, mainly formal clothing such as suits, overcoats, coats, jackets and blazers.

Washing temperature

The average European washing temperature is about 43°C (A.I.S.E., 2014). When wool is washed in a washing machine, the washing temperature varies between cold and 40°C, but the median temperature across European countries is 30°C. This indicates that the washing temperature of wool is at least ten degrees lower than the average for laundry in Europe. The difference is less in countries where it is more common to wash all laundry at low temperatures.

Another difference is the used washing cycle/program, as a gentler wool wash cycle is used. For this cycle, the laundry load is smaller, usually recommended to be around 1/3 of the maximum capacity of the machine (Laitala & Klepp, 2016).

Even though the laundry load of wool wash is smaller than average, the energy consumption per kg textiles is still less than the average. The water consumption per kilogram of textiles per laundry load is higher in delicate and wool wash cycles than other commonly used wash cycles (Table 2). However, the use of water in washing machines is highly dependent on the type of machine (vertical axis top loading machines use a lot more than horizontal drum types), the age of machine (new machines are more efficient due to stricter energy labelling requirements and improved automatic water level adjustment to fit the amount of laundry), maximum capacity of the machine, and the selected program.

Dry-cleaning

Conventional dry-cleaning with Perchloroethylene (PERC) requires about twice as much energy compared to regular laundering, about 0.586 kWh/kg textiles (Table 3). In addition to high energy consumption, the solvents used in dry-cleaning have negative health effects and cause environmental hazards when not handled safely. Professional wet cleaning is more energy efficient than regular laundering and poses the least risk to human health and the environment of the cleaning methods listed in table 3 (Troynikov, Watson, Jadhav, Nawaz, & Kettlewell, 2016).

Cleaning process/solvent	Electricity use [KWh/kg textiles]
GreenEarth® (decamethylcyclo-pentasiloxane (D5))	1.195
Hydrocarbon	0.783
LCO2	0.681
PERC	0.586
Wet cleaning	0.205

Table 3. Estimated electricity usage of dry-cleaning and wet-cleaning processes/ solvents (Troynikov et al., 2016).

Drying

Drying wet laundry requires energy that is either "free" when the laundry is dried outdoors or in unheated rooms indoors, but comes at a cost if added heating is required. In general, drying laundry in a dryer uses more energy than washing the laundry. Due to wool's inherent properties, tumble-drying is usually not recommended to avoid shrinkage.

Washing method	Hand wash		Machine wash		Dry clean	
Fiber content	Men	Women	Men	Women	Men	Women
Cotton and cotton blends	6%	10%	82%	79%	9%	4%
Wool and wool blends	7%	15%	33%	37%	47%	25%
Synthetics and man-made materials	8%	11%	70%	73%	12%	6%

Table 1. Main washing methods for clothing made of different materials (The Nielsen Company, 2012).

Type	Temperature [°C]	Load user [kg /cycle]	Energy use per load [kWh /cycle]	Energy use per kg laundry [kWh /kg]	Water use per kg laundry [liters/kg]
Cotton	49.7	3.18	1.02	0.32	13.8
Mix	42.2	2.64	0.66	0.25	16.7
Easy care	39.3	2.8	0.67	0.24	15.7
Delicate	36.5	2.36	0.76	0.32	18.6
Wool	25	2.46	0.56	0.23	17.9

Table 2. Energy consumption as a function of washing programmes based on metering data from 100 households in Germany (Gooijer & Stamminger, 2016).

We did not find literature on consumer practices related to drying of garments made of specific materials. However, some product examples were found. A recent survey showed that over 80% of American consumers use a tumble dryer to dry their t-shirts and jeans, while the share in Germany and Sweden was about 20%, and even less in Poland, 12% (Gwozdz, Steensen Nielsen, & Müller, 2017). A Swedish survey showed that items that were most likely to be either tumble dried or dried in a drying cabinet/room were socks, underwear, and nightwear, while items least likely to be dried with extra energy were dresses, blouses, shirts, jackets, thick jumpers and skirts (Granello, Jönbrink, Roos, Johansson, & Granberg, 2015).

Number of days in use before laundering

The number of days in use before laundering varies between garment types. Table 4 summarizes studies that report average number of wears between washes of some specific garments.

Comparison of similar wool and cotton products shows that woollen products were likely to be used about twice as long between washes than cotton products.

Although there are too few data to make regional comparisons, we see that except for jeans, there is little evidence that would suggest there are regional differences between developed countries on the number of days in use before washing. The most recent surveys indicate the number of wearings before wash has increased. Hence, the difference may not primarily depend on geographic variations, but also to changes in general laundering frequency of jeans due to campaigns by several producers promoting less frequent washing (Nudie Jeans, 2015; O'Connor, 2016).

Clothing lifespans

The length of clothing use period is usually referred to as clothing lifespan or lifetime and often expressed in years, or sometimes as number of wears, or number of washes. Recently, use of the term "duration of service" has become more common. Effective life-time refers to the time the clothing is in active use, and can be shorter than the total use period when clothing is inactive and stored for periods of time. There are some differences in the way these terms are used.

Using real data on the actual service life of a product means that it can be determined how often a garment needs to be produced, to fulfil a functional unit. If for example a functional unit of 10 years of wearing for a specific use area was assumed, a garment that lasts two years only needs to be manufactured 5 times, whereas a garment that lasts one year would need to be produced 10 times (Slocinski & Fisher, 2016). Garments that remain unused do not contribute to any functional unit related to wearing.

	Norway [1,2] (3 surveys)	Netherlands 1,[3] (1-2 surveys)	Greece1	Spain 1	Other countries	Average estimate
Woollen sweater	8.9 (mode 10) >7.1 (mode >10 days)	10.3				10
Cotton sweater	4.7 (mode 2)	6.9				5
Woollen undershirt or thin sweater	3.4 3.9 4.3	3.2	2.8	2.7	3.2 USA[4]	3
Cotton T-shirt	1.8 2.1 2.8	1.4 1.7	2.0	1.5	2.26 USA, Sweden, Germany and Poland[5]	1.5
Jeans	4.7 >5.7	3.3 4.2	3.0	3.6	9.5 Canada[6] 5.4 Australia[7], 8.9 Sweden[8] 8.24 USA, Sweden, Germany and Poland5	5.5
Blouse/shirt	1.9	1.6 2.0	2.0	1.6		2
Sports clothing	2.3	1.5				1.5
Thin socks	1.5	1.3	1.4	1.1		1.5
Wool socks					2.3 USA4	2.5
Underpants/briefs	1.2 1.3	1.1	1.2	1.1		1

Table 4. Number of days different garments are used before wash. Average estimate rounded to closest half day.

[1] Arild, Brusdal, Halvorsen-Gunnarsen, Terpstra, and Van Kessel (2003)

[2] Laitala and Klepp (2016)

[3] Uitdenbogerd, Brouwer, and Groot-Marcus (1998)

[4] Slocinski and Fisher (2016)

[5] Gwozdz et al. (2017)

[6] McQueen, Batcheller, Moran, Zhang, and Hooper (2017)

[7] Jack (2013)

[8] Granello et al. (2015)

Most Western consumers own a large amount of clothing, and do not necessarily remember when each item was acquired. Therefore, estimating the total length of lifespan as well as the active service life of garments that are used a lot is methodically challenging.

The length of clothing lifespans has been discussed in some studies, but very little information is available of actual lifetimes and use times of clothing. For example, Beton et al. (2014) have estimated that all garments have a lifespan of 1-3 years based on expert opinions, but without referring to empirical research data. Results from various consumer studies on clothing lifespans are collected in Table 5, including the average and the range of values.

Some consumer groups are more likely to keep their clothing longer than average, including men, older people, people on low incomes, and people in higher social grades. Socks, tights and stockings as well as knickers and underpants have the shortest expected lifespans, while swimwear, jackets, blazers and coats have the longest expected lifespans (Langley et al., 2013).

Survey data from seven countries (The Nielsen Company, 2012) included a question of "When did you buy this clothes item or accessory?". The current age of the garments was multiplied by two to get estimated total lifespan. The results for various types of garments were given in Table 5. In addition, comparison of garments made of different fibers showed that garments made of silk had the longest lifespans, 9.4 years (mainly due to the high proportion of men's ties). This was followed by cashmere clothing (6.7 years), wool blends (6.6 years), synthetics (6.3 years), 100% wool (5.3 years), cotton blends (4.2 years), merino

Garment type	Wardrobe audit based on survey in seven countries (Nielsen Company, 2012)	Wardrobe audit with interviews Norway (textile waste) years (Laitala, 2014)	Survey, Norway (Klepp & Laitala, 2016)	Online survey,3244 respondents UK (Langley, Durkacz, & Tanase, 2013)	Survey, UK (Cooper et al., 2014)	Calculations 16 households based on ownership and purchases ,Netherlands (Uitdenbogerd et al., 1998)	Survey Netherlands (Uitdenbogerd, 2007)	Survey with 4617 respondents, 100 from each country (Germany, Poland, Sweden, & USA) (Gwozdz et al., 2017)	Online survey with 1060 respondents, Finland (Aalto, 2014)	Total lifespan, average and range
T-shirts	4.6	4.2		4.0	3.3	6.8		3-4	4.5	4.6 (3.3-6.8)
Blouses / shirts	4.6		5.6	3.3 / 4.3	3.6	7.2			5.7	4.8 (3.3-7.2)
Jumpers / sweaters	5.8		10.8 (wool)	4.5	3.7	7.1	6.17 (wool)			6.0 (3.7-10.8)
Suits	8.7									8.7
Jeans	3.9	4.3		3.8	3.1		2.45 (cotton)	3-4		3.5 (2.5-4.3)
Trousers / pants	4.9		4.4	5.4		6.2			5.3	4.7 (2.5-6.2)
Skirts	4.8	4.1		5.2		15.2				6.9 (4.1-15.2)
Dresses	4.5			4.7						7.1 (4.1-15.2)
Jackets / Blazers	5.3	4.0		6.5		11.5				6.8 (4.0-11.5)
Coats	6.3		6.4	6.2		11.6			7.6	7.0 (4.0-11.6)
Underwear briefs / boxers	2.5	4.4		2.4					3	3.1 (2.4-4.4)
Bras	3.0									3.5 (3.0-4.4)
Socks	3.6 (incl. stockings)	2.9		2.4	1.8				2.3	2.6 (1.8-3.6)
Average of all garments	4.7	4		3.3						4

Table 5. Summary of garment lifespans in years from various studies and estimated average lifespan based on these data (only the period with one current owner is used, not the total age of preowned clothes).

wool (4.0 years), and finally the shortest lifespans were reported for 100% cotton garments with 3.6 years.

Use frequency

The WRAP clothing longevity protocol estimated use frequencies of five different garment examples (Cooper et al., 2014). According to their assumptions that were validated by industry interviews, jeans have the highest wearing frequency of 75 wears per year, followed by socks (50 wears), knitwear (50 wears), t-shirts (25 wears) and finally shirts (16 wears). They indicated that each clothing item is worn 12 hours per wearing day, but this will also vary depending on how many times a day the user changes clothing. For example, sportswear is likely to be worn shorter periods per instance of wear, mainly during the activity. Many people also change to casual clothing after coming home from work. The authors consider also best practice scenarios, and suggest a target lifetime that is one third longer than the current practice (Cooper et al., 2014).

A consumer survey conducted in four countries (USA, Germany, Sweden and Poland) showed that the respondents estimated they kept jeans and t-shirts for about 3-4 years and wore them at least monthly, in total 36 to 48 times during their use period (Gwozdz et al., 2017). Another survey in Sweden reports a lot longer use period, as 93% of respondents said they wore their jeans at least 100 times before disposing of them (Granello et al., 2015). A survey conducted in the USA concentrated on woollen socks and garments, and these results indicate wear frequency of 9.2 wears per month for socks, and 8.3 wears for the next-to-skin garment (Slocinski & Fisher, 2016).

Conclusions

Consumer decisions during the use period of clothing are important from an environmental point of view, as they have an effect on the energy consumption during care, lifespan of clothing, as well as the potential for reuse and recycling. Many LCA studies on clothing have revealed that the consumer use phase often has the largest contribution to most environmental indicators, but also that the studies are often limited to small number of textiles and are not consistent which makes the comparisons difficult (Chapman, 2010). When it comes to LCA studies on wool, they often exclude the use phase of garments and are only performed as “cradle to gate” studies, stopping at the farm gate or factory gate and thus excluding the consumer stage (Henry, 2012). Therefore, there is a need for more information of the use phase of wool, but also of other fibres that enable comparisons of the environmental impacts of various materials.

The results from this review indicate that clothing made of different materials can be used, maintained and disposed of in different ways. Therefore, fibre content is a relevant property and should be considered when modelling the use phase in LCAs and tools based on a LCA approach.

To summarise, compared to other textile materials, the consumer use phase for wool is characterised by:

- about ten degrees lower washing temperature than the average for laundry;
- higher likelihood of either dry cleaning or hand washing;
- lower likelihood of tumble-drying;
- lower washing frequency, with about twice as many days between washes, then similar cotton products;
- longer average lifespan (especially for wool blends).

These studies show that clothing lifespan varies greatly in length depending on garment type and type of use, as well as fibre content and user related aspects such as the age, gender, income and area of living. They also show that empirical data is difficult to obtain, as most of the studies are based on consumers’ own reported behaviour, and they may not know or be aware of how old all their garments are. In addition, estimating the lifespans of pre-owned and second hand clothing is challenging. It is easier to obtain data concerning the maintenance, but some knowledge gaps remain there as well. For filling these, studying the following areas should be especially prioritized:

- Obtaining information on the number of times and/or hours that each garment is used during its lifespan (service life).
- More studies in continents outside of Europe and USA where most studies have been conducted.
- More studies that combine surveys and practice-based methods in order to validate the survey data
- Development of a reliable method for measuring effective lifetime, where the unit is adapted to the clothes’ function.

Acknowledgments

This publication is written on a basis of two research projects, and we would like to thank Australian Wool Innovation Limited (AWI) for financing project “Use phase of apparel: A literature review of relevant data for conducting Life Cycle Assessment on wool and other fibers”, and Norwegian Research Council for financing project “Enhancing local wool value chains in Norway (Krus)”.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-208

Open and closed loops: how to teach and get students to embrace circular design

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Keywords
Behavior Change
Design Education
Circular Economy

Abstract
Design schools, being the places were new products and services are invented and conceived are extremely important stakeholders in a much needed change towards sustainability. A circular economy is based on closed resource loops so that large volumes of finite resources (used by organizations), are captured and reused (Huber, 2000) as well as open approaches to innovation and information exemplified by the share economy and business models based on use rather than property. For the very spread of a circular economy as a concept to be successful, an open stream of information and ideas must be established. Design as a discipline needs to radically change its curriculum to help generate sustainable social and economic value and this paper is like a case-study of a curriculum that was changed from a linear to a more circular approach. In short, the authors believe that design schools – with their responsibility in educating students, who in turn shape the world of tomorrow- must move from teaching closed business models to teaching open and globally-linked ones. Another aim is to stress the importance of human factors- economical, psychological and evolutionary- in speeding up what Chesbrough calls a paradigmatic shift in innovation management (Chesbrough, 2006). Design students may be interested in greener design, but few adopt the necessary business models for such a design to be truly sustainable. In a circular economy, a business is forced „to take responsibility for the entire lives of their products“ (Kleindorfer et al. 2005, S. 487).

Introduction

In 2014 the department of Design and Product Management (DPM) at the Salzburg University of Applied Sciences underwent a thorough overhaul of its curriculum, placing much more emphasis on sustainable product design. In November 2015 the department hosted an international conference on Circular Design (http://www.circular-design.eu/Circular-Design-Deutsch/CD-Konferenz-2015/Programm/, accessed 20/12/2016).
Roughly half of our curriculum currently focuses on product management, which in the context of the circular economy implies a rethinking of all steps along the product-lifecycle from production to use and circulation of resources. This seems to be a strong base for teaching students “circularity” in design (Walcher & Leube, 2017). This text should not be seen as a description of the only possible curriculum but rather as a meditation of what seems to work pedagogically.

Systemic Thinking

First and foremost, it is necessary for design students to have some understanding of the quality and quantity with which humans have tampered with nature. Thus, a mandatory course for Master students at DPM is “Design and Anthropology”, where, a systemic view of human production and consumption is taught.

About 800,000 years ago humans first used biomass fuels for their fires the world over. In Jared Diamond’s 1987 article, “Worst Mistake in the History of the Human Race” he claims radically that much later, in the Neolithic agricultural revolution humans embarked on a far more destructive path of dependency (Diamond, 1987). Perhaps the most satisfactory explanation for why we have become so careless with our commodities comes from Thorsten Veblen, who explained why we conspicuously consume (Veblen, 2009). Modern runaway consumerism seems to follow some archaic patterns and when combined with planned obsolescence obviously has detrimental environmental consequences (Slade, 2007).

A philosophical underpinning for a wasteful, linear economy came with nineteenth-century *positivism*, which raised technology to Godly heights and with it created a semi-religious faith in techno-scientific progress and empirical methods and *unilineal evolutionism*, which saw all societies necessarily progressing through the same technological stages. The danger and far-reaching consequences of such ideas become apparent when considering their relationship to *modernization theory* (Rostow, 1990) via the writings of the so-called *neo-evolutionists* (White, 1949) and consequently world developmental politics. Indeed, it seems that the Cartesian worldview- a narrative that sees humans separate from nature and has produced the phenomenon collectively labeled *industrial revolution* - is responsible for what is called the linear economy (LaFreniere, 2012). As old as this problem seems to be, it is not human nature that we need to blame for the thrashing of the planet but rather *culture* that has taken a wrong turn, resulting in a system bent on consumption and exploitation of natural resources. Design (as a discipline) is intrinsically path dependent since options are reduced with advances in the design process. However, the creative process is not teleological and, as Karl Popper remarked, "the future is open" (Popper, 1967).

The market model collectively known as the *share economy*, lying somewhere between owning and gift-giving has the potential to shift society toward a system that better utilizes existing assets. While such a model is based on development at all stages of the design process, *closed innovation* is based on growth and is simply a point of view asserting that successful innovation necessarily requires control (Chesbrough, 2006). In the current economic system responsibility is outsourced whenever possible but such views need to be challenged in order for the circular economy to be successful. Although alternative concepts such as *co-creation*, *participatory design* or *inclusive design* are being discussed in design research (Manzini, 2015) and are subject to rigorous research in the business sciences (Reichwald & Piller 2009), they remain exclusive in the ivory towers of academia.

We feel that the only way to reconcile design and ecology is thinking in terms of a *circular economy*, which at a system level goes back to the 1950s. The Austrian biologist Ludwig Von Bertalanffy, generally credited as the founder of the *general systems theory* noted that a system is characterized by the interactions of its components and the nonlinearity of those interactions. (Von Bertalanffy, L., 1973). A *circular economy* is based on a closed resource loops so that large volumes of finite resources (used by organizations), are captured and reused (Huber, J. 2000) as well as open approach to innovation and information. 'Closed loops' and 'cradle to cradle' in a business context were ideas already voiced as early as 1976 by Walter Stahel, a key industrial ecology thinker (Stahel, 1981). At its simplest level, the extraction of virgin materials would be kept to a minimum since these materials would be owned (and reused) by companies.

Business models (rather than just commodities) need to change if resources are to be kept in closed technical and biological cycles (Braungart & McDonough, 2010). As for the business plan, sale of products is no longer a top priority in what has been called a *performance economy* (Stahel, 2010). For a viable circular design process, material selection is paramount and dependent on use. The choice of materials was less important in the past since production and sale was based on short product-life spans and responsibilities for use and disposal were given exclusively to the user. Here, marketing is far from rendered obsolete, since much public relations and sensitization are needed for any systemic change (Birkeland, 2002). The authors have created the diagram below as a teaching tool for students.

Sustainable Product Design leading to Behavior Change

There exists a myriad of ways to design- and produce-sustainably and the authors observe a strong desire amongst Bachelor-and-Master students to do so. Thus, students create things to last for as long as possible materially (*product attachment*), produce things that can

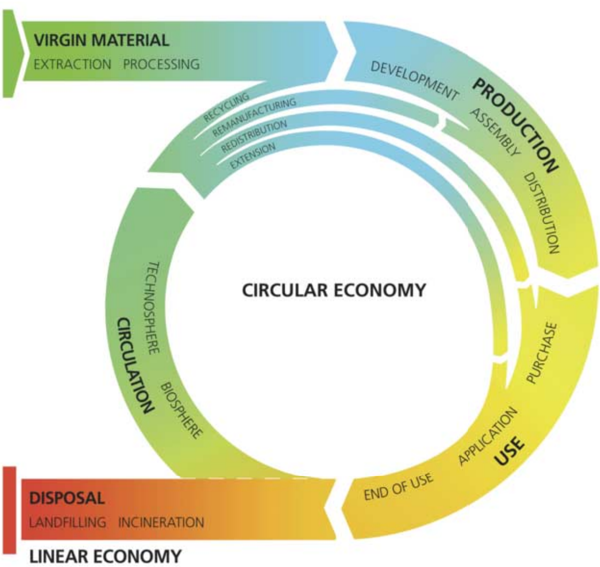

Figure 1. Material Flows in a Linear and Circular Economy. (Source: Authors)

easily be recycled in order to prolong product lifetime cycle or produce things out of material previously employed in different products (*up-cycling*). *Emotional durability* is also very popular as an approach amongst students. This design direction addressed by Jonathan Chapman seeks to create stronger emotionality and enduring interaction with things, which in turn can lead to a more sustainable use of resources (Chapman, 2015). Our everyday things might also be longer lasting by purposefully injecting *animacy* into design (Norman, 2004) so that human *animist* tendencies can be triggered (Leube, 2016). Frugality in the use of resources as well as recycling can also help to reduce the need for extraction of raw materials, but the current economic system remains fundamentally open and linear, only delaying its unsustainable demands on the environment. A kind of bottom-up approach is suggested here, where the products swamping the market have an ecologically sound design and the status quo than follows with ecological behavior.

Recent research in various behavioral sciences (prevention science, cognitive psychology, neurology, and experimental economics) shows that certain interventions can prevent many of the behavioral problems that trouble society. It is now possible to positively influence the further evolution of cultural practices (Wilson et al., 2014) and such knowledge might be crucial for designers. Perhaps the most relevant for designers is the so-called *nudge* theory, stating that non-forced compliance can be achieved at least as effective by positive reinforcement as by negative sanctions (Thaler&Sunstein, 2008). Especially designers of services and social innovation – but also those of commodities-can thus become choice architects by shaping the situations in which people make choices. This argument can also be made using cold economic logic. Designs that reduce morbidity –rates in society will reduce the burden the strain on tax-payers in a welfare state (Miller, 2009).

Cradle-to-Cradle and Material Selection

The concept of "cradle to cradle" as formulated by Braungart and McDonough is required reading at DPM for both Bachelor and Master students. Instead of doing "less bad", designers should be encouraged to do "more good", to *upcycle* rather than *recycle* (Braungart & McDonough, 2010, 2013). An inherently positive approach for designers, it is based on clever use of material rather than renunciation of abundance.

The cradle-to-cradle approach is also taught in an effort to sensitize students to toxicity (of materials) and closing material loops. The selection of materials for products and buildings has to guarantee that there will not be any *off-gassing* of toxic substances during their use, and that the material loop can either be closed biologically or technically. In short, the design student is required to deal with issues of biodegradability, disassembly, recyclability, ability to upcycle, reverse logistics and material toxicity. There are other variables to be considered, such as origin (of resources) and mono-materialism (Bakker et al, 2014). Students are required to attend technical courses on material selection.

Our students are encouraged to consider the materials used for their designs as early as possible; such choices are fundamental for every step of production and the relationship between tools, materials and manufacturing. Thus, materials have to be chosen for their functionality rather than aesthetics and any time one material can fulfill a given functionality better, their exchange for another should be considered (Papanek, 1972). An example is our mandatory semester project called "Experimental Design", where students are required to design products with at least two separate lives. With an eye on the entire design process, we encourage our students to mark or designate each and every part of materials used in a poly-materialistic product so that a return into the given technological cycles can be guaranteed.

As with conception, assembly of products needs to be different in a circular economy. Products modeled for semester projects as well as Bachelor and Master theses should be modular in design, so that after use the product can easily be disassembled to ensure future use of the separate materials. Certainly, the use of epoxies and glues which ensure that products remain sealed are strongly discouraged at our department.

Co-creation and Product Management

Prior to the sale of a particular product and/or service an open stream of information and ideas must be established. Such topics are subject to rigorous research in the business sciences (Reichwald&Piller 2009). Already in the year 2003, Chesbrough wrote that society is in the middle of a paradigm shift in its treatment of innovation (Chesbrough, 2003). The shift in innovation paradigms is one moving from closed business models to more open and globally-linked ones. The heavy term "paradigm shift", borrowed from the historian of science Thomas Kuhn is

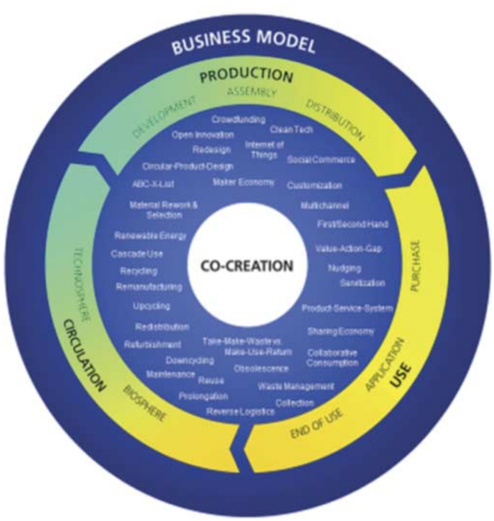

Figure 2. Design-related aspects to be considered in a circular economy. (Source: Authors)

used in order to emphasize the fundamental change in how companies commercialize industrial information and knowledge. Closed innovation is simply a point of view saying that successful innovation necessarily requires control (Chesbrough, 2003). Such a view needs to be challenged in order for the *circular economy* to be successful.

Contrary to a closed innovation process, the boundaries- or “membranes” to borrow from biology- are permeable, making the exchange of information with other organizations possible (Walcher, 2012). The reason for this is that at the core of the circular economy lies the *share economy* and business models based on use rather than property. Currently, concepts such as *co-creation*, *participatory design* or *inclusive design* are being discussed (Manzini, 2015). Manzini (2015) reflects on the very definition of the “designer”, arguing that in a world of endless technical possibilities it is possible for everyone to be a designer. The exchange of ideas is inclusive; it takes place between customers, workers and business partners in workshops and is designed to address the needs of a given target group. Designers play a major, but not the only role in the creative process (Ramaswamy, 1996).

Teaching Circular Design: Marketing and Usage

Contrary to the appeal of Victor Papanek for more responsibility (1972), new products rarely arise from necessity and instead are mostly fueled by marketing ambitions. Indeed, what is currently billed as “innovation” in industrial design is marketing-driven, which means that new desires must be created amongst customers in order for new products to be designed, produced and consumed. Such a model consequently produces considerable waste at every stage of production.

Although environment and corporate social responsibility are again at the forefront of management thinking and research (Chan and Lau, 2003) they are rarely more than *green washing*. The anticipated rise in green consumer behavior predicted for as early as the 1980s was a gross disappointment (Prakash, 2002) and the mass consumer market for green products still needs to be developed. Although this is disappointing on many levels as it shows that mass consumerism is slow to move in a sustainable direction, it is also reason for optimism. Marketing needs to reinvent itself in an emerging *circular economy* as the consumer needs to be educated on such a new system. Basically, the benefits of products made in a new fashion need to be advertised.

Conclusions

Mankind seems to be undergoing a paradigmatic change and we find ourselves as the first generation that has the ability and responsibility to shape the future of all of mankind (Jakob v. Uexküll, 1982). Perhaps the historians of tomorrow will look back at this point in time and realize that the means were there to change most current problems. It is up to the designers to use those means. By implementing the above changes to our curriculum, students seem to experience less anxiety and more sense of purpose. Undoubtedly, moving towards a circular economy requires new thinking, skills and competence in design and all of it has to be systemic in nature. But, are designers familiar with CE principles or are they only aware of the buzzword? How well can the design community address CE challenges and turn them into realities with their products and services? It is the curricula of the design schools that have to change radically and quickly because designing for a circular economy would have to be truly disruptive and innovative and requires an open and creative process. It would have to be bold enough to lift the limitations imposed by current thinking and contexts.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-213

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Considering the user in the circular economy

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Keywords
Circular economy
Design
User-centred design
Consumption
Product lifetimes

Abstract
This paper reflects on how much of the dialogue and literature regarding a move towards a circular economy tends to focus on production and that this language reflects a technological narrative around innovation for a future circular economy. The authors argue that there is a need for a more profound consideration of users in both the research activity and practical implementation of the circular economy, where the real needs, desires and values of the end user are incorporated from the outset, whether as part of research agendas, theories, frameworks or business models. The paper concludes by arguing that changing the way that the circular economy is framed so that it is more inclusive of the consumption side of the development process would open up greater opportunities for success.

Introduction

Much of the dialogue and literature regarding innovation for a circular economy (CE) focuses on potential innovations in our production system (Ellen MacArthur Foundation, 2013). This reflects a technological/infrastructural narrative of innovation (e.g. 'biocycle', 'technocycle') and is represented in a number of innovation frameworks (Ghisellini, Cialani, & Ulgiati, 2015; Lieder & Rashid, 2016). This techno-centric focus is reminiscent of the early days of 'ecodesign', which primarily focused on (material and energy) resource efficiency. However, within the field of ecodesign it has become widely recognised that a systems approach is needed and focusing on production alone will not solve today's societal challenges (Dewberry & Monteiro de Barros, 2009; Meadows, 1999). In addition to this it is now understood that user choices are not wholly rational and are influenced by a multitude of diverse and complex factors such as socialisation, living conditions, alternatives on offer and the cumulative effects of past choices (Vezzoli & Manzini, 2008). A move towards a CE will require fundamental changes in how businesses sell goods as well as how people buy them (Gregson, Crang, Fuller, & Holmes, 2015), as such an emphasis on understanding user expectations and levels of acceptability will be key to the success of many CE propositions.

While some studies consider elements of consumption (De Los Rios & Charnley, 2016; Murray, Skene, & Haynes, 2015; Van Weelden, Mugge, & Bakker, 2016) and recognise its importance (De Los Rios & Charnley, 2016) this area is currently under-addressed. Studies such as those by Lofthouse & Bhamra (2006) and Van Weelden et al., (2016) have started to investigate specific consumer-related aspects of the CE, such as identifying factors that influence consumer acceptance of refillable packaging systems and refurbished mobile phones, respectively. However, these types of studies are not numerous. Bakker et al. (2014) have made developments in recognising the need for innovation through a combination of technical product design and business model innovation strategies, they also call for consideration of 'new experiences and relationships with products'. This work illustrates theoretical progress in this area, however there is still considerable lack of progress regarding consumption in terms of practical application (Ellen MacArthur Foundation, 2015), which comes up against many challenges. For example, Hobson and Lynch (2016) state that if we are to truly achieve the transformative agenda set out by the CE it needs to acknowledge and address the 'deeply embedded' societal issue of overconsumption. This is all the more prescient in an age of substantial and rapid changes in how products are brought to market, such as through co-design activities, prosumption, peer-to-peer platforms and collaborative and sharing economy initiatives.

It has long been recognised that taking a user-centred approach to innovation can create radical change. For instance, amongst other studies, Von Hippel (1976) found that three out of four successful cases of commercial product innovations were based on responding to genuine user needs rather than a 'technological opportunity'. It is at this intersection with the user, that industrial design is predominantly oriented. Industrial designers are recognised as being very skilled at understanding the user, influencing values (Vezzoli & Manzini, 2008), attitudes and perceived consumer/user needs, which means they are well positioned to help change culturally dominant value systems (Wahl & Baxter, 2008). This suggests there is a more strategic role for industrial designers to influence user-led innovation for a future CE, than is currently being acknowledged. It is important to recognise this more fundamental role of design, to encourage companies to draw on design skills in the development of products and services for the CE.

This paper uses illustrative case studies from the literature to consider the opportunities and challenges of taking a user-centred approach to innovation within CE contexts. Many published CE examples showcase business-to -business (B2B) case studies that focus on supply chain innovation and reverse logistics (such as Prendeville et al., 2017). The user-centered focus of this paper means that we are predominantly interested in business-to-consumer (B2C) models where there are distinctly fewer examples.

Recognising the consumer in business model innovation

Many B2C approaches require considerable behaviour change on the part of the user and we know that this is complex (Lilley, 2009; Wilson, Bhamra, & Lilley, 2016). Depending on how involved the user is required to be, circular business models typically require some form of behaviour change. The scale of user involvement and therein potential behaviour change required may vary depending on different models (e.g. take-back scheme, rental model). In particular, the way in which a service or system responds to genuine user needs, how it is delivered and also the user's experience of using the service and any new financial models are important. If we do not understand users, how can we expect to design business models that they aspire to?

Business strategies can fail due to nuances in individual preferences such as desire for 'behavioural control' in the context of product- service- systems (Tukker, 2015). Alternatively, consumers may adjust their behaviour in unanticipated responses to the new offering (Scott, Bakker, & Quist, 2012). Added to this, Edbring, Lehner, & Mont, (2016) found that while users may respond positively to short-term leasing, in the case of hardware tools for example, buying second hand furniture and buying products that retain their value on the second-hand market (e.g. high end kitchenware brand Le Creuset[1]), this is not the case for all products/markets. Therefore, by better understanding levels of acceptability in use against different business models, industry will be better equipped for successful innovation.

Reflecting on existing approaches to the circular economy

There are many reasons why businesses may explore new circular business models in the B2C sector, including: opportunities for innovation; it being the overarching motivation of the organisation; foreseeing future regulatory changes; recognition of threats to future business within a linear economy. There are also a number of different strategies that are regularly drawn upon to facilitate a more circular approach.

A common approach in the apparel sector is to extend product lifetimes by offering a range of repair services (e.g. Nudie jeans and Patagonia). Such approaches tap into a growing consumer awareness and propensity towards repairing products rather than replacing them. Rentez Vous (2017) by contrast, focus on increasing resource intensity through a user-oriented service that facilitates the short-term rent of high-end clothing to consumers, who would otherwise be unable to afford them.

Mud jeans have adopted a rental model where consumers can "wear new, up-to-date jeans without owning them". Via the rental model *"users can… lease Mud Jeans for €5 / month. After one year, the user... can swap their jeans for a new pair, and continue leasing for another year, pay for four extra months at €5 each as a 'deposit', after which the user can wear the Jeans as long as he likes, or end the relationship by returning the jeans to Mud. Free repairs are included in the offering. For those who... keep the jeans, the company offers financial incentives to return items, to encourage recovery." ("Mud Jeans," 2017)* When you consider that it is not unusual for a westerner to own around 10 pairs of jeans at any one time, there are a number of challenges to a model which requires such commitment to one brand.

"Open Desk" (2017) connect consumers to local makers by contracting designers to develop designs that can be hosted on platforms and produced with local materials in makerspaces. This approach is entirely predicated on a contemporary trend towards personal-making and distributed production. Such practices have the potential to support the CE, insofar as it represents a significant shift in how people engage with products and have genuine potential to revolutionise 'prosumer' behaviour (Prendeville, Hartung, Brass, Purvis, & Hall, 2017). However, at present such approaches are niche and require direction and leadership (ibid).

Take back schemes, where there is minimal user interaction are relatively low risk for all involved. For example, HP's Instant Ink ("HP," 2017) service uses Wifi technology to anticipate when new printer cartridges are required and posts them to the user for a low monthly fee (based on number of sheets printed). HP can benefit from economies of scale by using much larger, refillable ink cartridges that are returned to them by pre-paid envelope as part of the service whilst the consumer has an uninterrupted supply of ink at a significantly lower price to traditional cartridges. Similarly, flexible leasing of products such as pushchairs (e.g. Bugaboo) where users only need the product for a short period of time, can be very desirable to users/consumers if the price point is well defined and the design of the product can sustain multiple use cycles.

[1] https://www.lecreuset.co.uk/

Islabikes are an interesting example of a company exploring the principles of the circular economy. The company (which manufactures and sells high quality children's bikes) recognised that the increasing cost of the natural resources needed to manufacture bikes was a potential threat to the affordability of their bikes ("Isla Bikes," 2017). They responded by undertaking new product development (alongside their current product lines) to develop durable products which will perform in line with brand expectations, in the rental market. The innovations in bike manufacture required as part of their Imagine 20 project have forced them to think differently about their bike design, leading to innovations in frame construction, the materials used, the pedals and the handle bars (Islabikes, 2017). This example is also illustrative of a threat being turned into an opportunity for innovation.

Understanding the user to inform business model success

Circular business model innovation needs to be informed by a detailed understanding of what consumers will accept, what they expect and what they desire.

A challenge for Islabikes is that their products are widely recognised as holding their value in the second-hand market. For some consumer demographics, this is an attractive proposition that influences their purchasing behaviour, making them more willing to make the initial high investment in the knowledge that the product will retain up to 80% of its value on resale. New service models will need to take this into consideration, as if ignored the circular economy model could fail.

While some consumers may be, realistic and project their financial scenarios into the future, other consumer demographics struggle to rationalise the complex relationship between value, quality and cost. Furthermore, socialisation towards higher levels of consumption, the interdependent relationship between purchases and the residual influence of past consumption behaviours all coalesce to inform consumer behaviour in the present (Douglas & Isherwood, 2009). Therefore, given that consumer purchasing behaviour is tied to past experience, it can be difficult to adjust, and this would affect the potential success of circular business models. This includes (for example) 'sufficiency' approaches that ask for a higher upfront cost (such as Vitsoe's range of durable furniture) or 'Buy Me Once'[2] propositions such as 'The 30 Year Collection'[3] where every garment is built to last a lifetime.

Edbring et al., (2016), found that consumers are not likely to respond positively to long-term leasing contracts for certain items. Consumers who are on a monthly budget, for instance, might see a substantial difference between committing to a one-off purchase that can be saved for (or put on credit) and having to find (and justify) a rolling monthly fee. Leasing of products, which one might expect to own for a number of years, such as jeans, can drive prices above that of a once-off purchase.

New service contracts that companies might offer, also need to consider the realities of people managing multiple service contracts for everything from pushchairs, to mobile phones, fridges and drills. The authors suggest that there is a need for a more realistic understanding of how people prioritise purchasing decisions in order to avoid developing naive business models which may not progress beyond pilot schemes, single line products or products that have poorly thought out requirements of users. While effective service design can begin to respond to this need, further investigation is required to better understand what types of services and financial models different group of users/consumers find acceptable and which models suit which product categories. Design approaches can play an important role in understanding these types of users and conceiving ways to respond to their identities.

Conclusions

Research has shown that designers do not typically associate themselves with techno-centric approaches, which is seen as the domain of engineers and scientists (Lofthouse, 2004). Through greater consideration of user needs and values, the field will become more inclusive, as managers and designers alike realise that, as with ecodesign, design teams have a valuable role to play regarding understanding users' values etc.

The EMF states that CE principles can be applied to everything. However, research so far (Edbring et al., 2016; Lofthouse & Bhamra, 2006; Tukker, 2015) suggests that this is contextual and subject to delivery. In reality a CE approach may be more suited to some B2C offers than others. To facilitate a successful transition to a future CE and encourage uptake of these types of business solutions, there is a need to know more about user/consumer attitudes towards alternative consumption models, to recognise the challenges of behaviour change and to understand what approaches are acceptable and even desirable.

Outside the scope of this paper are additional and substantial issues relating to how the circular economy paradigm addresses overconsumption, user/consumer relationships to circular business model conceptions, the legitimacy of the needs being fulfilled by propositions so far (medium-to-high-end Western consumer markets), as well as privacy and consumer rights related issues. Furthermore, the emergence of Industry 4.0, the evolution of production and consumption systems enabled by digitisation, requires a more progressive and ambitious exploration of relevant business models for a future circular economy, which at present appear to be linked to more traditional approaches.

[2] http://www.buymeonce.com/clothes

[3] https://www.tomcridland.com/collections/30yearcollection

This paper concludes by arguing that changing the way that the circular economy is framed so that it is more inclusive of user/consumer needs and behaviours would open up greater opportunities for success. Moreover, by starting with genuine needs there is arguably more opportunity to respond to very real societal issues that we face, that would have a very positive contribution to society beyond consumerism.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-217

Planned obsolescence: who are those planners?

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Keywords
Planned obsolescence
Product development

Abstract

There is a controversial discussion on the phenomenon of "planned obsolescence". However, shrinking product lifetimes and product qualities do not prove that actors in the product development process take conscious decisions toward premature obsolescence.
Current product faults like exploding batteries in Samsung's Galaxy Note 7 foster the suspicion that manufacturers are also struggling with unintended product obsolescence. The relevant question is in which limits the planning of product lifetimes leads to intended and unintended consequences.
The reasons and intentions behind product features and whether these features are intentionally at all can just be determined in direct contact with the actors of the product development processes. The research project LOiPE could establish contacts in strict confidence to development departments of 23 major German companies. The objectives of the survey were to find out about the development process in their point of view, its paradigms and their experience with "planned obsolescence".
All interviewees assured that when they had to balance cost against lifespan, lifespan always prevailed.
The allegation of a deliberately intended premature obsolescence was vehemently rejected by all of them. The limitations through obsolescence are caused by the basis conditions of developing and producing: rising complexity, increasing speed of innovation cycles and high cost pressure. These conditions and their constraints leave little space to single actors of the development process and to companies. In this sense obsolescence is systemic. So, a perspective towards more sustainable production and consumption lies in a combination of different approaches.

Introduction

There is still a controversial discussion among professional circles, the media and a broad public community on the phenomenon of "planned obsolescence". The explanations and varieties of planned obsolescence are manifold and date back until the 1930s, where Bernard London described it the first time as an economic concept to end the currently recession (London 1932). In the last 7 years the concept has emerged as a buzzword in several discourses on product-related environmental protection and eco- and circular design aspects. Google Trend Statistics also is indicating ongoing search requests for topics related to "planned obsolescence" (Google Trends 2017).

A major part of the public perception and the obsolescence research is concentrated on product and material properties, also known as "built-in obsolescence" of products (Wieser 2016: 156). Especially popular science books focus on the analysis of product life-time and durability aspects in product design to postulate that proven or perceived shortcomings and faults of products are caused intentionally (ex-post-proofs) and speak therefore of planned premature obsolescence (i.a. Schridde 2014:26-94, Eisenriegler 2016:29-53, Reuß 2015: 27). Therefore, the term "planning" not only refers to objects in which obsolescence occurs, but also active persons (subjects) which first trigger this effect through their deliberate decisions. However, the observation of defective inkjet printers, bonded batteries, or broken electrolytic capacitors does not provide an adequate explanation for the decisions of designers, engineers, developers, managers and other relevant actors involved in the product development process to increase or decrease product lifetimes. In short, shrinking product lifetimes and product qualities provide no sufficient proof that actors in the product development process take up intended decisions for planning premature obsolescence.

This paper strives for a different perspective, namely the ex-ante causes of action, the basis for decision making and the conditional framework for planned obsolescence in product creation. Later, the paper presents some empirical evidence on the complex conditions for the planning of obsolescence in product development processes.

A formal definition of Planned Obsolescence

There a several definitions of planned obsolescence, with a different bias on the intention of planning and premature obsolescence. These include the contributions of Packard (Packard 1964), Bulow (Bulow 1986), Kreiß (Kreiß 2015), Pope (Pope 2017) and the predominant part of the public media (cf. Prakash et al. 2016:21). The following definitions are exemplary for this narrow focus:

"Planned Obsolescence is the production of goods with uneconomically short useful lives so that customers will have to make repeat purchases." (Bulow 1986: 729)

"The objective of planned obsolescence is to stimulate replacement buying by consumers". (Guiltinan 2009: 20)

„Among these is the practice of planned obsolescence, the aim of which is to make manufactured products prematurely obsolete." (Pope 2016: 1)

The present definitions are one-dimensional in three respects and thus not adequate for the description of planned obsolescence.

Multiple forms of obsolescence

Obsolescence has multiple forms of appearance and is occurring at all levels of the product life cycle. According to Granberg and Cooper, there are obsolescences which act directly on the product and can be called absolute obsolescence. This includes material wear, technical causes or missing possibilities for repair and lack of spare parts or components. These effects are predominantly in the domain of the manufacturers, since they have a direct influence on the product quality and production processes. In addition to the absolute obsolescences, Granberg and Cooper also name the relative obsolescence. These include the group of psychological, economic, or functional obsolescences, or "mind, money, matter" (Cooper 2004: 425). Relative obsolescences are far more subtle than absolute obsolescences and are a challenge for politics and research because the causal chains are longer. This can be illustrated on the following example: If a material defect leads to the obsolescence of a product, the connection from effect (obsolescence) to cause (material design) can be easily identified. In the case of relative obsolescence, this relation is no longer direct. Why do consumers choose a new Smartphone, even though their old device is still working? Here factors such as advertising, technical progress, general consumption patterns and economic status often act side by side at the same time and in varying intensity.

For political control attempts it is important to note that relative obsolescence now have a greater impact on product life than absolute obsolescence (Cooper 2004: 400). For the further scientific discussion on the topic, it is necessary to differentiate between the different varieties of obsolescence in the future, and to ask about the actual influence of all actors on obsolescence. The one-sided derivation of planned obsolescence as direct consequence of the interests of manufacturers or consumers is insufficient.

Planning for premature and delayed obsolescence

Many definitions explicitly or implicitly postulate that the planning of obsolescence is aimed solely at the shortening of product life. These definitions systematically rule out that in various cases product planning is aimed at the exact opposite, namely, the delay of obsolescence in order to prolong product life-time. Design for repairability, maintenance strategies, upgradeability, minimum life and reuseability are all planned product strategies to prevent premature obsolescence (Oehme et al., 2017).

Although there are many indications that product life-time in the consumer field is often insufficient, it is analytically insufficient to restrict the direction of planned obsolescence only to premature obsolescence. This is especially true because the product life and the timing of obsolescence are always estimations. In practice, the expected product life time may therefore always be not achieved or exceeded (Figure 1).

Bounded rationality and limits of planning

The term „planning" is a key word in history and refers to the idea of achieving goals through rational patterns of organization. The word combination "planned obsolescence" comes from a period in which a distinct planning euphoria prevailed (van Laak 2010: 5). Today's and future's demands on product development are increasing (Anderl et al. 2012: 8). It is therefore necessary to question the traditional imagination of "planned obsolescence" with its tendency to assume a strict form of product lifecycle planning.

Ironically in the same period when the concept of planned obsolescence emerged for the first time, the sociologist Robert Merton published one of the first distinct analyses on: "The Unanticipated Consequences of Purposive Social Action" (Merton 1936). Later, the political scientist Herbert A. Simon follows this idea with his concept of "Bounded Rationality" (Simon 1947). Both authors presented a basic idea: What if actors take up irrational decisions that result in non-intended consequences?

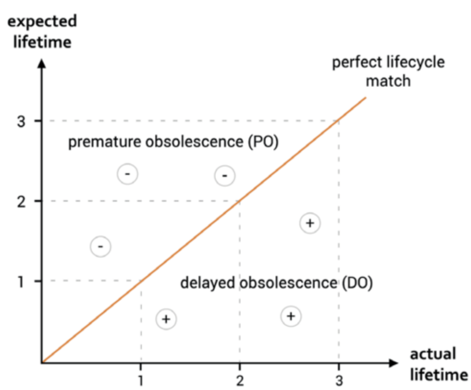

Figure 1. Product lifetime expectation versus actual product lifetimes.

Current product faults like exploding batteries in Samsungs Galaxy Note 7 (Mozur 2017) foster the suspicion those manufacturers are also struggling with problems that lead to unintended product obsolescence. The assertion that product lifetimes are plannable, does not exclude the possibility of unintended consequences. The planning of obsolescence is not a binary decision of 'yes' or 'no'. The relevant question is in which limits the planning of product lifetimes and obsolescence leads to intended and unintended consequences.

Planned Obsolescence and it's 3 Dimensions

Based on the preceding considerations, we propose a formal and unbiased definition of planned obsolescence, which is partly based on Hindles formulation (Hindle 2008:147):

Planned Obsolescence (PO) is a strategy in which the obsolescence of a product is planned and built from its conception.

a) *Form: PO results in absolute or relative obsolescence.*
b) *Time: PO leads to premature or delayed obsolescence of the product.*
c) *Intention: PO has intended and unintended consequences.*

Interviewing the planners

As shown, the intentions leading to proven or perceived shortcomings and faults of products cannot be derived directly from product properties. The reasons and intentions behind product features and whether these features are intentionally at all can just be determined in direct contact with the actors of the product development processes. To establish this contact is one of the main objectives of the project LOiPE (Langlebigkeit und Obsoleszenz in der Produktentstehung / Lifetime and Obsolescence in Product Development). It is funded by HBS, the foundation of German trade unions and carried out by Sustainum – Institute for Sustainable Economy Berlin. The collaboration with trade unions, particularly with the German Metal Workers Union (IG Metall), eased direct and unofficial access to the actors as a prerequisite for open and honest answers.

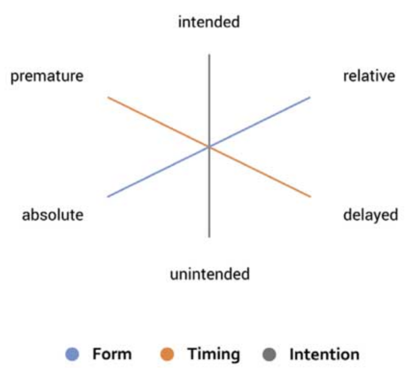

Figure 2. Planned Obsolescence and the 3 Dimensions Form, Time, Intention (FTI).

To date the project could establish contacts in strict confidence to development departments of 23 major German companies, mainly producing consumer goods, but also investment goods. Most of the interviews were led along a semi-structured questionnaire, some in a more informal atmosphere. All interviews took place without surveillance through company officials. Most interviewees came directly from development and design departments, sometimes also from quality assurance, research and marketing. In some cases, we interviewed more than one person from a company. All in all, we were able to conduct 28 interviews with insiders usually considered the "planners of obsolescence" (in the following we will refer to them as "developers"). All interviewees were employed in Germany where the products in global scales tend to have high labour costs and – related to this – a high standard. Therefore, the companies have a reputation to lose should their products show a high degree of absolute obsolescence, i.e. the findings can not necessarily be generalized globally.

The objectives of the survey were to find out

- the development process in their point of view, focusing on the circumstances under which their work takes place,
- the paradigms that are prevailing in their work, and
- their perspective as "planners of obsolescence".

The development process

As a fundamental of engineering, all technical artifacts are developed and designed for a certain lifespan determined in advance. This will be an essential part of every requirements list of a new product. All interviewees left no doubt about this. However, contrary to widespread assumptions, they all agreed that when they had to balance cost against lifespan, the latter was more important for their decisions. This paradigm is not unlimited, and is more likely to be found in the development of expensive products than of cheap ones, but lifespan prevailed in all cases. And still, the developers all agreed that their products not always met the targeted lifespan. They named three main reasons for this:

The first one is the rising complexity of new products. New features, more options, additional electronic control with growing numbers of sensors etc. cause interdependencies that are difficult to overlook. So, the single components will in most cases be adequate to the requirements. Nevertheless, the system as a whole might lack stability.

This leads to time constraints as the second reason. They are caused by a steadily increasing competition among companies for innovation leadership, resulting in a permanent pressure to reduce time to market. So usually it is the time budget (and not the technical skills of developers) that limits in-depth-mastery of endurance of components as well as of interaction of sub-systems. Since traditional testing is often too time consuming, companies rely more and more on short-cycle-testing and simulation – both leaving a lot of space for uncertainty.

This limits the predictability of lifespans and functionality considerably. Product recalls in the automotive sector are popular examples for this.

The third reason is cost pressure. Product prizes are calculated top down, i.e. the marketing or the sales department explores which type of product, comprising a list of properties, can be sold at which prize. Then appropriate component prizes and manufacturing costs are derived from this. This again limits the quality that is possible under these circumstances.

The core problem of a development process under these (market) constraints is that each company has just a very limited leeway in decision-making. Therefore, it can be stated that, as a general rule, the observed forms of absolute obsolescence emerging from this are unintentional. It should be remarked that this still leaves a lot of developers unsatisfied – they definitely would like to create better products.

Paradigms of development

As said before, in most development processes durability of components was said to outweigh the costs. However, a closer look showed a classical engineering approach: durability was often just considered as the time until the first failure of the first component – when it is broken, the lifetime is over (not in the automotive sector, since cars are so expensive that upgradeability pays off). So, we asked for the paradigms commanding the development process. As figure 3 shows, other aspects that might contribute to a delayed obsolescence are of far less importance, in particular upgradeability.

The planner's point of view

The allegation of a deliberately intended, premature obsolescence was vehemently rejected by all our interviewees. They all agreed that no company and no engineer would do something like this, they considered

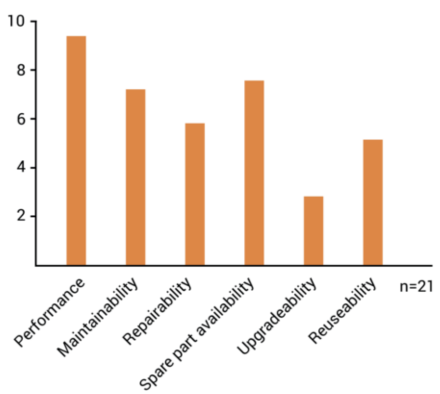

Figure 3: Paradigms of product development.

it completely out of question. It would collide with their identity of "engineers as problem solvers". Moreover, they indicated that one deliberate weak point in a product would make all their efforts useless to make other parts of the product more durable – and the costs of this would be misspent. On the contrary, they were generally proud to participate in a quest for good products. All of them were committed to develop products that were as durable and functional as possible under the given circumstances. However, unintended obsolescence is still possible and taking place, also in their judgement, since the "given circumstances" are beyond their control and often also beyond their company's control. Then it will be the internal structure of a company as well as market conditions that determine the lifetime of a product.

Conclusions

The limitations of useful life through absolute obsolescence including the consumption of resources going along with it are not caused by an intentional weakening of single components – aiming at fast replacement – but by the basis conditions of developing and producing: rising complexity, increasing speed of innovation cycles including shortened tests and high cost pressure. These conditions and their constraints leave little space, if any at all, to single actors of the development process and to companies. In this sense obsolescence is systemic.

So, since all single actors in this field – manufacturing companies, developers, commerce and customers – have only very limited options, a perspective towards more sustainable production and consumption lies in a combination of different approaches:

Changing customer demand, looking more towards sustainability. They could e.g. put more emphasis on simple products that are easy to handle, maintain and repair, or go for refurbished second hand products or leasing rather than owning. By this they would open new business models for producers and commerce.

Changing the legal side so that products for short term usage become expensive and sustainable products and manufacturing more profitable for companies.

Based on this: developing products whose lifespan does not end with the first failure; instead paying more attention than nowadays on easy maintenance, repair, refurbishment, and the option to modernize single modules (which again needs and supports new business models).

Development of mission statements in companies: „What kind of enterprise do we want to be and which demands of customers and society are guiding us?". This would also leave more space for the desire of developers to minimize absolute and premature obsolescence.

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*Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)*

DOI: 10.3233/978-1-61499-820-4-222

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Design for the wise consumer

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Keywords
Wise Consumer
Design for Wisdom

Abstract
In response to dominant patterns of mainstream consumption evident in developed economies, Consumer Wisdom offers a positive alternative whose objective is to simultaneously promote the well-being of the individual, society, and the natural environment. The current research has two objectives. First, through a series of in-depth interviews with individuals nominated for their wisdom, we provide an empirically grounded theory of Consumer Wisdom. Our theory of Consumer Wisdom is composed of five interdependent facets: Contemplation, Intentionality, Emotional Mastery, Openness, and Transcendence. Next, we synthesize design principles from existing design frameworks and philosophies that align with the facets of consumer wisdom, and we build on these to reflect new insights derived from our theory.

Introduction

The consumption related decisions and behaviors that individuals make every day have a significant effect on both the individual consumer's well-being and, collectively and cumulatively, on society and the natural environment. There is a growing recognition that today's mainstream consumer lifestyles are not scalable globally due to resource and other constraints, and the significant unintended negative effects of conventional consumption patterns on current global challenges such as pollution and climate change (Assadourian 2013). A critical question, then, is "what is the alternative to the mainstream consumer lifestyle dominant in developed economies?" The first objective of our research is to study a nascent, contrasting phenomenon of Consumer Wisdom. Based on extensive fieldwork, we develop a theory of Consumer Wisdom consisting of five, interdependent facets: *Contemplation, Intentionality, Emotional Mastery, Openness, and Transcendence.*

Further, while wise consumers may make better decisions and behave in ways that better promote their own well-being and that of society, they are limited by the consumption alternatives that are readily available in the marketplace. Therefore, the second objective of our research is to use the insights gained from our study of wise consumers to develop a set of guidelines for designers to consider in both their choice of what to design (i.e., the characteristics of product or service categories that most appeal to wise consumers) as well as how to design for the wise consumer (i.e., design criteria to consider given a chosen product or service category). These preliminary guidelines offer the possibility of better serving the wise consumer as well as the potential to promote similar choices and behaviors amongst traditional, mainstream consumers. These choices and behaviors, which we illustrate through our research, include many practices that have been previously identified as contributing to the extension of product lifetimes and reduced aggregate consumption levels (e.g, collaborative consumption). We synthesize, build upon, and motivate these practices based on original, empirically grounded insights about wise consumers.

Methodology: A Theory of Consumer Wisdom

Participants

Following Baltes et al. (1995) who studied the psychology of personal wisdom, our interest was in interviewing wise individuals. Our recruitment approach was highly selective and involved a nomination process — a common approach in wisdom research — in order to identify our 31 informants (Ardelt 2003; Baltes et al. 1995; Glück et al. 2013).

Given that some consistent themes have begun to emerge from research on the psychology of personal wisdom, such as "pragmatic knowledge" (Baltes and Staudinger 2000) and "pro-social" (Bangen et al. 2013), we used purposive sampling to identify specific subpopulations of interest that we believed would be particularly well suited to exploration of these themes within a consumption context. For example, to facilitate the identification of participants who are pragmatic, we sought to identify small-farm owners in the Northeast of the United States. Likewise, we sought to identify urban progressives in the Pacific Northwest to facilitate identification of participants who are pro-social. To increase the range of experiences explored in aggregate, we also sought some diversity with respect to a variety of factors such as age, gender, occupation, region of the country (all in the U.S.), and community type.

Procedure

Each interview began with informants providing some information about their background and lifestyle. Next, informants were reminded that the interview was focused on "everyday decision making" and that we would use the context of consumption, which was defined for them, for us to understand their approach (i.e., both their practices and philosophy). We then asked them to describe in detail a "significant consumption related decision" that they had made in the prior 6-12 months. We repeated this line of questioning for other consumption choices, including those that they would consider to be "relatively minor, weekly, or daily choices." We probed as needed to explore all stages of consumer decision making and behavior, from need identification, through choice, ownership, and disposition.

Analysis

An initial high-level coding scheme was developed based on our literature review. The coding scheme was iterated throughout by creating and maintaining sub-codes as well as memos for all sub-codes. Codes at both levels were added or expanded or, conversely, collapsed or deleted to reflect the emergent meaning, prevalence, and distinctiveness of each code and sub-code. Next, we revisited all coded passages in a second comprehensive review, this time reviewing passages by code and sub-code (Thompson, Locander, and Pollio 1989). Throughout this final stage, we refined the memos describing the attributes of each code and sub-code, and recoded passages as needed. In doing so, we were able to further refine the meaning and boundaries of our codes towards identification of the facets that collectively constitute the foundation for a parsimonious theoretical framework of consumer wisdom.

Findings: A Theory of Consumer Wisdom

Our analysis yielded an integrated set of five facets of consumer wisdom which we describe below: Contemplation, Intentionality, Emotional Mastery, Openness, and Transcendence. Further, we provide illustrative practices for each of these five facets of consumer wisdom (see Table 1).

Contemplation. Contemplation involves reflection across time and perspectives, and the reasoning required to integrate and reconcile often incomplete and even contradictory information. Thus, contemplation is active and situational, yet builds upon and contributes to the individual's knowledge and understanding. Although it was most evident in informants' everyday consumption related behaviors, contemplation was equally important in their overall lifestyle envisionment.

Intentionality. Intentional consumption is borne from the consumer's recognition of the inexorable and equivocal relationship between their lifestyle and discrete consumption related behaviors, and the assumption of personal responsibility for their deliberate management. Specifically, intentionality is reflected in the wise consumer's ongoing lifestyle envisionment and their deliberate planning and management of the resources needed to realize their chosen lifestyle.

Emotional Mastery. Emotional mastery refers to informants' awareness, understanding, and management of the full spectrum of consumption-related emotions, and the behaviors and experiences that elicit them. Beyond the situational regulation of emotions that might thwart their intended behaviors or experiences, emotional mastery also encompasses avoidance of the contexts and behaviors that might lead to undesired emotions and emotional states, such as regret, guilt, and stress. Moreover, it also includes an explicit pursuit and attainment of desired emotions and emotional states, such as joy, gratitude, harmony, and flow, and the intentional approach towards the consumption-related contexts and behaviors that enable them.

Openness. Our informants were characteristically curious, open-minded, and drawn to new ideas and experiences, which was reflected in an ongoing evolution of their values, goals, preferences, and behaviors. For some, this personal growth was enabled by consumption, e.g., through travel. For others, it was manifest directly in their consumption behaviors and reflected an openness to experiment with and selectively adopt alternative consumption practices. These alternative consumption practices span the breadth of consumption-related activities, from production through acquisition and use, and often seek to provide benefits beyond traditional utilitarian and hedonic attributes, such as personal connection and enactment of other-oriented values. These practices include many that are consequential for extending product lifetimes, including alternative ownership models, collaborative consumption, repair, and re-use.

Transcendence. Beyond pursuit of their own envisioned lifestyle, informants' consumption stories also demonstrate a concern for the consequences of their consumption and a recognition that consumption relates to, and can support, supra-existential motives. Building on a caring for the self and others, transcendence reflects many of our informants' desire for connections with others, with the natural world, and, ultimately, a sense of interdependence of the 'self' and 'other'.

Design Implications for the Wise Consumer

Given an understanding of the consumption related tendencies of the wise consumer (i.e., their disposition to think, feel and act in specific ways), we turn to the second objective of our research which is to identify, define, and organize a set of guidelines for designers to consider in both their choice of what to design (i.e., the characteristics of product or service categories that will most appeal to wise consumers) as well as how to design for the wise consumer (i.e., design criteria to consider given a chosen product or service category). There are many well established models and philosophies of design that, to varying degrees, provide guidelines consistent with the facets of wise consumption. These include Life Cycle Analysis, Natural Capitalism, Cradle to Cradle, and the Circular Economy (see Shedroff 2009 for a review of many of these). Therefore, the guidelines we propose are based on a synthesis of existing practices — identifying, prioritizing and organizing principles and practices that align with the facets of consumer wisdom — as well as generation of derivative or new guidelines based on insights gained from our research on the five facets of consumer wisdom (see Table 2). While a detailed elaboration of each of these guidelines is beyond our current scope, the following example – focusing on a dimension within the facet of Emotional Mastery – serves as an illustration.

One of the characteristics of the wise consumer is that they selectively use products and services as a means to enable positive experiences characterized by emotions and emotional states such as joy, excitement, pride, and flow. Thus, to the degree possible, designers will be relatively more successful when they focus their talents and efforts on products and services that provide these benefits. This suggests favoring product categories such as bicycles and pianos, for example, as opposed to stationary gym equipment and garage organization systems. While the latter product categories provide some benefits as well, the highest potential product categories will be those that exhibit multiple characteristics that appeal to the wise consumer, including the generation of positive emotional states.

Next, following the same logic, products within a given category, say bicycles, will be especially appealing if they continue to provide these positive emotional experiences over time. A design challenge emerges from the reality that consumers learn and adapt. Since the positive experience of 'flow' is obtained at a moderate level of challenge where the individual is neither bored nor overwhelmed (Csikszentmihalyi 2008), this means that the product itself must adapt as well, or at least have a design that accommodates varying levels of capability as the user's skill and confidence increase. For example, most bicycles that are designed for off-road use (i.e., "mountain bikes") are designed to accommodate a given tire size that is optimal for a typical user and typical conditions. A better design, however, would be more versatile — allowing for changes in tire size (diameter and width) so that the user could reconfigure the same bicycle at minimal cost for significantly different conditions that require more advanced levels of ability and confidence. Consider that bicycles for young children often have detachable "training wheels" for the same reason (i.e., to accommodate their development) – yet that logic is seldom applied to adult bicycles. Instead, consumers often grow tired of the things that they own, meaning that they need to spend more in order to obtain the same level of positive experience. This dynamic hurts the individual, who must spend more money and time, as well as the environment, given the need for resources to support the proliferation of dormant products. This is just one of many guidelines that we believe would lead to products and services that the wise consumer would be especially likely to notice, use, and appreciate over time. Further, though they might not recognize it as readily as the wise consumer would, such design would also benefit more mainstream consumers, also enabling their extended use of similarly versatile products over time.

Conclusions

Consumer Wisdom offers a positive alternative whose objective is to simultaneously promote the well-being of the individual, society, and the natural environment. Our hope is to provide an empirically grounded theory of Consumer Wisdom that will, in turn, provide insights and guidance to product designers as well. There are limitations to our research, some of which provide excellent opportunities for future research. Purposive samples are narrow by nature, but nonetheless ours served the intent to explore consumer wisdom among a set of individuals highly respected by their friends and colleagues. It remains to be determined if these same wisdom facets would arise among consumers from a wider range of socioeconomic classes and ideological tendencies. Similarly, our findings are based upon the U.S. cultural context, and thus future research is needed to determine if and how the wisdom facets identified manifest similarly in other settings.

In addition, while our set of proposed design guidelines were informed in part by existing design frameworks and philosophies, future efforts could extend our research by engaging more directly with the design community. Specifically, a logical next step would be to share our theory of consumer wisdom with design practitioners and to engage their help with refining and building upon these preliminary guidelines. However preliminary, the guidelines serve the purpose of illustrating the benefit of developing actionable guidelines for designers that are informed by original, empirically grounded theory that intends to help re-orient designers and others around an aspirational model of consumer wisdom.

Acknowledgments

The author acknowledges the support of the Templeton Foundation through a grant from the Enhancing Life Project, a project of the University of Chicago School of Divinity and Ruhr-University Bochum, Germany.

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Consumer Wisdom Facet	Definition	Exemplary/Illustrative Practices
Contemplation	The practice of considering discrete consumption options and their consequences across time through *retrospection* and *prospection*, as well as the *reasoning* to synthesize and reconcile often incomplete and even contradictory information	• Learning from one's own past consumption experiences • Learning from observing others' consumption behaviors and their consequences • Imagining future consequences of a potential consumption choice • Simulating the outcome of a potential purchase • Evaluating consumption options holistically and making decisions that align with values and intended lifestyle
Intentionality	The practice of ongoing *lifestyle envisionment* and the deliberate *personal resource management* needed to realize a chosen lifestyle	• Assuming personal responsibility for lifestyle and resource management • Developing a lifestyle vision that aligns with values and resources • Development of resource plan/budget • Active management of budget, including budget-shifting • Periodic re-evaluation of lifestyle and resources
Emotional Mastery	The balancing of both *restraint and the avoidance of negative emotions*, and the *pursuit of positive emotions*, including an active avoidance of, or approach towards, the consumption-related contexts and behaviors that elicit them	• Delaying or avoiding consumption that might lead to regret, guilt, and anxiety • Pursuing consumption that promotes joy, excitement, flow • Avoiding contexts that thwart intended consumption behaviors • Approaching contexts that support intended consumption behaviors
Openness	*Openness to personal growth* through the contexts and content of consumption and the selective adoption of *alternative consumption* practices	• Consumption that promotes the development of skills or enables new experiences • Consumer goods production/co-production • Borrowing/sharing • Buying used, custom, or small-batch produced goods • Extending the value of goods already owned
Transcendence	*Caring* for the self and for others and, building on this ethic of caring, the pursuit of *connections* with others and with the natural world, ultimately manifesting in a sense of interdependence with a greater reality	• Consumption that promotes one's own physical and emotional health • Pro-environmental and pro-social consumption • Consumption that supports local community • Consumption behaviors (including reduced consumption) that reflect a recognized interdependence with natural world

Table 1. Summary Descriptions of Consumer Wisdom Facets and Illustrative Practices.

Consumer Wisdom Facet **Dimensions**	**Product or service category characteristics to consider (when choosing *what* to design)**	**Design criteria to consider (*given* a chosen product or service category)**
Contemplation **Retrospection** **Prospection** **Reasoning**	• Clear purpose and realizable value (utilitarian and/or experiential) • Observable value • Use over time (and value over time) can be easily and realistically simulated or imagined	• Focused set of features/capabilities with the greatest value (for the targeted user, over time) • Superior overall value relative to existing alternatives (but not across all possible dimensions) • Aesthetically distinct to aid identifying its value in use • Can be experienced or simulated pre-acquisition
Intentionality **Lifestyle envisionment** **Personal resource management**	• Promotes user's well-being (physical and/or mental) • Serves a lifestyle-relevant purpose or goal • Saves time and/or money (longer term, not necessarily at acquisition) • Multi-purpose • Minimizes ownership requirements • Once owned, can be rented or resold to free resources of time and money	• Unobtrusive; does not interfere with lifestyle • Easy & low cost to learn how to use • Easy & low cost to use • Easy & low cost to store • Easy & low cost to maintain • Easy & low cost to diagnose and repair • Reliable/predictable • Durable • Modular/upgradeable • Avoids waste
Emotional Mastery **Avoiding negative emotions** **Pursuing positive emotions**	• Does not entice or allure with exaggerated or false promises of value • Promotes positive behaviors and habits • Contributes to experiences of joy, excitement, pride, and flow	• Honestly conveys capabilities/affordances • Versatile; accommodates wide range of expertise, allowing growth in user capability and avoiding boredom • Timeless; the product's emotional value does not wane over time due to fashion or technological obsolescence • Easy to dispossess in a responsible way
Openness **Openness to personal growth** **Openness to alternative consumption**	• Provides opportunity to develop new skills • Provides new experiences • Promotes personal growth • Can be co-created • Can be shared with others • Can be exchanged with others • Can be repurposed	• Provides ease of initial use (minimize features) • Enables user accommodation/customization (e.g., adjustable) • Universally appealing to many • Maximizes portability (e.g., attractive, durable cases) • Robust; durable and reliable in different contexts
Transcendence **Caring** **Connection**	• Promotes self-care (physical and mental) • Facilitates relationships • Promotes community • Promotes cultural capital • Promotes intercultural understanding • Connects consumer with the natural environment • Promotes a sense of interdependence with all life	• No/low environmental/resource cost to produce • No/low environmental/resource cost to use • No/low environmental/resource cost to dispossess • Easy to reuse, repurpose and/or recycle • Positive social impact in production and acquisition • Positive social impact in use • No/low social cost to dispossess • No/low cultural cost in use

Table 2. Design Implications for the Wise Consumer.

*Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)*

DOI: 10.3233/978-1-61499-820-4-227

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Operationalizing contextmapping as a means for increment of product durability in kitchen utensils design

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Keywords
Participatory design
Contextmapping
Product durability
Kitchen
Utensils

Abstract

Increasing products lifespan is a strategy for a greener and more sustainable future. From a societal vantage point, disposing or discarding products results into consumerism with mountains of waste. Kitchen utensils, regarding their high frequency of usage, are not exceptions of this matter and their design, alongside with their material quality, specify their longevity factor. User-product interaction plays a major role for the design of products which would last longer, whether emotionally or functionally. There are many products which due to poor physical interaction design, destined to breakage, disposal or discardment. In this study, one of the popular tools in participatory design was used to elicit firstly, deep layers of user-product interaction in an authentic environment (like daily routine life), and secondly evaluate the possibility of engaging users in the design process for this rubric. Contextmapping is originally developed to discover latent needs and tacit knowledge of users and in this study, with minor modifications derived from semiotics, context mapping with the goals of product durability was used to find its viability in user-product interaction and glean design principles on product longevity from an actual product-user.

Introduction

Today's society approach has inclined towards disposing and generating waste. Durable products proved to be a successful plan for a sustainable future (Ossevoort, 2010). As materials and physical quality play major factors for product life span (Fuad-luke, 2010) product designers are considered very potential for designing durable goods. The influence that designers can have on a product's life span has been studied by numerous authors (Chapman, 2012; van Nes & Cramer, 2005). Furthermore, the factors that can have impact on the end of a product's life, are varied. Including physicality, perception and performance (Ossevoort, 2010; Packard, 1963; Shedroff, 2009; Walker, 2006), in which the user may dispose of the product or stop using it. Kitchen utensils, due to their high frequency of use (Brooks, 2004), are likely to get out of the usage process, caused by either breakage or simply becoming inoperable. A short survey on these users done by the authors, showed the high amount of disposability and obsolescence in kitchen utensils; mainly because of the inoperability and difficulties users had to cope with. Eliciting their context-of-use may be a promising solution in order to shed a light on kitchen utensils disposability. Accordingly, on account of overlapping studies on participatory design and sustainability (Cramer, 2011), Contextmapping was elected to elucidate the context of use in kitchen utensils i.e. in order to discover the context and also make the users co-designers for the process team. The main hypothesis is that Contextmapping can be a good tool to improve product durability. The research question is whether those tools can be used directly or some changes might be needed in order to align them with durability goals. The study was designed in order to reach these goals. The secondary hypothesis was that if modifications of context-mapping tools through semiotics can enrich the possible results from using such tools or not.

Mapping the Context

Designers' knowledge and their experience can't always cover the scope of users' knowledge. What users experience throughout their lives and the knowledge they gain by interacting with different objects makes a model in their minds, which Norman calls 'mental models' (Norman, 1988). Usually users' mental models differ with the designers' and because of this matchlessness, products would be used wrong, which lead to errors in user-product interaction and consequently results in discarding the product. Contextmapping has been introduced as a tool to elicit tacit knowledge and latent needs of users by firstly make them sensitive about their daily experiences and let them engage into the design process as co-designers (Visser, Stappers, van der Lugt, & Sanders, 2005). The process consists of users making designerly artefacts like collage, models and drawings in order to express their experience and let designers access them (P. Stappers, Sleeswijk-Visser, & Keller, 2003). Contextmapping studies are often used in elicitation of cultural, societal and experiential context of user-product interaction (Chamorro-koc, Popovic, & Emmison, 2007).

Human-product interaction does consist of another realm of physical interaction (Chamorro-Koc & Popovic, 2008) which relates to the issue of users' understanding of product and how to interact with it. Product semantics (Kannengiesser & Gero, 2010; Krippendorff, 2005), Affordances (Kannengiesser & Gero, 2010; Srivastava & Shu, 2013; Turner, 2005) and Information-for-use (Frens, 2007), which connects directly to all human skills (perceptual-motor, emotional and cognitive skills), all are related to the users' experience and thus is inextricably connected to the context-of-use. It is hypothesized that by using the robustness of this tool, designers might be able to extract and elicit issues of physical interactions of users on the first step and then engage users in the process of design in order to evaluate their ability of generating ideas.

Materials & Methods

For the study, based on the principles of Contextmapping guides (Esser, 2017; Sanders & Stappers, 2012; P. J. Stappers, 2010; P. J. Stappers & Sanders, 2003; Stappers P.J., 2006; Visser et al., 2005), the number of participants, type of sessions, stages, objects, tasks and methods were defined.

Utensils

As of the time of this study and regarding the skills of homemakers who partook in it, 14 utensils were elected. None of the utensils were powered (gas, steam or electric) and they were consisted of mechanical and non-mechanical parts. It was desired to choose types of utensils which not only require users to "grab" and "hold" it but also offer the fewest amount of visual information like signs, arrows or text labels. Other factors of assortment were the saliency of the tools; whether they are used routinely or not, and moreover, the amount of discardment (disposing/junking) of the utensils. Some of the ordinary items like spoons or ladles can mostly be repaired and reused, as it was stated by participants. The list consisted of: a) Can Opener, b) Kitchen Shear, c) Sifter, d) Chef Knife, e) Vegetable Peeler, f) Grater, g) Skillet/ Fry Pan, h) Saucepan, i) Colander, j) Nut Cracker, k) Mechanical Ice-Cream Scoop, l) Hand Juicer, m) Teapot[1] , n) Samovar (a tea urn for hot water/kettle). Users were not limited to interact with a specific type or brand of utensils and could use arbitrarily.

Participants

Homemakers who usually spend a considerable amount of daytime in the kitchen are mostly women. Therefore, 15 participants, ranging from 35 to 65 y/o, who were chosen randomly, were females, albeit they could obtain the aid of their family or siblings during the study. All the volunteers were housewives and none were employed in any form of vocational work, neither part-time nor full-time.

The number of participants was chosen based on principles of Contextmapping concerning higher numbers of participants might conclude to imprecise and perplexing results.

Probes & Guidelines

Contextmapping includes different stages, including three main phases: Preparing, Collecting and Communicating (Esser, 2017). Some Alternations were made to the probes, as the essence of Contextmapping probes are usually for cultural, societal and experiential rather than physical interaction. The aim of probes was to sensitize participants about the issues that hinder proper and complete interaction. Issues that generally result to breakage, destruction, ruination or make the artefact "inoperable". On this account, the probes which developed were mostly recording ethnographic tools of participants' daily tasks with the specified utensils. That being so, developed probes ought to elicit objective interaction in an authentic and unfeigned environment (such as daily normal life in a house) rather than in a simulated one (in research laboratories). A map, developed by authors, can clarify the scope of objective interactions to be discovered in the authentic environment; furthermore, the study of physical interaction is in the realm of objective interactions and a real environment shown in the figure as a blank area (Figure 1).

A guideline in a form of pamphlet was designed explaining the tasks and tools participants should put into actions, then a group was created on Telegram Messenger™ (because of its popularity in Iran) for further contact and support. All Participants were added to the group

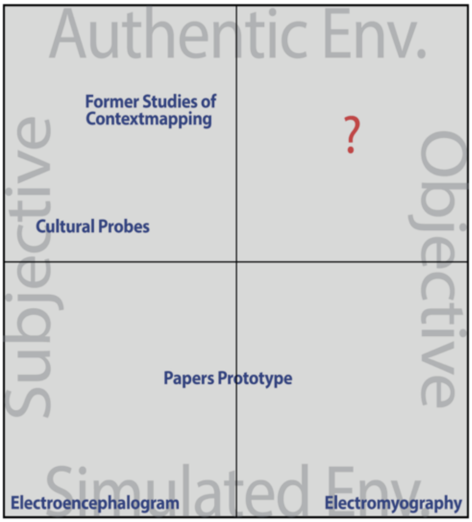

Figure 1. Biaxial map Depicting the scopes of research methods for subjective and objective interactions in different environments.

[1] *Teapot is hardly considered as a "utensil", but like fry pans or pots, it's a culinary-related container; Due to the habitual usage of teapots for making tea (usually 3 times a day) in Persian culture, teapot was also included.*

[2] *'Elder notes' is a technique developed by the authors of this study founded on "Narrative Structure in Semantics & Semiotics".*

including authors, and the guideline was uploaded to the group alongside with the printed version which handed to them.

Probes that were used in the study were video diaries (Brown, Costley, Friend, & Varey, 2010), Photo Analogy and Elders' Notes[2] (Trifonas, 2015). Each one comprehensively was explained in the guideline.

The Procedure of Study

The study was conducted for two months. Firstly, a short ethnographic survey was executed to acquire details about the problems in interaction of kitchen utensils. The method was gathering verbal protocols of participants indicating the reasons for discardment.

After the survey, probes and guidelines were prepared for succeeding stages. Participants had 3 weeks to be sensitized, also they were assigned to use the three probes i.e. gather their interactions and notes, record and capture them and share them in the Messenger Group (Fig. 2 and 3).

Sensitization

During this phase, they were supposed to use their mobile phones or a camcorder to record videos at home; meaning without any interruptions, cuts or transitions. Videos should have taken 5 to 7 minutes and participants were allowed to send their experience with the video diaries in the form of short footages. In these 3 weeks, they reflected their comments and ideas upon the issues of the utensils; apropos of their lifespan and durability. Each of them has worked and interacted during their real and genuine culinary processes; in other words, they collected and submitted their experiences of interaction, when doing routine and regularly tasks of life, which yielded original results due to the habits and knowledge they had about using kitchen utensils. The questions about the procedure and germane subjects were all answered by authors; but inquiries about the "way" a utensil should be used were evaded by instructing them to "use their own discretion".

In addition to videos and photographs, participants submitted comments about the elder notes. These notes were all the tips and tricks of using utensils by their parents or elder relatives. Some of the participants were elders and they had their own hints of using utensils; but others collected these notes out of scribbles on the side of a cooking book or recipes, observing how the elders use a specific utensil or by asking them. All data were saved and stored.

Session

After the sensitizing phase, a generative session was set to be held at university of Tehran. Participants were given two set of techniques; containing collaging and mindmapping. The session was recorded by a camcorder and a mobile phone (sound recording), lasting for about 5 hours (Fig. 4 & 5). The participants then started using techniques to express their experiences and their ideas about the kitchen utensils. The technique for collages was inspired from Synchronic and Diachronic arrangement, generated from semiotics (Chandler, 2007). Participants were free to change the elements of the kitchen utensils (such as handles, body, materials and etc.) based on the choices given to them (that is what is meant by synchronic). As an example, in the potato peeler by OXO (Hustwit, 2009), designers found out that bicycle handles are more comfortable for users than ordinary peelers' handles. We interpreted such a creativity story through diachronic and synchronic technique. The collage phase consisted of outlined pictures of utensils without textures or colors, and 60 pictures of different visual references; e.g. different types of grips in tools, instruments, transportation vehicles; joints like Lego Bricks™, mountain climbing gears, industrial components, faucets, chains, etcetera.

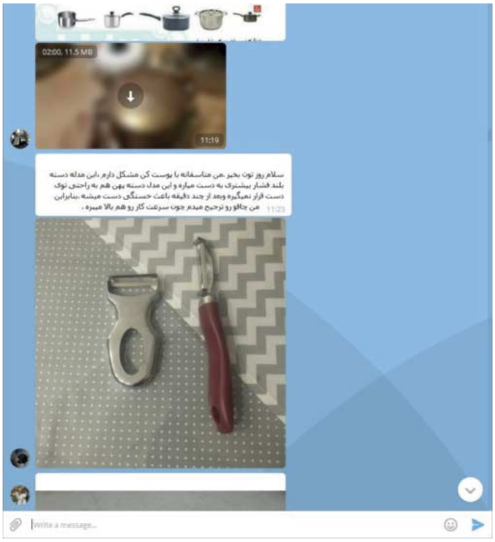

Figure 2 & 3. Screenshot of the Messenger Group showing participants response in the form of Videos, Photographs, and texts.

Figure 4. Participants discussing and sharing their comments about their artefacts.

The mindmapping phase followed the same strategy, but participants used words and links to express their ideas and experiences.

Results

After finishing each stage of the Contextmapping procedure, notable and significant results have emerged. In the sensitization phase, participants noticed varied problems in utensils; they indicated that apropos of errors, difficulties in interacting and troubles when working, they had decided to discard the product. Consequently, problems were categorized in 4 main concerns: changeability, learnability, functionality, and facility.

Changeability

Nearly all participants had problems with the can opener, peeler, samovar, shear, nut cracker and scoop due to the lack of changeability of their components. The reasons which were stated were disfigurement or being spoiled because of usage, in which participants tend to change a specific part of the product with a spare part. Notable product was samovar/kettle which the tap usually clogs because of sedimentation. The lack of changeability of the tap was resulted to 4 samovars going to junks (an elder participant's comment). Another example was the blade of the peeler which 4 of participants explicitly commented in the group; they were unable to change the blade when it became dull.

Figure 5. The generative session with participants. Each participant had a specific amount of time to share her insights with others.

Learnability

Participants had many problems with using some of the utensils for the first time. Comments revealed for can opener, scoop, nut cracker and hand juicer that they wanted a leaflet for the purpose of the utensil and how to work with it. This issue was noted while participants mentioned the form and shape of the utensils are lucid and almost inviting to interact. Other utensils like sifter, grater, pans, shears and knives were mentioned neutral.

Functionality

All volunteers stated that their decision for a utensil whose functionality has been limited, is discardment. One of the elders noted: "I'd repair some of simple ones like a sifter or a grater; but I'd prefer to buy a new one". Functionality was approximately the most remarkable hindrance for durability, as by any means which leads to malfunction will mostly end up in disposing; whether its new or not. In fact, functionality in participants' view surpasses aesthetics and beauty of the product. Problems with functionally were mostly derived from the design of the utensils rather the material quality. Although appearance of the utensils had forced participants to choose products that showed less aging (e.g. black pans rather than red pans), they preferred to own a durable and functional product than an appealing one.

Facility

An easy to use utensil was the most coveted item among the comments of participants. Alongside with functionality, volunteers stated that a complex-looking utensil mostly dissuade them to buy or use it. Facileness was a parameter which in the absence of it, made participants to junk utensils in the drawers, cabinets or the storage.

Made Artefacts

Using the two techniques, participants had the chance to showcase their designerly made objects. They were given scissors and glue pens for the collage phase, and papers and pens for mindmapping. They made artefacts which were innovative, each one specifically derived from their own problems. They used pictures of various industrial components to sort out their personal problem. After sharing their work in the session, other members found the artefacts promising and attractive for the stated problem; meaning, although the artefacts were created on personal problems, it inclusively answered the needs of other participants. "I wish all other graters in the market were like the one you made" one of the elder volunteers mentioned about a grater made by a member. The greater was equipped by window hinges, concerning the angle participants preferred to give to the grater (Fig 6).

Another example was the colander, which was created based on explanations around the artwork in a text format. The participant wanted to have a flexible colander with a firm base, so she could shape it and guide the contents to the pot facilely (Fig. 7).

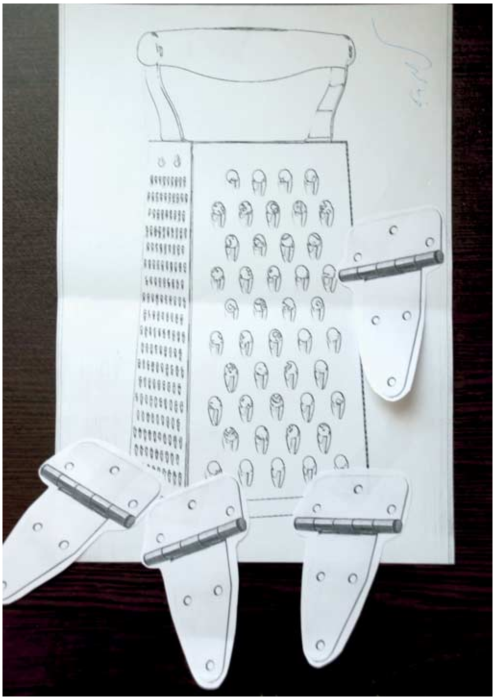

Figure 6. The grater geared with hinged for the angle participant wanted.

Figure 7. The Colander was chosen by authors but the user added texts about the artefact.

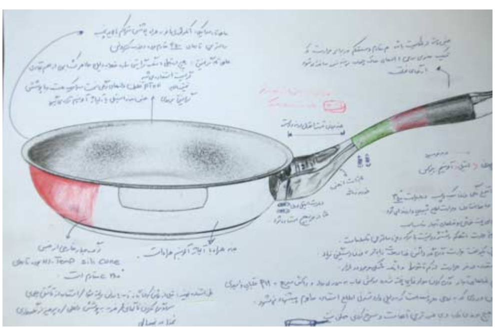

Figure 8. The pan with the defined details about the magnet handle.

A pan with a detachable magnetic handle with was one of the eye-catching artefacts. The user had added a button to detach the magnet so the pan can be released of the handle. This idea was generated based on the frying pans with burnt handles; and the participants had disposed them (Fig. 8).

Conclusion

According to the hypotheses, Contextmapping was fruitful in the study. However, the question was whether these techniques need any modifications for understanding product durability or not. On that account, two refined techniques were generated that were used in the session, collaging and mindmapping. Both were using synchronic and diachronic axes i.e. possible exchanges were offered to participants. The results showed that context mapping did need modifications but the essence of this tool answered the goals of the study.

Another prominent outcome of the study was the principles they suggested for designers. So Contextmapping factually availed the participants for design ideas on durability and product longevity. They implicitly used innoduction (Innovative Abduction) logic for idea generation; it can be concluded that semiotics for product durability could be a method for further research.

Ultimately this tool for eliciting issues and problems for designing durable products is still at its infancy. Participatory design has far more approaches to offer for sustainable product/behavior design and design researchers have yet to discover them.

Acknowledgement

We would like to appreciate all the time and energy our participants spent for our study; also, our humblest gratitude to Dr. Vahid Choupankareh, Associate Professor of school of industrial design, for preparing the University class as a locale for the generative session.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-233

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Reducing clothing production volumes by design: a critical review of sustainable fashion strategies

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Keywords
Sustainable fashion
Design strategies
Production volumes
Attachment
Durability

Abstract
Based on a literature review, this article discusses how the challenge of diminishing clothing production volumes has been approached within the field of sustainable fashion. We identify six common strategies in literature and discuss the approach of user involvement in the process of design and/or manufacture of garments in detail. A critical analysis of the state of the art in the field points out that these strategies have been constructed, studied and promoted without empirical validation. The article concludes with a recommendation to move forward from conceptual to empirical studies. Analyses of existing initiatives and their results in terms of consumer buying behavior and obsolete inventory are recommended as first steps towards validation.

On the challenge of diminishing clothing production volumes

"Efforts to lessen the impact of the fashion sector at the level of individual garments have been eclipsed by the vastly increased total number of garments that we now buy", states Kate Fletcher, Professor in Sustainability, Design and Fashion at the University of the Arts London (Fletcher, 2015). In this claim Fletcher acknowledges the value of actions aimed at reducing the environmental impact of garments, while calling for attention to a complementary approach in sustainable fashion: that of enabling a decrease in the enormous amount of garments in circulation; a particularly relevant challenge in a sector where utilization and longevity of products are in decline.

Fletcher's statement is in line with scholars studying the environmental impact of rising consumption in general, such as Jackson (2009) and Mont & Plepys (2008). These authors show evidence that humanity's environmental efforts have focused on improving resource efficiency as a way to integrate increasing economic output and decreasing environmental impact. However, such efforts have not had an overall positive effect, given a more significant increase in production and consumption levels. Their main claim, put in very simple terms, is that along with a resource-lighter industry we should promote a consumption-lighter society, an argument that has evident application in the apparel sector.

According to Euromonitor, the amount of clothing items purchased per capita was growing slowly but steadily in Western and North European countries until around 2005. The popularization of fast fashion retailers, the economic crisis, environmental and economic policies or environmental awareness may have had particular effects in different countries. Figure 1 shows that after that year national consumption rates have differed. For example, in the UK annual individual purchases escalated up to 36.7 items in 2016, while Denmark reached its peak between 2007 and 2010, with 37.8 items. France and the Netherlands, on the other hand, have been slowly decreasing their volume per capita since 2007. In Germany, developments have been more predictable, with a small increase in purchase rates during the last 15 years.

Analyses of the environmental effects along the different stages of clothes' life cycle also illustrate the importance of tackling the issue of production and consumption volumes. These studies do not always coincide since footprint per phase depends largely on product category. For example a cotton T-shirt requires less energy and water during production than during use (frequent laundry is central here), while for a winter jacket the relation is the opposite (Allwood, et al., 2006; Roos et al., 2015). However, studies that consider clothing as a whole agree in that production is by far the most intensive phase. A report elaborated by the WRAP organization in the UK states that the production phase "contributes over three-quarters of the carbon footprint, over 90% of the water footprint, and around one-third of the waste footprint of the whole lifecycle" (WRAP, 2012). According to the same publication, the great majority of CO2 emissions in the sector are created during material production. A Swedish Life Cycle Analysis based on five clothing categories shows similar results (Roos et al., 2015).

These studies are useful to discuss the effects of strategies aiming at developing a more sustainable fashion industry based on the current state of affairs. For example localizing production does not have such a significant impact since only a very small portion of the footprint is ascribed to distribution. Similarly, recycling textile material, even if using the least harmful mechanical techniques, diminishes only in part the footprint involved in fibre production. This underscores the argument given above; that the amount of clothes being produced is a central issue. However, approaches to diminish production volumes are particularly challenging, since brands, manufacturers, media and consumers are all benefiting from the ever-growing fashion industry.

Enabling decreasing production volumes in the apparel sector by design

Sustainable fashion scholars have proposed a variety of solutions to tackle the issue of growing clothing volumes. Literature on design strategies aiming at diminishing clothing volumes was collected in a systematic review, starting by well-known sustainable fashion books (e.g. Black 2008, Fletcher 2008, Fletcher & Grose 2012, Niinimäki 2013, Gardetti & Torres 2013) and related journals (e.g. Journal of Cleaner Production and Fashion Practice). An analysis of the above-named publications helped to identify suitable keywords to refine and continue the literature search, namely: slow fashion, multifunctional garments/clothing/fashion, modular garments/clothing/fashion, durability, longevity, craft, DIY, customization, co-design, participatory design, product-service systems, collaborative consumption, etc. Subsequently, relevant references were traced leading to other publications; the review included publications issued before July 2016.

The literature search resulted in 27 relevant publications including books, book chapters, journal articles, articles presented in academic conferences, and PhD theses. Their relevance for this review was determined on the bases of two aspects, namely (a) that they were written from a design perspective, and (b) that they discussed ways to reduce clothing production volumes, explicitly or implicitly. In some of these publications the focus lays on slowing down clothing consumption, extending life spans of garments or enabling intensive use rather than reducing production volumes. However, the implicit expected effect on the environment is that of avoiding overproduction and therefore reducing resource use. Therefore, such sources were included in the selection.

Within the selected publications, design strategies to diminish clothing production volumes are either presented side-by-side with strategies to reduce environmental impacts per garment (see e.g. Fletcher & Grose 2012) or they are discussed individually in detail, within a sustainable fashion framework and focusing on implementation (see e.g. Hur & Thomas 2011).

Table 1 presents an overview of the strategies found in literature, namely production on demand (S1), service-based fashion systems (S2), multifunctional, transformable and modular garments (S3) design for slowness and longevity (S4), design for repairing (S5) and user involvement in design and/or manufacture (S6). These strategies are included in the table on the bases of their expected effect in decreasing production volumes. They may have other benefits in terms of sustainability -such as increasing user awareness of material qualities or enabling take-back systems for recycling- but these are not considered here as the focus is on the challenge of quantity. In Table 1, the strategies are organized in six different categories; however, their implementation or implications sometimes overlap. For example, both S4 and S5 aim at extending the life span of garments, but the implementation of the former is based on aesthetic and material qualities of products (emotional and material durability) while the later proposes to enable consumer care by design; therefore, in Table 1 these are considered as separate categories.

The brief descriptions in the second row of Table 1 clarify the main characteristics of each strategy and how they

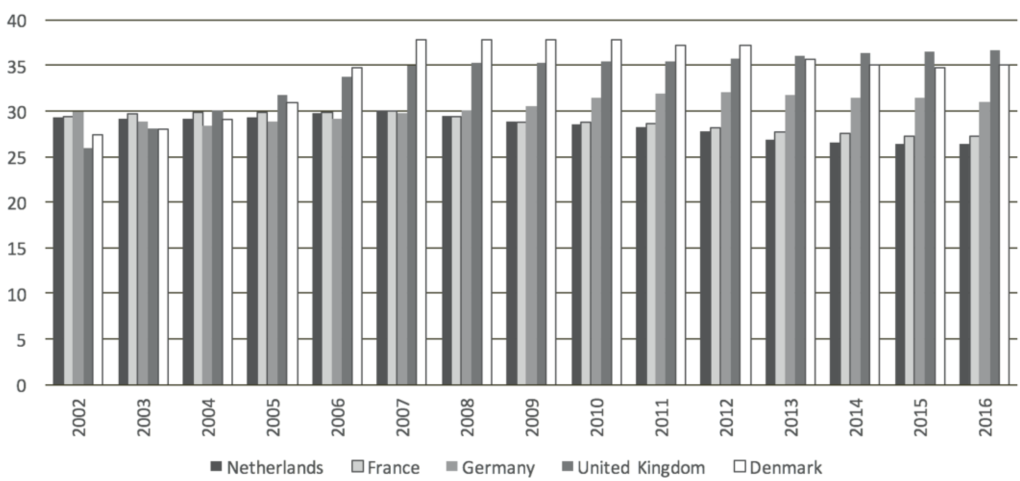

Figure 1. Retail volume per capita (items) in some European countries. Source: Euromonitor.

Strategies in random order	S1) Production on demand	S2) Service-based fashion systems	S3) Multifunctional, transformable and modular garments	S4) Design for slowness and longevity	S5) Design for repairing	S6) User involvement in design and/or manufacture
Description	Garment production based on individual demand, avoiding whole-garment waste (obsolete inventory)	Collaborative consumption, leasing and exchange systems for increased use intensity, detaching material production from company revenue	Versatile garments designed to diminish the material resources needed to keep variety. One garment performs as many garments.	Clothing longevity through attachment based on meaningful aesthetic experiences, material and confection quality and season-free styles	Enable better consumer care by design, for clothing longevity	Design for customization and DIY leading to production on demand and/or longevity through attachment. User involvement in production enables further repairing.
Sources	Niinimäki & Hassi, 2011 Niinimäki, 2013, p. 26	Fletcher, 2008, pp. 154–159 Niinimäki & Hassi, 2011 Fletcher & Grose, 2012, pp. 102–103 Niinimäki, 2013, p. 132 Armstrong, 2013 Armstrong, et al., 2015	Fletcher, 2008, p. 132 Hur & Thomas, 2011 Niinimäki, 2012 Fletcher & Grose, 2012, pp. 77, 80–84 Koo, 2012 Karell, 2013 Cao et al., 2014 Karell, 2014	Fletcher, 2008, pp. 164–169 Fletcher, 2010 Laitala & Boks, 2012 Niinimäki & Hassi, 2011 Niinimäki, 2012 Fletcher & Grose, 2012, pp. 85–87 Cooper, et al., 2013 Aakko, 2013a Aakko, 2013b Laitala, et al., 2015	Fletcher, 2008, pp. 100–103 Laitala & Boks, 2012 Fletcher & Grose 2012, pp. 60–62, 101 Mclaren & Mclauchlan, 2015	Black, 2008, pp. 83–84 Fletcher, 2008, p. 194 Busch, 2008 Niinimäki, 2009 Black et al., 2009 Niinimäki & Hassi, 2011 Laitala & Boks, 2012 Niinimäki, 2012 Busch, 2013, pp. 226–229 Fletcher & Grose, 2012, pp. 105, 143–150 Hirscher, 2013 Hirscher & Fuad-Luke, 2013 Ballie, 2013 Armstrong et al., 2015

Table 1. Strategies aimed at diminishing production volumes of clothing from a design perspective in sustainable fashion literature.

are expected to perform. S1 has the objective of avoiding obsolete inventory (whole-garment waste), S2 is intended to increase clothing use intensity, reducing the amount of garments in circulation, S3-S5 aim at delaying new purchases by extending or expanding the use of garments, and S6 is mainly expected to add emotional and functional value, resulting in intensive and/or extended use.

The literature review pointed out that the above-discussed strategies, in spite of their promises for reducing production volumes, currently remain at a conceptual level. The actual results of these strategies are barely discussed, and only a few authors have acknowledged potential limitations with minor attention. Among those acknowledging that the effect of these strategies is still unknown are Niinimäki & Hassi (2011). The authors discuss "strategies that offer opportunities to better meet an individual customer's needs, create deep product satisfaction and thereby offer the opportunity to decrease consumption" such as customization services. However, they point out that consumer behaviour is not easy to predict; "it is not yet verified whether this happens in reality. Consumers may still increase total consumption". Similarly, Hirscher & Fuad-Luke have mentioned after a participatory sewing workshop with halfway products (to be finished by the user) that "it cannot be assured whether [the participants'] overall consumption of garments has reduced or if the made garments maintain a stronger value than bought fashion or clothing. This needs to be evaluated over a longer period of time" (Hirscher & Fuad-Luke, 2013, p. 186). Finally, Fletcher & Grose (2012, p. 77) have discussed the difference between conceptual and real applications of these strategies by questioning the effects of transfunctional garments; intended to augment use intensity and to reduce the amount of clothes manufactured based on, for example, the use of waterproof yet breathable materials. "If the end user's behaviour remains unstudied," they stress, "there is no guarantee that the sustainability savings made on a single transfunctional product will not be lost on an additional purchase".

In the same line, we argue that as these strategies are based on conceptual explorations that are not validated in practice, they may not have the anticipated effect in terms of sustainability. Therefore, for the time being, they should be considered as hypotheses for the challenge of reducing production volumes rather than demonstrated solutions. For instance, S2 is based on the idea that detaching material production from company revenue may reduce overall production volumes. Examples of such initiatives are rental systems of clothing, where ownership of the product remains at the company and consumers benefit only from their use; a concept that can be implemented by brands or independently, through clothing "libraries". However, it is still unknown if consumers use such services as a substitute of personal wardrobes or as a way to increase variety while keeping purchasing and discarding their clothes at the same pace. As long as the effects of such initiatives in terms of production volumes remain unstudied we will stay uncertain of how they may affect our future.

The approach of user involvement in design and/or manufacture

As shown in the table, S6 (user involvement in design and/or manufacture) is the method that appears most frequently in literature. A central argument behind this strategy is the possibility of reducing consumer demand by extending the life span of garments through attachment. The sources cited by the authors in S6 indicate that this strategy is inherited from conceptual explorations in the field of industrial design as enabler of emotional attachment and durability (e.g. Chapman 2005; Mugge

2008). The hypothesis is that the participation of users in the process of creation adds emotional and functional value to objects and encourages attachment, leading users to keep and take care of them for longer periods and preventing early replacements. As a result of longer lasting object-user relationships, replacement frequency decreases and production volumes will decrease. Kohtala (2015) has pointed out that this series of linked concepts are often promoted as a "formula" for sustainability, which is illustrated in figure 2.

Some of the elements in figure 2 and their correlation have been subject of academic research. A few studies have tested the correlation between user involvement and product value and attachment empirically -based on experiments with other product categories- with positive results. For example, Franke & Piller (2004) have confirmed the positive effect of personalization on perceived value in an experiment based on watches; Mugge et al. (2008) have pointed out that this relationship enables a particular emotional bonding with products in a study of personalized bicycles; Norton et al. (2012) have confirmed a positive relation between user participation in manufacture and perceived value in an experiment with cardboard boxes and Atakan et al. (2014) have investigated the effect of user participation in design and manufacture on product evaluation, affective commitment, and identification of participants with the product. This last study is based on a series of separate experiments for participation in the design and manufacture phases; involving CDs, cardboard photo frames, and coffee mugs.

The relationship between attachment and durability, however, has only been marginally assessed. Moreover, the results of these studies are less supportive of this "formula". Mugge et al. (2006) conducted an investigation based on scenarios, where subjects where asked to predict the degree of product attachment and durability of two different watch models ("extroverted" and "introverted") for two parallel user personalities. The findings indicated that although personality congruity leads to product attachment, a long product life span was expected only for the "introverted" watch. In another study, Maldini (2016) analysed the attitude of users towards self-designed, digitally-fabricated objects. The author found that users were strongly attached to their projects, however this did not lead to long-lasting objects given that the technology used enabled the manufacture of copies relatively easy. As a result, users regarded the material outcomes of their projects as disposable.

Finally, the effect of durability on decreasing production volumes has not been studied at all, not only within the apparel sector but also for other consumer products. As a consequence, it is unknown to what extent keeping a product for a prolonged period prevents new consumer purchases.

Further research is required to investigate whether this strategy can contribute to diminishing production volumes in the apparel sector. Two aspects deserve special attention: the effect of user involvement in design/manufacture on the use intensity and longevity of clothing, and the extent to which the relationship between durability and less consumption applies to clothing, given that garments can be easily stored in a forgotten corner of the wardrobe and they are often not bought with the purpose of replacing an existing item. These points emerge when we analyse the validity of this approach critically, keeping the variables involved in actual practices in mind.

Moving towards empirical validation

In the previous section we discussed one of the strategies aimed at diminishing clothing production volumes in more detail, but the lack of validation applies for the other strategies as well since none of the sources in the table refers to studies assessing their effects. This does not mean that sustainable fashion scholars are not informed about actual practice. On the contrary, many of these strategies have been developed on the basis of empirical studies. For example Laitala et al. (2015) propose a series of design guidelines for clothing longevity based on a previous thorough analysis of discarded clothing (Laitala & Klepp, 2011) and Niinimäki (2012) builds on a consumer survey of product characteristics leading to satisfaction and longevity. What is missing is a complementary assessment after these strategies are put in practice.

Experiments such as the ones employed in the studies mentioned earlier (Atakan et al., 2014; Franke & Piller, 2004; Mugge et al., 2008; Norton et al., 2012) are not suitable for such an investigation because they do not take into account variables such as consumer motivation and product category. These variables are rather neutralized for the purpose of the experiment and participants are included regardless of their desire or need of a new personal CD, watch or box.

Production of garments on demand, service-based fashion systems, multifunctional, transformable and modular garments, design for slowness and longevity, design for repairing, and user involvement in design and/or manufacture are already available. A first step to establish the validity of the strategies in Table 1 is to study existing initiatives with emphasis on (a) obsolete inventory (S1) and (b) long-term buying behaviour of consumers engaging with them (S2-S6). By systematically observing the influence of these strategies in practice, we

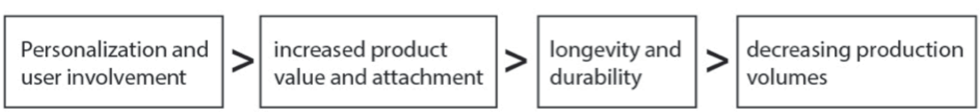

Figure 2. A common strategy aimed at decreasing production volumes lacking empirical validation.

may not only understand to what extent they are valid and effective, but also under which conditions. On the bases of these inquiries we may contribute to the emergence of a consumption-lighter society by design, one that along with a resource-lighter industry enables us to flourish within the constrains of our ecological limits.

Acknowledgments

The first author is grateful to her PhD supervisors Javier Gimeno-Martinez, Prof. Hein Daanen and Prof. Pieter Jan Stappers.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-238

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

The look of rough: visual and tactile perceptions of cosmetically aged materials

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Keywords
Material selection
Ageing
Cosmetic obsolescence
Product lifetime extension
Emotionally durable design

Abstract
The aesthetics of material performance within design is typically only considered up to the point of sale, a false end state in which the 'newness' of the product is protected by the hermetic packaging in which it is sold. Beyond this, the 'ageing' of a material is thought of only in terms of utility or easily measured technical parameters such as durability or toughness, and rarely reflects upon, or accounts for, the user's experiential relationship with the material. Here, we explore changes in tactile and visual perceptions when sample materials have been artificially aged through the application of a taxonomy of damage observed from real world products. This paper argues that to expand our current knowledge in material culture and to assist in providing a more nuanced understanding of the user's long-term relationship with materials, we, as designers, need to observe, record and reflect upon attitudinal reactions to aged and used materials.

Introduction

The relationship that we have with materials and their associated meaning is constructed from tangible interactions combined with the tacit semantic baggage of meanings that are defined by our collective material culture (Demirbilek & Sener, 2003; Dunne, 2005; Sudjic, 2008; Chapman, 2015). Current understanding of how material wear and damage fits into our lexicon of material meaning is anecdotal and not always "…a necessary design consideration to assist the extension of product life spans in graceful and socially acceptable ways." (Chapman, 2014, pp.141). In addition, if the concept of a "scratch-free world of slick polymers" (ibid) is synonymous with digital products, there is an implication that the materials that are used in analogue products are, given societal and semantic norms, more accepting of wear, for example the leather strap of an heirloom watch or the working surface of an old oak butchers block. In the case of electronic products wear has a detrimental effect on the appreciation of the materials when they are used in the outer casings of digital products (Fisher, 2004; Odom and Pierce, 2009) but again conclusions in the majority of current literature are primarily drawn from tacit and anecdotal evidence, not backed up with the rigour of an empirical study. There are some notable exceptions with Lilley et al., (2016) being the best case so far for assessments of material affect using repeatable scientific methods.

The current semantic language that is linked to user's perceptions of materials has been codified through a set of studies that explore, mainly, the tactile and visual characteristics of new, rather than aged, material samples (Pedgley, 2009; Karana and Hekkert, 2010; Rognoli and Karana, 2014, Zuo et al., 2001), omitting consideration of the use phase of a product, where the material will inevitably suffer wear and tear from everyday use. This illustrates a large gap in knowledge where the meanings of materials and the products that are manufactured from these materials are understood only until the point of purchase. The majority of the life of the product is in use and it is during this period that significant changes to the meanings of materials and products take place. This paper explores this shortcoming drawing on the findings of a study which identified, and provided a taxonomy for wear occurring on real world products during their use phase, (Manley, 2015) which was completed in partial fulfillment of a PhD research project (Manley, forthcoming).

For the purposes of this paper, and within the interests of brevity, this paper will report on the results of user evaluation of three materials: Plastic Gloss, Metal and Wood Matte. The Plastic Gloss and Metal were chosen as they represent two of the most commonly used materials in the manufacture of portable electronic products. Wood Matte was chosen to test a central hypothesis of the PhD that worn natural materials are more favourably judged than their man-made counterparts.

The full analyses, findings and conclusions of the entire study can be found in Manley, (forthcoming).

Methods

This paper utilises the tried and tested Semantic Differential Method (Osgood, 1964), to elicit attitudinal responses to the material samples used during the study (See Figure 1 for material samples used). Firstly, a series of seven word pairs[1] were used to assess the material samples that were presented in each of the five material states (No Wear [control samples], Abrasion, Ablation, Impact and Accumulated Dirt), to a group of 18-25 year-old participants (n=35) engaged in study at XXXX University. From this, and the subsequent quantitative analysis (Wilcoxon Signed-Rank Test) of the participant responses, affective responses to certain types of wear and damage were identified [Study Part A].

Next, five phrase[2] pairings were used to enable participants to evaluate the full range of material samples with all four wear types present at the same time [Study Part B] (the No Wear control samples were not used at this time as the phrase pairings were focused on the accumulation of wear and damage and the assumption that the materials had been 'used'). The participants were explicitly instructed to consider the material samples within the context of portable electronic products. This differentiated the research from prior studies in which material swatches devoid of a product context were considered (Karana and Hekkert, 2010; Rognoli, Karana, 2014, Zuo et al., 2001). Participants were asked to identify and rank, with three numbered tokens, their top three materials based on the five phrase pairs (see figure 2).

For Part B the samples included the CLEVER material.

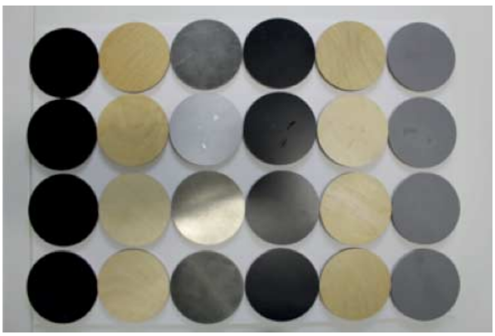

Figure 1. Material sample discs used in study [From left to right; Plastic Gloss, Wood Gloss, Metal, Plastic Matte, Wood Matte and CLEVER material. From top to bottom; Abrasion, Ablation, Impact and Accumulated Dirt.] (Authors own image)

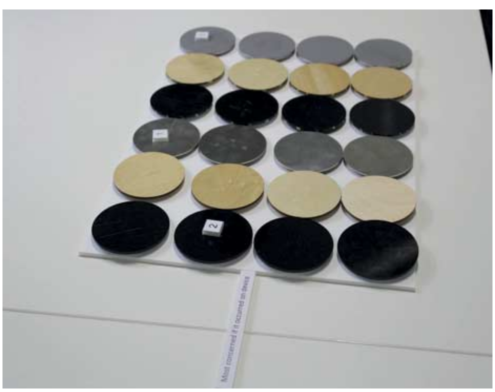

Figure 2: Material sample discs being selected using rank phrases for Part B. (Authors own image)

Findings

Part A

Table 1 indicates the p-value scores (used to statistically identify significance) for each of the samples being compared based on median scores. As a result, the p-value can indicate (if $p<0.05$ and highlighted in green) that the median scores for two samples that differ in their wear type, have elicited significantly different reactions based on the semantic differential scale being used. It can be seen that the assessments of the material samples are indeed affected by the introduction of wear. It is interesting to note that wear had an influence on all the materials depending on the semantic scales being used to assess them. There is evidence also, by observing the lack of a difference in assessment (p-value > 0.05), that certain semantic associations do not change. For example, it was seen, without exception that the perceptions of hard-soft were not affected by a change in the wear on the samples.

Findings Highlights

It was seen that the comparison between No Wear and Impact drew fewer significant differences with only Plastic Gloss being seen to be less old, rougher and uglier when Impact was present. It also made Wood Matte uglier.

The findings also identified that the presence of Accumulated Dirt was seen to have a greater negative influence than the other wear types which was not anticipated. To visualise the effect that differing wear types had on the assessments of the samples, the median scores have been plotted with each material sample being shown on the semantic differential scales used in the study. [red arrows identify p-value<0.05, green arrows identify p-value>0.05, see table 1.

Plastic Gloss

It can be seen the Accumulated Dirt sample for Plastic Gloss scored significantly lower on all but the boring-interesting scale (see figure 4). Abrasion was also often seen to be assessed lower than the other wear types with it being disliked, rougher, uglier and looking to have aged worse than both Ablation and Impact. There was little difference in the assessment of Ablation and Impact which

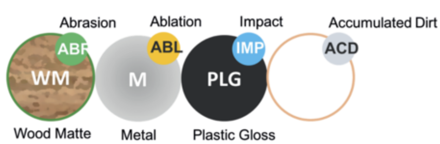

Figure 4. Legend for material samples with wear.

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[1] Aged Badly-Aged Well, Boring-Interesting, Dislike-Like, Hard-Soft, Old-New, Rough-Smooth, Ugly-Attractive

[2] Dislike/like, indicates a device getting old/does not indicate, most/least concerned if occurred on a device, looks worse/better after more of the same wear, most/least likely to encourage product replacement.

SD SCALE	Material Sample	No Wear-Abrasion	No Wear-Ablation	No Wear-Impact	No Wear-Acc. Dirt	Abrasion-Ablation	Abrasion-Impact	Abrasion-Acc. Dirt	Ablation-Impact	Ablation-Acc. Dirt	Impact-Acc. Dirt
Aged Badly-Aged Well	Plastic Gloss	NO DATA				.013	.000	.000	.123	.000	.000
	Wood Matte					.005	.000	.065	.000	.534	.000
	Metal					.234	.000	.283	.000	.106	.000
Boring-Interesting	Plastic Gloss	.023	.334	.287	.056	.341	.340	.520	.765	.073	.102
	Wood Matte	.433	.016	.002	.016	.034	.026	.052	.400	.889	.446
	Metal	.047	.006	.689	.031	.332	.125	.816	.007	.368	.126
Dislike-Like	Plastic Gloss	.000	.020	.188	.000	.005	.002	.000	.475	.000	.000
	Wood Matte	.001	.017	.745	.006	.027	.001	.149	.025	.316	.007
	Metal	.006	.004	.185	.002	.798	.056	.347	.056	.545	.007
Hard-Soft	Plastic Gloss	.945	.528	.452	.334	.395	.689	.259	.627	.080	.057
	Wood Matte	.991	.464	.688	.908	.533	.691	.983	.270	.330	.624
	Metal	.075	.168	.712	.051	.673	.130	.691	.296	.459	.092
Old-New	Plastic Gloss	.000	.000	.000	.000	.119	.013	.000	.370	.000	.000
	Wood Matte	.004	.118	.117	.001	.071	.000	.730	.029	.004	.000
	Metal	.049	.021	.967	.006	.587	.026	.232	.010	.785	.002
Rough-Smooth	Plastic Gloss	.000	.000	.000	.000	.708	.013	.000	.022	.000	.000
	Wood Matte	.043	.686	.695	.228	.030	.022	.480	.390	.249	.110
	Metal	.589	.490	.060	.077	.936	.155	.016	.073	.007	.001
Ugly-Attractive	Plastic Gloss	.000	.001	.002	.000	.039	.034	.000	.697	.000	.000
	Wood Matte	.852	.984	.001	.472	.511	.000	.736	.001	.802	.000
	Metal	.010	.008	.845	.059	.238	.004	.898	.001	.461	.008

Table 1. P-Values calculated using Wilcoxon-SIgned Rank test. Green=study hypothesis has been confirmed [no difference in assessment], Red=study hypothesis being violated [significant difference in assessment].

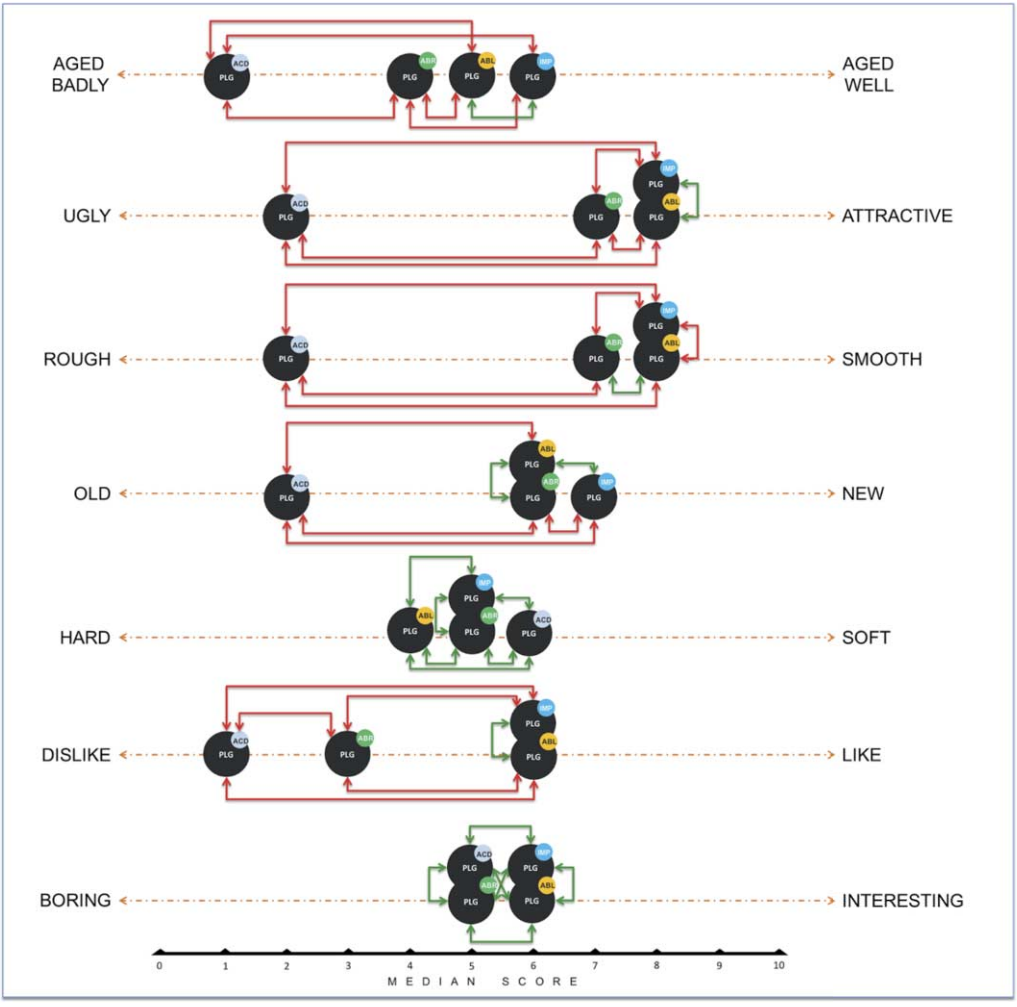

Figure 4. Sample comparisons across wear types within Plastic Gloss. [green lines indicate confirmed study hypothesis; no difference in assessment and red lines indicate contradiction of hypothesis; significant difference in assessment.] (Authors own image, 2017)

were seen to be assessed the same within the Plastic Gloss sample apart from when Ablation was seen to be rougher.

Metal

For the metal sample the assessments were all much closer between the four wear types but the common assessment being that Impact was not as bad as Abrasion, Ablation and Accumulated Dirt. Impact scored better for interest, likability, newness, attractiveness and ageing better in most cases. Again for the metal sample, the assessment of Hard-Soft was not affected by the introduction of wear.

Wood Matte

In opposition to the assessment of Impact being the better type of wear in most scales when occurring in metal; the reverse is true for the Wood Matte sample (see figure 6). Impact was seen to be more disliked, older, uglier and seeing to age worse over time. As with the other samples, hardness was not affected by the introduction of any of the wear types with it still being assessed as soft.

Part B

When all the discs were appraised together, the highest three ranked of the twenty-four samples were identified. This is rationalised by there being a ranking of the top/bottom three by the participant's taking part and as such reflect the overall cohort in how the material samples were appraised. Table 2 shows the top ranked samples for each of the rank phrases.

It was interesting to note that there were some common samples that appeared to be least and most favourable given the semantic differential scales that were used. For example, the Wood Gloss and Matte with Abrasion samples were seen to look better after more of the same wear and least likely to encourage product replacement. The Metal sample with Impact was ranked the highest for being liked, not indicating a device would be getting old and causing least concern if occurring on a device. The Wood Matte with Abrasion also ranked in the top three for being of least concern if occurring on a device and not indicating that device was getting old.

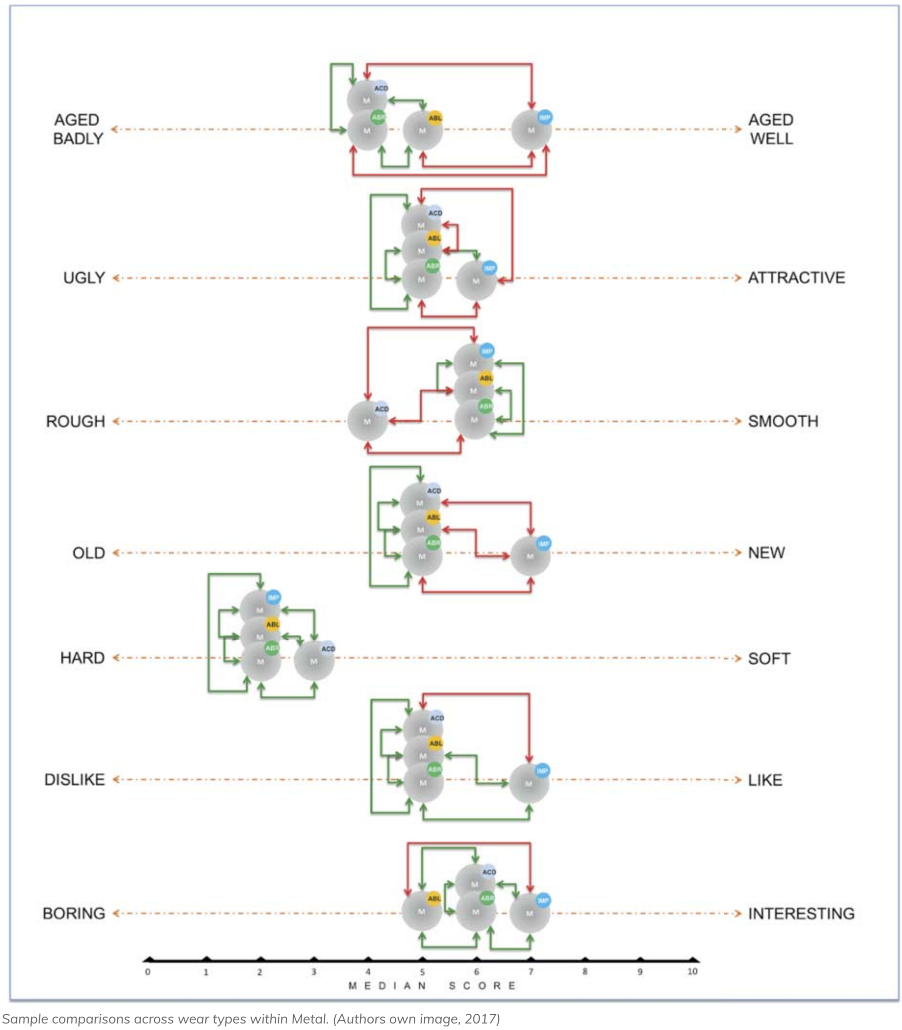

Figure 5. Sample comparisons across wear types within Metal. (Authors own image, 2017)

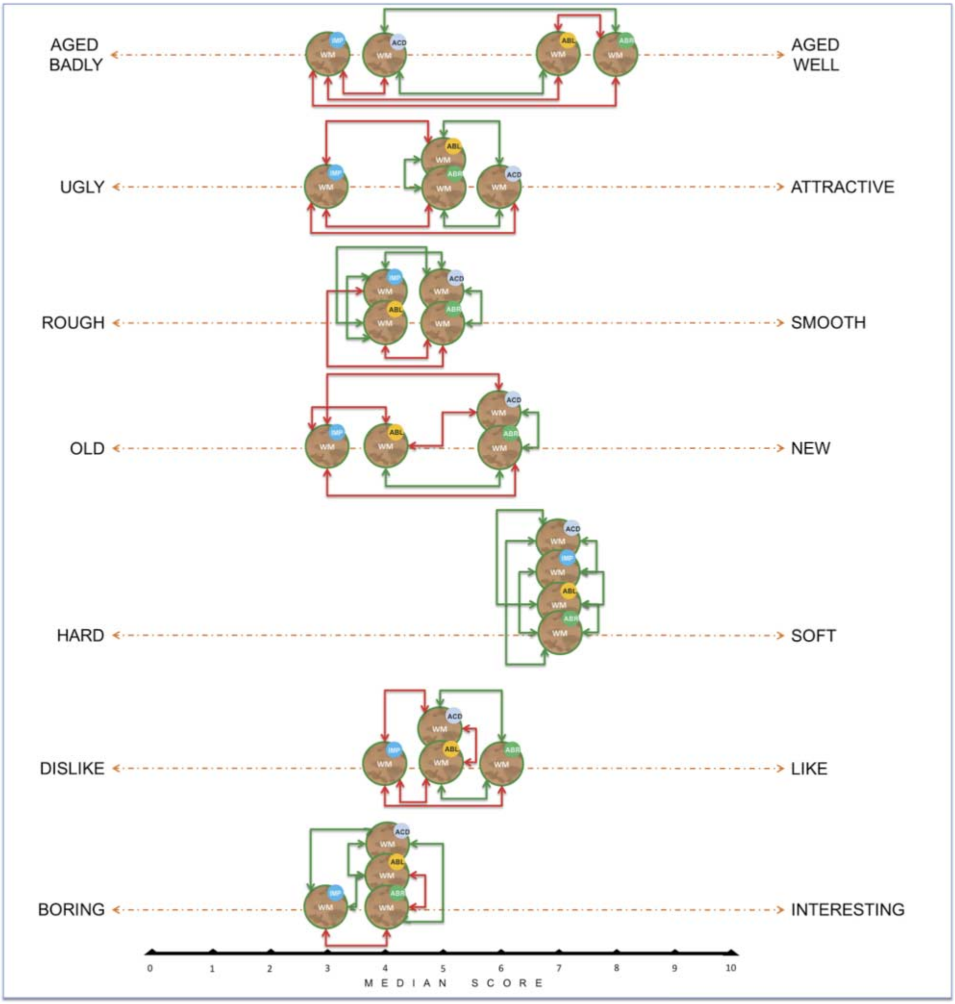

Figure 6. Sample comparisons across wear types within Wood Matte. (Authors own image, 2017)

DISLIKE:			LIKE:		
ACCUMULATED DIRT	PLASTIC GLOSS	1ST	IMPACT	METAL	1ST
ABRASION	CLEVER	2ND	IMPACT	PLASTIC GLOSS	2ND
ABLATION	CLEVER	3RD	IMPACT	PLASTIC MATTE	3RD
INDICATED THAT A DEVICE IS GETTING OLD:			DOES NOT INDICATE THAT A DEVICE IS GETTING OLD:		
ACCUMULATED DIRT	PLASTIC GLOSS	1ST	IMPACT	METAL	1ST
ABRASION	CLEVER	2ND	ABRASION	WOOD MATTE	2ND
ABLATION	CLEVER	3RD	IMPACT	PLASTIC GLOSS	3RD
MOST CONCERNED IF OCCURRED ON DEVICE:			LEAST CONCERNED IF OCCURRED ON DEVICE:		
ACCUMULATED DIRT	PLASTIC GLOSS	1ST	IMPACT	METAL	1ST
ABRASION	CLEVER	2ND	ABRASION	WOOD MATTE	2ND
ABLATION	CLEVER	3RD	IMPACT	PLASTIC MATTE	3RD
LOOKS WORST AFTER MORE OF THE SAME WEAR:			LOOKS BEST AFTER MORE OF THE SAME WEAR:		
ACCUMULATED DIRT	PLASTIC GLOSS	1ST	ABRASION	WOOD MATTE	1ST
ABRASION	CLEVER	2ND	ABRASION	WOOD GLOSS	2ND
ABLATION	CLEVER	3RD	ACCUMULATED DIRT	WOOD GLOSS	3RD
MOST LIKELY TO ENCOURAGE PRODUCT REPLACEMENT (Even if device was still working):			LEAST LIKELY TO ENCOURAGE PRODUCT REPLACEMENT (Even if device was still working):		
ABRASION	CLEVER	1ST	ABRASION	WOOD GLOSS	1ST
ACCUMULATED DIRT	PLASTIC GLOSS	2ND	ABRASION	WOOD MATTE	2ND
ABLATION	CLEVER	3RD	ACCUMULATED DIRT	WOOD GLOSS	3RD

Table 2. Ranking of materials based on Rank Phrases.

Conversely it was seen that the CLEVER material with both Abrasion and Ablation (which revealed layers of differing colour from the original top-coat) ranked amongst the least favourable responses.

The Plastic Gloss with Accumulated Dirt sample also ranked in the least liked, looked worse after more of the same wear, most likely to encourage product replacement, dislike, indicated the device getting old and most concerned if occurred on device.

Conclusions

Between Materials within Wear Types

When looking at the influence of materials it was seen that the type of material has notable effects on visual and tactile user perceptions. The most interesting finding highlighted the difference in the attitudinal reactions between plastic or metal and wood. The wooden samples engendered some positive reactions to some of the wear types. The plastic and metal samples all had attitudinal reactions that were more negative when the wear had been applied. The wooden samples were seen to look best after more of the same type of wear and were less likely to encourage product replacement, as confirmed in Part B. In Part A the wooden samples were also, unexpectedly, seen to be newer, more attractive and more liked in some cases with the wear applied. It was found that material types influenced the perception of a specific type of wear with the clearest example being the assessment of Abrasion which ranked the highest in negative Rank Phrases when it was applied to the CLEVER sample but drew the most positive rankings when applied to the wooden samples.

Between Wear Types within Materials

The influence of wear on participants' attitudinal responses was significant and it was seen that there were notable differences in the assessments of the differing types of wear on the different material samples that those differing types of wear occurred. The differences in the assessments, in some cases, were mirrored across the material types. For example, the assessment of Accumulated Dirt was seen to be assessed as less attractive and less liked across the majority of the material types. Impact was often the wear type that elicited the least difference from the control state of No Wear across the material types. This was confirmed in Part B where samples with Impact present were ranked in two of the top three samples selected for the positive rank phrases. If the wear types were to be ranked in terms of their influence on attitudinal reactions to the cosmetic condition of materials it could be said that Impact elicited the least reaction and Accumulated Dirt drew the biggest difference from the control samples. The material sample that drew different attitudinal responses was the wooden samples. These material samples were seen to, in some cases, age better, look and feel more attractive and be liked more when wear was present.

Expanding the Semantic Lexicon

Before this study was conducted there was some evidence that non-homogenous surfaces and more 'natural' materials could elicit more positive reactions. This was (in the majority but with notable exceptions; Lilley et al., 2016, Sauerwein et al., 2017), tacit and anecdotal with little confirmation from quantitative methods. This study confirms this tacit understanding and quantifies to some extent the influence of more natural material finishes in the attitudinal assessments of material samples. The study also goes further and for the first time identifies the influence of wear and damage on these attitudinal perceptions within the context of electronic products. Further work is of course needed to confirm these findings, but there is a strong implication that in terms of the way that materials are assessed and selected during the design process, ageing is an important aesthetic factor. It also points to a newer and fuller understanding of our cosmetic perceptions of materials from not only a practical/technical perspective but also from an experiential stand-point where the visual and tactile characteristics of a material should be part of both our semantic understanding and an influencing factor in how we interact with products that inevitably age during use.

As such, if the start point for a designer were to be which material would be best if one was to expect a specific type of wear; it can be seen that there are preferences that could be concluded from the attitudinal responses.

Within the material selection process for product design, the physical state of a material past new is rarely considered. When considering the emergence of circular economy business models and the recent, yet small, upsurge in the concentration of academics and industrialists to consider products that last (Bakker et al., 2014; van Hinte, 1997); the influence of materials choices that are sympathetic to product's ageing is increasingly important. The traditional material choices, for electronics at least, are understandably myopic given their short use cycles. Materials can be chosen or developed that are appreciated in their visual and tactile appearance by considering their technical qualities to encourage longevity (durability for example), but by also selecting them on propensity to engender emotional durability which necessitates taking into consideration and building into the design process, a space for materials that age with grace.

Acknowledgments

The authors would like to thank the participants of the study, XXXX University for support and logistics for the study to take place and the UK Engineering and Physical Sciences Research Council who provided partial funding for this study as part of the Closed Loop Emotionally Valuable E-waste Recovery project (EP/K026380/1).

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-245

Redefining retail experiences: formulating ideas for the future of retail design to promote product longevity

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Keywords
Retail Store Design
Product Longevity
Slow Consumption
Responsible Consumption
Millennial Generation Consumer Behaviors

Abstract
This paper is a descriptive case study of a multi-disciplinary retail design studio's educational process and the resulting ideas for designing a sustainably focused retail experience. The key participants are undergraduate seniors in Industrial Design, Interior Design, and Visual Communication Design. The objective of this studio is to explore the future of retail where sustainability and product longevity drives customer experience and behaviors. Through this exploration, students evaluated current retail service models and product lifecycle journeys in order to propose a more sustainable business practice, reaching beyond simply selling a product and maximizing sales per square foot, to foster a community of consumers who want to change the world. Examining the successes or missed opportunities of current generous brands' retail environments, from programmatic components to storytelling elements, students were able to develop strategies for designing a deeply meaningful connection between the product, the brand, and customer beliefs. Through redefining the purpose of the retail environment, students formulated ideas of the future of sustainable retail based on research and their beliefs as Millennials. As a generation of conscious consumers, these principles informed the overall customer experience, customer journey, and service model to change consumer behaviors towards slower product consumption.

Introduction

Creating a cultural shift towards slower consumption is not the sole responsibility of product designers and manufactures, but also that of retail environmental designers, which includes the disciplines of Industrial Design, Interior Design, and Visual Communication Design. Working with retailers, designers can lead the way in redefining a more sustainable retail culture through educating consumers and modifying the service model of the store.

As we look to the future of retail design, driven by the consumer behaviors of the rising Millennial generation, concern for retail's impact on the environment is becoming more critical. Over the last decade, consumer demographics have shifted putting Millennials and their beliefs at the forefront. Millennial consumers are forming deep and emotional bonds with brands that align with their beliefs, resulting in brand loyalty (FITCH, 2015). By 2020, Gen Z (those born after 1995) will become the largest population worldwide, making up 40% of consumers in the U.S., Europe, and BRIC countries (Blum et al., 2010). Recognizing this shift, retailers are looking at insights from the Millennial generation's behaviors to inform the future landscape of the retail store experience. Based on consumer research of this generation, the roles of brick-and-mortar stores are changing, creating an opportunity to redefine the purpose of the retail store, paving the way for a more sustainable retail future. Rather than retailers designing for these generations based solely on insights, what would the future of retail be if it were a participatory design process where Millennials were actively engaged, contributing their ideologies to the conversation and collaborating with retail design practitioners?

Insights from Millennials

Studies show that the Millennial generation intends to change the world, making it more environmentally and socially conscious. In a 2014 survey by the MLSGroup of Millennials in 17 different countries, 78% said they would recommend a company they believe is a good citizen and 71% would be loyal to that business. Dutch Millennials placed the environment in their top 5 concerns, further expressing it should be a priority for businesses to address. In the Netherlands, almost all Millennials surveyed view being an active citizen from a local perspective: "What can I do to improve my local community through my own initiatives?" (MLSGroup, 2014). Despite being digital natives growing up in the world of social media, they value their community and human connections (Davies, 2015). Overwhelmingly, Millennials believe that people and corporations should be active citizens working towards the betterment of their local and global communities through environmentally and socially sustainable business practices (Makhija-Chimnani, 2014). These beliefs of connecting locally and globally reinforce the goals of slow fashion and consumption as described by Kate Fletcher (2008).

Millennials' consumer behaviors further support this agenda: customers are becoming more loyal to brands that share their values. Therefore, retail is experiencing the rise of "products with a purpose," ones with the intent of creating a social and environmental impact, and "generous brands," companies that go beyond simply giving back by taking action for social and environmental change, often encouraging responsible consumption habits. However, few retailers are currently capturing these ideals within their retail environments and product merchandising (Matheny, 2017). Instead, they are relying on their digital presence to communicate these principles of responsible consumption to their consumers.

Fletcher (2008) describes slow fashion as a movement that looks at the ways in which products are designed, produced, consumed, and used in everyday life to provide consumers better lives. This holistic approach to understanding a product's lifecycle journey resonates with Millennials values of authentic and transparent storytelling. Educating consumers is critical to connect this process in a meaningful way. Despite the desire to live more sustainably, Millennial consumers continue to struggle with the ability to reduce consumption and prolong product lifecycles. Therefore, to create a more sustainable future, retail designers need to understand how to strategically create experiences that resonate with Millennials while promoting responsible consumption and prolonged product lifecycles. What elements are needed within a store design to educate consumers and influence their behaviors towards environmental and social good? If retail design pedagogy shifted to allow retail environmental design students to address a product's lifecycle and change consumer behaviors towards slower consumption, what would become of the retail store? How would these generations propose transforming the retail experience to create a sustainable business model?

Designing with Millennials

To better understand how Millennials foresee a sustainable retail future, this paper presents proposed design strategies from an advanced undergraduate retail design studio. In the spirit of participatory and multidisciplinary design, the studio formed design teams of seniors from three disciplines: Interior Design, Industrial Design, and Visual Communication Design. The objective of this studio was to redefine the future of retail where sustainability and product longevity drives customer experience and behaviors. Student teams were charged with formulating ideas on the future of retail, designing experiences to both educate and encourage responsible consumption habits. Through design research and ideation, teams developed strategies for a sustainable retail culture. Teams reflected on their personal values of environmental and social sustainability to select a brand that they believed aligned with their ethics and which currently does not have a brick-and-mortar location. As a generation of conscious consumers, principles of environmental or social responsibility defined the overall customer experience, customer journey, and service model to encourage slower product consumption.

Formulating Ideas

Developing a strategy

Mirroring professional practice, students began conceptual design and programing processes by developing case studies of a similar typology. For this project, it was challenging to find appropriate precedents of retail experiences that successfully promoted sustainability and responsible consumption through their design. Once a precedent was selected, students utilized Fletcher's (2008) principles of slow fashion, analyzing the retail environment and evaluating their ability to connect pleasure with awareness, educate consumers, create connection with local and global community, create trust in the brand, communicate core values, and provide a sense of uniqueness through customization, care of craftsmanship, or scarcity. While generous brands Toms, Lululemon, LUSH, and Hessnatur were found to be leaders in this area, students also discovered needed improvements for brands such as Frye, Nike, Eileen Fisher, and others. Examining the successes or missed opportunities of current generous brand retail environments, from programmatic components to storytelling elements, students were able to develop

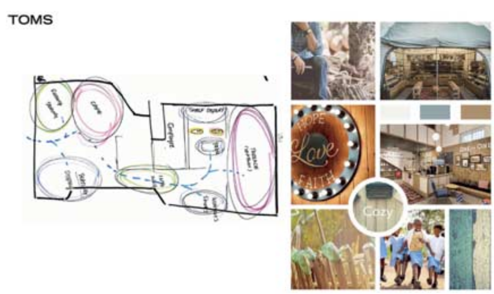

Figure 1. Case study analysis of TOMS store by team Oliberté.

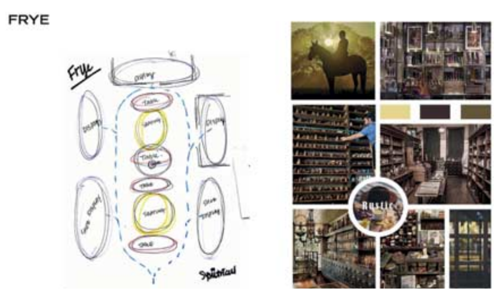

Figure 2. Case study analysis of FRYE store by team Oliberté.

strategies for designing a deeply meaningful connection between the product, the brand, and customer beliefs. Through this case study exploration, students understood how service touch points are implemented to create a more sustainable business practice, reaching beyond simply selling a product and maximizing sales per square foot, to foster a community of consumers who want to change the world.

Communicating the brand story through the customer Journey

Utilizing completed case studies as a springboard, students divided into five multidisciplinary teams. The generous brands selected to design for throughout the course were Oliberté, FEED, WeWood+BoxWater, The Little Market, and Taluma. Through researching their selected brand, teams developed a deep understanding of the environmental and social purposes that drive the brand and its products. Based on this research, teams organized their information into 9 categories: people, place, price, product, projection, promotion, process, planet, and purpose. Synthesizing this research, teams then developed two visual representations: a brand soul diagram and a visual positioning board. The brand soul diagram captures the brand's key attributes and its uniquely defining characteristics that fall into the 9 categories (see figure 3). The visual positioning board (see figure 4) captures these characteristics through a collage of images, allowing for the elements of design (color, texture, pattern) to begin defining the sensorial experience of the space. The process of discovering the brand soul, leading to the visual positioning board, becomes the foundation for developing the customer narrative and experiential touchpoints in the customer journey.

With this rich understanding of the soul of desired

Figure 3. Brand soul diagram by team Oliberté.

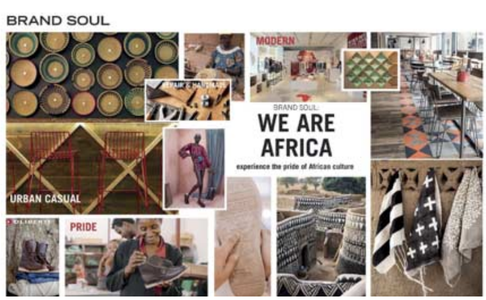

Figure 4. Visual position board by team Oliberté.

brand, each team then developed a strategic framework for redefining the customer experience, including the customer journey and service model. Leveraging their design research, each team developed a strategy of storytelling elements, from programmatic components to graphic projection, which communicate brand ideologies, educate consumers, and influence behaviors toward environmental and social good. This strategy was realized into a series of customer journey touchpoints that challenge consumer mindsets and behaviors to promote slower consumption and product longevity.

Extending the product journey

Further research into each brand's products generated analysis of the current product lifecycle journey and opportunities for expanding and prolonging the product's lifecycle. Each team developed a proposed product lifecycle diagram including means for modifying the standard retail environment to include service components extend a product's life. As seen in figure 5, team Oliberté proposed providing a way for customers to learn how to repair shoes themselves through a DIY repair station. An on-site cobbler would not only provide repair services, but also teach and assist customers in the process of repairing their shoes. Including the cobbler within the store elevates the act of repair as a critical component of product longevity, establishing product value and trust in the brand.

Another approach for extending a product's life is to consider the process of down cycling. For WeWood, with products utilizing wood to construct watches, the team proposed a recycling center within their store. Rather than using new wood, customers would be able to bring in personal wood products, such as a cherished baseball bat from a grandfather, which could be turned into a new watch. By encouraging customers to bring in recyclable woods materials to be made into new watches, the brand could reduce their footprint while adding to the story and meaning of each product.

Within the context of the store experience, each team redefined the purpose of their store by including service components. The service touchpoints differed based on the products and the generous mission of each brand. In some cases classrooms were created to teach nutrition or skill based classes. In others, cafes serve as community action rooms. Team Oliberté proposed two separate store experiences: a flagship in an urban context (Figure 6) and a traveling pop-up shop. These two experiences were conceptualized to create a broader reach for consumer education. Within the flagship, in addition to the cobbler, an artist-in-residence brings a craftsman from the factory in Africa, creating a meaningful human connection between the manufacturing process, the people making the product, and the consumer. Through the inclusion of this makerspace, customers would be able to customize their shoes, which taps into Fletcher's (2008) notion of extending a product's life through the perception of care of craftsmanship, customization, and scarcity. Leveraging

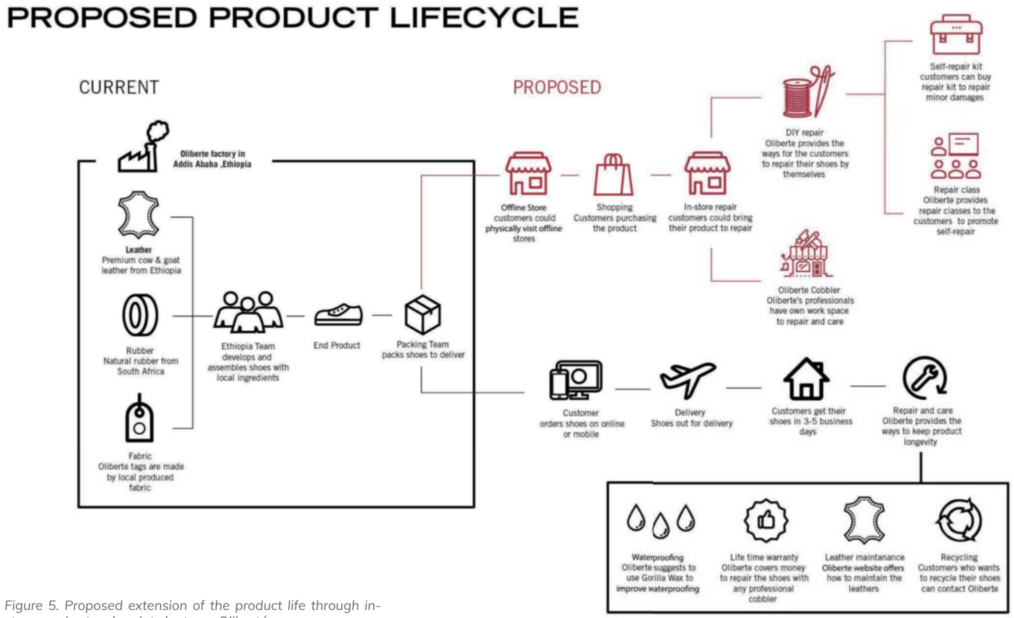

Figure 5. Proposed extension of the product life through in-store service touch points by team Oliberté.

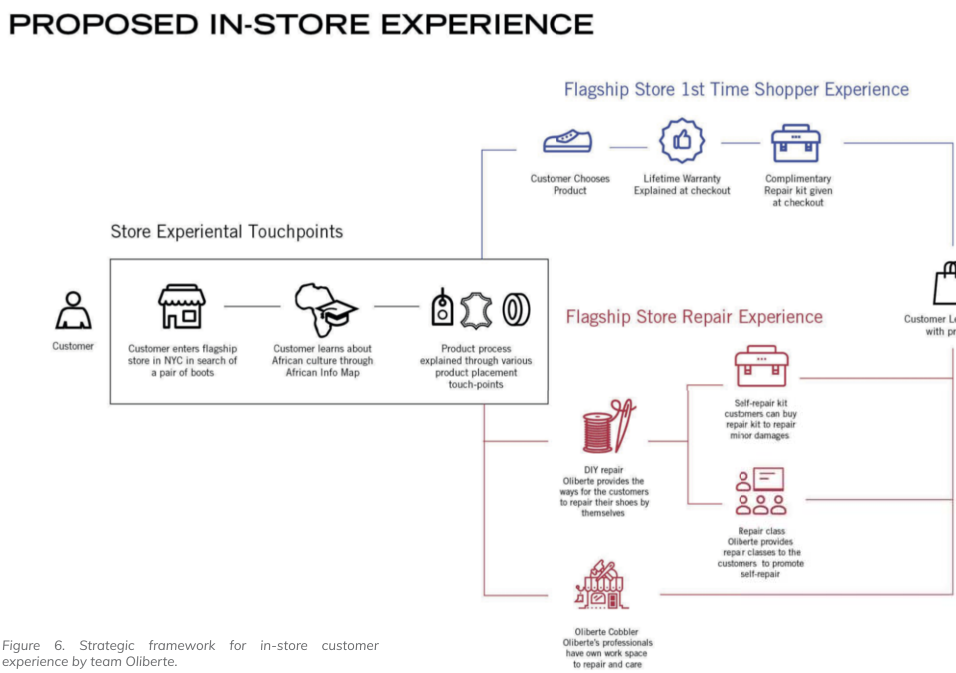

Figure 6. Strategic framework for in-store customer experience by team Oliberte.

the cobbler and artist-in-residence as valued educators, a community space provides room for a proposed outreach program which would allow Oliberté to connect the African communities to communities local to their stores. With the idea of liberating those in need, the proposed outreach program is designed to help inner city high school kids learn a trade and develop a career path which could help them to further their education and build a better life.

Conclusions

Redefining the Purpose of the Retail Experience

For Millennials, the brick-and-mortar store is not dead. However, brands need to design an experience that is tangible, engaging, educational, and memorable. Brands cannot continue to keep their ethics contained only within their digital presence. In order to create a larger impact, the store environment needs to go beyond the product to connect to the customer on a human level. As FITCH

(2015) describes, these digital natives have grown up in the world of social media, resulting in an increased value in their community and human connections. To create a more sustainable retail culture, the student designers proposed strategies for a retail space that, from their perspectives as Millennials, creates a meaningful and memorable connection between the brand purpose, the product, the physical environment, and themselves. The strategic takeaways from this studio were:

1. Make room for human interactions. Programmatically, stores should occupy half of the square footage with displays aimed at selling products, while the other half should be dedicated to creating human connections. This reallocation of square footage shifts the priority of the store and the mindset of consumers away from the product as the driver, placing the focus on how the product supports people and their value driven lifestyle.

2. Community is central. Stores need to provide areas to cultivate a community of advocates and activists with shared values. Carving out community space, either in the form of a separate meeting spaces, education rooms, informal gathering areas, or even cafes, allows the brand's mission to be at the heart of the store experience, positioning values above product consumption.

3. Educate customers through engagement. Visual communication is necessary; however, providing in-store services that create human interaction touchpoints have a larger impact on changing behaviors. Incorporating customization areas brings personal value to products while in-store repair areas elevate the trade to a valued service and inspire a prolonged investment in the product.

4. Forge trust through transparent storytelling. Leverage elements such as digital video messaging showcasing manufacturing process, physical exhibitions that showcase a product's evolution through time, care instructions, or interactive/pictorial elements that connect customers to the people making the product is positively impacting.

5. Go beyond visuals alone to communicates the brand's story. By developing a complete sensorial experience, through materiality and merchandising, the brand can communicate their sustainable values by connecting a pleasurable experience with educational awareness. Sourcing local materials or using materials which are part of the product's manufacturing process such as recycled fibers or coke bottles, can further tell the brand story.

6. Create a collection. Combining brands who share a similar goal can create a larger impact. Collaborations can tell a holistic story, creating a more connected sustainable lifestyle. A larger global brand can also bring in complementary local products to make a more meaningful connection.

7. Reach out beyond the borders of the store. Pop-up shops are one way to reach out and engage the local community through events that provide additional services, learning opportunities, and service opportunities.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-250

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Slow fashion in retail environments: why storytelling is critical for product longevity

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Keywords
Slow and Fast-Fashion
Retail Design
Storytelling
Millennial Generation
Apparel Industry

Abstract
This paper presents a series of case studies examining selected slow fashion retailers' use of storytelling elements within their respective store environments to communicate their brand's sustainable process and mission. The term slow fashion, coined by Kate Fletcher, informs and encourages conscious consumers on responsible product sourcing and manufacturing, allowing them to feel connected to their local and global community. For slow fashion brands, fostering a strong and nurturing relationship between consumer and producer is invaluable, however few of these retailers capture that goal within their retail experience. Striving to educate and entice consumers towards more sustainable consumption, this paper presents case studies examining how storytelling elements are utilized within the retail environment to forge the consumer-producer connection.
Currently, many slow fashion retail environments lack storytelling elements, varying little from fast fashion stores. When the retail story and experience is not differentiated from those promoting mass consumption, products hold little emotional value and are disposable. This paper describes how three North American slow fashion brands (Shinola Detroit, Levi's, and The Local by Lululemon) implemented storytelling within their store, educating consumers towards shifting their behaviors. Understanding the emotional connection between storytelling components and products reinforces slow fashion's goal by elevating products from disposable to cherished artifact. Through this analysis, designers and retailers will be provided with tools to better educate their consumers and promote a slower consumption lifestyle.

Introduction

The slow fashion movement, introduced by Kate Fletcher (2007 and 2014), communicates the ideology of linking pleasure with an awareness of environmental responsibility within the apparel industry. It educates consumers on responsible product sourcing and manufacturing while connecting them to their local and global community. Current retail trends show consumers desire products that are "scarce, customized and carefully made," reinforcing the growing slow fashion movement (Fletcher, 2014). What is the purpose of the retail store in slow fashion and how does it support consumers' desires for responsible consumption?

Redefining a Sustainable Apparel Retail Industry

Driven by the elevated importance of environmental and social sustainability within Millennials and GenZ, physical retail's purpose is transforming. A 2014 survey of Millennials from 17 different countries indicated 78% would recommend a company they believe is a good citizen and 71% would be loyal to that business (MLS Group, 2014). Millennials, compelled by a mission instilling personal connection or trust in a business, act quickly when products or services align with their values (Feldmann et al., 2015). In a survey of GenZ, 60% aspire to have jobs that make a difference and have a social impact, while 76% are concerned about humanity's impact on the planet. GenZ also best communicates with images; they connect to a brand or a cause on a personal level through successful visual communication (Sparks & Honey, 2014). These generational characteristics reinforce the importance of storytelling within slow fashion's physical environments to educate and drive consumers towards a more sustainable lifestyle.

Resonating with these generations' beliefs, slow fashion challenges the ways in which products are designed, produced, consumed, and used in everyday life (Fletcher, 2014). However, these generations also demand authentic and transparent retail storytelling to create a connection between their beliefs and the value they place on products (FITCH, 2015). Retailers need to rethink their store's environment, creating memorable experiences through storytelling that connects to customers' ideals and communicates their authentic brand story. This connection forges a personal relationship to the product, elevating the product from disposable to cherished artifact.

Storytelling in Retail Environments

Currently, most retail environments lack sustainable storytelling, varying little from fast fashion stores. Some fashion retailers, like Anthropologie, integrate storytelling, creating immersive lifestyle experiences, effectively creating meaningful emotional connections between the brand identity and the consumer's life. Similarly, athletic retailers Nike and Adidas, draw the consumer into an athletic lifestyle, however these environmentally responsible companies lack sustainable storytelling, missing the opportunity to educate their customers on becoming better stewards towards the environment. When the expressed retail story continues to promote mass consumption rather than responsible slower consumption, products continue to be disposed quickly.

Adidas' New York flagship store drives a relationship with their customer by creating areas for people to connect to the products through test zones. Though the store uses technology in new ways to connect to Millennials, such as digital touchscreens displaying shoe design features, the product's sustainable construction elements and care instruction remain missing. The brand's compelling sustainable story, mainly featured on their website, is easily overlooked in-store. They only communicate their collaboration with Parley for the Ocean, turning ocean plastic into product displays, through small text on hangers and on plaques below mannequins. Throughout the store, benches contain display cases featuring shoes; one case features the same passage partnered with their eco-shoe. However, the complete story of capturing and transforming harmful ocean plastics into product material along with why Adidas values this initiative is missing within the overall store environment (Matheny, 2017).

For these generations, driven by environmental sustainability, storytelling within the physical environment creates an awareness and trust in brands, forging a stronger connection between the customer, the brand's environmental stewardship, and the product's sustainable construction. This may translate to increased sustainable product purchasing, while cultivating emotional value in the product and encouraging its longevity.

Building a Case: A Design Tool Kit for Storytelling in Slow Fashion

Research (Davis, 2015) indicates customers "speak" with their purchases by remaining loyal to brands sharing core values. However, few retailers capture ideals of responsible consumption within their retail environments. As the maker movement's popularity illustrates, value is placed on products where the story of authentic and responsible manufacturing is told. These generations are willing to spend more and buy less when a deep connection to the product exists. As designers look to create a sustainable future by promoting product longevity, how can a store's design utilize storytelling to educate consumers towards making environmentally responsible decisions? How can these elements inform consumers of product care and longevity?

This paper takes an in depth look at how three North American slow fashion brands (Shinola Detroit, Levi's, and The Local by Lululemon) implement storytelling within their store to promote product longevity. Emotional connections between storytelling components and products reinforce slow fashion's goals. Through this analysis, designers and retailers will be provided with tools to better educate their consumers and promote a slower consumption lifestyle.

Case Study 1: Shinola Detroit, Toronto

From bicycles to leather goods and their iconic watches, Shinola is founded on cultural integrity of hard working

Figure 1. Adidas + Parley for the Ocean plastic mannequin. © R.Matheny

Figure 2. Adidas + Parley ocean plastic fiber shoe design. © R.Matheny

and long lasting manufacturing from which Detroit was built. "Shinola is founded in the belief that products should be well-made and built to last. Shinola stands for skill at scale, the preservation of craft, and the beauty of industry" (Shinola, 2017). These values are represented within their retail environment at every turn. The materials within the store are not pretentious; exposed and worn concrete floors are the bedrock for simple wood displays. A simplistic palette creates focus on the limited selection of high-quality products and their manufacturing story, which is visually represented throughout the customer journey.

Upon entry, a radial display of bikes hangs from the ceiling, drawing the customer into the space to the Willard custom watch bar. As Fletcher (2014) describes, customization and the perception of owning something unique and scarce plays a significant role in slowing down consumption. This programmatic element allows customers to create a human connection between themselves, the brand, and product. The sales associate assists in designing the custom piece while describing the manufacturing process and product quality and care, thus instilling confidence and belief in the company. A visualization of the process paired with an organized display makes the design process accessible. Reiterating customization, a vintage letterpress machine provides customers the option to select their favorite journal or leather product to personalize.

Making product education accessible, product displays integrate a plaque describing construction and unique features. Shinolas' limited edition watch series honors great Americans such as the Wright Brothers and their contribution to innovation and industry. The Maya Angelou display leverages her evocative words from the "Caged Bird," creating a small, but significant, storytelling moment. Visual links between timeless products and significant figures connects to people in a meaningful way. This human connection is reiterated by visual brand message: "A true manufacturing company is built

Figure 3. Shinola's custom watch display in their Toronto store. © R.Matheny

Figure 4. Shinola's Toronto monograming station. © R.Matheny

Figure 5. Shinola's limited edition Maya Angelou collection. © R.Matheny

Figure 6. Shinola's Toronto store makers lounge. © R.Matheny

not by the things is makes. It's built by the people who make them." Alongside images of watchmakers and craftsmen, this collective statement speaks to the brand's principles and connects to their customers' social and environmental values. An in-store service/repair area communicates dedication to product longevity, ensuring that a certified maker does repairs from the company. The story of Shinola's store is rooted in their brand's mission of excellence of craft and pride of work by fostering a community of consumers that value the art of well-made products.

Case Study 2: Levi's, New York

As a major leader in the consumer apparel industry, Levi's has changed both their corporate and retail culture to be more environmentally conscious. With a holistic approach to manufacturing clothing, they consider every step of the process, such as working with growers, product care, and afterlife. Levi's dedication to decreasing the company's environmental footprint is visible in many of their store locations where much of their original and historical characteristics are maintained. In the SoHo, New York store, customers are met with mirroring showcases depicting the signature 501 jean and classic jean jacket as it ages from one to ten years of wear and care. Exposed historical Corinthian columns communicate strength, stability, and trust to the customer. These visuals encourage consumers to embrace the aging and weathering of their product as it becomes more unique with time.

Levi's "Made of Progress" philosophy targets four key areas: materials, process, people, and the environment. Levi's highlights their mission to be transparent on their website and in-store campaigns. A significant mission is to produce and care for clothes made from recycled, durable material while using less water in the manufacturing process is visible throughout the retail journey, from garment tags to smaller signage on merchandise displays. Customers are encouraged to reduce water and energy consumption themselves through recycling or donating used products. An in-store tailor shop, within their flagship store location, follows Fletcher's (2014) notion of customization to facilitate slow consumption. Known as a brand that creates customized jeans to ensure a pleasurable experience, the effort ensures that customers value and treasure their product. Further connecting to consumers' values, Levi's Pride Collection exhibits their San Francisco roots through donating proceeds benefiting the LGBTQ community to the Harvey Milk and Stonewall Community Center. Going beyond product sales, initiatives like these allow Levi's to connect to Millennial's and GenZ's commitment to corporations they believe are good citizens.

Case Study 3A: The Men's Local by Lululemon, Toronto

Lululemon has taken the idea of localization to new levels with the opening of a new store type. "The Local" Toronto opened in December 2016, introducing a fundamental shift in both retail organization and purpose. Programmatically, the product display space is reduced to

Figure 7. Levi's SoHo store longevity showcase. © A.HernándeZ

Figure 8. Levi's SoHo store jean longevity display. © A.Hernández

Figure 9. Levi's PRIDE collection. © A.Hernández

highlight the unique community space. When making a new purchase, "The Curator" (store manager) will remind customers of product care instructions: "Simple is better, it will last longer if you wash in cold water and hang dry." The brand's investment in the local community is demonstrated through the provision of a place to connect, collaborate, and create, implementing Fletcher's (2014) approach of creating local connections through pleasure and awareness.

Figure 10. The Local Men's store by Lululemon's . © R.Matheny

Bringing the brands commitment to improving the local community to the forefront of the retail experience, every Saturday a local barber provides services donation, which is then given to a local charity. Reinforcing local community connections, the barber chair is both visual storytelling and a functional, programmatic element. Local artisans and makers craft featured artwork and activity tables, creating an environment that is less about merchandise and more about the local community. As explained by their community coordinator, the store needs no advertisement, as people are naturally motivated to collaborate in the welcoming space and to be part of a community supported by a generous brand.

Figure 11. The lounge space within The Local Lululemon Toronto men's store. © R.Mathney

Case Study 3B: The Queen West Local by Lululemon, Toronto

Lululemon's flagship store on Toronto's Queen Street is not only a retail space, but also a local pop-up shop, art gallery, living room, and practice studio. Customers are greeted not by merchandise, but by a pop-up shop within "The Residency," featuring ever-changing vendors and artists, bringing the company's value of community investment to the forefront.

Figure 12. Message board at Lululemon's Queen Street location. © R.Matheny

A main attraction on the first floor is "The Hustle," a multifunctional space where the community comes to hang out, hold meetings, or attend classes on sustainable living, community activism, and wellness. This dedicated space cultivates community activists who, in turn, become brand ambassadors. Forming community spaces emphasizes the brand's dedication to educating, inspiring, and challenging communities to become leaders in sustainability. This space also features a hem and repair station where a seamstress is a valued feature within the brand's product lifecycle. In a typical store, customers might not realize that Lululemon's products can be repaired by the company or that they recycle

Figure 13. Introduction to The Hustle space within Lululon's Queen St. location. © R.Mathney

98% of its damaged products into mattress stuffing and home insulation (Lululemon Athletica, 2017). Integrating this work zone within the first-floor experience allows customers to interact with the seamstress, whose other role includes educating customers about the company's sustainable initiatives and explaining how to reduce product waste through the repair process.

As a billboard within "The Residency" reads: "Every family has a story … Welcome to ours." This message is carried throughout, from a vintage trailer that encourages customers to share their story, to "The Hustle" living room space, and to "The Attic" on the third floor, offering yoga, meditation, boxing, and other classes. The entire customer journey is a telling of the brand's story and values. When designing a sustainable retail future where product longevity is a goal, these programmatic and service initiatives are steps in the right direction to change consumer behaviors.

Figure 14. Lululemon's seamstress repairing a customer's leggings. © R.Mathney

Conclusions

While we are all consumers, how we consume is just as important as what we consume (Fletcher, 2014). Through storytelling in retail environments, there are opportunities to establish product value that promotes longevity. These case studies demonstrate innovative ways brands utilize storytelling methods to connect to Millennials and GenZ, educating and encouraging them towards sustainable behavior. The following are key insights these retail cases offer.

Bridge the digital with the physical.

Many sustainable retailers solely communicate their stories online, however to create impact, retailers should also communicate their stories through physical experiences that have meaningful impact on consumers' lives.

Establish retailer and consumer accountability.

Creating transparent storytelling moments within the retail space communicates both brand and consumer responsibility in a product's lifecycle. Communicating the origins of a product prior to purchase connects the customer to said product's journey. In-store storytelling also provides consumers with clear and concise product care directions while repair shops encourage product maintenance.

Create trust through visual narratives and displays.

Visual communication methods such as Levi's longevity display serve as a testament, reassuring consumers that their product will stand the test of time. Creating transparent, authentic, and honest storytelling moments allows consumers to recognize their own beliefs through the store's projected narrative. This also signals a shift from the current culture of ignoring where products are made to one demanding greater transparency across all markets.

Engage customers through redesigning the retail store.

Storytelling is not simply graphic elements; creating connections between the brand, the customer, and store's function is critical in changing how people consume and should be done through in-store services that showcase and encourage product longevity initiatives, such as repair shops, tailors, and community rooms.

Let the Architecture speak.

Developing a physical language that aligns with the values of the company is key. Embracing an aesthetic that is pure and sustainable reinforces the brand's values.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-256

Implementing "preparation for re-use" in WEEE management: an analysis of the European experience & recommendations for Ireland

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Keywords
WEEE
EEE
Re-use
Preparation for re-use
Resource efficiency
Waste
Waste hierarchy

Abstract
Proper treatment of waste plays an important role in global concerns regarding resource efficiency and climate change. Waste electrical and electronic equipment (WEEE) is of particular importance due to high use of critical resources and production/recycling energy as well as the potential for toxic pollution when improperly disposed of. Preparation for re-use plays an important role in alleviating these issues.

Within Ireland the regulated preparation for re-use sector exists in an embryonic stage. This paper identifies supports, through analysis of EU systems, to encourage the growth of the Irish system in the form of recommendations for policy makers, providing a baseline for other systems to do the same.

EU member states reporting the highest re-use rates of LHA and IT equipment were identified through Eurostat data; analysis of the barriers/facilitators to this success within each country was conducted through interviews with reportedly successful organizations. Subsequently, Irish stakeholders were interviewed in order to record input on the current system, contrast it with successful models and identify what action might be needed to move forward.

Several themes were identified through these analyses as related to success in preparation for re-use activities including involvement of social enterprises, access to equipment, segregation of waste with potential for re-use at the earliest point possible, adherence to quality national/international standards, a positive relationship with the Producer Representative Organizations responsible for enabling access to the materials, and implementation of targets when necessary. Recommendations are presented in regards to policy supporting preparation for re-use in the Irish system.

Introduction

The proper treatment of WEEE plays an important role in global concerns regarding resource efficiency and climate change. Promoting lifetime extension is of particular importance for electrical and electronic equipment due to the use of numerous critical raw materials which do not emerge from recycling systems in addition to the very high manufacturing energy, particularly for low entropy components. By offsetting additional production with the concomitant reduction in mining and manufacturing energy these issues associated with the production of WEEE can be alleviated through preparation for re-use. Considering the benefits of re-use, discussed in further detail below, and its prioritization in EU legislation, this work aims to identify what hinders and encourages success in preparation for re-use organizations concerned with consumer WEEE as this question has yet to be addressed on an Irish or European scale.

Research by Allwood et al. (2012) and Gutowski et al. (2013) has demonstrated that the scope for future improvements in efficiency of material production is limited. Therefore, in order for a reduction in industrial emissions to contribute to the mitigation of climate change, a reduction in material production through strategies such as re-use and preparation for re-use will be necessary. In particular, EEE re-use has been prioritised by a wide range of global policies and regulations as a prudent approach for conserving resources and reducing environmental pollution. The majority of laws that regulate movement and disposal of equipment containing potentially hazardous materials urge re-using equipment, e.g., the EU WEEE Directive (EC, 2012), EU Eco-Design Directive (EC, 2009), EU Waste Framework Directive (EC, 2008), the China Decree 551 (State Council, 2008) and the Illinois Electronic Products Recycling and Re-use (Illinois General Assembly, 2008).

While both contribute to alleviating the aforementioned concerns, it is important to note "re-use" and "preparation for re-use" are separate activities as shown in Figure 1, and are distinguished by the status of the product: non-waste for re-use; waste for preparation for re-use. This distinction is very important as products not considered as waste are not covered by the WEEE Directive. As a consequence, the directive only speaks about preparation for re-use.

Overall, the benefits of re-use and preparation for re-use are well supported within the literature and are prioritized in EU legislation, falling above recycling and other methods of treatment within the Waste Framework Directive's hierarchy. However, the widespread success of preparation for re-use systems within the EU is limited. Specifically within Ireland, the regulated preparation for re-use sector exists in an embryonic stage. This paper identifies supports to encourage the growth of the Irish system in the form of recommendations for policy makers. The findings presented here not only provide the opportunity to support a legally defined system in Ireland through evidence based policy recommendation, but also a baseline for other systems to do the same as conclusions should be applicable across the EU and similar systems.

Analysis of EU member states

EU member states reporting the highest rates of "preparation for re-use" of both large household appliances and IT equipment were identified through Eurostat data and an analysis of the barriers and facilitators to this success within each country was conducted. The countries selected were Austria, Belgium, France & UK. These countries showed consistent and comparatively high levels of re-use within Eurostat data gathered for both LHA and IT equipment. Additionally, Spain was included in the study due to its recent adoption of specific and separate preparation for re-use targets. Successful preparation for re-use organizations were selected within each selected country (Table 1) and interviews with each organization were recorded, transcribed, and reviewed for accuracy.

Several themes were identified through these analyses as related to success in preparation for re-use activities, which have been separated for discussion as follows:

Social enterprise

The most consistent of the themes was the heavy involvement of social enterprise in preparation for re-use systems. Although the definition of social enterprise can vary across borders and organizations, all interviewed parties self-identified as such. Social enterprise involvement included providing employment opportunities to persons with disabilities or the long term unemployed, discounts for the underprivileged and unemployed, donations to charities and schools, and the workforce integration and training of both young and elderly employees. These activities were reported by each organisation to be an essential part of the main company mission, and were specifically reported to be included in the contracts between French compliance schemes and preparation for re-use organisations. The provision of funding as a social enterprise was less consistent across the groups, although similarly this was a significantly tying theme with all parties reporting varying degrees of subsidized funds in the form of partial wage reimbursement, grants, and other contracts in addition to revenue gained from economic activity.

Access to quality equipment

Access to equipment was reported as a common barrier to preparation for re-use and an essential facilitator to success when this barrier is overcome. The point at which organizations receive access to was varied among organizations, with an emphasis placed in most systems on obtaining equipment as close to the end user as possible. Most commonly, direct access to equipment from retailers, civic amenity sites, and sometimes door to door collection was provided to preparation for re-use organisations. It was agreed across all parties that the highest quality and most desirable equipment comes from retailer take back systems. These direct access systems exist under specific agreements between preparing for re-use organisations and compliance schemes, such as that between Envie and the French compliance scheme Eco-Systémes. Limiting the transport of materials by accessing equipment directly from the retailers or homes of consumers is reported as a benefit to allow for protection against damage commonly caused in transport between locations, damage is a common occurrence and is reported to be a limiting factor for organisations gaining access to quality materials suitable for the preparation for re-use process. Furthermore, in Austria, where equipment is largely accessed at civic amenity sites, it was reported that prior to any contact with re-use organisations the equipment is sorted to an extent by asking those who drop

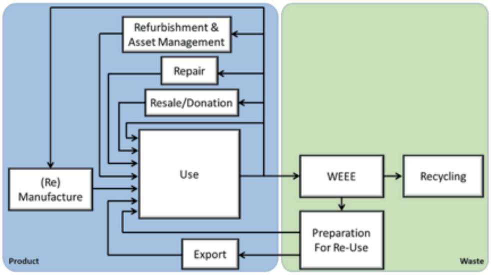

Figure 1. Positioning of "preparation for re-use" within the lifecycle of electrical & electronic equipment.

Country	Organisation	Products covered
Austria	Demontage- und Recycling Zentrum (DRZ)	Mixed WEEE
Belgium	Komosie	WEEE, clothing, furniture, bicycles, etc.
France	Envie	Mixed WEEE
Spain	Aeress	WEEE, textiles, furniture
United Kingdom (N. Ireland)	Refresh Appliances	LHA

Table 1. Interviewed preparation for re-use organizations.

off the equipment to deposit it in sections depending on type of equipment.

Relationships with Compliance Schemes

The most important identified factor in obtaining a suitable amount of fit for purpose material is a positive relationship between preparation for re-use organizations and the compliance schemes representing the producers and responsible for providing access to the waste stream. This relationship is essential in obtaining and maintaining access to quality materials, and was reported to be positive between the French compliance scheme Eco-systémes and the preparing for re-use network Envie, by Refresh Appliances in the UK, as well as within the comparable structure between the Belgian non-profit in charge of recycling, Recupel, and the Komosie re-use network. Thus, those countries with the highest reported re-use rates according to Eurostat are also those with positive reported relationships between compliance schemes and preparing for re-use organisations. The relationship between the Spanish interviewed network, Aeress, and the accompanying compliance schemes was less sure, reporting hesitance from the scheme to support re-use. Adherence to national and international quality standards such as PAS 141 is common throughout the interviewed systems, providing an assurance of the competency in preparation for re-use organizations and further facilitating a positive relationship.

Targets

In Spain, where these factors were identified as previous barriers and the relationship between compliance scheme and preparation for re-use organizations was not resulting in progress, authorities determined that targets were necessary. The separate re-use targets are suggested to address the issue of hesitance from Spanish producers and compliance schemes with regards to preparation for re-use. Support for similar targets was present across interviewed organizations, most openly from Envie in France.

Irish Analysis

An additional focus was placed upon the preparation for re-use system in Ireland as a case where the system has not grown at a successful rate and the identification of measures to encourage further progress is necessary. Irish stakeholders including preparing for re-use organizations, compliance schemes, recyclers and equipment consolidation points, as well as retailers and civic amenity sites were interviewed in order to collect opinion on the current system, contrast it with successful models and identify what action might be needed to move forward.

Findings

In relation to organizations interviewed within the EU analysis, Ireland differs most significantly in funding for social enterprise functioning in the preparation for re-use of WEEE area, which is very limited, and in the point of access for preparation for re-use organizations to obtain equipment. In Ireland, material is collected at retailers and civic amenity sites, collected by compliance schemes and brought to consolidation points from which preparation for re-use organizations are given access to material. Both compliance schemes and preparation for re-use organizations acknowledge that a suitable amount of quality material is not reaching preparation for re-use facilities and it is generally accepted that the highest quality of material is obtained at the point closest to the end user. All parties are open to exploring access to this material at point of collection from end user by approved preparation for re-use organizations, and civic amenity sites are open to separating material on site although retailers would likely be more hesitant due to extra costs. It is also to be noted that the approval process for preparing for re-use organizations, although extensive, is well received by all parties as a means to ensure material is only obtained by qualified, competent, and law abiding organizations.

Conclusions

These themes identified exhibit a number of factors that appear to be present in successful preparation for re-use systems:

- Access to a sufficient amount of fit for purpose material,
- Adherence to quality standards,
- The integration of social enterprise,
- External funding,
- And a positive relationship with compliance schemes.

However, these facilitating themes can quickly become barriers when absent, most notably when a positive relationship between compliance schemes and organizations is not maintained, as compliance schemes are in control of waste streams and access to material. In particular, the barrier of lack of access inhibiting the preferred preparation for re-use behaviour may be a consequence of how Extended Producer Responsibility (EPR), which places the responsibility for supporting re-use activities into the hands of producers, has been implemented. This aspect of the legislation appears to be serving as a significant barrier in itself to preparation for re-use within countries lacking in a strong history of re-use prior to the EPR requirement (such as Spain and Ireland). The implementation of targets to oblige the development of a preparation for re-use system would likely be necessary in those states where resistance may be stronger and in particular where retailers have been employed as a significant part of the WEEE collection system.

For the case of Ireland, the following recommendations are made to support the expansion of preparation for re-use:

- Introduce distinct preparation for re-use targets for large household appliances and IT equipment. The targets should be modest to begin with and increase gradually over the course of time.
- A preparation for re-use social economy sector should be encouraged through technical, financial and facilities support. This should be resourced

from a variety of sources including EU Social Entrepreneurship Funds, The Department for Social Protection, WEEE Compliance Schemes & philanthropic funding.
- Retailers and civic amenity sites should be encouraged to segregate material with potential for re-use.
- It should be permitted for approved preparation for re-use organisations to access WEEE at retailers and civic amenity sites
- Charity shops with a formal arrangement with an approved preparation for re-use organisation should be permitted to receive donations of WEEE with potential for re-use from the general public
- Logistics and pre-treatment operators within the current WEEE management system should be encouraged to become approved preparation for re-use organisations and exploit opportunities that may be available to them

Acknowledgments

This report is published as part of the EPA Research Programme 2014-2020. The programme is financed by the Irish Government. It is administered on behalf of the Department of Communications, Climate Action, and the Environment by the Environmental Protection Agency which has the statutory function of coordinating and promoting environmental research.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-260

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Dynamics of social capital in relation to the development of a sustainable product-service system applied to distributed production

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Keywords
Social capital
Design
Sustainable development
Sustainable Product-Service Systems
Distributed production

Abstract
Due to the people's lack of engagement on sustainability, the impacts of industrial production continue to increase. Many people see sustainable development as a distant reality and dependent on factors exclusively linked to technology, ignoring that the transition to more sustainable life styles requires a social learning process marked by collaboration and participation of people, i.e. through social capital. Sustainable Product-Service Systems and Distributed Production are approaches that favor behavioral change about artifacts' production and consumption. However, few empirical data has been generated about these promising models and their potential to promote sustainability. This paper presents data collected in the UM PASSO project, one of these initiatives located in the state of Pernambuco, Brazil. Through observation, questionnaires and interviews, the possibility of social capital strengthening related to these new practices of design, production and consumption is investigated. The results indicate that replication of local initiatives can promote a discontinuity in consolidated behavior, combating individualism and lack of cooperation, opening a debate and strengthening essential aspects for sustainable development.

Introduction

Despite the theoretical evolution of the theme, for many people in Pernambuco, Brazil, the Sustainable Development concept is understood as a reality dependent on external factors.

This limited perception causes two distinct situations as consequence: The feeling of impotence in which individuals think that there is nothing to do except wait for technological evolution to the point of delivering a truly sustainable development. Or, in second case, consumers believe that purchasing recyclable or recycled products, in a way, cancels out the impacts of production and consumption. Both are superficial views of this theme.

The human activity has caused consequences like depletion of natural resources, pollution, and other problems that require urgent solutions, and the above situations give rise to a sense of transference of responsibility about disturbances caused in the ecosystem, which has the greatest impacts represented by industrial production.

According to report Our Common Future (WECD, 1987), sustainable development requires organized citizens' participation and empowerment through communities with decentralized management. In this sense, formation of social capital can contribute to the transition to sustainability by facilitating coordinated actions aiming at a general benefit. According to Putnam (2006) this lack of engagement is characteristic in communities with low levels of Social Capital. This term describes aspects of social organization which facilitate coordinated actions and increase the efficiency of society in solving collective dilemmas (PUTNAM, 2006).

To Manzini (2008a), transition to more sustainable life styles, will be a diffuse social learning process, and creativity, knowledge and management capacities will be valued as flexible as possible.

Product-Service Systems applied to distributed production are cases of social innovation characterized by collaboration of local actors. These initiatives constitute an alternative production model to the large-scale industrial system, in order to reduce impacts, promote equity in distribution of wealth and natural resources, thus pointing a path towards sustainability.

Despite its potential, some authors state that studies on these systems have been summarized only in developed countries (BACHETTI, VEZZOLI & LANDONI, 2016), or remains in the field of modeling, providing little empirical data (KOHTALA, 2015).

So, this paper accompanies the UM PASSO project's implementation (which in Portuguese means "One Step"), acronym for Artifacts Production Model Unit for Social Sustainability. This initiative integrates individuals around activities that combine design, production and consumption, promoting mini-courses for wooden artifacts production that are destined to a philanthropic institution. The hypothesis is: The learning of design and traditional woodworking techniques through horizontal interactions develops a sense of trust and empowerment in the actors involved.

The purpose of this article is to observe the developing process of an initiative for distributed production of wooden artifacts, and its contribution to the formation of Social Capital in Caruaru, interior city of Pernambuco, Brazil. Thus, generating empirical data related to implementation of enabling platforms and dissemination of systems that facilitate social integration, distribution of wealth and knowledge about sustainability.

Social Capital

There are several definitions for the term social capital. Many researchers in social sciences argue that the greatest impacts on the concept are credited to Robert Putnam (BAQUERO & CREMONESE, 2006; FIELD, 2017).

According to Putnam (2006, p.177), "social capital refers to characteristics of social organization, such as trust, norms and systems, that contribute to increasing the efficiency of society, facilitating coordinated actions". The term represents a shorthand for social scientists who want to refer to social networks, norms of reciprocity and trust originated in these networks (SANDER & PUTNAM 2010).

Putnam's studies suggest that a fall in social capital levels has contributed to the contemporary phenomena of people's distancing, externalization of responsibilities, distrust and lack of generosity.

These same characteristics are pointed out by Bauman (2008) as by-products of consumer society, in which solidarity and cooperation do not appear as part of the social construction plan. This Individualism creates an inability to cooperate, generating opportunism and lack of trust (PUTNAM, 2006).

The social capital concept can be divided in factors related to individuals' participation in a community, trust, security sense and honesty in social environment.

Encouraging adults to socialize more, join more groups, and work more as volunteers, as well as teaching young people to become more socially connected are requirements to restore social capital levels (SANDER & PUTNAM, 2010). Therefore, through the concept of Sustainable Product Service Systems, the action UM PASSO project was created.

Sustainable Product Service Systems (S.PSS)

One way to develop more sustainable lifestyles is to break the perception that relates well-being and the possession of products. A potential guideline to reduce the large-scale production impacts is to promote a service economy by offering access to objects instead of possession (MANZINI, 2008b; MONT, 2004; VEZZOLI, KOHTALA & SRINIVASAN, 2014).

Briefly, a S.PSS proposes to shift the business focus from the sale of products to the offer of a combination of products and services that meet the "Satisfaction Unit". It can be exemplified through a simple hypothetical situation: Usually, people do not want a sun umbrella, but the shade that this object provides. Therefore, a S.PSS could offer as "Unit of satisfaction" periods of time under the shade. The service provider owns the products involved, in this case, the sun umbrella.

Since suppliers own the products, there is an economic benefit in optimizing their life cycle. (VEZZOLI, 2010). The longer the object is used and in good performance, the more profit this will yield to the company. It is a contrary phenomenon to programmed obsolescence.

One of approaches of Product-Service Systems is called "Providing enabling platforms for customers" (VEZZOLI et al, 2014). When a company offers access to products, tools and structures, allowing clients to obtain the result they seek and meet their needs from available support. This can enable communities to adopt systems with lower consumption of materials (VEZZOLI, 2010; MANZINI, 2008b).

S.PSS and Distributed production

In medium/low income contexts, the cost of purchasing equipment and machinery often precludes initiatives of social innovation (VEZZOLI, 2016).

But, when a S.PSS offers access to equipment, for users or communities to perform their tasks, investment of purchase it is reduced or even cut. So, enabling solutions disseminate opportunities to collaborative initiatives, and promote socialization (MANZINI, 2008a). An initiative like that, connecting autonomous elements in a non-hierarchical interaction can configure a distributed production.

According to the LeNSin project (International Learning Network on Sustainability) A Distributed production system is a small-scale production unit, at or near the point of use, where the users are the producers – whether individuals, small businesses and/or a local community (VEZZOLI, 2016).

In other words, it is a space where "Prosumers"

Figure 1. Collaborative activities.

Figure 2. Participants.

Figure 3. Table and chairs models co-produced in UM PASSO project.

(Producers+Consumers) manufacture artifacts, in small scale, collectively, to meet their needs and desires.

This dynamic allows, at the local level, systemic discontinuities that defy consolidated modes of consumption, promoting "participatory services in locations where the same services are based on an absolute passivity on the part of users" (MANZINI, 2008a, p.63).

This association can boost the process of sustainable development by promoting social capital and indicating new ways of producing and consuming artifacts.

Methodology

The development of a distributed production unit was observed, moreover questionnaires and interviews were applied in various project phases.

At the beginning, a socio-demographic data collection of 16 participants was made. But 6 abandoned the activities and the final sampling has 10 individuals.

The questionnaires are elaborated in Likert scale with 5 points (from strongly agree to strongly disagree), similar to those used by Putnam (2006) and Onyx & Bullen (2000). The data from questionnaires are represented in graphics with yellow background.

After all, interviews were made, looking at the evolution of the following dimensions: "Trust and Collaboration" and "Participation" among individuals. The data from interviews are represented ahead in the graphics with gray background.

UM PASSO Project

The UM PASSO project aims to teach woodworking techniques to people who, in exchange for learning, apply this knowledge to produce artifacts to donate to philanthropic institutions. It seeks to promote sustainable behavior in which the well-being is not simply linked to consumption of industrialized goods, but rather to an active learning and engagement process that result in formation of common goods, and artifacts' production for people on the social margins.

The place is an enabling platform, where some joinery equipment, such as saws and drills, are available.

This study observed activities occurred between April 15 and May 1, 2017, in four days of work and socialization (figures 1 and 2). Participants produced several tables and chairs for children (figure 3). The objects were donated to the social center "Mãe Morena", which helps families living in extreme poverty.

Local Context and Participants' profile

The project was developed in Caruaru, where live more than 350 thousand inhabitants, in 2013, Caruaru's per capita/year GDP was US$ 7,088.72, being the Pernambuco's state 6th largest GDP. The UM PASSO small shed is located in a suburban neighborhood, inside an area of a woodworkers Association, highlighted on the map (figure 4).

All participants are Caruaru residents, and came from many professions. For 8 of them, woodwork was a totally new activity. Table 1 shows some information about them.

Factor	Class	Number
Gender	Male	6
	Female	4
Age	<30 years	4
	31 years	2
	46 and 52 years	One of each
Education	High school	3
	Undergraduate	2
	Graduate	5

Table 1. Participants' profile

Figure 4: Association area and UM PASSO project location. © www.google.com.br/maps.

Dynamics of social capital related to the UM PASSO project

Here are demonstrated the most relevant results about dynamics of social capital, divided in two dimensions.

Trust and Security

Trust is a social capital basic element. A dimension that encompasses mutual trust among members of society, in governments, as well as perceived security.

The initial issues revealed high distrust levels. Asked about "What best defines the politics of the state of Pernambuco?" The answers express that the participants do not trust political authorities (figure 5).

Another indicative of distrust installed is that all of participants believe that people of the city tend to disobey the laws. According to Putnam this distrust favors opportunism, for it does not seem logical to obey the rules when expected everyone to despise them (PUTNAM, 2006). This creates a sense of insecurity.

Figure 6 shows that most of the participants said, "I do not feel safe", either in their neighborhood or in the neighborhood where UM PASSO project is developed. An indicative of high level of distrust.

However, when comparing the initial data with those collected at the end of activities, there is evolution in trust, relationship between participants and perceived safety.

Faced with the question "In the UM PASSO project workshop, when we were working, did the issues of violence come to your mind?", most participants said that forgot about violence when they were in the project (figure 7). The reasons were "we were in group", "we were in an association" and "we were working". This indicates that engaging in group activities provided a sense of security.

Another trust improvement indicator is that when participants were questioned "If an unknown person's car broke in front of your house, would you feel safe inviting this person to come into your home and use your phone?" The answers were negative (shown in the left column in figure 8).

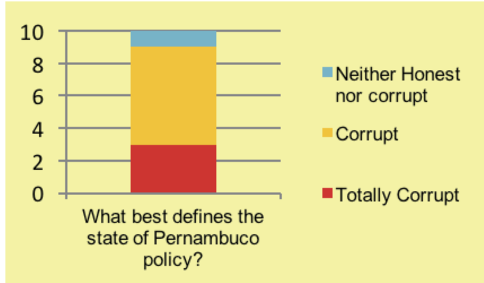

Figure 5. Distrust of participants in public administration.

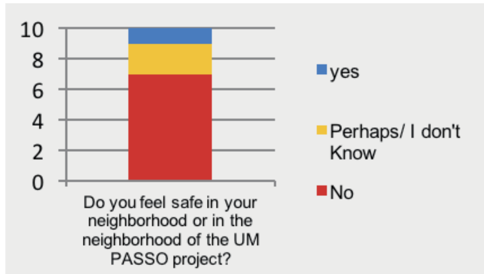

Figure 6: Insecurity of participants in relation to the community.

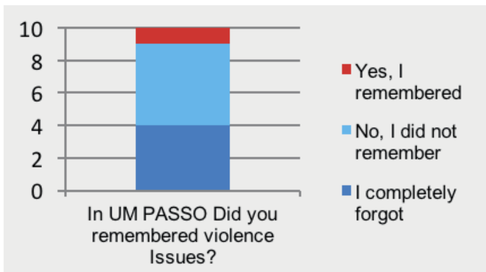

Figure 7. Perceived Security when in the UM PASSO project.

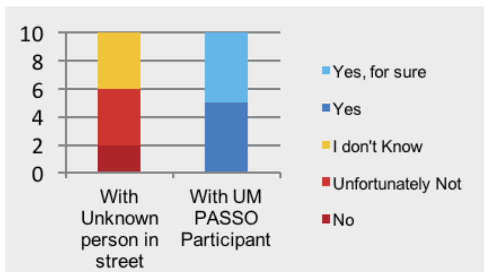

Figure 8. Participants' trust in helping someone by inviting them into your home.

Answer	Number of citations
The person's presence in a project that donates objects to philanthropic institutions	8
Have had an initial contact with the person	4
Trust in someone who knows that person	2

Table 2. Reasons for trust between members.

But when the same scenario is proposed, replacing the unknown person, by someone they met only in UM PASSO project, the answers became totally positive (right column in figure 8). This demonstrated that there is a trust relationship among the members of the initiative that were not known even in only 4 days of living together. The result was expected as a consequence of social interaction.

When they were asked about the reasons to trust more in people they met on the project, responses varied according to table 2, this indicate that, this sense of trust grown through factors related to the objective of the project.

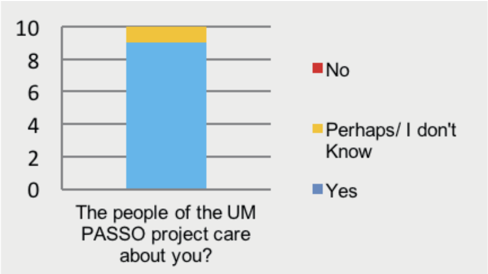

Figure 9. Sense of Trust and closeness among members.

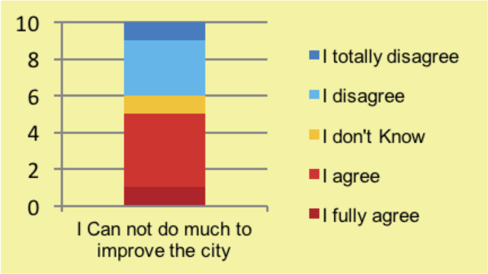

Figure 10. Civic impotence.

Figure 11. Delivering objects in the social center "Mãe Morena".

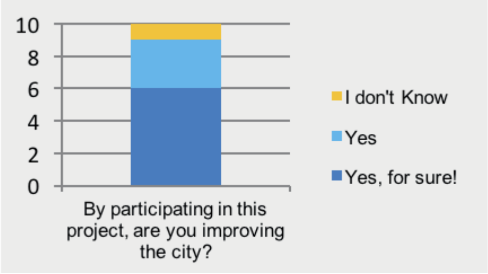

Figure 12. Participants' empowerment.

At first, all participants agreed that "The city's people are not really concerned about what happens to them". But, at the end of activities, to the question "Are the people in UM PASSO project concerned about you?" The answers prove again the growth of trust and closeness among participants (figure 9). The participants' socialization around the enabling platform has developed trust and an increase momentary the perceived security.

Participation and Empowerment

This dimension describes the individuals' involvement in community, covering cooperation activities, volunteering, or any type of group activity that articulates a common good.

In first data collection, the following statement was made: "You feel that they cannot do much to improve the city" Participants responded according to figure 10. Half of participants felt what Putnam (2006) called civic impotence.

However, after the actions, and delivery of the objects to the philanthropic institution (figure 11), participants stated that they were actually improving the city. The sense of participation has increased considerably (figure 12).

According to Putnam (2006), participation in civic organizations develops a sense of cooperation, common responsibility, and fosters trust among members. The more developed these systems, and the more horizontal (non-hierarchical) relationships, the greater the possibility for citizens to cooperate for mutual benefit. In this case, the action was only possible from the access to the enabling platform equipment.

Conclusions

The implementation of a Product-Service System applied to a distributed production unit is exposed, and indicates the potential of this model in dissemination of sustainability, strengthening the trust and cooperation. The replication of units that associate design and production dynamics, converting them into new modes of consumption, can indicate guidelines for behavioral changes. Knowing that social capital formation is a slow and hard process, this paper opens future studies possibilities to discover more evidences in this sense.

It is clear that people from sample were willing to help and engage in volunteer activities to improve the community, so, these new studies can reveal why these activities do not happen frequently, and how S.PSS can, in fact, contribute more to social initiatives to sustainability. With their new perspective on design and "prossumption", these systems can foster sustainable development, even in small initiatives.

The engagement of individuals fights the sense of transferring responsibility and individualism, demonstrating that even in local contexts it is possible to contribute to a systemic discontinuity, opening a debate about sustainability.

After all, given one step forward, we will not be in the same place.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-266

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Product lifetimes through the various legal approaches within the EU context: recent initiatives against planned obsolescence

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Keywords
Planned obsolescence
Circular economy
National initiatives

Abstract
Our today's society is often called a 'throwaway society', based on a linear 'take-make-use-dispose' economy. Many studies point out that median lifespans of certain consumer products are in decline. One of the main sources of this problem is the phenomenon of 'planned obsolescence', covering all types of techniques used to artificially limit the durability of a manufactured good in order to stimulate repetitive consumption. Various types of planned obsolescence are omnipresent in our daily life. Planned obsolescence has huge drawbacks, for consumers as well for the environment, and, arguably, its potential positive side effects do not outweigh these drawbacks. The willingness to shift towards more durable and sustainable products has led to major legal developments and proposals over the past years. The purpose of this paper is to outline some of the various approaches followed in Europe to tackle planned obsolescence. After providing a glimpse into the EU policy actions, the paper will describe the recent purely national initiatives undertaken in France, Belgium and Germany.

Introduction

In industrialized countries, the current economic conditions encourage producers and consumers to use more materials and energy for higher satisfaction, without developing the capacity to absorb and reuse waste and by-products. This problem of overconsumption and excessive production of short-lived and disposable items has been demonstrated in a growing number of empirical studies (Prakash et al., 2016; Schridde et al., 2014; Wang et al., 2013; Wieser & Tröger, 2015). The linear economy is generally identified as the root and support of planned obsolescence (Aladeojebi, 2013; Brönneke, 2014), defined as "*the assortment of techniques used to artificially limit the durability of a manufactured good in order to stimulate repetitive consumption*" (Slade, 2006). People and media typically confine the concept to material (introducing functional defects into the product or making it harder to disassemble) and technological obsolescence (incompatibility with later or competing versions). Yet this practice should be described in broader terms, encompassing psychological (no longer attractive in consumers' mind) and economic obsolescence (high costs preventing necessary repair and maintenance) (EP, 2016; Wieser, 2016).

The willingness to shift towards more durable and sustainable products, for the sake of protecting consumers and the environment, has led to major legal developments and proposals within the European Union (EU) over the past years. Nevertheless, the mechanisms to prevent and combat planned obsolescence are scattered across plenty of instruments, resulting in a three-tiered legal fragmentation. Firstly, both the EU and its Member States have devoted efforts to promote product durability and sustainability. Secondly, planned obsolescence has been addressed through various types of laws, which either have a general scope or concern only specific products. Finally, a range of norms shape the product throughout its whole life cycle, while others shape the relationship producers-consumers surrounding it. This paper fits into a PhD research (supervised by Prof. Dr. Bert Keirsbilck) that aims to identify and evaluate this panoply of rules. Here, the focus will specifically be on purely national initiatives undertaken in France, Belgium and Germany. After providing a brief overview of the EU legal framework governing planned obsolescence, the most recent initiatives of the selected Member States will be described and assessed in the light of EU law.

European Context

Although no EU legislation makes explicit reference to planned obsolescence, the wide body of EU law comprises instruments that frame the practice. At the conception and production stage, EU rules such as the Ecodesign Directive (Directive 2009/125/EC), the Directives on Waste (Directive 2006/66/EC; Directive 2008/98/EC; Directive 2012/19/EU) or the Product Liability Directive (Council Directive 85/374/EEC), shape products to make them easy to repair, upgrade, re-use, disassemble and recycle. These product requirements include for example minimum durability for hoses and motors of vacuum cleaners (Commission Regulation (EU) No 666/2013) as well as the general obligation for manufacturers to provide independent operators with information to repair products (Directive 2012/19/EU, art. 15). At the marketing and contracting stage, some EU rules, including the Unfair Commercial Practices Directive (Directive 2005/29/EC), the EU labelling rules (Directive 2010/30/EU) and the Directive on Consumer Rights (Directive 2011/83/EU), allow for better information on products, to help consumers to take cost-effective and environment-friendly purchasing decisions and to incentivize producers to make sustainable goods. The principle of conformity laid down in the Consumer Sales Directive (Directive 1999/44/EC) also deters producers from shortening product lifetimes. If the product does not match the expected quality or performance, consumers are entitled to claim repair, replacement, price reduction or the rescission of the contract within two years from delivery, with a presumption of non-conformity for the first six months.[1]

Despite this set of rules, the EESC and the BEUC advocated further amendments, the former calling for a total ban on in-built (here 'material') obsolescence (EESC, 2013) and the latter suggesting a review of the EU legal framework to prolong the useful lifetime of consumer products (BEUC, 2015). As a reply, the European Commission (EC) delivered an Action Plan 'Closing the loop', with the aim of gradually transitioning towards a circular economy, where "*the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised*" (EC, 2015). This long-term target constitutes the guiding thread of all the measures capable of curbing the accelerating obsolescence of products. Along with these policy actions, several studies have been carried out at EU level and could contribute to the adoption of legislative proposals as well as to ongoing debates on existing regulations (EC, 2015; EESC, 2016; EP, 2017). A good example is the study on 'A Longer Lifetime for Products' commissioned by the European Parliament (EP) (EP, 2016), which gave rise to a Draft Report (EP, 2017) whereby the EP gives recommendations on possible measures to extend product lifetime.[2]

Hence, there is a wide array of existing and future EU rules that trigger product sustainability and durability. Not only do they harmonise the law framing planned obsolescence, but they also give incentives for Member States to address this matter in their legislation. Therefore, in addition to EU rules and the national measures implementing them, some Member States have taken the lead in complementing the EU minimum threshold of protection against planned obsolescence.

Purely National Initiatives

France

In France, both public and private sectors are particularly active in the transition towards a green and circular economy.[3] Over the last decades, not only the Government, but also local authorities, have undertaken a significant number of policy initiatives and programmes to support that long-term objective (SWD(2017)44 final). An illustrative example is the two recently adopted legislative measures, which contribute to tackling planned obsolescence.

With the Energy Transition for Green Growth Act (Loi n° 2015-992), France became the first country worldwide to outlaw 'planned obsolescence', defined as "*the set of techniques designed to deliberately reduce the lifetime of a product to increase its replacement rate*" (Art. L. 441-2 Consumer Code) (Mugdal et al., 2012). Producers pursuing such a strategy in France could be held guilty of a criminal offence (two years' imprisonment and 300.000€ fine). This Energy Transition Act was adopted as part of the French Waste Prevention Programme 2014-2020 (Ministère de l'Écologie, du Développement durable et de l'Énergie, 2014), as required by Article 29 of the Directive 2008/98/EC and supported by Articles 4 and 22 of the Directive 2012/19/EU.

The French Consumer Code had earlier been modified by the Hamon Law (Loi n° 2014-344), the second act of utmost importance in the fight against planned obsolescence. It firstly extends to two years the period during which the non-conformity of the product is presumed, as allowed by the minimum harmonisation approach of the Consumer Sales Directive. This considerably strengthens consumers' guarantee rights as the burden of proof lies longer on producers.

Secondly, the Hamon Law improves product reparability by requiring information on the availability period of essential spare parts to be brought to the consumer's attention, and by imposing the provision of spare parts within two months of a request by a seller/repairer. Failing to comply with these two obligations may result in an administrative fine. Despite its protective aim, the Hamon Law has come under criticism, which mainly deplores the lack of clarity and precision (Dupont, 2016). Its effectiveness has also been called into question since, unlike the initial legislative proposal (Projet de loi n° 1015), a closer reading of the law and its implementing Decree (Décret n°2014-148) does reveal that producers are under no obligation to provide this information. Thus, it paradoxically encourages producers not to give any information on spare parts so that they escape these newly established obligations.[4]

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[1] *This presumption period might be extended to two years for online and distant sales. See Proposal for a Directive of the European Parliament and of the Council on certain aspects concerning contracts for the online and other distance sales of goods, COM/2015/0635 final.*

[2] *For example, it recommends voluntary European label with durability and reparability criteria, obligation for producers to make spare parts available and inform consumers about it, European definition of planned obsolescence.*

[3] *A wide range of associations and agencies are involved in sustainable consumption, and some of them actively participate in the adoption and implementation of environmental policies. See amongst others: les Amis de la Terre, la Fabrique écologique, ADEME, Association « Halte à l'Obsolescence programmée ».*

[4] *See the claim for annulment brought before the Council of State ('Conseil d'Etat') by the association Halte à l'Obsolescence Programmée, which deplores the implementation of the Hamon law: C.E. (FR) 27 mars 2017*

Belgium

Belgium had already been considered as pioneer in the field of planned obsolescence on account of the 2012 Senate Resolution, whereby the Government was requested to curb the practice at national level and to call for the adoption of a legal framework at EU level (*e.g.* product labelling including information on product lifetime and reparability). While progress has been made on the part of the EU, Belgium is still at the stage of making legislative proposals.

In 2016, three legislative proposals have been dedicated to this topic, putting forward different types of measures. One is to define planned obsolescence, with the support of sanctions, either from the Civil Code (nullity of the contract and full reimbursement) or from the Criminal Code (from 500 to 100.000€ fine and from one to five years' imprisonment). It is noteworthy that sanctions already exist according to the Law of 29 June 2016, as planning the obsolescence of products could be qualified as an unfair commercial practice. For instance, producers who misleadingly fail to give information on essential characteristics of products (like on their lifetime) could be asked to submit their products to a quality check at their own cost (Art. 39) and might have to withdraw them from the market (Art. 40), together with a fine from 26 to 10.000€.

In addition to coercive measures, others rather aim to provide incentives to make longer lasting and reparable products, without regulating the product design in itself. They consist in (1) extending the guarantee period beyond the two-year minimum of the Consumer Sales Directive (either five years for all products or a period that varies depending on products)[5] as well as the presumption period (from six months to two years), (2) providing more information on products (lifetime expectancy, reparability, availability of spare parts and repair instructions), (3) imposing the availability of spare parts and (4) giving economic and fiscal support to circular economy (*e.g.* a lower VAT on repair and selling spare parts services).

In October 2016, an Action Plan on circular economy(Peeters & Marghem, 2016) restated and complemented the measures abovementioned with a total of 21 measures to be taken by 2019, some of which having already been implemented. As a first example, a contact point has been established to enable consumers to report their suspicions of planned obsolescence cases and to receive answer from competent services.[6] Moreover, a report on planned obsolescence issued in May 2017 identified, assessed and recommended different packages of measures to the federal legislator. They aim to foster ecodesign and sustainable purchases, encourage a better use of consumer products and facilitate repair.

[5] *The guarantee period has already been similarly extended in some Member States, like in Ireland and in the Netherlands.*

[6] *This contact point adds up to the one set up by Test-Achats ("trop-vite-usé") which counted more than 6000 claims in June 2017, attesting the consumer dissatisfaction with product lifetime.*

Germany

In Germany, the concepts of circular economy and planned obsolescence increasingly permeate into policies and laws (BGBl. I, Nr. 10, S. 212). In addition to timely and full implementation of EU environmental rules, the German Government pursues a proactive sustainable development strategy at national level, characterised by high recycling rates, no landfill, high worldwide demand for German technology and good eco-innovation performance (SWD(2017) 38 final).

Given this involvement to keep production and consumption patterns within sustainable bounds, it is not surprising that two legislative proposals against planned obsolescence were launched in 2013 (BT-Drucks. 17/13096; BT-Drucks. 17/13917). Although they were finally rejected, they were both characteristic examples of legislation promoting longer product lifetime. The first proposal was consumer-focused, calling for the introduction of a minimum period for the use of products. Concretely, it proposed to provide information on this period, as well as a list of products with their corresponding period of use, to ensure better after sales services, to maintain the two-year guarantee period and to place the burden of proof on producers in case the product breaks before the minimum period of use. Furthermore, similarly to the French approach, it prescribed the prohibition of intentional in-built obsolescence.

The second proposal, by contrast, was mainly intended to improve product requirements (*e.g.* extension of ecodesign requirements, improvement of product reparability, collection, reuse and recycling) on the basis of the 2014 study commissioned by the parliamentarian representation Büdnis 90/Die Grünen (Schridde et al., 2014). This proposal also insisted on examining the possibilities given by EU legislation, like the Ecodesign Directive and the EU Waste Directives, to curb planned obsolescence, and on strengthening them at EU level.

Although there is currently neither specific legislation on planned obsolescence nor a concrete project to put into place such measures, many studies have been issued (Prakash et al., 2016; Schlacke et al., 2012; Schridde et al., 2014) and workshops been organised by legislative key stakeholder groups (Brönneke & Wechsler, 2015). In a policy brief from March 2017, the German Environmental Agency ('Umwelt Bundesamt') recommended six political strategies against planned obsolescence: (1) product standards with minimum lifetime, (2) information on availability of spare parts and repair services, (3) a manufacturer's duty to issue a guarantee statement, (4) improved framework conditions for repairs, (5) reduced value added tax for repairs, and (6) strengthened product appreciation. Furthermore, there are many German self-regulatory initiatives, the best known being the Blue Angel ('der Blaue Engel'). The latter certifies the ease of repair and durability of many products, but also ensures guarantees that go beyond legal requirements and spare parts provided after the end of the sale.

Conclusions

In brief, it can be asserted that Europe is actively engaged in the fight against planned obsolescence, along with the search for the implementation of new economic models, mainly the Circular Economy ideal. The EU has already positioned itself against the limited product lifetime through the policy actions and studies undertaken by its institutions and organs, the most recent ones being the EC's Action Plan 'Closing the Loop' or the Draft Report delivered by the EP on 'A Longer Lifetime for Products'. The Member States are also following this trend. In addition to implementing EU rules, many have deployed initiatives to tackle planned obsolescence. The commitment of France, Belgium and Germany accurately reflects the general mobilisation against the phenomenon.

Through this paper, it has been seen that various approaches can be followed to settle the issue, although most of them combine the different types of measures. While some are product-oriented, with either a general or specific scope, other measures rather focus on consumer rights. At EU level, both types of measures can be found. Another distinction exists between coercive measures, like the criminalisation of planned obsolescence in France, and preventive or incentive measures, as exemplified by the Belgian legislative proposals which suggest economic and fiscal support for repair services. The German approach also highlights the potential of self-regulatory measures, like the Blue Angel certification, as an alternative to mandatory legal requirements.

While purely national initiatives are generally encouraged by EU institutions (EC, 2015), the same measures could be regarded as barriers to market access and market integration. Having to satisfy rules different from one Member State to another could indeed create financial and administrative burden for producers who will then pass on the costs to final consumers. Moreover, it exacerbates the legal fragmentation issue, obliging consumers and producers to deal with a real legal maze. Allowing for greater levels of protection for consumers and the environment could thus undermine the smooth functioning of the internal market. Therefore, to facilitate and increase cross-border trade within the European Union, it might be preferable to define and clarify the rules governing planned obsolescence at EU level.

However, the fact that Member States take initiatives could serve as an experiment and an example for the EU, provided that they are consistent with EU rules. Since it takes less time to adopt measures at national level, the Member States could play the role of national laboratories. If it is successful at their level, the measures could then be initiated at EU level. Hence, it goes both ways: the EU feeds the Member States and the Member States feeds the EU. On the one hand, actions at EU level are needed to facilitate and support the uptake of activities at national level and also to ensure a level playing field for producers. On the other, it is important to leave Member States a margin of manoeuvre in adopting national legislation, so they could be a source of inspiration and discussion within the EU.

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*Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)*

DOI: 10.3233/978-1-61499-820-4-271

Improvement design in Portuguese wool lifecycle: ecological yarn collection

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Keywords
Wool
Ecological
Yarn
Dyeing
Lifecycle

Abstract
Abstract: Wool is a light, comfortable, and durable fibre that forms a protective covering against both heat and cold. In Portugal, raising sheep, wool collection and production of yarn has been a domestic craft work for centuries, concentrated mainly in the East and South of the country, particularly in Serra da Estrela and Alentejo. The sorting and storage of wool is done by companies associated to "Merino" wool producers, however, this type of wool is only a small percentage of the country's total production. The country has many other varieties of wool but these may end up burned, which generating toxic waste, if they do not make it to the market to be sold. This paper presents a general approach, discussing the possibility to recover these remaining wool fibres that did not sell, through the manufacturing of artisanal and ecological yarn. This aims to promote animal welfare and ancestral spinning techniques and processes, practices from a long-nurtured Portuguese textile heritage. The practical experiment and study express concern over fast fashion, presenting points of interest for a slow product system, which may provide for a circular life cycle for products. The creator of eco-friendly yarns also represents an important role as a mediator and an interventionist in the garments design, thus creating value for the products and increasing material lifespan.

Introduction

The wool production from sheep is an ancient practice, particularly suitable for poor and rocky terrain that is unfit for agricultural crops. The biggest wool producer is Australia, where a controversial and painful practice named '*mulesing*' is often performed. European and American trade organizations as well as animal rights associations (e.g. PETA) have made some efforts to reduce this practice. Its eradication is therefore already a crucial requirement for most European clothing brands, which are also starting to trade timeless products in a more productive slowdown system.

Nature-based approach to fashion and sustainability is most commonly expressed when designers become more engaged. Thinking about all the impacts of textile materials and garment processing depends on fibre types, fabric specifications and garment design. Although convoluted, there are some principles that can be applied to guide design decisions supporting better practices for the environment. The general decision is using fewest resources and causing least impact but sometimes this may mean avoiding industrial processing steps and working within slow systems, in local economies, inspiring to live from nature's bounty.

According to Sandy Black, "What can be more ecologically sustainable than a self-renewing fibre which grows continually and can be shorn from the animal without harm?" (Black, 2008)

The present research aims to demonstrate how the recovery of cut wool fibres from households can still be useful for the production of consumer goods. And, instead of rejecting and burning them, domestic producers can deliver the fibres to produce yarns and fabrics for fashion products, extending their lifetime and reducing toxic waste.

Wool in Portugal

Portugal and Spain has offered the best characteristics for transhumance, having numerous itineraries for sheep herds and providing pastoral arts specialization, namely dairy products and wool-based fabrics. Between the 14th and 17th centuries, Serra da Estrela (in Portugal) supplied the entire Portuguese territory (including the islands), developing natural spinning techniques.

The art of spinning is one of the oldest practices in humankind, since it is from the thread that the process of fabrics and clothing begins.

In Portugal, the practice of craft spinning started as a domestic task, essentially done by women either for their own consumption or to sell (Sequeira & Melo, 1977). In the beginning of 20th century it suffered a collapse as obtaining both fibre and yarn were very time-consuming. In the largest population centres, domestic labour quickly progressed to an industrial system.

At the moment, this practice is in disuse because there is no one to transform or work it. Nevertheless, Portugal continues to produce wool and 15 native species of Portuguese sheep can be counted (Bernardo, 2015).

Amongst the diversity of sheep breeds that provide for different types of wool, colour and texture, many fibres do not get sold, particularly those coming from very small herds or from species that do not have best commercial quality properties, such as Merino wool. Therefore, having no market these fibres will eventually be burned, generating waste.

The realization for an artisan and ecological yarn collection originated from a master's degree research aiming to eliminate toxic practices, whilst, simultaneously, revitalizing ancient, already forgotten, spinning practices. This project reveals concern on fibre waste and the importance of slow processes (e.g. reducing waste, eliminating toxicity); it is believed that it will minimize environmental impact as well as raising awareness towards a sensible consumption behaviour.

Wool Life-Cycle

The structure of the wool cycle depends on the final product to be purchased. The following figure (Figure 1) shows all the steps that wool fibre may involve, from the simplest to the most complex path.

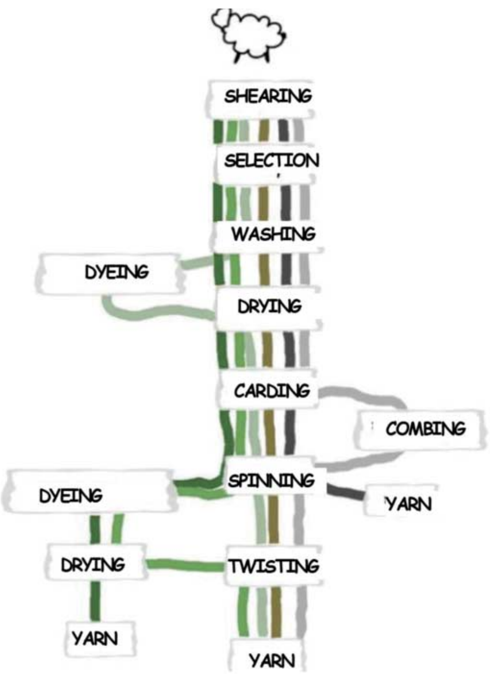

Figure 1. Illustration of the wool cycle, by Vanessa Barragão (2016).

When wool gets sheared from the sheep, it is prepared for spinning but first it has to be selected, washed and dried. By carding process, the fibres are teased out from the fleece over drums of wires into a fine web, which is then gathered and formed into a loose unspun rope. Ready for spinning, combing process can be short and produce shorter fibres or can go through a further process to remove the short hairs and make more refined worsted-spun yarns, usually used for fine woven cloths.

The dyeing process can either be applied to the fibre wool after washing or to the yarn after spinning. There is even a way to dye entire woollen garment, depending on the final specifications referred to.

Project Methodology

The practical project focuses on a slowdown system of products transformation and eliminates the use of polluting chemicals.

It was carried out according to handcraft practices, with the following sequence: obtaining the woollen veils, treatment of fibres, dyeing process, wool carding and spinning process.

Eight veils of merino wool were obtained from household with small herds. The fibres were selected, treated by washing with biodegradable detergent and then air-dried. Fibres proceeded to the dyeing process, which was applied into the raw fibres without bleaching and divided into two moments: experiments and the final dyeing.

In the experiments, natural materials that were found locally were used, such as yellow flowers of sour grass *(Bermuda buttercup)*, the black bean, a beetroot and the saffron of the Indies; all these dyes were put into a glass pot to dye the fibres by solar technique. The wool was not previously prepared to fix the dyes and the mordents were placed at the same time as the dyer bath. Salt was added to the yellow flowers of sour and to the saffron; and to the black beans and beetroot it was added vinegar and salt.

The final dyeing was carried out in a different way, starting with the previous mordant bath for branch fibres. From

Figure 2. Ecological yarns by Vanessa Barragão (2016).

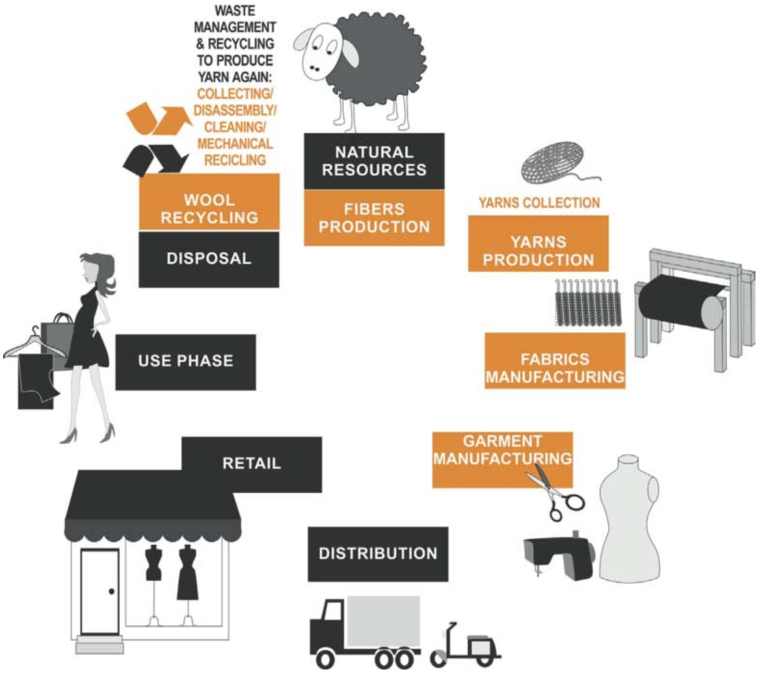

Figure 3. Wool garment Lifecycle, exposing the importance of Design stage to close the loop (orange highlight). Illustration by Carla Morais.

experiments it was used the yellow flowers of sour grass *(Bermuda buttercup)* and the black bean, adding a new material, the madder *(rubia tinctorum)*, which according to the literature is a very reliable dye (Dean, 1999). As mordant aluminium potassium was used, as it is less toxic to the environment and also advised (Dean, 1999; Duerr, 2010). Subsequently, impurities were manually removed from the fibres, then carding and spinning processes followed. Some fibres were twisted again using two similar threads or different one's to obtain a differentiated final effect.

The collection of yarn resulted in 2 sets: a set of yarn with the natural colours of wool, composed of six threads, and a set of died yarns, composed of five threads.

In order to carry out each step, different types of tools were used, such as pots and pans, thermometers, mordents, natural dyes, carding machine, spinning wheel, spinning needles and winder.

Some tools were designed and produced by hand such as the spinning needles, built from roots and unused wood. The remaining tools were reused or purchased.

Regarding to natural resources and other ingredients, the aim was to use natural products to ensure the minimum pollutant residues; that also occurred with the water that was reused in the greatest possible amount of the process. The wool and the natural dyes applied in dyeing bath came from the Algarve area research.

Introduction of ecological concepts and sustainability criteria in the life cycle of products made in wool

The issue of raw materials in clothing chain is not simple because a fabric production may carry out many operations including woven or knitting (Collier, Bide, & Tortora, 2001). Consequently, yarn can be made just in one material thread or more than one thread with mixed fibres yarns and colours. These technical aspects about fibres and fabrics intimidate designers because many of them do not have higher qualifications when compared to the 'experts'. However, Design is a confident approach that can create positive feedback loops and dramatically change subsequent processing steps before and during the manufacturing chain (Fletcher & Grose, 2012). It is essential in fibres, yarns and fabrics processing, once there is creative development in all of them. Properties like texture, smell or comfort are very important for the final product performance as well as for its ability to be reusable or recycled.

Woollen yarns are part of a pre-production stage of the woollen garment life cycle or other textile products produced by them. The inclusion of ecological and sustainability criteria in the products are now essential and the materials to be considered are those having less impact to the environment. In addition to that, other requirements are important, like 'paying attention to animal welfare', thinking about 'optimization of production', 'efficient distribution system', 'minimum impact on user level', 'time optimization in the life system ', etc. (Hemel & Cramer, 2002; Vezzoli & Manzini, 2008).

In this sense, the creation of ecological wool yarns promotes the production of less polluting consumer goods and the materials reuse after their end of life.

Closing the Fashion Cycle

The construction of an environmentally friendly product is inversely proportional to the its multi-functionality (Wang, 2006). Products made of mixtures composited or produced in multilayers are more difficult to recycle than simple ones while they may compromise more complex purposes.

By planning garments with mono-composite yarns (100% wool) we are guaranteeing their future recycling (Figure 3).

This point of view changes the way one sees products lifecycle and reveals to be closer to the cradle-to-cradle» philosophy (Braungart & MacDonough, 2002). It is, therefore, possible to create value through raw material processing and to introduce it again to another life cycle, such as clothing, prolonging the functionality of the material.

Textile waste management strategies

The textile waste sector has had a long history of recovery working with rag collectors and shoddy manufacturers that have been reusing and recycling fibres for long.

In this practical case, we are suggesting the making of woollen yarns to produce woollen garments; avoiding the landfills by being easy to recycle. Using a shredding machine to cut discarded woollen garment into small pieces it is possible to produce yarns again with a carding machine. This mechanical recycling process offers a low-impact alternative, compared to other fibres sources (Morais & Carvalho, 2015). An advantage is separating clothing by colour; it does not need to dye the yarns again or fabrics that will be produced. To ensure the quality of the final fashion products it even will be possible to mix recycled and virgin woollen yarns to produce quality fashion items.

Conclusions

This research explains the elementary processes of the wool cycle, from shearing to spinning, leading us to have a flush experience as aware individual within a better community.

Using wool, that would otherwise be burned by households, to make handcrafted yarns was a way to maximize resources and reduce the environmental impact. Besides that, a garment cycle made of those woollen yarns is shown as well as an example how we can increase the durability of materials and their lifetime.

Analysing the importance of designer's knowledge and his involvement with manufacturing processes it is concluded that his role is extremely important to plan greener products and close the loop of their lifecycle.

Acknowledgments

The authors of this paper would like to thanks the Centre for Research in Architecture, Urbanism and Design (CIAUD) of the Faculty of Architecture of the University of Lisbon for founding this project. The authors would also to thanks Mrs Gabriela Forman for making the English review.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-275

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Taxonomy of design strategies for a circular design tool

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Keywords
Circular Design Tool
Design for Sustainability (DfX)
Circular Economy

Abstract
This paper presents the development of a circular design tool created from a taxonomy of design strategies related to circular economy aspects that emerged from an extensive literature review. The taxonomy was presented to 10 experts on circular economy and design through a survey to identify an importance factor that could guide product designers to rate different concepts. The taxonomy and their rates are presented in a circular design tool to help product designers to avoid uncertainty of which design concepts meets circular economy aspects. A pair of trainers are used as an example on how the circular design tool can be used. The paper discusses how the chosen design meets the identified circular design aspects and acknowledges that more trials with different product categories are needed to determine further areas of improvement. A larger survey is also suggested to develop a more accurate scoring system when it comes to rate each concept. The paper concludes that more detail guidelines are needed for product designers in their early career, so they can consider design for circular economy. In addition, the final remarks elucidate that future research is needed to cross-reference the circular design aspects with technical aspects of each product, new manufacturing technologies and materials.

Introduction

The circular economy ideology replaces the end-of-life concept with restoration, using renewable energy, eliminating the use of toxic chemicals that impair reuse, and aims for the elimination of waste through the superior design of materials, products and systems. As such, design for a circular economy must consider design strategies for closed-loop systems within a technical cycle (synthetic materials stay in continue use without losing their properties and value) and a biological cycle (organic material returns to the natural system providing nutrients that don't cause harm) (McDonough and Braungart, 2002).

In early 2017, design consultancy IDEO with The Ellen MacArthur Foundation released the 'Circular Design Guide' (IDEO, 2017) that complies 24 different methods classified in four different stages: Understand, Define, Make and Release. The guide combines Circular Economy and Design Thinking principles to inspire designers to create solutions for the Circular Economy. The guide is built for design tangible (e.g. durable products) and intangible (e.g. services) solutions.

Despite the 'Circular Design Guide' presents a handful of methods and templates to inspire designers, it misses to help product designers to avoid uncertainty of which concept meets circular economy aspects. In addition, the guide also misses to include valuable literature on Design for Sustainability, considered as the predecessor of Circular Design (Moreno et al. 2016).

The aim of this article is to identify a taxonomy of design strategies that could be useful to guide product designers on how to conceptualise durable and single use products for a circular economy by foreseeing possible solutions for close-loop systems. To meet this aim, the paper presents the development and a first implementation of a circular design tool for an European context.

Methods and scope

To build the proposed circular design tool, first the authors conducted a literature review to complement the taxonomy of DfX approaches translated into circular design strategies presented by Moreno et al. (2016). The latter work presents an inclusive taxonomy with all the DfX strategies suitable for circular design, resulting in the most comprehensive one to build upon this current work. This is because most of the academic and grey literature on circular economy has focused primarily on the development of business model structures (e.g. Lewandowski, 2016; Lacy and Rutqvist, 2015; Bocken et al., 2013,2015; Stahel 2013 and Tukker, 2015) with a small number of studies addressing design strategies and principles (Bakker et al., 2014a, 2014b; Bocken et al., 2016; den Hollander et al., 2017) that cover all spectrums of the circular economy (i.e. technical and biological cycles).

The literature review focused on discovering other product design aspects that could be useful to implement a circular design. Business model and policy aspects that surround the product development were dismissed in this stage, as these were covered in the latter study. In addition, the focus on 'design' helped to untapped other design thinking aspects that can be integrated to change the role of design within the circular economy, such as technological developments and user experience.

Scopus and Google Scholar were used in the initial literature search using concepts like: 'circular design', 'circular economy', 'sustainable design', 'product design', 'design thinking', 'eco-design', 'sustainable design', and 'design for sustainability' with the combination of words such as: 'definition', 'guidelines', 'strategies', 'indicators', and 'standards.' The review of the literature is presented in full in 'A guide for circular design' (accessible via Kings Norton Library Master Thesis Archive), which describes in detailed how the revised taxonomy was built upon relating the identified design strategies to circular economy aspects.

This revised taxonomy was presented to 10 experts on circular economy and design through a survey. Respondents were asked to grade each identified design strategy and activity per the circular design aspects that they were related to. The answers of the survey helped to establish an importance factor between 0 and 5 that served as a guide to score a concept selection when designing a circular product. The taxonomy was then depicted in a tool that used a ludic approach to provide information by using visual elements to captivate its use along designers.

The tool was then used to conceptualise a pair of trainers, following a traditional design process. A pair of trainers was chosen, as an example of a durable product which follows a complex design within the take-make-dispose linear economy.

Taxonomy and survey results

The revised taxonomy (Table 1) takes a holistic approach to product development considering material selection, manufacture processes, distribution, use and end-of-life. It compiles and classifies different activities to consider in the conceptualisation phase of the design process, according to the identified design strategy and circular design aspects.

Through an online survey, experts in circular economy and design were asked to score between 0 and 5 each of the identified strategies and activities to define the impact (or importance) factor that each specific design strategy and activity have when developing a new product. An average score from the survey was calculated to stablish a circularity factor in which each activity is rated as seen in Table 1.

Circular design tool

From the presented taxonomy, a circular design tool (figure 1) was created to present the information in a non-scientific language with the aim to be easy to use, to educate and inspire during the concept development phase.

The tool helps to rate each concept according to the circularity factor. However, since the circularity factor came from experts' opinion, this cannot be considered as an ultimate score. As such, the tool is designed to consider a subjective score from the designer, considering the specific product and context around it. An explanation of how to use the tool to score each concept can be seen in Figure 2.

Figure 1. Circular design tool.

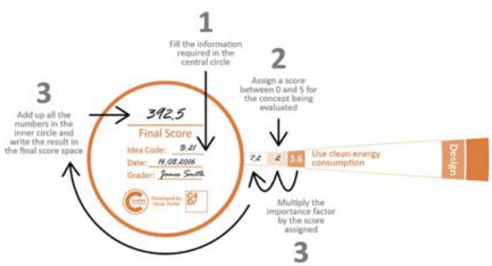

Figure 2. Circular design tool scoring instructions.

Designing a pair of trainers using the circular design tool

The tool was used to design a pair of 3D printed trainers by choosing different design strategies and scoring different concepts (Figure 3).

The selected design consists of a two-part trainer (Figure 4). A Selective Laser Sintering (SLS) technology was selected with a Thermoplastic Polyurethane Elastomer (e.g. Duraform Flex) as the base material to produce the trainers. This material is fully recyclable and can be used again in a SLS printer. Its properties are ideal for the footwear industry as it is flexible, durable, tear-resistant, soft-touch and washable. The design of this pair of trainers allows new disruptive business model such as offering trainers as a service through a subscription model. This model provides a personalised service if the trainers need to be repaired, maintained or parts need to be replaced, as

Circular Design Aspect	DfX Approach	Strategy	Factor
Resource Conservation	Design for energy conservation	Use clean energy consumption	3.6
		Reduce energy consumption in manufacture (eliminate yield losses)	3.3
		Improve manufacture (production steps, supply chain)	3.5
		Use processes suitable for low scale production	2.5
	Design for material conservation and eliminate waste	Select the best materials (non-toxic, pure if possible)	3.8
		Choose local materials (no-rare to avoid scarcity)	3.0
		Consider a healthy material flow	3.7
		Eliminate unnecessary parts and sub-assemblies	2.6
		Reduce material (light weighting)	2.8
		Reduce or eliminate packaging	3.2
		Reduce the size of components (miniaturise)	2.6
		Avoid composites and coating (difficult to separate materials)	4.3
		Avoid toxic adhesives, use easy-mechanic joints (fasteners, visible joints)	3.4
		Use pure materials to allow biodegradability	3.2
Life Cycles (end-of-life)	Design for optimising/extend product life	Assure reliability (quality)	3.8
		Allow reusability	4.3
		Encourage maintenance (repair/refurbish)	4.4
		Ease assembly/disassembly	4.3
		Standardise parts for compatibility (modularity)	4.1
		Remanufacture	4.0
	Design for multiple life cycles	Recover material (easy to clean, collect and transport)	4.1
		Allow cascade use	3.8
		Motivate the user to recycle	2.9
		Assure spare parts availability	4.0
Whole System Design	Design for sustainability	Shift the ownership of products into a service (swap, rent, share)	4.2
		De-materialise products into digital platforms	3.4
		Allow upgradability and flexibility to adapt	3.9
		Strengthen local industry	3.3
		Create regenerative systems (biomimicry)	3.3
		Care about social impact	3.5
		Create wealth through a good business practice (improve cost-benefit relationship)	3.6
		Develop a trace-and-return system	3.8
Customer	Design for users	Customise to wants and needs of each person	2.8
		Enhance durability (avoid built-in obsolescence)	3.9
		Develop attachment/loyalty (experience, meaningful design)	3.3
		Reduce waiting times in delivery to consumer	2.3
		Based on long-lasting trends, no ephemeral fashion (timeless aesthetics)	2.7
		Implement poka-yoke principles to ease use	2.6
Development	Design for the present towards the future	Use mobile technologies	3.1
		Use Machine-to-Machine communications (M2M)	3.2
		Use cloud computing	3.2
		Use social media technology	2.6
		Use big data analysis	3.3
		Use new material (intelligent, organic)	3.2
		Use 3D printing (avoid subtracting technologies)	3.0
		Create multi-functional teams to consider different aspects in the design	4.1

the main body detaches from the sole with a mechanical joint. In addition, trainers will be produced in local stores. The concept also includes the use of other technologies such as the ability to scan your foot to produce every trainer to measure and an augmented reality application to virtually try the trainers on. These technologies will allow the custom production of trainers avoiding a surplus of unsold products and utilizing the minimal amount of material.

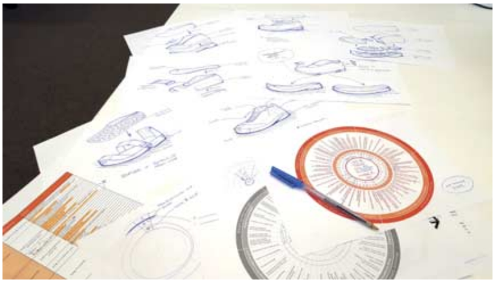

Figure 3. Concept development and scores using the circular design tool.

Figure 4. Pair of 3D printed trainers using the circular design tool.

Assessing the circular design aspect of the selected design

This section discusses how the trainer meets the identified circular deign aspects.

Resource conservation: The trainer is suitable for being built in a low scale production in a single location, improving the manufacturing process by reducing the steps needed to create a final product (Allwood et al., 2011). In this case, only the process of printing is used, removing other processes like cutting, sewing, gluing and heat forming. Using 3D printing as a main process of manufacture means that there is no waste in the manufacturing process.

Life cycles – end of life: The trainer is designed to be maintained. The design allows users to change the damaged parts without disposing the entire product, as it has a mechanical joint between the sole and the upper body that helps to easy disassemble to final product (Bogue, 2007; Plant et al., 2010). Being able to recover parts of the trainer, allows to cascade the material back into the manufacturing process (Accorsi et al., 2015). In addition, the selected design and manufacturing process allows assuring spare parts, as they are printed by request.

Whole System Design: The chosen design allows certain flexibility in colours and styles, having an adaptable design (Bakker et al., 2014a). Biomimicry was included by considering a restorative process when either the sole or the upper body gets damaged by using 3D printing for repair (Andrew, 2015). The design also allows to include a servitisation model if needed.

Design for users: 3D printing allows to personalise a design with different shapes and styles, reducing waiting times in delivery to the user (Berman, 2012). The design also intends to create an attachment between the product and the user, through updating or upgrading the trainer when needed to keep on track with any fashion trend. This might help avoid built-in obsolescence (Bocken and Short, 2016).

Design for the present towards the future: Using augmented reality and 3D printing technologies can help to avoid surplus of manufactured products and unwanted items returned to the manufacture or store. The analysis of big data (out of scope on this paper) could help to assess product integrity (Ijomah et al., 2007).

Discussion

From this trial of using the circular design tool, it can be said that future versions of the tool should consider a more accurate scoring system of each concept developed, including different factors for different product categories. The current scoring system is based on qualitative data, which was translated into quantitative information based on the survey results. However, the obtained factors were based on a small sample of answers, which might vary if a larger sample is considered. In addition, the tool was conceived considering only aspects related to the circularity of the product, leaving out of scope the aesthetics and the business model around the product. Whilst there isn't an 'ideal' business model that is preferable to achieve true circularity when designing a product, it is acknowledged that future versions of the tool should include a cross match between the design and the business model, as choosing the most fitting circular design strategy is highly dependent on the specific product context in which the product will function, as acknowledge by one expert when answering the survey. In addition, the tool should be adapted to customise importance factors for different product categories, companies or contexts as pointed out by another expert. These considerations will help to tailor better a circular design approach to a chosen business model for the successful transition into a circular economy.

As a first attempt to test and use the circular design tool, the result of the designed trainer shows a good example of circularity from conceptualising a product to a final prototype. A third expert in footwear design mentioned: "the result seemed appropriate as it reduce parts and eliminates components, such as the laces. It has good aesthetics that could help to create attachment with the user, and it considers important characteristics of trainers' design such as ventilation and shock absorption." Despite this concept shows a good first attempt of using the circular design tool to conceptualise a product, still more research has to be done to cross-reference circular design aspects with technical aspects of each product, new manufacturing technologies and materials to make a fully commercial product. I.e. 3d printing technologies are in early stages of development to be used for the footwear industry, and thus further tests and adaptations to the presented design might be required for full commercialisation.

Conclusion

Designers define to a great extent, the impact a product will have through its lifetime, and thus the aim of this paper was to identify a taxonomy of design strategies that could be useful to guide product designers on how to conceptualise a product with circular economy in mind, especially in their earlier career. As discussed, the paper presents a good example on how this tool could be used to conceptualise a product, acknowledging that there is not only one answer when designing for a circular economy. In addition, a more accurate scoring system would be needed, to account for suitable importance factors for each strategy presented. Therefore, future research would see the implementation of a larger survey to have a more accurate scoring system, as well as further trials with different product categories considering the business model.

Acknowledgments

The Engineering and Physical Sciences Research Council (EPSRC- EP/M017567/1) and the Charter Institute of Waste Management (CIWM) have funded this research under the Network on Redistributed Manufacturing Consumer Goods and Big Data (RECODE Network) project.

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*Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)*

DOI: 10.3233/978-1-61499-820-4-280

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Sustainable fashion tailoring: an approach for creating a heightened emotional attachment to garment apparel at undergraduate level, through pedagogy, story telling, digital technologies and traditional craftsmanship

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Keywords
Visual Communication and Clothing
Fashion Design Education
Technology and Craftmanship
Higher Level Thinking Skills
Emotional Durable Design
Tailoring

Abstract
Higher Education undergraduate programmes of study have a responsibility to educate learners within their discipline, bridging the gap between education and the real world. Never before has it been so important to equip learners who can adapt and accommodate change within their practice responding to external socio-economic, cultural, political and environmental concerns. With sustainability a key global concern, it is imperative that educational institutions educate its learners to help change the direction of a throwaway and environmentally unsustainable industry.
"Fast Fashion Is the Second Dirtiest Industry in the World, Next to Big Oil" Sweeny (2015)
This paper is a case study of second year undergraduate learners on a UK fashion design degree programme who were challenged by the luxury brand Ted Baker to design a collection of men's formal wear suits, combing sports detailing with traditional tailoring for the brands DNA and customer demographic. The primary argument of this paper arises from the need to further develop the theoretical aspect of the design process to improve learners understanding of the key principles of design, consumer behavior and basic human phycology. The inquiry adopted a practice based approach gathering data from workshop/seminar observations, client feedback and assessment of student 2D and 3D outcomes. Learners were exposed to the technical challenges of tailoring and encouraged to embrace and experiment with CADCAM technologies and unorthodox design and pattern cutting methodologies as well as traditional methodologies in order to affectively communicate a considered narrative. While assessment of outcomes indicate an improvement to the depth of thinking and creative application of story telling by the majority of learners, surface learning was still evidenced as a concern, encouraging further analysis of future pedagogy approaches.

Introduction

It is widely reported through mixed media channels about the impact fashion and textiles industries have on the global environment and its mass contribution to landfill, pollution, climate change and encouraging a throw away consumer behavior – fast fashion.

"Cheap garments, often made from manmade materials which cannot be recycled easily, are being worn just a few times and then binned," (Telegraph, 2008)

Higher education institutions have an important and fundamental impact on shaping the mindsets of future generations of designers as the majority of new designers entering the fashion and textile industry have predominantly some form of under or post graduate qualifications due to the highly competitive nature of the application and selection processes.

Encouraging a deeper and critical level of thinking is particularly pertinent during the conceptualization stage of the design process (Aspelund, 2010) and gives focus and further meaning to design practice and philosophies, moving away from a "design because I like" or personal design practice (Dorst, 2008) approach moving towards a "responsible design for consumer" acumen. During semseter 1 in the second year of a BA Fashion Design degree at Sheffield Hallam University, learners were set a Live client brief by the British brand Ted Baker and challenged to combine sports detailing with formal menswear tailoring to create a new "Sports Luxe" tailored aesthetic, one which compliments the brands DNA while also connecting in some capacity to the consumer. Learners were encouraged to focus on a relevant sport(s) in order to create an informed narrative which is not only fitting and marketable by the brand itself but also one which the customer can relate to on an emotional level. Ramakers (1999) argues that 'the only difference between designer and user is that the designer has made a career of creating meaningful experiences. The theory is that by creating an emotional experience (connection) to the garment, it will increase the care the owner places on the product and thus reducing the need to replace or prematurely dispose of, ultimately reducing waste and environmental damage. This is a view support by Chapman (2005) who states that,

"A revolutionary consumer relativity is born, catalysed by new provocative genres of emotionally durable objects and experiences that are designed for empathy" he continues by linking consumers to manufacturers and object care " Radical new commercial environments are pioneered in which objects provide conversation pieces that link consumers with manufacturers, facilitating upgrade, servicing and repair".

Ted Baker states "From the beginning Ted has had a very clear, unswerving, focus on quality, attention to detail and a quirky sense of humour, gaining the title of 'No Ordinary Designer Label'. Everything produced under the Ted Baker name has his personality woven into its very heart."

With this in mind learners were encouraged to risk take, innovative and approach this project with humor and an open, inquisitive and emphatic mindset.

Story Telling Through Tailoring

Pedagaogy – Setting the thought process.

Typically on undergraduate fashion design courses, the first year of study focuses on introducing core skills, in this case CAD, visual communication, research methodologies and ideation strategies, pattern cutting and construction. Theory is introduced by a carefully scaffolded approach, thus considerably less in comparison to the second year, where learners are more prepared to challenge processes; theories and ready to formulate considered and informed arguments and opinions. To enable this to take place, it was therefore imperative to educate learners on key theoretical design principles fundamental to setting the context of designing for a brand and client. Through discussions, lectures, workshops and observational analysis, learners developed a heightened critical and questioning approach to the application of their intended outputs displaying a higher order of thinking expected at undergraduate level. Dorset (2008) highlights the need for learners to engage in situations that involve strategic choices before the final realization of a product. Experiential learning methods enabled the learning of the practical skills of tailoring and history of, highlighting the importance of quality and craftsmanship as opposed to fast and cheap fashion. Immersive learning through field trips to cloth manufacturers, Savile Row and Ted Baker itself enabled learners to experience the atmospheric and emotional environment of time served experts, historic surroundings and the brand store, thus developing an emotional connection between designer, heritage and appreciation of this craft. By educating learners of key design principles, sustainability, design for want, need, (Maslow, 5 levels of need phycology) form and function, semantics and semiotics (including colour theory and symbolism), ergonomics, ethics, morals and basic human phycology (through analysis of branding strategies) it was intended that learners design thinking became informed and directional with an increased ability to forge a connection between designer and tailoring and customer and product.

Researching and Collating.

Learners were encouraged to carry out independent extensive research from a wide variety of sources and approach styles in order to forge an informed and appropriate narrative. Qualitive research methodologies included customer shopping behavioral observations, interviews with customers, store operatives brand designers, questionnaires to selective consumers of suitable demographics, all in an attempt to analyse and gauge consumer needs, wants and expectations. History of the brand and brand success was researched through secondary research, via publications, documentaries, HMRC submissions, company reports etc. Quantative research was evident through the investigation of the market place and competitors, Mintel reports and other accessible statistical sources. This type of research developed a better understanding of brand product offering and factors affecting business decision-making. Global trend and lifestyle forecasts were discussed through seminars and workshops by analysing key web and social media applications as well as reliable publications. Learners chosen themes were researched via a combination of all the aforementioned research strategies, with primary research encouraged over secondary, it an attempt to ensure originality and authenticity.

Figure 1 shows an example of a football related narrative and some of the scope of research carried out by this learner. Here were can see primary and secondary investigation into fabrication, branding, equipment, clothing, player movement, historical archives and a photograph taken from attending a match first hand. This is just one page of many, with others covering, ticket stubs, trading cards, memorabilia, stadium analysis, pitch markings, team formations, team loyalty, fan behavior and comradeship etc. Football was a popular choice of sport amongst learners, due to the British origins and its popularity, providing various scope for exploration and interpretation (see figure 2). It was identified amongst Ted

Figure. Generating primary and secondary research.

Figure 2. Looking beyond the obvious.

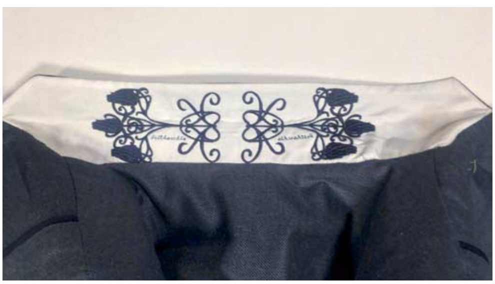
Figure 3. Digital embroidery used to add decoration to the jacket undercollar.


Figure 4. Combining creative cutting with digital technologies.


Figure 5. Jacket lining enhanced by applying both digital and sublimation printing processes.


Figure 6. Screenprint applied to the external of the jacket and buttons.


Figure 7. Handpainted lining using paint inks and dyes.


Figure 8. Handembroidery applied to the inside of the trouser waistband creating a more artisan and crafted aesthetic.

consumers that football has or does play an integral part in their life experiences, either as a child playing in the park with friends, part of a school team or even collecting trading cards and playing football on games consols. The levels of connectivity to football varied considerable based on the consumers experiences. Tutor to learner discussions on levels of experiences and connectivity were encouraged throughout the project either individually or within a group environment.

Technology and Craftmanship

It is important that traditional craftsmanship skills survive and are appreciated for the benefits they can offer a designer maker within their practice, however technology driven processes need to be harnessed and understood in order to develop the employability skills of learners, meeting the expectations of future employers. At higher education; given time restrictions and the muliti disciplinary demands of fashion design itself, manageable, selective craftsmanship sewing skills were taught alongside digital CADCAM technologies and traditional printing methodologies. Learners were educated on menswear design and design for detailing and encouraged to design for not only the visible aspects of the garment but also the hidden areas which are not noticeable without searching. It was an agreed consensus that the Ted man is inquisitive by nature and relishes the high level of seen and unseen attention to detail that can be located on a Ted Baker tailored suit.

Figure 3 shows how CADCAM technologies have been used to embroider on the under collar of a suit jacket.

Figure 4 shows a mixture of experimental pattern cutting with contrasting piping detailing, combined with digitally printed lining and hand woven wool chest paneling.

Figures 5 & 6 combine screen printed exterior check patterning with digital and sublimated printed interior lining. Hand sewn detailing on the buttons add to the detailing.

Figure 7 shows a hand painted lining using inks, paints and dyes, creating a unique, personal and energetic outcome symbolic of uniqueness and exclusivity.

In figure 8 we can see how the application of hand embroidered detailing on the underside of the waistband has added an artisan and craft feel to the garment, with each fish slightly differing in stitch quality.

Narratives and Themes

Once the learners understood the key design principles and an improved understanding of the consumer, brand, menswear tailoring, manufacturing processes and soci economic factors affecting design, it aided in forming a relevant and thought provoking narrative which was intelligently devised and creatively communicated. Narratives and themes covered: Nostalgic and Historic, Rivalries and Conflict, Hero Worship and Role Models, Family and Loyalty, Strategic Sports, Patriotism and Royalty, Status and Class, Heroism and Adventure, Geographic, Objects and Mechanics. Often these themes overlapped, but all could be linked to identified attributes of either the brand, consumer or both.

Figure 9 is based on the British past time of fishing, drawing on inspiration from British ports and docklands, wreckages, historic portraits and paintings, fish, stories and sayings. This narrative is a development from a current Ted Baker fly-fishing theme and introduces detachable hoods, waterproof fabrication and ribbing. Learners who chose this pastime linked fishing to relaxation and also to the parental bond between father and son, building on the emotional memories of the importance of belonging and family.

Strategic Sports narratives included Snooker (this also linked Sheffield to the Crucible home of the UK Snookers World Masters), crochet (figure 10), archery, show jumping, golf and cricket. These types of sports connected to Ted Bakers unswerving attention to detailing, accuracy and quality all of which appeal to the Ted Man as highly important. The skill and control required to perform the fore mentioned sports to a high level, reflected on the intellectual and analytical mindset of the consumer.

Figure 11 linked TEDs origins back to Scotland and the traditional and favored sport of Golf. This narrative focused on the Ryder Cup and Rivalries between Europe and the USA, particularly that of Rory McElroy and Tiger

Figure 9. Paying homage to fishing.

Figure 10. Crochet used to connected to the brands unswerving attention to detailing, accuracy and quality.

Woods. Although learners on occasions chose the same sport, the chosen avenue for exploration created differing narratives. While Golf is focusing on competitiveness, patriotism and rivalry, in figure 12, (below) we see how golf is explored through its Royal and military heritage, with a focus on the banning of the sport by King James II in preference of archery to increase military excellence in war. The narrative also explored the secret up take of the prohibited sport by the upper classes and Royalty, creating exclusivity and divide in the social class system.

Figures 13 & 14 paid homage to combat sports and looked into "fight or flight" and male behaviors particularly when threatened or provoked. Here the learner was interested in self control in confrontation and rising above the situation i.e "Being the better man". Traits identified within the brand ethos and consumer personalities. Investigating and analyising Taekwondo and spiritualism resulted in a more relaxed cleaner cut tailored aesthetic with embroidery creating an optical illusion effect, symbolizing the idea of restraint, control and things not always seeming what they first appear.

In figure 15, spiritualism, war, conflict and patriotism is also explored in the contact sport of Mia Tia and translated through the lining print and embroidered literal narrative on the inside paneling of the jacket. The floral print is a sacred plant indigenous of the natives who popularized the sport.

Spiritualism, mindfulness and a heightened sense of emotional self control and awareness were attributes learners associated with identified consumers through observational analysis, conversations and additional studies of buying habits and behavioral traits. Other sports covered in this category included medieval jousting, karate, kendo and boxing.

Hero worship was a popular narrative with inspiration drawn from iconic British sports personalities, to include

Figure 11. Golf to focus on competitiveness, patriotism and rivalry.

Figure 12. Exploring golf through its historical origins.

Figure 13. "Fight or flight" and male behaviors.

Figure 14. Embroidery applied to create an optical illusion effect, symbolising restraint, control and things not always seeming what they first appear.

Figure 15. Embroidered narrative on the inside paneling of the jacket.

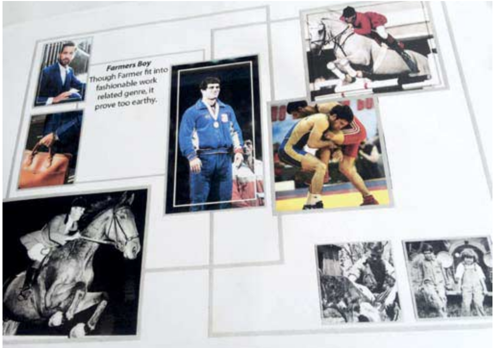

Figure 16. Hero worship - hero worship.

Figure 17. Inspired by the biography, life style and reputation of Len Hutton.

the British formula one champion James Hunt, the horse rider and wrestler Harvey Smith (figure 16), superbike champion Carl Fogarty, British cyclist Sir Bradley Wiggins and (figure 17) the cricketer Len Hutton the highest scoring batsman in test cricket. Inspiration was not only drawn from the sport itself but also biographies, life style analysis and reputation. Learners in this instance linked the desire to succeed in the consumer with icons who were aspirational and excelled in their sport.

The print in figure 18 was created by the oxygen sample provided by a professional cyclist in the British Tour Da Yorkshire (The brother of the learner). Each colour represents an O2 score at a given point within the race. The abstract print is combined with a photograph taken of the finish line scene creating an unrecognizable pattern. The learner was keen to create a print that was not obvious until further analysis and study, symbolising the multi layers and depth in the consumer personality.

Controlled thrill seeking, rebellious and adventurous traits were identified in the TED man and covered through sports such as cross country skiing and shooting, in the example in figure 19 linking to James Bond, the ultimate fictitious British special agent, who lived life on the edge and was idolised by men and loved by women.

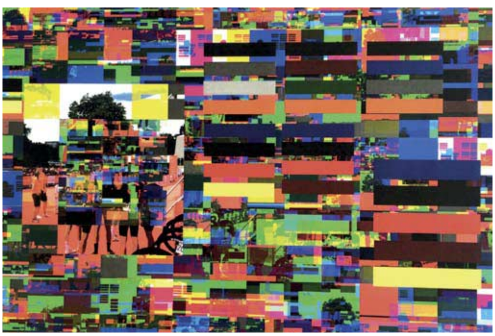

Figure 18. Abstract print fusing an interpretation of scientific O2 data and scenic photography.

Figure 19. Exploring thrill seeking, rebellion and adventure.

Figure 20. A humorous print symbolising the wearers inner rebellion to tradition and rules and conformity.

Figure 21. Team sports and the Ashes.

Gambling, adrenaline rush and risk taking were also evident through formula one and horseracing narratives. In figure 20, the learner has focused on creating a humorous print of a horse sticking its tongue out, symbolizing the wearers inner rebellion to tradition and rules emphasized by the contrasting the detailed interior contrasting with the clean cut minimal exterior of the jacket.

Team sports featured a lot within narratives particularly through contact sports such as football; local Derbies and iconic occasions or events e.g. 1966 England world cup win. Tennis and the Davis Cup, Golf and the Ryder Cup, Cricket and the Ashes (figure 21), Rugby and the Seven Nations. Learners in these instances were interested and keen to play on the consumers loyalties to their friends, families, clubs and patriotism to England. Learners also identified that TEDs customers were habitable in nature and loyal to brands, stores, hairdressers, garages etc.

Conclusions

The approach to this live client project does indicate that by firstly educating learners on the key influencing variables affecting design; that of the principles of design, consumer needs and wants, human psychology, semantics, socio – environmental, and sustainability, all contribute in the creation of a foundation in which to formulate a theoretic narrative offering focus for research exploration. This knowledge combined with the practical skills of tailoring and introduction and access to technologies and resources enables learners to experiment and risk take in the visualization of their ideas.

The narrative and underpinning are paramount in the success of the outcomes in order to appeal to the consumer on an emotional level in some form of capacity. Learners in the above approach understood their role and responsibilities as a designer and the need to create an opportunity for an experience or connection to evolve between the consumer and object. By encouraging learners to reflect on their own behavior and their relationship to their own clothing and other objects of possession, through its life cycle – purchase, care and discard, it helps create future designers who have a better understanding on considered, social responsible design through a developed understanding of emotional consumer connectivity, empathy and how improved quality can positively impact on reducing waste through changed consumer behavior. Educating learners on the impact fashion and textiles plays globally on the environment and encouraging self-reflection increases a desire to make a difference and by providing strategies and opportunities to problem solve in a supportive and encouraging environment should be the responsibility of education providers within their disciplinary area. This project shows one approach which could be adopted across design related disciplines and helps to set the path for a more sustainable design approach while still maintaining an enjoyable and engaging learner experience.

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Photographs

All photographs are taken from the second year student tailoring project at Sheffield Hallam University.

Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-287

The influence of information about prior use on consumers' evaluations of refurbished electronics

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Keywords
Refurbishment
Consumer behaviour
Circular economy
Evaluations

Abstract
Refurbishment – the process of collecting used products, assessing their condition, and replacing and/or upgrading parts in order to resell them to other consumers – is increasingly seen as both economically and environmentally advantageous. The present research investigates in an experimental study and with qualitative post-hoc interviews how information about prior use – offered in either a visual (signs of wear and tear) or verbal (textual description) form – influences consumers' evaluations of refurbished products. The findings show that providing consumers with information about the prior use of refurbished electronics does not have a univocal effect on consumers' evaluations of such products. Visual information about prior use, in terms of signs of wear and tear, has a negative effect on consumers' evaluations of refurbished electronics. Furthermore, presenting consumers with verbal information on prior use can negatively affect consumers' evaluations of a refurbished if no signs of wear and tear are present because it confuses consumers. If signs of wear and tear are present, verbal information about prior use will not influence consumers' evaluations.

Introduction

Refurbishment – the process of collecting used products, assessing their condition, and replacing and/or upgrading parts in order to resell them to other consumers – is increasingly seen as both economically and environmentally advantageous (Pigosso et al. 2010). Past research covers the strategic and logistic factors involved in refurbishment, acknowledging it as both economically and environmentally advantageous (e.g., Ijomah et al. 2007; Rathore et al. 2011). Nevertheless, refurbishment is only effective when consumers accept such products as a viable alternative to purchasing new products. Currently, this is questionable. Previous studies indicate that consumers display a lower willingness to pay (WTP) for refurbished products (Hamzaoui Essoussi and Linton 2010, 2014; Michaud and Llerena 2011; Tsen et al. 2006) and perceive refurbished products to be of lower quality (Ferguson and Toktay 2006; Hamzaoui Essoussi and Linton 2014). For companies engaging in refurbishment, it is therefore important to tailor their production and marketing strategies to improve consumers' evaluations to succeed with refurbished products.

The present research contributes to the extant literature on refurbishment by investigating two factors related to companies' production and marketing strategies for refurbished products, which distinguish such products from new ones. Specifically, we investigate how information about prior use – offered in either a visual (signs of wear and tear) or verbal (textual description) form – influences consumers' evaluations of refurbished products.

With respect to visual information about prior use, in the form of signs of wear and tear, companies have different options for refurbishment (Hazen et al. 2012; Sharma et al. 2014). Manufacturers can either update the exterior or leave signs of wear and tear from prior use untouched. Previous studies on refurbishment concluded that the product appearance is not a primary criterion in consumers' purchase process of a refurbished product when the wear and tear is not severe and as long as the product still functions (Van Weelden et al. 2016). Consumers indicate that their evaluation of a refurbished product is mainly based on its functionality (Jimenez-Parra et al. 2014; Mugge et al., 2017), suggesting that wear and tear plays only a minor role. However, research on product appearance has demonstrated that consumers use the appearance of a product to draw inferences about a product's performance quality (Mugge 2011; Mugge and Schoormans 2012; Page and Herr, 2002). For example, consumers perceive products with a less attractive appearance as having lower quality. As the presence of wear and tear on (electronic) products is generally believed to be unattractive, we expect that these inferences about lower quality will negatively affect consumers' evaluations of refurbished electronics.

In addition, we investigate the effect of providing verbal information about prior use on consumers' evaluations of refurbished electronics. Consumers generally experience a higher perceived risk and uncertainty for refurbished than for new products (Hamzaoui Essoussi and Linton 2010; Van Weelden et al. 2016). Prior studies concluded that gathering more information lowers the perceived risk when consumers purchase a new product (Derbaix 1983; Gabott 1991). In line with these findings, Van Weelden et al. (2016) concluded that consumers are more likely to purchase a refurbished product when they receive verbal information about its prior use. However, there is also research stating that providing such verbal information about the prior use can be counter-productive. A study on second-hand clothing revealed that consumers had a higher disgust rate when informed that the clothing had previously been used, cleaned, and sanitized (Ackerman and Hu 2015). To this end, we propose that verbal information about prior use will interact with the effect of visual information (in the form of signs of wear and tear) on consumers' evaluations of refurbished electronics. Prior research concluded that consumers prefer congruence between the information provided by a verbal cue and the visual product appearance (Van Rompay et al. 2009; 2010). A state of congruence is established when the visual and verbal information communicate equivalent information. When refurbished electronics show no signs of prior use, consumers are less aware of the prior use through the presented visual information. Then, verbal information about prior use is incongruent to consumers' expectations and maybe detrimental to their evaluations of refurbished electronics as the verbal information makes consumers more attentive of the prior use. However, when refurbished electronics show signs of wear and tear, consumers realize that the products have a use history. In such a situation, presenting consumers with verbal information about prior use will be congruent to their expectations, and will not influence their evaluations of refurbished electronics.

To investigate the effects of visual and verbal information about prior use, we performed an experimental study in which both types of information were manipulated. Furthermore, we conducted post-hoc interviews in order to gain a contextualized understanding of the experimental findings.

Experimental study

Method

Study design and participants

The experimental study used a 2 (verbal information about prior use: present vs. absent) × 2 (visual information about prior use: wear and tear present vs. wear and tear absent) between-subjects design. One hundred and ten members from a consumer panel participated in the study (52% male, mean age = 46 years; response rate = 55%). They were approached by e-mail and received a small compensation (€3.45) for their participation.

Stimuli

An Apple iPhone 5 was selected as the stimulus product. At the time of the study, refurbished iPhone 5s in different conditions were sold on the Dutch consumer market by such retailers as Leapp and Iused. To create stimuli for the manipulation of the visual information about prior use, a picture of an iPhone 5 showing no wear and tear was digitally altered. Scratches were added on the backside of the phone together with a small scratch and a dent on the front (see Appendix A).

To create stimuli for the verbal information about prior use, a pre-test was conducted among eight respondents who were asked to report on their recently discarded smartphones. Based on these responses, a text was created to provide a realistic prior use scenario for a refurbished smartphone (see Appendix B). All stimuli were accompanied by general information about the price, warranty, aesthetic and technical state of the smartphone.

Procedure and measures

In the online questionnaire, participants first received a brief explanation that refurbishment is the process in which a used product is refurbished to a proper working condition by disassembling, checking, and cleaning it, and by replacing or upgrading parts that do not meet the standard. Subsequently, they were shown one of the four conditions and were asked to respond to a series of questions.

Consumers' evaluation of the refurbished smartphone was measured using four 7-point scale items anchored by bad/good; dislike/like; unfavourable/favourable; negative/positive (α=0.95). To assess the success of the manipulations of verbal and visual information about prior use, multi-item measures for the perceived wear and tear (e.g., This phone is visibly damaged; α=0.96) and participants' knowledge of the smartphone's prior use (e.g., I know how the previous user used this phone; α=0.76) were included. To control for attitudinal and trait differences in participants, we also included multi-item measures for environmental concern, novelty seeking, and their attitude towards the Apple brand.

Results and Discussion

Manipulation checks

To test whether the manipulations were successful, a 2×2 ANOVA with perceived wear and tear as the dependent variable and both visual (i.e., wear and tear) and verbal information about prior use as the independent variables was performed. A significant main effect was found for visual information about prior use, which showed that this manipulation was successful ($M_{wear\ absent}$=2.40 vs. $M_{wear\ present}$=5.74; $F(1,106)$=198.17 $p<0.001$).

A 2×2 ANOVA on participants' knowledge of prior use revealed a significant main effect for the independent variable verbal information about prior use, again providing support for the manipulation ($M_{Info\ absent}$=1.96 vs. $M_{Info\ present}$=3.91; $F(1,106)$=49.51, $p<0.001$).

Main findings

To test the effects of visual and verbal information about prior use on consumers' evaluations of refurbished electronics, a 2×2 ANCOVA was performed on attitude towards the product. Environmental concern, novelty seeking, and attitude towards the Apple brand were included as covariates.

First, a main effect was found for visual information about prior use (i.e., wear and tear) on consumers' attitude, indicating that participants evaluated refurbished electronics more positively when no signs of wear and tear were present compared with when it had signs of wear and tear ($M_{wear\ absent}$=4.65 vs. $M_{wear\ present}$=3.84; $F(1,98)=9.16$, $p<0.01$). Furthermore, a significant interaction effect was found ($F(1,98)=4.69$, $p<0.05$), which suggests that the effect of visual information about prior use on the evaluation of refurbished electronics depends on the presence of verbal information about how the product was used before. Two separate ANCOVAs showed that when the refurbished electronics had no signs of wear and tear, participants evaluated it more positively when no verbal information about prior use was provided ($M_{verbal\ absent}$=5.11 vs. $M_{verbal\ present}$=4.18; $F(1,42)=5.91$, $p<0.05$). In contrast, when signs of wear and tear were present, participants' attitude towards the refurbished electronics did not differ depending on the presence or absence of verbal information about prior use ($M_{verbal\ info\ absent}$=3.72 vs. Mverbal info present=3.99; $F(1,53)<1$).

These findings suggest that the role of wear and tear is more prominent than previously assumed in the refurbishment literature. Wear and tear may first of all reduce the aesthetic and symbolic qualities of electronics. Furthermore, it may influence its perceived functional value. As it is difficult for consumers to judge the performance quality of refurbished electronics, consumers may use the product appearance as a quality que and, accordingly, evaluate these less positively in the presence of signs of wear and tear.

Qualitative post-hoc interviews

We devised qualitative post-hoc interviews to obtain a contextualized understanding about how consumers evaluate refurbished electronics. We performed 12 focused interviews with a convenience sample of Dutch adults between 20 and 65 (mean age=40.4, seven males). All interviews were audio recorded and transcribed for further analysis. We started the interview by explaining the concept of refurbishment. Next, we presented them with one of the two pictures that we had used for the wear and tear conditions in the experimental study. After having inspected their assigned picture, they were asked to state their immediate thoughts and opinions about this refurbished smartphone, followed by specific questions probing the risk they perceived in purchasing the product and their overall evaluation. Following this first (visual) evaluation of the product, we presented them with the verbal information about prior use from the experimental study and asked them to reassess their first evaluation.

We analysed the interviews through two stages of thematic coding. For the first stage of coding, we familiarized ourselves with the data through open coding. We inductively extracted a first set of themes (topics) covering what had been discussed during the interviews. For the second stage, we deductively analysed the interviews further through closed coding, iteratively refining our analysis as we reviewed and compared the different reasoning patterns in the transcripts.

Findings

The interviewees spoke freely and without any problem about the refurbished smartphone during the interviews, often elaborating on their reasoning without a need for additional probing. The presence/absence of visual wear and tear was immediately commented upon at the beginning of each interview. The interviewees who first had been given the phone with wear and tear were initially more hesitant, frequently stating that the phone was too expensive given its current condition (e.g., "For this price, I wouldn't buy a phone that is still damaged," F41). In contrast, interviewees who first had been given the refurbished phone without wear and tear typically expressed more interest in buying the phone before reading the verbal information.

Having access to the verbal information elicited different responses about the refurbished smartphones from the interviewees. Specifically, and corresponding to the results of the experimental study, access to verbal information about prior use did not change consumers' evaluations for the refurbished phone with wear and tear but resulted in more negative evaluations for the refurbished phone without wear and tear. When the interviewees had been presented with the smartphone with wear and tear, the verbal information about prior use typically confirmed the interviewees' prior assessment of the phone and was thus considered congruent:

> *"Cosmetically, I can see for myself how it looks. Then, it doesn't matter what happened to it earlier. Furthermore, it doesn't influence the way I think about this phone's functionality." (F41)*

In contrast, when the interviewees had been presented with the phone without wear and tear, the impact of verbal information on their initial responses can best be described as confusing and incongruent. In fact, a number of the interviewees immediately asked for reassurance that the verbal and visual information were about the same phone:

> *"Because it says here that it is like-new. Of course that doesn't have to be contradictory, because maybe they changed the casing, I mean they made sure it looked like new again, so it's confusing this way." (M26)*

In probing into the need for providing verbal information about the product and the refurbishment process, none of the interviewees that had seen a smartphone without wear and tear expressed an interest in information about prior use. Instead, they explained how it tempered their enthusiasm about the phone and raised some doubts about whether the phone would look like-new or be damaged.

Conclusions

Refurbishment provides an interesting strategy for consumer electronics companies to contribute to a circular economy but its success depends on consumers' acceptance of refurbished products as an alternative to purchasing new ones. Companies thus need knowledge on how to tailor their production and marketing strategies to increase the success of their refurbishment practices. This study contributes to this stream of research by investigating in two studies how information about prior use – in either a visual (signs of wear and tear) or a verbal (textual description) form – influences consumers' evaluations of refurbished electronics. The findings show that providing consumers with information about the prior use of refurbished electronics does not have a univocal effect on consumers' evaluations of the refurbished product. In general, consumers evaluate refurbished products with visual information about prior use (i.e., wear and tear) more negatively. Furthermore, presenting consumers with verbal information on prior use will only be appreciated by consumers if a refurbished product shows signs of wear and tear and there is congruence between the visual and verbal information. If no signs of wear and tear are present, incongruent verbal information confuses consumers, thereby negatively affecting their evaluations.

Our research findings suggest that from a consumer's perspective, it is best to update the exterior to a like-new condition. Consumers evaluate refurbished products more positively if no signs of prior use are visible. In this situation, companies should not remind consumers of the product's first life by providing verbal information about its prior use because this will lower consumers' evaluations.

When a manufacturer decides not to upgrade the exterior (e.g., due to high costs), it can be interesting to provide verbal information about the prior use of a refurbished product. Consumers then consider this information "nice to know" and it may help them in trusting the functionality of the refurbished product.

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Appendix A

Manipulation of visual information about prior use: wear and tear present (left) vs. absent (right)

iPhone 5, refurbished

Aestethic condition:	Visibly used
Technical condition:	Like-new
New-price:	€599,-
Price refurbished:	€367,-
Warranty:	1 year

iPhone 5, refurbished

Aestethic condition:	Like-new
Technical condition:	Like-new
New-price:	€599,-
Price refurbished:	€367,-
Warranty:	1 year

Appendix B
Manipulation of verbal information about prior use

Previous use

For how long did you use this product?
2 years

How frequently did you use it?
Several times a day

What did you use it for?
The phone was my main source of communication. Furthermore it was used to check the news, plan my trips, listen to music, watch videos, gaming and taking photos.

Why did you dispose of the product?
The phone was not sufficient anymore. It was too slow and the battery life had decreased a lot. Besides that, the software was malfunctioning, not running some apps anymore.

Can you give an explanation of the wear and tear on the product (when present)?
There are some scratches on the back. These were mostly caused by my keys being in the same pocket or bag. The dent in the corner was the result of dropping my phone on the street during cycling.

Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-293

Is there a market for refurbished toothbrushes? An exploratory study on consumers' acceptance of refurbishment for different product categories

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Keywords
Refurbishment
Consumer behaviour
Circular economy
Evaluations
Product category.

Abstract
Refurbishment is the process of collecting used products, assessing their condition, and replacing and/or upgrading parts in order to resell them to other consumers. Although refurbishment is increasingly seen as both economically and environmentally advantageous, it remains questionable whether consumers will accept refurbishment as a viable alternative for all sorts of product categories. In-depth interviews among 18 participants were conducted in which participants were asked to sort 30 product categories on their likelihood to accept or reject a refurbished product from this category and to elaborate on their underlying motives for this. The results revealed the following reasons for either accepting or rejecting a refurbished product for a certain category: financial, functional quality, aesthetic quality, warranty, contamination, and personalisation. Based on the type of product category (e.g., hedonic vs. functional, high vs. low involvement), these reasons are either more or less important to consumers. When designing for refurbishment, designers need to tackle the relevant reasons for the specific category in their design process to stimulate consumers to accept refurbished products.

Introduction

Many companies and scholars believe that refurbishment is a promising approach to retrieve more value from discarded products. Refurbishment is the process of collecting a used product, assessing its condition, replacing and/or upgrading parts in order to establish a satisfactory working condition and resell the product to other consumers (Pigosso et al. 2010). Contrary to recycling, the original product's functionality is preserved and products are offered a second life with only limited new resources needed.

Presently, refurbishment is implemented mainly in computers and smartphones. Considering changing market and environmental conditions (e.g., raw material prices, environmental awareness), refurbishment is gaining interest among original equipment manufacturers (OEMs) producing various consumer products. In theory, refurbishment can be implemented in many other product categories, such as furniture, home appliances (e.g., washing machines, coffee makers), baby equipment (e.g., strollers, breast pumps), and tools (e.g., drills). However, for refurbishment to work consumers need to accept refurbished products as substitutes for new ones. This raises the question how consumers respond to refurbished products for different product categories. Although prior studies have investigated a few different product categories (e.g., smartphones, printers, car tires, cameras) (Hamzaoui Essoussi and Linton 2010; Hazen et al., 2012; Jiménez-Parra et al., 2014; Michaud and Llerena; Van Weelden et al., 2016), a comprehensive understanding is missing of consumers' motives for accepting or rejecting refurbished products for various product categories. This research aims to fill this gap.

The few consumer studies that investigated refurbishment provided participants with descriptions of what refurbishment entails, and determined their willingness to pay (WTP) and quality perceptions (Harms & Linton, 2015; (Hamzaoui Essoussi and Linton 2010, 2014; Michaud & Llerena, 2011). Their findings suggested that consumers' WTP and quality perceptions are lower for refurbished products than for new products.

Furthermore, Van Weelden et al. (2016) uncovered how consumers decide to choose for a refurbished smartphone. Their findings demonstrated that consumers weigh the benefits (e.g., financial, environmental) and the risks (e.g., obsolescence, performance) of a refurbished smartphone and only include a refurbished smartphone as a potential option in their consideration set if the benefits outweigh the risks. Another study on refurbished smartphones demonstrated that consumers differ in their perceptions of these benefits and risks (Mugge et al., 2017). Accordingly, different consumer groups were distinguished that are more or less likely to accept a refurbished smartphone and that have different needs with respect to the refurbishment process.

An important limitation of these two studies is that they focus only on the product category of smartphones. Even though consumers may be unwilling to purchase a refurbished smartphone, this does not imply that they would also reject refurbished products from other categories. In addition to individual differences between consumers, different product categories may thus also increase or decrease the importance of specific benefits or risks. The present research contributes to the literature by providing a comprehensive overview of the different reasons why consumers either accept or reject refurbishment for a specific product category, focusing on tangible products. Companies interested in refurbishment can use these insights when tailoring their refurbishment processes to a specific product category.

Method

In-depth interviews were conducted with 18 participants (9 males; ages ranging from 21 to 60 years) who were selected from a consumer panel to ascertain a large variety in age, income, background etc. In the interviews, participants were first explained the refurbishment concept. Subsequently, participants were presented with 30 product categories. We selected product categories that differed greatly in terms of use frequency, involvement, price, and use situation in order to obtain a comprehensive overview of the various product categories for which refurbishment would be feasible. Examples of included categories are: laptop, coffee maker, electric toothbrush, drill, office chair, microwave, washing machine, hanger, and camera. The complete list is shown in Figure 2.

All product categories were presented on individual cards in text together with an illustrative icon (see Figure 1). Illustrative icons were used to trigger participants to think of the product category in general, rather than on a specific product.

We asked participants to perform two tasks. First, participants sorted the cards based on the possibility to accept a refurbished product from this category into two groups (potentially accept vs. reject). Second, we asked participants to take the categories for which they would potentially accept refurbishment and rank those on their likelihood to do so. Participants were asked to clarify their reasons for accepting or rejecting different refurbished product categories. Interviews took on average 60 minutes and were audio recorded. All recordings were fully transcribed. Photographs were taken from the final sorts. A qualitative content analysis was performed by the research team on the transcripts, which resulted in 16 overall themes and 46 subthemes.

Results

The categorization went well and participants spoke freely and without any problems about their motives to either accept and reject refurbished products for certain categories. Our findings demonstrated that participants' willingness to accept refurbished products depends first of all on their familiarity with and understanding of the refurbishment concept. If consumers know better what procedures are executed during refurbishment, they have greater trust in refurbished products, which positively influences acceptance. Moreover, consumers differ in their likelihood to accept refurbishment between various categories. Figure 2 represents the number of participants who indicated that buying a refurbished product was an option for each of the 30 product categories. Many participants suggested that refurbishment was an option for categories, such as, a wardrobe, a drill, a desk lamp, and a suitcase but it was not often considered a viable alternative for categories, such as a kettle, an electric toothbrush or sunglasses.

When discussing their motives to either accept or reject a refurbished product for a certain category, participants mentioned the following reasons: financial, functional quality, aesthetic quality, warranty, contamination, and personalisation.

First, participants need to see the financial benefit that refurbishment can give them. If products are relatively cheap (e.g., hangers), there is not much to gain by refurbishment and people are more likely to purchase a new item. So, the financial benefit should be large enough for refurbishment to have an appeal on consumers.

"I think for me the biggest reason not to really have bought a refurbished product was maybe that the price difference is not that much."

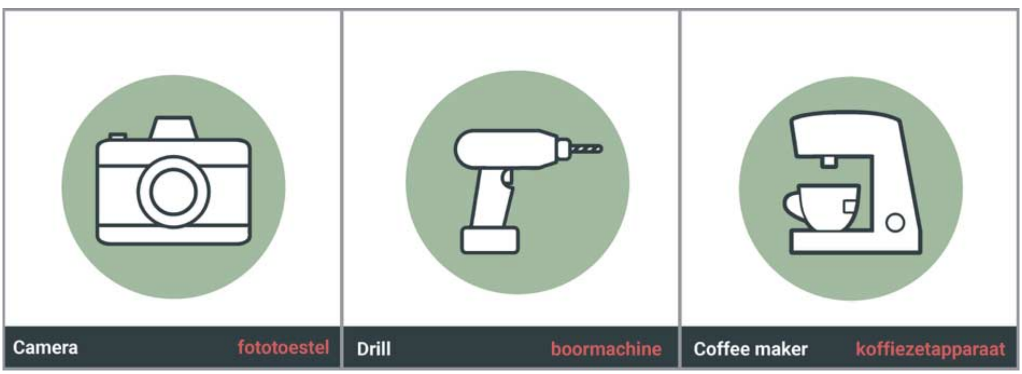

Figure 1. Examples of illustrative icons.

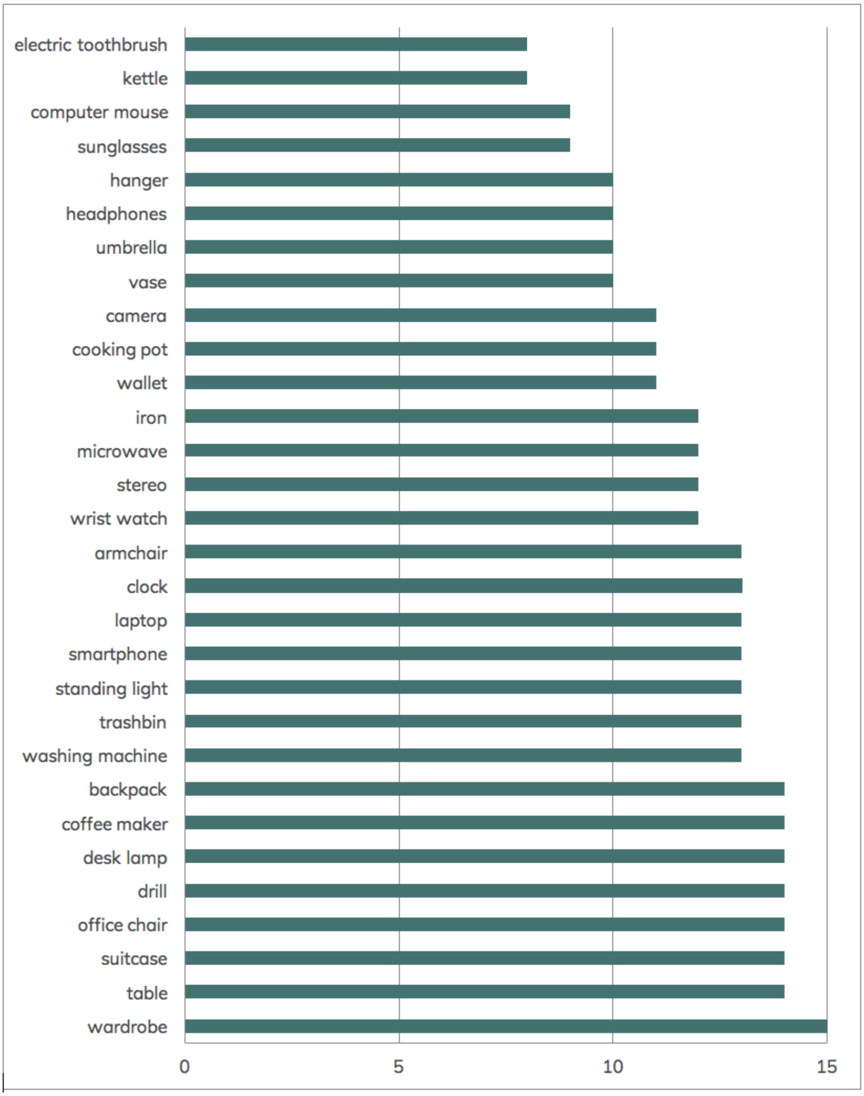

Figure 2. Number of participants (n = 18) who indicated to potentially accept refurbishment for a specific product category.

Second, participants mentioned quality reasons related to either the product's functionality and aesthetics to either accept or reject refurbished products. Functional quality reasons relate to how easy it is to check a product's quality or repair it. Participants mentioned that they can easily check the functional quality for furniture but that this is more difficult for electronics, due to which they see more risks with these refurbished products.

"I think things like furniture I would doubt least because usually what you see it's what you get"

The importance of the product's function was also mentioned in this respect. If the function a product fulfils has little importance to a consumer (e.g., because it is not needed frequently), (s)he is more likely to accept a refurbished product as an alternative than when it has great importance.

Another issue related to functional quality that was mentioned is the speed in which the product's functionality will become obsolete due to technological changes (e.g., smartphone, laptop).

Aesthetic quality relates to the significance of aesthetics. For certain product categories (e.g., watch, sunglasses, wallet), it is imperative that the product looks new because it is used to express one's identity or is regularly visible to others. However, for product categories that serve a primary utilitarian purpose (e.g., drill, iron) and are generally hidden away in a closet, participants indicated that they would consider refurbished, even if these were visually damaged. Furthermore, for certain product categories (e.g., furniture) visual wear and tear can give a 'vintage look' to the product, thereby enhancing its appeal to consumers.

"This one [desk lamp] because it's a working place and then it's okay but if I go for living room stuff [referring to the icon of the standing light] then I expect that I'll have to be a little bit picky."

Warranty was mentioned as a way to reduce the potential worry accompanying refurbished products for certain categories. In this respect, warranty is considered to be an important differentiator from second-hand products.

Contamination suggests that participants perceived certain product categories as being 'contaminated' by the previous user. Baxter et al. (2016) have defined contaminated interaction as "the idea that an interaction with an object can differ from its natural or intended condition due to another interaction by someone or something." Contamination can involve hygienic concerns as refurbished products were considered less clean than new ones. In this respect, participants were not likely to accept a refurbished toothbrush. Also, reservations were raised about food-related categories, such as a refurbished microwave.

"I'm gonna slide the kettle and the coffee maker as something I would buy new. A bit the same as with the toothbrush. You see it's stuff that you eat from. I don't wanna – I wouldn't buy that second-hand or refurbished. I need those new and clean for some reason… because I'm consuming out of it."

In addition, participants mentioned a potential problem of digital contamination for digital devices, such as the laptop and the smartphone. Participants suggested that they had little trust whether traces of the prior owner were sufficiently wiped out from the memory of the product during the refurbishment process.

Finally, participants were less likely to accept refurbished products for categories that they need to personalize, such as sunglasses with a prescription. This personalization may also take place for objects that are worn close to the person and used every day due to which the object is shaped by the personality of the owner.

"A wallet so it's kind of personal, though I can't really say why… I would kind of feel weird having somebody else's wallet because I would probably … yeah you could see the usage marks and stuff like that."

Design recommendation for refurbishment

Based on our findings, we were able to distinguish eight types of product categories: hedonic products (e.g., watch, vase), utilitarian products (e.g., suitcase, drill), high involvement (e.g., laptop, smartphone), low involvement (e.g., hanger, kettle), dynamic (laptop, smartphone), static (e.g., iron, kettle), hygienic (electric toothbrush, microwave), and personalised (wallet, sunglasses).

Depending on the product categories at hand, companies selling tangible products should pay attention to specific reasons in order to encourage consumers' acceptance of refurbished products. Based on our findings, we can provide some preliminary strategies on how to tackle this.

For hedonic products, consumers especially value the product for its aesthetic quality. Consequently, companies should focus the product design and refurbishment process on possibilities to enhance the aesthetic quality or to provide a brand new aesthetic quality for example, by making use of durable and gracefully aging materials or by designing for resurfacing.

For utilitarian products, functional quality is essential. Consequently, companies should implement their design and promotion activities in such a way that consumers gain reassurance about the product durability and long use. Furthermore, companies should try to mitigate negative connotations on the functional quality of a refurbished product. Potential strategies would be to design for upgradability, adaptability, and ease of repair.

High involvement categories usually imply a great financial investment and thus companies need to convince consumers that the refurbished product is worth their money by emphasizing its satisfactory functional and aesthetic qualities through either its product design, promotion or service activities. For example, warranty, certifying product quality control and more transparency on the refurbishment process can help to give consumers this assurance.

A potential issue of refurbishing low involvement products is that the financial benefit is usually considered to be too low. To encourage consumers to choose a refurbished product, it is beneficial to make consumers more aware of the environmental benefit. Then, the refurbished product gains additional value for consumers.

Dynamic product categories are products that are subject to great technological advancement. Consumers may then see potential obsolescence as a risk for refurbished products. Consequently, companies need to focus on reassuring consumers about the product durability and taking away the negative connotations on functional quality. Potential strategies would be to design for upgradability, adaptability, and ease of repair.

Opposite to dynamic products, static product categories do not easily lose their functionality and are less vulnerable to obsolescence. However, for many of these products consumers do not see the financial benefit and thus it is important for companies to make consumers aware of the additional environmental benefits of refurbished products.

Personalised products are categories that are considered to be very personal and therefore unsuitable for refurbishment. A potential design direction for companies interesting in pursuing refurbishment for such categories would be to add customization opportunities to the refurbishment process by making use of a modular product design.

Finally, hygienic products are products that are used for preparing food or are in contact to consumers' skin. For these categories, refurbishment will trigger contamination issues. Companies thus need to minimize these contamination concerns by enhancing ease of cleaning and by communicating the effort of cleaning and disinfection done during the refurbishment.

Discussion

To establish a circular economy and reduce the negative impact of the present consumption patterns, refurbishment provides an important strategy to retrieve more value from used products. However, consumers will not easily accept these as viable alternatives. Our research contributes to the literature on refurbishment by providing insights in the specific product categories for which consumers are more or less likely to be accept a refurbished product. In addition to the existing strategies for designing for refurbishment (e.g., Ijomah et al., 2007), companies can use these insights to tailor their design and communication strategies to address the specific issues of a product category.

The research described here focused on tangible products as such. If these products are offered as part of a product-service system, the balance between perceived benefits and risks is likely to change for a number of the product categories. This will also affect the design strategies and deserves further attention.

Another limitation of our research is that we did not provide participants during the interview discussions with specific examples of refurbished products. It is likely that depending on how the refurbishment is executed, consumers may be more or less persuaded to purchase these. Future research should investigate specific refurbishment strategies to uncover the actual value of refurbishment.

Conclusions

Our research provides insights in the potential value of refurbishment for various product categories. Although our findings suggest that it may be challenging to implement refurbishment for certain categories due to potential financial, functional quality, aesthetic quality, contamination, and personalization issues, this does not necessarily imply that companies producing these products should not pursue refurbishment. By providing specific services, changing the product design, or by communicating important information about the refurbishment process, it may be possible to resolve these issues and evoke positive consumer responses. Our insights provide a first step to help companies to successfully achieve this difficult challenge.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-298

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Will durability be a characteristic of future cars?

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Keywords
Car
Electric vehicle
Embedded carbon
Embodied carbon
Business models

Abstract
The car industry believes it has already done a lot to meet the sustainability agenda. While there has been considerable progress in terms of reductions in toxic emissions, as well as greenhouse gas emissions, they are still very far from being sustainable either as an industry or in terms of the products they make. This point was made by Stuart Hart in 1997 (Hart, 1997), and despite progress since then, the same still holds today. Progress so far has been along an 'eco-efficiency' trajectory – i.e. doing the same thing we have been doing, but more efficiently. In reality, we need to stop doing what we have been doing and work out an alternative means of achieving what we are actually trying to achieve – motorised personal mobility with optimum enjoyment, comfort and safety levels. We need to do things differently, in other words.
It is clear that we are at the start of a technological transition from IC to EV powertrain technology in cars and light commercial vehicles. This brings with it a shift in the lifetime carbon impact of the vehicle from the use to the manufacturing and recycling phase (Ricardo 2011; Hawkins et al. 2012). This would suggest a longer product lifespan would be desirable for EVs. It has also been suggested that the current or imminent transition in the personal transport system involves not only a technological transition from IC to EV, but also a transition in ownership patterns from private ownership of cars to various types of PSS, such as car clubs, leasing models, etc. (Marletto 2014). Does this mean that we will witness a further alienation of the user from the product? If so, would this result in an even lower value being placed on the product by the user than we have already seen so far? Alternatively, would such a move instead create an incentive on the part of the new owner, i.e. the provider of the PSS, to regard the vehicle as an asset that needs to be valued for its ability to enable the business to operate, the 'P' in the PSS.

Introduction

Industry's response to legislation

There has been considerable progress in terms of reductions in toxic emissions, as well as greenhouse gas emissions from cars. However, they are still very far from being sustainable. More significantly, the inevitable shift to increasingly electric rather than internal combustion powertrain brings with it a shift in the lifetime carbon impact of the vehicle from the use to the manufacturing and recycling phase (Ricardo 2011; Hawkins et al. 2012), as summarised in Figure.1.

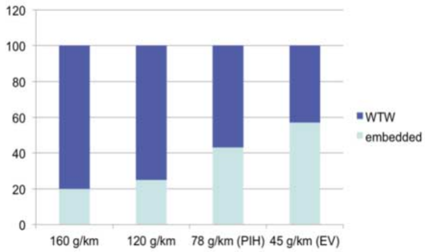

Figure 1. Embedded emissions increase with electrification.

In this respect then, its continued use is to be valued, as its replacement would constitute a cost to the business that is best avoided, or at least postponed for as long as technically feasible. This would then create a new (to personal motorised mobility at least) incentive towards more durable cars. This dynamic towards more durable cars will be explored in this contribution.

What are Cars for?

The key issue is really what do we need from our cars? What kind of functionality do we require and how is that best satisfied, in the most sustainable manner? We have a long way to go in this, but first let us assess where we are now, because even cars with similar functionality can have very different environmental impacts. Power, weight and fuel efficiency are key performance parameters. However, to the customer, there are other factors, such as top speed and acceleration, image, status. All of these are part of a car's functionality, not just transport. Acceleration conveys the sensation of power, although more due to power to weight ratio than to outright power. In simple terms, the functionality of the vehicle can be expressed as the number of people the vehicle can safely accommodate. CO2 emissions and weight do provide a rough indication of overall environmental impact in terms of production (Nieuwenhuis and Wells, 1998; Wells and Nieuwenhuis, 1999).

Using the above parameters to map onto a ‘radar’ or ‘spider’ graph, we can create virtual footprints for different car models; the smaller the footprint, the better. It is clear from these diagrams how performance parameters, notably power, acceleration and weight are interrelated and linked with CO2 emissions. In this way, of the vehicles presented in Figure 2 , the Range Rover has the largest footprint, resulting from a combination of weight, power and acceleration. In terms of functionality one could argue it has off-road capability, unlike the other two; a parameter I have not included, but which could be added to the functionality calculation. The Smart comes out best, although its functionality is more limited by the fact that it seats only two. The vehicles compared here are 2013 model year Smart Fortwo 1.0 70 mhd Pulse, Volkswagen Golf 1.2 TSI 85S and Range Rover Vogue 4.4TD V8. These are all typical for their respective model ranges.

It is also clear from comparing the Golf and the Range Rover, how with a similar functionality, weight and performance do impact on CO2 emissions.

The weight of the average European car grew from around 900 kg to around 1120 kg in the 30 years up to 2003 (Jochem et al. 2004). Similarly, the range of weights for popular EU cars rose from 680-900 kg in 1970 to 1150-1250 kg by 2002 (WBCSD 2005), although it has stabilised since in the pursuit of lower CO2 emissions. A heavier car takes more energy to accelerate to a given speed than a lighter car. For this reason, the power also increased, while for other, more market-driven reasons, acceleration has increased.

This effect is illustrated in Figure 3 which shows a comparison between a 2013 VW Golf 1.6 TDI and its 1970s equivalent, the 1976 Golf 1.6 S – typical popular variants from the middle of their respected ranges. The graph also shows the CO2 advantage derived from the shift to diesel. According to Eberle and Franze (1998) reducing vehicle weight by 100kg translates into a saving of between 0.34 and 0.48 litres per 100 km. The industry has attempted to compensate by adding lighter materials. Thus, in 1975 the average car contained 75% steel, but by 2000 this had come down to 59%. Instead, aluminium content had risen from 3% to 8%, plastics from 6% to 14% and elastomers from 12% to 14% (Jochem et al. 2004). This has implications for end-of-life processing.

With the move to EVs, the picture changes, as illustrated in Figure 4. The BMW i3, Nissan Leaf 24kWh and Tesla Model S P90D are representative of the range of EVs currently available. These are all notionally zero emissions, as the NEDC assumes this to be the case. In reality, EV emissions depend on the generating mix used to charge them and this is too variable to include here. Hence the CO2 parameter is somewhat redundant, although here too, a heavier vehicle, such as the Tesla, will inevitably need more energy to accelerate, than a lighter one, while it will also contain more embedded carbon in the form of a range of new and conventional materials. The Nissan uses mainly conventional steel for its basic structure, while the Tesla uses aluminium and the BMW an aluminium chassis with carbon-fibre body (BMW AG, 2015; Nissan, 2017; Car and Driver, 2016).

Once we move into more esoteric materials and technologies, therefore, both in terms of body construction and powertrain, we can move towards a situation whereby we both have zero emissions at point of use and the functionality we need, want or crave.

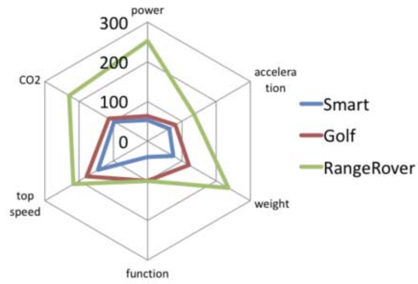

Figure 2. Ecofootprint comparison Smart, Golf, Range Rover

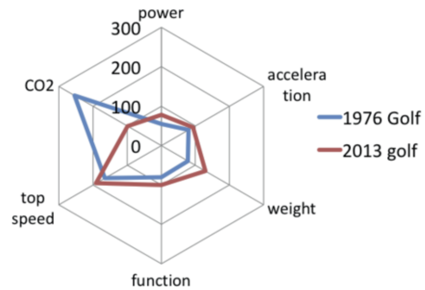

Figure 3. Comparison VW Golf 1976 v 2013.

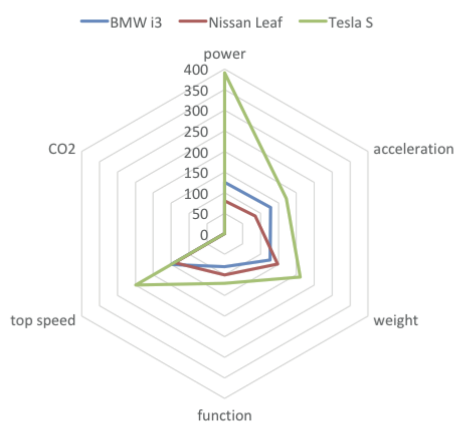

Figure 4. Footprint comparison EVs.

Embedded Carbon

The notion of product durability has long been on the margins of environmental concern, yet key events in the early development of the SCP concept consistently mention product durability (OECD-MIT 1994, UN 1997). Nevertheless, work in this area is still sporadic at best (Cooper, 2005), although some durability work has focused specifically on the car (Porsche 1976, Stahel and Reday-Mulvey 1981, Nieuwenhuis 1994, 2008; de Groot and McCrossan Maire 1998). This issue of a car's life expectancy has come to the fore once again due to work on embedded (or 'embodied') carbon in cars (Ricardo/ Carbon Trust, 2011; Hawkins et al., 2012). It is clear from this that as we move towards greater electrification of the powertrain from hybrid, through plug-in hybrid, to battery EV, the proportion of embedded carbon increases in relation to carbon emissions in the use phase (Figure 1). Embedded carbon refers to the carbon emitted as a result of producing something, rather than from its use. In the case of a car this includes the mining of raw materials, their transport, production of components, as well as the production of the car itself. In the context of the EVs presented in Figure 4, we could point out that steel typically contains around 20 GJ/t of embedded energy, compared with around 80 GJ/t for plastics and around 155 GJ/t for aluminium (Allwood and Cullen, 2012), so the differences are considerable as we move from IC to EV, even in the materials used for their structures. Once we have invested carbon or energy or other resources in a product, we should not really waste them.

The Ricardo study shows that even with conventional technology, the car body contains the largest proportion of embedded carbon (30%), followed by the engine (20%). The study shows that by optimizing existing technologies, this could be reduced by around 50%, however, there is also an increasingly strong case to be made for extending the useful life of the car itself. The analysis by Hawkins et al. (2012) focuses specifically on the difference between 'conventional' and electric vehicles. They calculate that the global warming potential benefit of EVs, as a result of this, amounts to 10-24% with the European electricity generating mix, assuming a lifespan of 150,000km. Increasing the lifespan to 200,000km increases this benefit to 27-29% relative to petrol cars and 17-20% relative to diesel. However, decreasing the lifespan to 100,000km reduces the benefit to 9-14% against petrol, and no discernable difference with diesel. They suggest reducing the impact along the supply chain while also reducing in-use emissions through lower carbon energy generation. Whilst neither study specifically advocates a longer lifespan, this seems a logical implication. Van Wee et al. (2011) agree; they argue that the more embedded energy there is in a car, the older the car should be before it is scrapped. Experience with older EVs indicates that EVs already are likely to last longer than IC engined vehicles, however, will consumers be able to adjust to keeping cars for longer? And, will the industry be able to handle such a development?

The precise impact of an EV in use will depend on the electricity generating mix from which it is charged, and this can vary considerably, from high carbon coal, to zero carbon renewables such as solar or wind. Another area of potential concern is the battery technology currently used for EVs. Ellingsen et al. (2013) calculate that production of a 26.6 kWh, 253kg battery pack contributes 4.6 t of CO2e. This size of battery pack is similar to what is used in a Nissan Leaf. To put this 4.6t for the battery pack into perspective, the authors compare this with the 6.1 t of CO2e needed to make an entire Mercedes A180 compact car (Ellingsen et al., 2013; Daimler AG 2012).

In addition, there are still issues around the recyclability of traction batteries and their expected lifespan. Although EV batteries in use are lasting longer than expected, their maximum useful life is still unclear. Alternative uses for batteries that have reached the end of the road in a car for energy storage from e.g. solar or wind generation has been suggested, implying some residual value for used EV batteries, easing the pain of replacement if the vehicle structure and powertrain are otherwise still usable – an increasingly likely scenario (Richardson, 2016). However, Tesla CTO Straubel argues that recycling batteries makes more sense. Tesla foresees a useful life of at least 10-15 years for its batteries, which – due to their high capacity and range – need fewer charging cycles than most and it is these that age a battery pack (Shahan, 2016).

End-of-life issues

Around two million vehicles are scrapped in the UK alone in a typical year, yielding waste amounting to nearly two million tonnes a year, while around 17% are scrapped prematurely as a result of being 'written off' by insurers (Kollamthodi et al., 2003). Few studies have investigated the reasons why final owners dispose of their vehicles, although Hamilton and Macauley (1998) find a correlation between lower maintenance costs and longer useful vehicle life, making maintenance and repair cost a key element, while replacement cost is always a key issue (Nieuwenhuis 1994). Assuming that premature scrapping is wasteful, or indeed even morally questionable, as Kohak (1985) argues, is it possible to make consumers more attached to their cars and thereby reduce this waste burden? The longer a product lasts, the less often it needs to be replaced and therefore the less often it needs to be produced, thus reducing overall production and resource use. At the same time, durable products significantly change patterns of consumption (Nieuwenhuis, 1994). The mass car industry has long resisted the move towards more durable products, with some exceptions (de Groot and McCrossan Maire, 1998), although many specialists, such as Rolls-Royce, have prided themselves on their products' long life expectancy. That mainstream cars now last longer and are capable of much higher mileages has been due to the pressure to improve product quality.

Porsche (1976), Stahel and Reday-Mulvey (1981), and Deutsch (1994) made it clear that cars can be made to last 20-30 years without significant additional cost. The

Porsche work by its research arm in Weissach was also used internally by the car division, which began to specify the galvanization of bodies for its cars. Some Porsche models were made by Audi at this time, which then introduced this process on its own cars from the 1986 Audi 80 onwards, as well as taking another idea from the Porsche (1976) study on board, namely the use of aluminium bodies. This led to the Audi A8 with its aluminium spaceframe technology, developed in conjunction with Alcoa. Other firms, such as Volvo, already had a durability ethos, making long-life cars (LLC) that linked up with their quality image.

Changes in car use

Marletto (2014, 174) points out that the imminent transition is not only technological, but involves the broader business model as it will "…simultaneously weaken the dominant position of the 'individual car' system and support alternative transition pathways." In this context we could highlight the move towards various forms of car sharing, as well as moves towards more connected and autonomous cars. The move towards sharing takes a number of forms, such as peer-to-peer sharing schemes whereby a privately owned car is rented out to other people while its owner does not need it. More popular are car 'clubs' whereby members own the cars collectively and can access them for specific journeys. While initially these were indeed clubs, more and more this model is taken on by commercial organisations such as the Enterprise City Car Club and Autolib, the Paris-based EV car sharing scheme. In such cases, the car becomes part of the business model in that it is the tool that allows the business to operate (Deutsch, 1994). As such, the pressure to retain it in use is much greater, as its replacement constitutes a cost to the business. In this context, then, such business models could lead to longer product lifespans.

Conversely, the more intensive use that some promoters of such schemes advocate as a key advantage, could also reduce lifespans through more intensive – and possibly less sympathetic – use than is typical for individually owned private cars. In practice, the very fact that vehicles have to be available when a user requires their use, means that many shared cars will spend much of their time waiting to be picked up, so the net benefit in terms of use intensity may be limited.

Conclusions

This contribution has shown, then, that with the move towards greater electrification, the traditional balance between in use and embedded energy, carbon and resources will shift from the use phase to the production phase. This should prompt a dramatic change in how product lifespans of future cars are perceived. Given that both producing new cars and recycling their materials at end-of-life will represent a rapidly increasing environmental burden, the pressure to move towards significantly longer lifespans seems inevitable. Clearly this requires a significant rethink in terms of the automobility system; existing 'fire and forget' business models are no longer adequate and some form of product stewardship, material leasing system, combined with a much longer in-use phase would seem inevitable. New business models would need to consider managing people's emotional attachment to private cars over longer lifespans (Nieuwenhuis 2008, 2014), although where cars are shared, business thinking will increasingly see the car as an asset to be 'sweated' as its replacement means a cost to the business. EV business models would need to accommodate scenarios whereby the vehicle structure, motor, inverter and controllers outlast the battery, such that easing battery ownership and replacement would need to be part of the model. With the steady acceleration in the shift from IC to EV the time to consider such alternative business models is now.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-303

How modularity of electronic functions can lead to longer product lifetimes

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Keywords
Modularity
Electronic products
Life cycle assessment
Trade-off analysis

Abstract
Although electronics are not the cause of the biggest environmental concerns in absolute terms, they receive special attention, because the impact per unit can be very high even for small devices and because electronics pervade our everyday life and our business life. Since a huge amount of resources is embedded in the products as they are delivered to the market, extending the product use time is for many product categories a primary ecodesign improvement option. Yet there are many obstacles to simply making products more robust and longer lasting – and to adapt the user behaviour and the business models to these potentially higher priced products. It is therefore worthwhile to rethink product concepts for the circular economy by using modularity to achieve better repair, better upgradability and in general a better customisation to the changing needs along a chain of ownership.

1 Introduction

Modularity is a long-standing design principle, which appeals to product designers and cost cutters alike. When applied correctly it lowers design costs, assembly costs, product prices, increases the margins of companies, and allows reaching more diverse consumers with the same basic design. It may lower waste in production, resource consumption per function and enable shorter time to market for new product variants. Finally, as will be the main focus in this paper, modularity opens the potential for exchanging, restoring and upgrading functionality during the use phase.

If all of this were true for all modular designs, we should have a host of successful examples in the stores, at home and at work. Yet, modularity can have all of the listed effects in exactly the opposite direction as well. Intrinsically, modularity does have at least some additional effort and initial resource expenditure involved to overcome the technical complexity that comes with the job. Over the past years it seems to be a declining rather than increasing feature from the consumer perspective. Possibly, it simply did not work well enough in the past for consumer electronics (functionally and/or economically).

So why bother to re-introduce and rejuvenate modularity?

The simplified answer is because the circular economy needs modularity. But this paper will delve deeper into what is the cause and what the effect, where modularity is on the rise and where it has never disappeared.

2. New Focus on Modularity

From an environmental background (i.e. omitting the purely economic cases) the re-emergence of modularity has three main reasons.

First, to increase the resource efficiency of especially modern mobile devices, modularity has been identified as one possible enabler.

Second, the integration technologies and the high functional density of modern electronics are enablers for new types of modularity (and not only obstacles).

And third, with the shift to circular economy we expect and need a shift to new decentralised business models – and specialised business models have been the province where modularity has always retained its niche.

Since these three driving forces are not without contradiction in detail, we need to explain the arguments a bit further.

Life Cycle Profiles as a Driver

Where 20 years ago most early product assessments for electronics showed, that the energy consumption of the use phase is the main environmental aspect, by now we have a much more diversified view of main life cycle impacts from electronics.

It has been shown that for some products the environmental impacts embedded through production and resource generation is much higher than the impact of all other life cycle phases, including the use phase. This is especially true for mobile ICT products, such as smartphones, tablets and laptops (Schischke 2015). Section 4 shows the example of an LCA for the Fairphone 2.

This balance or imbalance between life cycle phases for highly integrated electronics leads to the conclusion that we have to make the most use of the environmental expenditure embedded during the production phase. Thus, longer use times would be especially relevant for these modern electronic products – contrary to what is happening in many of these product categories.

So, when shifting the focus from energy efficiency to resource efficiency as a goal, modularity repeatedly pops up in discussions as one enabler for extending the use time of products (or of their main components embodying the highest percentage of the environmental impacts).

Integration Technologies as Enablers

In the past, the pace of technological progress has continuously limited the window of opportunity, where modular upgrading and repair are technically and economically feasible. In extreme cases, an upgrade or repair does not even make sense environmentally, when the efficiency gain of the next generation product is so high that prolonging the use of the old generation yields a net negative effect. In many other cases however, there would be an environmental benefit to repair or to re-use of the main components.

Miniaturisation, higher functional density as well as higher power densities and more company specific customisation of integrated circuits (i.e. ASICs and SoCs) mean less leeway for repair on the component level, thus only allowing the level of exchanging full printed circuit boards (such as the complete mainboard).

In this way, one more commonly heard scenario is that modularity (and the ability to test and repair) decreases further as core elements of the electronics are integrated further.

But the high level of integration and the evolution of numerous interface technologies also open new options, where the same rate of technical progress is used for new modularity concepts. When considering modularity as an encapsulation of a complex function by establishing a defined interface to the outside (a more precise definition will be given in the next section of this paper), we can state that a complex function such as a traditional computer now fits into a few cubic centimetres: the volume of the mainboard of a smartphone. The volume will still decrease further and the compute power will increase, giving birth to a universal compute module.

If interfaces could be defined to be long-term stable, backwards compatible and possibly even forward compatible (Spacey 2016), it would not need a lot of additional engineering and material to establish families of such compute modules. Even though new versions of these modules could emerge on a regular basis, the previous versions would still retain a lot of their value.

For signal interfaces, it is now possible to go optical between modules or short-range wireless or use the already established high speed serial interconnects to minimise the number of contacts between modules. The power supply essentially still needs connectors, but can in principle also be wireless (space and efficiency permitting).

Some of these developments would also be possible for non-compute modules, such as sensors including cameras, and permanent storage.

The major obstacle here is agreeing on long-term standards for high volume modules. The pace of technology development is not the real barrier.

Circular Business Models

The circular economy with its business elements of more re-use, more upgrading of products, more business models, which link across company boundaries, and increasingly inclusion of the consumer as an active party can benefit from modular products on many levels (Regenfelder 2016).

On economic terms the case can be made that many small companies or developments can pool production

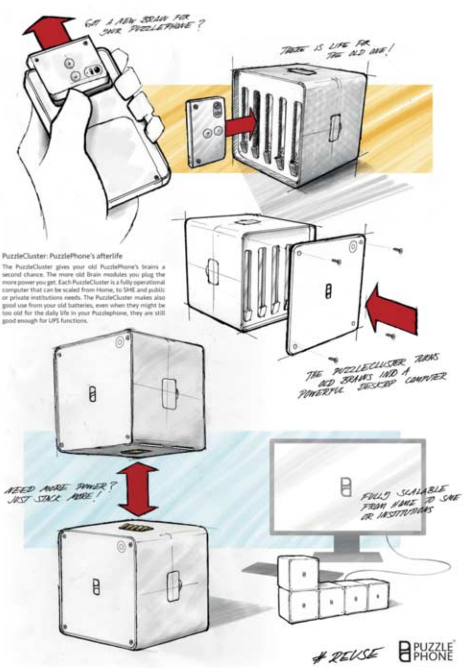

Figure 1. Design concept showing re-use of compute modules enabled through high integration technologies (Circular Devices 2015).

to achieve economies of scale and hence lower prices for customised products. Sharing of complex hardware and software modules may also mean sharing of testing, debugging, and patching efforts. This is not yet a specific effect connected to circular economy, but would help for many small scale and decentralised business ideas.

When business models intend to close the loop and make use of used hardware from other manufacturers, economies of scale are again of utmost importance. Making use of things that others see as waste will clearly work better in situations where many uniform pieces of hardware come back from the market. So, either we only have the chance to re-use the highest selling products of the past generations or the circularity could be enabled by shared hardware modules, which are in addition easy to detach from the used product.

As a side effect, modularity will improve the separation of material fractions on the recycling end (although that will be very case dependent – not all modular sub-assemblies are good recycling fractions). In end-of-life treatment standardised modules can also make automated disassembly more feasible.

In a more generalised sense, for complex products, modularity is key to enable and revitalise repair (professional or consumer based), to prepare paths for upgrading and to customise products during the use phase rather than at production. Opening the potential for upgrading and for consumer or third-party customisation can lead to environmentally strong circular economy business cases.

This can mean both an extension of a conventional business case to leasing or pay per use where the manufacturer retains ownership of the products, or alternatively interlinked business ecosystems, with a chain of ownership, where different players including the user are part of a servicing chain.

3. Categorisation of Modularity

A useful definition of modularity is as follows:

Modules in a modular product are structurally independent elements or sub-assemblies with clearly defined interfaces (Kashkoush 2016). Interfaces are non-permanent inter-connections.

For more complex functionalities we propose to add the notion of "hiding complexity" through "encapsulation", which is a wide-spread concept from software engineering. But encapsulation does not define modularity, so it is not part of the definition.

"Modularity" starts with an easily removable battery (example for a sub-assembly with a clearly defined interface) or a mono-material back cover (example for a structurally independent element).

Figure 2. Internal modules of the Fairphone 2.

Figure 3. The modular concept of the PuzzlePhone.

The next level is a product platform concept, which allows the manufacturer to ship individually configured units, also called variant production. Different products of a manufacturer make use of the same internal sub-assemblies or of printed circuit boards with the same layout but with a different subset of components attached. This can lead to lower production costs for key modules, as they are ordered in higher volumes.

Next, modularity can mean, that the user can easily replace some key subassemblies (or modules) when a repair is needed or more powerful components are wanted. The Fairphone 2 is an example, where the housing opens easily to access individual building blocks of the smartphone (see Figure 2).

The PuzzlePhone, which will be made of only three modules (Figure 3), the battery, the display and the main electronics part, all connected through a standardised interface (Jokinen 2015), or the Google ARA project (Google 2015) inspired by the earlier Phonebloks concept (Hakkens 2013), where numerous modules can be attached to an endo skeleton, have modularity, where the device need not even be opened.

Following from such examples we have defined 5 levels of modularity shown in Table 1, based on (Schischke 2016).

A product can incorporate several of the stated modularity

Modularity level	Characteristics	Conventional environmental design strategy	Smartphone examples (design studies, development projects, and products)
Add-on modularity	Range of peripheral functionalities can be attached to a given core (display-CPU unit)	Not applicable	Google ARA (2016), LG G5, Moto Z, Thuraya's SatSleeve for iPhones to enable satellite communication and other third-party extensions to smartphones
Material modularity	Some materials, such as covers and batteries can be easily separated	Design for Recycling	Fairphone 1 and several other conventional smartphones
Platform modularity	Product can be configured for a range of individual specs, configuration requires a basic technical knowledge or is only done by the manufacturer	Potentially Design for Repair / Refurbishment / Re-use depending on interconnect technology	RePhone
Repair modularity	Key components can be easily exchanged	Design for Repair / Refurbishment / Re-use	Fairphone 2, SHIFT5pro
Mix & match modularity	Range of specs for all modules, upgradeable, joint backbone and/ or standardised module interfaces, ultimately hot-swapping is an option, maximum flexibility; includes repair modularity	Not applicable	Phonebloks, Google ARA (2015), PuzzlePhone

Table 1. Definition of modularity levels (updated from Schischke 2016).

strategies. This becomes evident, when looking at any laptop or PC with CPU socket, DIMM memory socket, graphics card PCI slot: material modularity (PC housing), platform modularity, repair modularity, and mix & match modularity are all found in differing degrees in these conventional designs, but hardly yet in tablets or smartphones due to shrunk form factors.

4. LCA of Fairphone 2

The modularity of the Fairphone 2 is supposed to make Do-it-yourself or third-party repairs much easier as individual modules can be easily replaced (Hebert 2015). The modules of the Fairphone 2 are the display, the battery, the protective back cover, plus four electronics modules: The core module with the processor and memory, a rear camera module, the loudspeakers module with microphone and USB port ("bottom module"), and a receiver module with headset connector, noise-cancelling microphone and front-facing camera ("top module").

The Life Cycle Assessment of the Fairphone 2 (Proske 2016) resulted in a total carbon footprint of 44.1 kg CO2e, which is similar to other smartphones. Environmental impacts in all categories (global warming potential, abiotic resource depletion, humantoxicity, ecotoxicity) are dominated by impacts generated in the materials acquisition and manufacturing phase. Again, this is much the same as for any other smartphone.

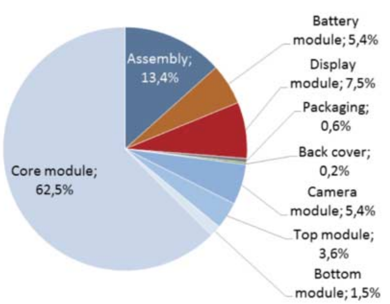

Figure 4. Carbon footprint Fairphone 2 per module or sub-assembly (production phase).

Electronics parts, and in particular all the semiconductors, dominate the carbon footprint. Consequently, the core module is correlated with more than 60% of the production carbon footprint. Battery and display come with a much lower impact, but are typically those which require repair or replacement most frequently. From an environmental perspective, these parts should not limit the lifetime of all other parts. Actually, the pie diagram in Figure 4 already includes a replacement battery.

The assembly processes have a rather high contribution to the carbon footprint, but this is mainly related to product tests, not to any specific assembly aspects of modularity.

However, there is a certain overhead for modularity, mainly related to additional housing of the modules, the board-to-board connectors with gold coated surfaces, and the additional printed circuit board footprint for the connectors. All this adds up to an additional environmental impact in the range of 10% overhead on production impacts, depending on the impact category considered.

Gold is the main driver for the additional impacts and this is also a typical effect of modularity: additional connectors are required, which withstand repeated connecting and disconnecting. The best reliability for such connectors is achieved with gold coated surfaces. This was also seen in

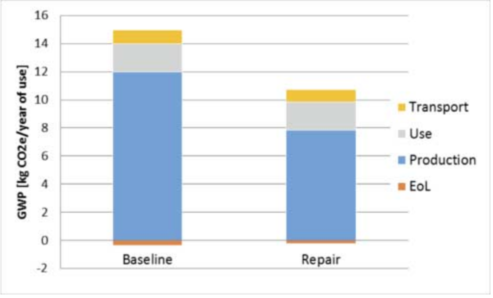

Figure 5. Carbon footprint Fairphone 2: Baseline and repair scenario.

the Google ARA (design spiral 2, (Knaian 2015)) where electrical contacts are made with gold pads and spheres.

Such an environmental overhead of modularity has to be assessed against the potentially longer lifetime of the device: A calculated scenario for the Fairphone 2 assumed a lifetime extension from 3 to 5 years, including a third battery and a certain share of replacing other parts and modules of the Fairphone after the first three years.

Such a repair scenario, which is plausible due to the very low barriers for DIY repairs in this case, results in a significantly lower environmental impact per year of use. The carbon footprint in this repair scenario is 30% lower than of the baseline scenario (Figure 5). Another way of expressing this scenario would have been to factor in the avoided production of a new smartphone after 3 years. The result would have been similar.

5. Modular Design as Enabler for a Circular Economy

On the example of modular smartphones and the objective to adopt a business model for a Circular Economy some new challenges for enterprises become evident:

The consumer has an important role to play, but with a high uncertainty, if he really plays this role well: The above repair scenario for the Fairphone 2 kicks in only, if a large share of users really invests in spare parts for DIY repairs. A number of additional steps have to be taken to make this happen, such as high availability and low costs for the spare parts, repair service offers for non-DIY users, but also making sure the software is maintained over a longer period. Only then the lifetime will be extended significantly. A "conventional user" with a modular smartphone will have a higher environmental footprint than a "conventional user" with a conventional smartphone.

Servicing users over several years requires a thorough – again highly uncertain – planning of spare parts needs over the years. This is related to the question, if spare parts should be produced in the beginning and put on stock (e.g. not advisable for batteries), or if batches of spare parts should be produced later on as the need arises. The latter is related to the problem of component obsolescence: In the semiconductor industry components are produced only over a very limited time and then discontinued – which would mean, redesigning a module to make it fit to components on the market later on, if this is feasible technically at all. At least, the modularity makes such a redesign simpler as only a dedicated module needs to be redesigned. The problem would be more severe for a non-modular smartphone which is supposed to be produced over many years as component obsolescence might mean a full redesign of the mainboard to accommodate a new component.

Reaping the full potential of modularity would mean not only to supply same-parts for repair, but also upgrade parts to increase performance of the device as the performance expectations of consumers grow. The first camera upgrade module for the Fairphone 2 has just been released in September 2017 (Fairphone 2017). This is technically highly challenging and also requires some standardisation, hardware and software, to keep interfaces stable over a longer time. Anticipating future technologies is one of the challenges of such a standardisation effort.

All this requires much more interaction and negotiation with other players in the value chain, including semiconductor manufacturers and software providers, to name only the two most critical other players. For a small to moderately large enterprise with limited market force this need for value chain coordination easily can turn into a huge barrier.

Another controversial aspect is the trend, that small Circular Economy affine companies in the smartphone business get the production phase financed through crowdfunding or pre-order campaigns (Fairphone with the Fairphone 1, PuzzlePhone, SHIFTPHONE). Pre-ordering means to order a phone when the one the user already owns is still in proper working condition – otherwise the user would not wait several months for a new phone. This might mean, existing phones are replaced by a crowdfunded phone before actually needed. This should not be a detrimental effect to start modularity through crowdfunding, but it might need further investigations.

6. How to Assess Modularity Effects

Some assessment problems have already come up in the previous sections, but there are many more, as the different modularity levels and the possibilities to mix them lead to a host of combinations and pitfalls.

Table 2 shows a selection of assessment challenges arising from quantifying design changes and business model changes connected to modularity.

The question is not "can it be assessed with LCA?" (in principle, it probably can), but rather how to set up suitable models, where to insert assumptions, and how to communicate the assessment results together with the assumptions.

Secondary questions are "is the allocation of burdens across the players involved fair?" and "do all players receive incentive and income to do this well and to potentially do this on a larger scale?". We should always remember that the circular economy needs many creative small-scale co-operations, but for a macroeconomic impact needs leverage through high numbers and repeatability, as well.

7. Conclusions

Modularity offers a number of potentials for products in the circular economy. The main leverage is through extending the use time of products with a high production impact, or extending the use of those product parts, which incorporate the highest percentage of embedded resources. Mobile ICT products fully fit into this scope.

Modularity focus	Addressed modularity level	Assessment challenges / examples
Changing external product design elements	Material modularity	Replacement back covers can extend consumer attachment and can be essential in repair cases, but could turn negative, when overdone for fashion reasons.
DIY repair	Repair modularity	Fairphone 2, see text. Scenario for effective average lifetime extension is complex to communicate. Further trade-offs not yet quantified (e.g. material recycling benefit).
Modularity to add functionality externally	Add-on modularity	Interface standards have to be stable across generations, or the core product must have additional lifetime extension strategies.
Mix and match modularity for customising functionality	Mix & match modularity	Potential to equip devices exactly as needed by the user (no hardware overprovisioning); but danger of buying more modules than needed (including fashion or as gifts).
Mix and match modularity for upgrading	Mix & match modularity	Interface standards have to be stable and powerful enough to support upgraded functionality. Forward compatibility in addition to backward compatibility (Spacey 2016).
Third party scavenging of modules	Platform modularity, repair modularity, mix & match modularity	Original manufacturer may lose modules needed for his own circular business model. Product liability issues similar to re-marketing of products (repaired, refurbished, remanufactured, etc.).
Interconnected business models and dynamics	All	Too many variables to include in assessment at design stage. Also, dynamic changes of user behaviour and professional players never complete in a model prediction.

Table 2. Examples of assessment challenges deriving from increased modularity.

The highest potential would derive from long-term stable standards for interfaces, e.g. for compute modules and for sensory and camera modules. Establishing and then maintaining such standards is the biggest obstacle at the same time, and standards development is likely to become even more driven by individual company strategies.

Evaluating the environmental and the lifetime extension effect is still problematic, but progressing. When considering that changing business models of the circular economy are likewise still hard to capture numerically, it is easier to understand why many forms of modularity are complex assessment problems. Many cases of modularity allow, or explicitly base, their assumptions on interlinked business models, and these are the most complex challenges.

The most rewarding schemes for the circular economy would be those where the benefit is not solely with the original manufacturer. Hence, new business models are essential – both to make sure that the original manufacturer has enough benefit to engage in more modularity and for the other parties who provide new business based on the modularity.

Acknowledgments

The presented research is partly an outcome of the project sustainablySMART, which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 680640.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-309

Circular business model framework: mapping value creation architectures along the product lifecycle

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Keywords
Circular economy
Circular business model
Business model innovation
Value management
Product lifecycle

Abstract
Circular business models are foreseen to contribute to enabling prolonged lifetimes of products and components through successive cycles of reuse, repair, remanufacturing and closing material loops. To realize economic viability and resource efficiency savings from a circular business model, early consideration and integrated planning of the product lifecycle and value creation architectures at the relevant points in the lifecycle is pivotal. However, the current frameworks for business model design have not been designed to recognize the specific opportunity points of the product lifecycle to create and capture additional value from cycling resources. They do not acknowledge that it often takes distinct value creation architectures and value propositions to capitalize on the value creation potential. To attend to this gap, this paper develops a circular business model framework that is based on the current understanding of resource efficiency strategies and systematically integrates lifecycle value management with traditional business model design thinking. Through this, the developed framework is intended to serve as guidance for circular business model development to incorporate circular principles and to capitalize on additional value from cycling resources. To explore the usefulness of the framework developed from literature, a comparative case study design with two cases of Swedish companies operating circular business models is employed. The framework proved useful to map the companies' distinct value creation architectures that enable cycling of resources and to point to opportunity spaces for additional value creation. Suggestions for further refinement are made.

Introduction

To realize circular economy principles and resource efficiency strategies in a way that they generate sufficient business and customer value, the development of circular business models is regarded as pivotal (Bakker, Wang, Huisman, & den Hollander, 2014; EuropeanCommission, 2015; Linder & Williander, 2015). Circular business models are envisioned as contributing to enabling prolonged lifetimes of products and components through successive cycles of reuse, repair, remanufacturing and closing material loops. If planned and managed effectively, cycling resources and preserving embedded value open new possibilities for creating and capturing value for companies (Bakker et al., 2014; Den Hollander & Bakker, 2016; Moreno, De los Rios, Rowe, & Charnley, 2016). Yet the management of such continued networks of value generation and maintenance leads to new needs regarding business model planning. To realize economic viability and resource efficiency savings from a circular business model, early consideration and integrated planning of the product lifecycle and value creation architectures at the relevant points in the lifecycle is pivotal.

However, the existing tools for designing business models, e.g. the business model canvas (Osterwalder & Pigneur, 2010), as well as the newly emerging tools aimed at the design of circular business models, e.g. the framework for sustainable circular business model innovation (Antikainen & Valkokari, 2016; Lenssen et al., 2013; Rashid, Asif, Krajnik, & Nicolescu, 2013) do not incorporate the idea of value management along the product lifecycle. They have not been designed to recognize the specific opportunity points within the product lifecycle to create and capture additional value from cycling resources and that it often takes distinct value creation architectures (Velte & Steinhilper, 2016) and value propositions (Araujo & Spring, 2006) to capitalize on them.

To attend to this gap, this paper aims to develop a circular business model framework that is based on the current understanding of resource efficiency strategies (Bocken et al., 2016; Willskytt, Böcking, André, Tillman, & Ljunggren-Söderman, 2014) and that systematically integrates lifecycle value management with traditional business model design thinking. Through this, the developed framework is intended to serve as guidance for circular business model development to incorporate circular principles and to capitalize on additional value from cycling resources. It is aimed to support the mapping, analysis, design, and communication of circular business models and the distinct value creation logic at the relevant points of the product lifecycle.

To explore the usefulness of the framework developed from literature, a comparative case study design with two cases of Swedish companies operating circular business models is employed. By applying the developed framework on the case companies, the validity of the literature-based framework is tested and evaluated. Its explanatory capacity is judged based on its ability to deliver insights that the 'linear' business model framework (Osterwalder & Pigneur, 2010) would not be able to deliver. In particular, additional information regarding distinct value creation architectures to cycle resources and to point to opportunity spaces for value creation. Based on this, suggestions for further refinement are made.

This paper proceeds with providing a literature background on circular business model innovation and value creation in section two, followed by the presentation of the framework. Section three presents the application on the case studies. Section four offers the validation of the framework. The paper concludes with a discussion and final remarks offered in section five.

Literature background and development of framework

Business model innovation

Business models can be used to present the organizational structure and value creation processes of a company (Wirtz, Pistoia, Ullrich, & Göttel, 2016), defining how an organization will convert resources and capabilities into economic value (Teece, 2010). A framework for conceptualizing business models that has been acknowledged for its practical relevance is the "business model canvas" by Osterwalder and Pigneur (2010). The authors distinguish nine business model elements. These elements describe three value dimensions:

(1) The value proposition - What value is provided and to whom? (comprising elements of value proposition, the offer, customer segments, and customer relationships)
(2) The value creation and delivery- How is value provided? (comprising elements of key resources, key activities, key partners, and channels)
(3) The value capture mechanisms - How does the company make money and capture other forms of value? (comprising elements of cost structure, and revenue flows)

Business model innovation has received attention as a way to implement and capitalize on resource efficiency strategies that enable cycling of resources (Planing, 2015). Through innovating what value is provided, an offer can be designed with a resource efficiency strategy in mind. Innovating how value is created, delivered, and captured, can help to implement and capitalize on a resource efficiency strategy and its associated value. Where value creation in circular business models stems from is explored in the following.

Value creation in circular business models

It is commonly assumed that value in circular business models is, to some extent, created differently compared with linear business models (Bakker et al., 2014; Bocken et al., 2016; Moreno et al., 2016). Particular about circular business model is that they preserve and utilize the value embedded in products, parts, and material through resource efficiency strategies of cycling resources. Generally, two fundamental strategies towards cycling of resources can be distinguished (Bocken et al., 2016; McDonough & Braungart, 2010; Stahel, 1994, 2010). Those that;

(1) prolong useful life of products through design for long-life and through life extending measures as reuse, repair, or remanufacturing (also referred to as slowing loops); and
(2) reuse of materials through recycling (also referred to as closing loops).

Cycling resources can create environmental gains from utilizing the energy and resources embedded in products as long as possible. Additionally, it can create economic gains from exploiting the residual economic value in products (Bakker et al., 2014) and from creating additional value-adding business activities (Ferrer & Clay Whybark, 2000) through the design of new offerings.

A logical consequence of cycling resources is that products, parts, and materials need to be in some form recovered at the end-of-use and reintegrated into the value chain for an additional life (Wells & Seitz, 2005). Moreover, long useful life should be enabled. When the end-of-life is irreversibly reached, material cycles should be closed (Bocken et al., 2016). Thus, capturing the embedded value through strategies for cycling resources, can be seen to occur through three generic interventions at different lifecycle points.

(1) recovery and reintegration in the value chain,
(2) enabling prolonged use, and;
(3) addressing the end of life.

When embedding strategies of cycling resources into a market offering, these three interventions should ideally be considered. To effectively utilize these opportunities beyond a single life of a product in the business model, timely consideration and integrated planning of the required activities is pivotal (Araujo & Spring, 2006). If a company spans more than one of these three phases, -to some extent separate- revenue architectures and value creation logics will need to be designed to effectively create, deliver and capture the potential value. For instance, to enable a second life of a product, its value proposition - from the beginning- needs to be thought of as more fluid, and subject to re-definition along the product lifecycle (Araujo & Spring, 2006).

To attend to these needs, based on the business model framework of Osterwalder and Pigneur (2010), a

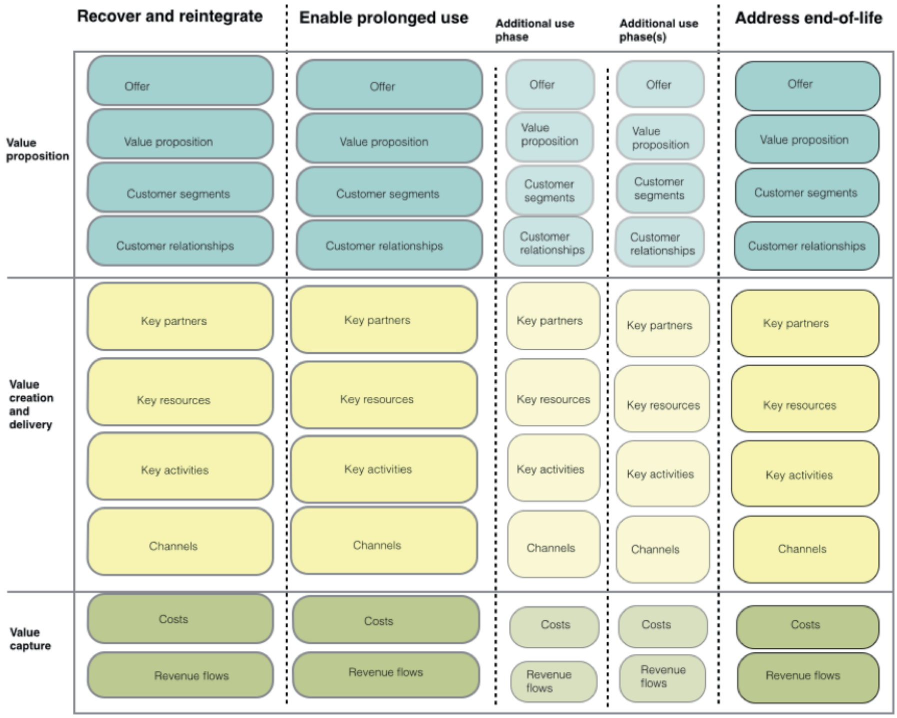

Figure 1. Circular Business Model Framework.

framework for circular business model mapping is suggested (Figure 1). The framework integrates the three value dimensions ((1) Value proposition, (2) Value creation and delivery, and (3) Value capture), and their business model elements, with the three lifecycle intervention points ((1) Recovery and reintegration, (2) Prolonged use, and (3) End-of-life). Prolonged use is subdivided in two segments. One accounting for prolonged single life by the same owner, and the other accounting for additional use phases, in which a change in ownership takes places. The framework is considered as a tool for further exploration in this study and tested in the following.

Case study application

Two Swedish companies, Company A and Company B, which operate business models that enable long life and cycling of resources were selected for an initial pilot study. The Swedish context was chosen due to its longstanding tradition of innovative business models, high consumer awareness of environmental issues, and forward-looking policies in regard to resource efficiency. To verify suitability of the framework for different circular business models and strategies, the case companies were selected to represent different value chain positions, product groups, types of offers, sectors, and resource efficiency strategies. Table number 1 offers an overview on both case companies' operations. Thereinafter, an analysis of each companies' business model is presented, using the developed framework. The analysis offers a short description of each business model, focusing on their value creation architecture along the product lifecycle.

Description of Company A's business models

Company A's business model to this date enables the recovery and reintegration of by-products from the wood and plastic company. These are used as an input for the production of a material composite. From the composite a variety plank products are manufacture that are designed for long-life and recycling. Figure number 2 presents Company A's value creation architecture from the by-product recovery to the end-of-life phase. Business model elements in the lifecycle points that are currently not fully addressed through the business model configuration are presented in dashed lines.

Mapping Company A's value proposition in each of the phases, highlights that two distinct value propositions can be identified; one to the material suppliers, and another to the customers of the product. While the one to the customers is comprehensive, including low maintenance and long-life products, resulting in low life-cycle costs, the value proposed to suppliers in the reintegration phase is developed to a lesser extent. Value to the by-product supplying companies does not go beyond a short-term market transaction, based on the highest price offer. Thus, there is potential to find partners to whom additional value could be offered, e.g environmental reports on closed-loop practices (Schenkel, Caniëls, Krikke, & van der Laan, 2015). Business developers at Company A are indeed currently pursuing such innovation (Fernlund, 2017).

The end-of-life of Company A's product is addressed by

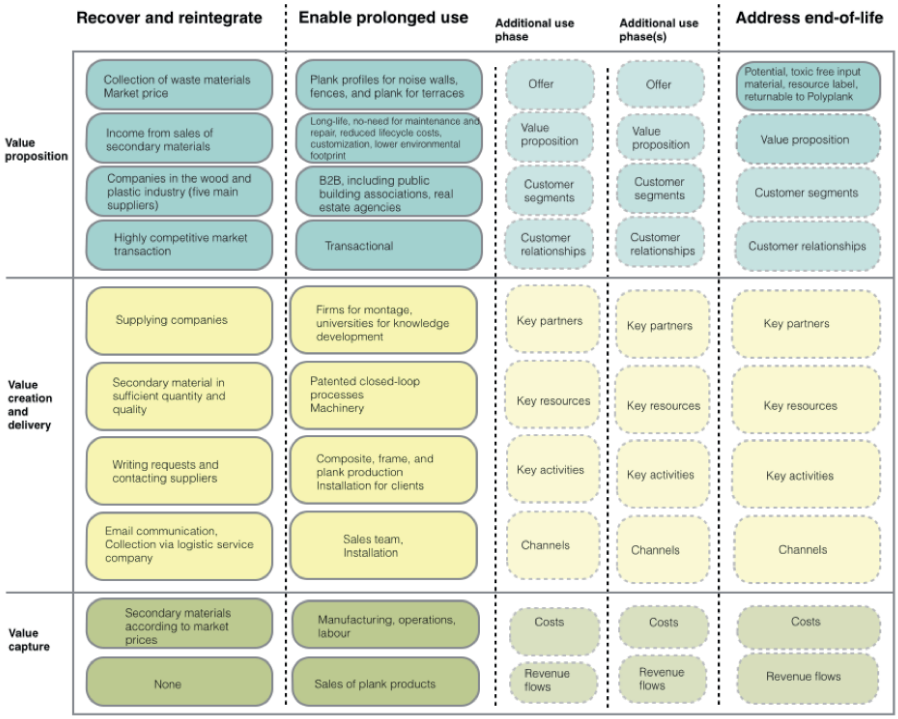

Figure 2. Circular Business Model Framework for Company A.

the products' suitability for recycling (either as hazardous substance-free input for waste-to-energy processes or as input material for their own production). Therefore, each product is labelled with a resource passport and company contact information. Yet, the business model mapping reveals that the associated value can currently not be fully captured. This is credited to the long lifetime of products (approximately 25 years), which hinders Company A to establish a take-back system. The product design for recycling and labelling however can be considered as important steps towards capturing this value. To further enhance value capture, for some selected short-term applications of the products, the value creation around the additional life phases and end-of-life could be revisited.

Description	Company A	Company B
Offer	Plank profiles from recyclable, toxic free and long-life material composite. Plank profiles are used for instance for noise walls, fences, terraces.	Match-making service to enable reuse of unused goods within an organization by means of an IT platform
Sector	Building	Various
Main product groups[1]	Fences, noise walls, terrace planks	Furniture and office equipment
Value chain activities	1) Production of material composite, 2) Production of frames 3) Assembly to plank profiles 4) Installation	1) Intermediator
Resource efficiency strategy enabled	Substitution of virgin material Design for long life Design for recyclability	Reuse
Number of employees	20	2

Table 1. Overview on Case Company Characteristics.

Description of Company B's business models

Company B's business model creates value from enabling reuse of unused goods in private and public organizations through offering access to an IT platform, through which new applications for surplus goods can be identified. Figure number 3 illustrates the value creation architecture around realizing reuse practices. Business model elements at the lifecycle points, that are currently not fully addressed through the business model configuration, are presented in dashed lines.

The value proposition dimension is designed to encourage provision of unused goods by one organizational unit and the purchase of these goods by another unit. This partly leads to two distinct value propositions (highlighted in bold in Figure 3). The providing unit benefits from reduced storage and waste creation, while the purchasing unit benefits from quick, worry-free and low-priced delivery of goods. Overall the customer organization that uses the IT platform benefits from utilizing residual value in goods, from monitoring and reporting of financial and environmental savings, and from consultancy services and training to establish organisational practices for reuse.

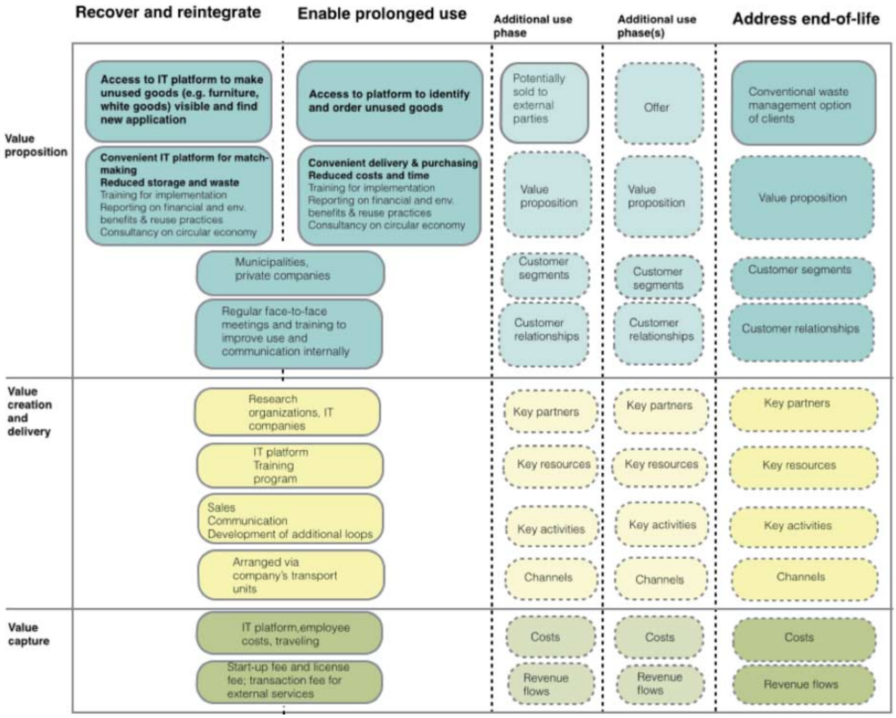

Figure 3. Circular Business Model Framework for Company B.

Application of the framework illustrates that, to this date, reuse is predominantly realized within one organization, as opposed to redistribution to third-parties. This explains why value creation, delivery and capture is configured in a similar manner for both, the recovery and use phase. The mapping reveals that opportunities exist for creating and capturing value from enabling several additional use phases, potentially through involving third parties. Such business model innovation is indeed currently explored by company managers (Östlin, 2017). It also shows that the end-of-life of goods, when no additional application can be found, to this date is handled according to the common waste management practices of the participating organization. Revisiting this lifecycle phases to explore innovation for additional value creation and capture could be another innovation opportunity. The framework may be of guidance in creating suitable revenue creation architectures around such additional offerings.

Validation of framework

Applying the framework showed that it lends itself to illustrate how value dimensions are configured at the distinct intervention points in the product life cycle to enable cycling of resources. For both case companies, it was useful to recognize, in which intervention points are currently addresses and which ones not. Although companies will certainly not always be engaged in all of them[1], this can point to opportunity spaces where potentially more of the embedded value could be captured and value-adding activities organized. Thus, a main benefit of the framework can be deemed its guiding function to address value creation opportunities from circular practices.

While in Company A's business model indeed distinct value creation architectures were identified, Company B's value creation architectures were similar, as the focus was on reuse within the same organization. Thus, the more cycles a company realizes and the more divers value architectures for each of the phases become, the more valuable the framework can be deemed. In these cases, the framework lends itself to analyse value creation architectures at each step in an integrated manner, recognize interdependencies, and innovation opportunities.

The framework was found suitable to depict different types of business model offers and resource efficiency strategies (e.g. service offer vs. a product offer, as well as long-life, recyclable product vs. reuse). Yet, more research is needed that includes different types of business models, as identified by Bakker et al. (2014), focusing on cases companies that enable several use phases. Future research should also validate the usefulness involving practitioners.

Conclusions

The developed circular business model framework can be judged useful to conceptually express the business logic of firms spanning various points in the product lifecycle.

[1] *For instance, due to external barriers to operate strategies of cycling resources. Or, because cycling resources in the specific case may not lead to economically and environmentally superior results.*

It appears to be valuable to map and analyse the case companies' distinct value generation architectures and networks at the relevant points of the product lifecycle. For business models that enable a limited number of cycles – or cycle resources within the same organisation - value creation networks can be assumed to differ to a lesser degree between lifecycle points. Here, the framework seems of lower added value compared to the linear business model framework. Yet, it can visualize potential opportunity spaces to further capitalize on the embedded value in products in other lifecycle stages. Thus, the main contribution of the framework can be deemed its guiding function and detailed analysis for business model design based on circular strategies.

Acknowledgments

This research was supported by the Mistra REES (Resource Efficient and Effective Solutions) program, funded by Mistra (The Swedish Foundation for Strategic Environmental Research).

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-315

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
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Planned obsolescence: the government's choice?

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Keywords
Planned Obsolescence
Government
European Commission

Abstract
Representatives of five Environmental Ministries and attached Agencies examined political instruments to ban products with built-in defects designed to end the product's life-cycle. The focus primarily laid on better consumer information. A lack of information concerning the durability and repairability of products creates an asymmetry in the market balance between producers and consumers. The need for common actions on EU-level was highlighted. Among these political instruments are voluntary measures and innovative economic models. The European legal framework for consumer protection has to be further evaluated, more specifically the concept of warranty law. With political feasibility being considered, conclusions were drawn unanimously. However, the authors take into consideration the findings of different national studies that could not validate the accusation of planned obsolescence.

Introduction

Building on their analysis Prakash et al. clearly state: "In the context of things, there is essentially no disagreement when it comes to the question as to whether manufacturers plan the life-times of their products" (Prakash et al. 2016, p. 49).

There is an emotional debate concerning how far the lifetime period of products is shortened on purpose, known as "planned obsolescence". Although products could be produced to last longer, the presumed aim is to engage customers to buy again earlier than needed, it is argued.
Obsolescence is an umbrella term to define the several reasons why a product is abandoned:

- defects due to lack of performance of materials or components (mechanical obsolescence)
- lack of interoperability of software and hardware (functional obsolescence)
- the desire for a new device, though the old still works (psychological obsolescence) and
- imbalance between repair costs and the cost of new products (economic obsolescence)

While there are ways to address problems regarding mechanical, functional and economical obsolescence the field of psychological obsolescence will not be considered further.

Method

This paper aims to address possible measures against planned obsolescence on a governmental or European level, with a special emphasis on legal steering tools. In order to find the most homogeneous solution possible, the final conclusions are the unanimous opinions of experts from Austria, Belgium, France, Germany, and Italy. They are all employees of Environmental Ministries or attached Agencies in their respective countries. They worked together as a subgroup of the "High Level Working Group", an advisory board of the Eco-Innovation Action Plan (COM(2011) 899 final).

After meeting twice and collecting national documents and studies on the issue of planned obsolescence over the past year, the group finally presented their findings to the European Commission in 2016. The conclusions highlight those strategies that have been identified by the authors to be the most promising ones and that can be implemented in a short to mid-term perspective.

Political Instruments

Voluntary communications by companies on durability

In France, Law n° 2015-992 concerning the energy transition for green growth states in its Article 70, the aim of "fighting against planned obsolescence of manufactured products by consumer information" and imposes that "experiments concerning the display of product life expectancy within consumer information can be launched on a voluntary basis." (Assemblée Générale, 2015).

Similarly, the European Economic and Social Committee (EESC, 2013) advocates voluntary measures:

> The awareness of consumers is a prerequisite for proper and sustainable use of products. Additionally it is important to properly inform consumers about the minimal product lifetime which is relevant when making a decision on product purchase. In this context, voluntary commercial and business initiatives and activities would be welcome. […] For example, in the white goods sector, 10-year or 20-year component warranties were a definite selling point. This guarantee could be standardised at the EU level for all products purchased in the 28 EU countries so as to avoid penalising European businesses. (p. 2)

Current Legal Framework: guarantee for a minimum technical life time

As the title already reveals it may be up to the legislative authorities, namely the national parliaments and/or the European Commission to take measures to avoid planned obsolescence from occurring.

According to Twigg-Flessner (2007):

> The fundamental argument that is often advanced in favour of greater harmonisation, or even unification of contract law, is that the diversity between the domestic contract laws effectively constitutes a non-tariff barrier to trade between the Member States. A unified legal framework would reduce transaction costs considerably, and consequently, a European Contract Code is needed for business. (p. 200)

Consumer product quality expectations, contractually agreed product properties and advertising statements by the producer fall within the scope of warranty law. Therefore it is more feasible for the consumer to claim legal guarantee rights, if there is a legal obligation to provide information on the minimum technical life.

The European Consumer Organisation (BEUC, 2015) claims:

> The EU 1999 Directive on Consumer Sales foresees a minimum legal guarantee period of two years combined with a six-month period for the reversal of the burden of proof for the defect. This means that only within the first six months after purchase it is presumed that the product was faulty from the start. Afterwards it is the consumer who would have to prove that the defect was already inherent in the product when he/she bought it. This will not be possible in most cases without an expert investigation due to the complexity of current products and the high costs implied in technical expertise to assess the defect. Only two countries, Portugal and France have expanded the period for the reversal of proof to two years and only a few countries have longer guarantee periods. (p. 12)

In this context the Reuse and Recycling EU Social Enterprises network (RREUSE, 2015) demands:

> There is an urgent need for EU wide laws that motivate producers to manufacture long lasting products and protect consumer rights at the same time, such as
>
> - Extending the burden of proof on the manufacturer to at least two years EU wide
> - Introduce requirements for showing the average expected product lifetime (AEPL) at the time of purchase in order to better inform consumers about purchase decisions
> - Explore the effects and impacts of extending minimum functional guarantee period, for example, on independent repair operators
> - Obligation to use only standardised, freely available components for as many parts as possible (e.g. screws, motors, pumps etc.)
> - An obligation to provide spare parts. (p.7)

In France planned obsolescence is now a crime. The country went one step further by implementing a law against planned obsolescence in their penal law code, including imprisonment up to two years and a fine rising up to 5% of the annual revenue generated in France.

Legally binding information and legal guarantee

Schlacke (2015) stresses:

> Civil law contains a great variety of obligations to inform. Those obligations in many cases derive from European directives, particularly from Directive 2011/83/EU on consumer rights. It contains basic duties to inform for B2C contracts, e.g. to inform the consumer of "the main characteristics of the goods" before the contract is concluded. A study on behalf of the German Environment Agency recommends specifying the term "main characteristics" by adding the minimum service life, the repair-friendliness and the energy efficiency as rule examples. (p. 29)

Legal guarantees and legal obligations to provide certain information can only be effective if closely linked together. While the legal guarantee concerns the relationship between buyer and seller, only the manufacturer has direct influence on the product properties such as durability.

Therefore – following Schlacke – "the producer should be obliged to inform about the time of the guarantee given by him. It is on him to set a period of time. He may decide not to give any guarantee, he would however be obliged to inform about it." (Schlacke et al., 2015, p 32). The risk of loss of reputation works as an incentive for giving a guarantee. This instrument could be combined with the information requirements on reparability. Minimum standards regarding the manner of information on the given guarantee have to be set by law in order to avoid misleading information for the consumer. In cases of a provided guarantee, claims directly against the manufacturer are made possible. Another advantage is that the absence of defects is promised not only for the time of delivery, but for the entire period of the guarantee, putting the customer in a stronger legal position.

Reparability

In order to provide a wide range of repair choices for consumers, repair and re-use activities have to become more competitive and attractive. Achievable goals might be:

- Durable and easy to repair product design
- Spare parts availability must be guaranteed for longer periods, aligned to the life expectancy of a product
- Free access to repair service documentation and software
- Easy access for consumers to high quality and convenient repair services

Promoting ease-of-repair and upgradeability criteria extends the lifetime of a product and therefore reduces the need to purchase a new one. Consequently, energy and production resources can be saved.

A first step into the right direction is the implementation of the WEEE Directive (Directive on Waste Electrical and Electronic Equipment 2012/19/EU), which includes guidelines aiming to promote the repair and preparation for re-use of products.

Availability of spare parts / Independent repair services

Twigg-Flessner (2010) raises:

> A major difficulty for consumers at present is that they will often be unaware of the availability, or otherwise, of spare parts and after-sales support. There is not even an obligation to inform consumers about the extent to which parts may be available. (p. 205)

Following a BE/DE/NL non-paper, mandatory provision of spare parts might be impractical or harsh for some product groups. It is proposed as a first step to provide information about the availability of spare parts, the length of time that they are planned to be available after the end of production and the availability of repair manuals. The Commission announced in the circular economy package (COM (2015) 614 final) that the availability of repair information and spare parts will be considered under the ecodesign directive. Products that are not provided with spare parts or repair manuals need to bear a mandatory warning. In that way the availability of spare parts and repair guides remain voluntary. (Soenen B., Akkerman F., Oehme I.,Siderius H.-P.).

For BEUC it is crucial that consumers must have access to single spare parts such as a door sealing or a door clip which will allow for minor maintenance works to be carried out by the consumers themselves. Such spare parts should be made available by the manufacturer/trader to repair services but also directly to consumers in cases where maintenance and easy self-repair can safely be done by them. Hence, we need to place a greater importance on the urgent need for a better design for reparability (BEUC, 2015, p.13).

Erler and Rieger (2016) propose a lifecycle concept, allowing the product to adapt, to improve and to update it regularly and continuously as known from software products or the automotive sector.

Service-oriented models

Following an Italian Resolution the transition from the concept of “product” to “product as a service” marks a fundamental step towards reducing the use of resources. For this transition to take place, first, companies must be encouraged to adapt their business model. (Senate of the Italian Republic, 2015, para. O)

One strategy could be to introduce leasing–models. The producer/retailer would remain the products owner and would be leasing the goods to the end consumer. Instead of buying the product, the costumer buys a service. Within this model service options etc. can be implemented.

“The implications on such an economical change would be of deep impact. There are pros and cons for both, the producer/retailer and the consumer side”.(Prakash et. al, 2016, p. 278)

Applying financial instruments

BEUC considers:

> A major focus to allow for an increased choice of greener products should be given to lower VAT rates which could be applied to reused or refurbished goods and to products which contain higher levels of recycled materials. Reduced prices for such goods will benefit lower income consumers. It could also be an incentive for multiplying repair shops and thereby contributing to job creating in Europe. (p.15)

Should the EU VAT Directive (2006/112/EC) be opened up, RREUSE suggests using differentiated VAT rates in accordance with the waste hierarchy to make repair more economically feasible:

- Zero VAT on repair, maintenance, upgrade services and sales of second hand/refurbished products
- Allow retailers to recoup VAT through donation of unsold new products to approved/accredited reuse centres from the social economy
- Zero rated VAT for preparation for reuse activities and services carried out by social enterprises

(p. 9)

Conclusions

The group takes into consideration the opinion of the European Economic and Social Committee on banning products with built-in defects designed to end the product's life. However, the group recognizes the findings of Prakash et al. (2016) which could not confirm planned obsolescence as regards manufacturers intentionally manipulating design or knowingly integrating weak points.

On the other hand it is proved, that devices are more and more replaced or disposed in another way after a short period of use.

Manufacturers and consumers interact with one another and influence product development and consumption patterns. The lack of information concerning durable and reparable products causes an asymmetry in the market balance and leaves consumers unable to make the best buying decisions regarding to their own needs.

1. A legal definition of planned obsolescence has to be worked out on EU level.

2. When it comes to political enforceability, all participating experts agree on the improvement of consumer information on the life-time expectancy of products. This measure – among others – will help building confidence on manufacturers, who are suspected of shortening life-time of products on purpose.

3. The displayed lifetime information needs to be verifiable. It should be supported by solid and objective methods. These could be measurement methods of the final product or a reference document providing guidance for the assessment of the durability of the product based on critical components and the way of assembling. Within the period of legal guarantee the fact that the producer displays lifetime information reinforces the consumers expectancy and therefore supports the consumer in claiming his/her legal rights.

4. Building on existing or future reference documents, displaying lifetime expectancy information (further than legal guarantee provided by the consumer rights directive) could be made mandatory for certain product groups. The producer who is unable to provide such information should instead mention: "no information available".

5. A prerequisite for durability of products is an appropriate design. The ecodesign directive is the right tool to set requirements.

6. Further studies, initiatives and experiments at large scale involving producers and consumers are needed at EU level to define for each product category the minimal durability based on the best trade-off between the product life cycle impact and cost, where the reparability phase is included and the consumers expected lifetime and willingness to pay.

7. Standards to check life-time expectancy of products or components should be developed and kept smart and coherent at an EU-level.

8. A mandatory information instrument concerning the voluntary guarantee as proposed by Schlacke et al. (2015) is necessary to bring clarity on the market and motivate to provide voluntary guarantee which establishes consumer rights to the manufacturer directly.

9. Repair-oriented approaches can save or create green jobs, respectively. The availability of spare parts and spare parts and/or repair manuals counteracts the prevalent suspicion of planned obsolescence. Adequate information needs to be available for end-consumers as well as repair services. In this regard the European rules established for the repair of vehicles (regulation (EG) 715/2007 in its present version) can serve as an example.

10. Improving the functioning of legal guarantees has to be further evaluated.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-319

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Measuring the historical change in the actual lifetimes of consumer durables

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Keywords
Actual lifetime
Consumer durables
Methodology
Lifetime extension
Indicator

Abstract
Product lifetime extension would contribute to establishing a circular economy and reducing the environmental impacts of mass consumption. Showing the situation of the historical change in the product lifetimes with quantitative data is needed for evaluating the contribution of product lifetime extension. The present study observed the historical change in the actual lifetimes of consumer durables in Japan by three different ways; direct observation; model calculation; simple indicator calculation. The average lifetimes of common consumer durables including home appliances, electronics, and passenger cars have been increasing in Japan over the past few decades. To evaluate the trend of the product lifetimes accurately, product lifetimes need to be observed or estimated based on actual data of discarded, collected, or in-use products. A questionnaire survey that relies on respondents' memory would not provide precise results enough to detect the historical change in the actual product lifetimes. Calculating the ratio of the number of in-use products against the sales would generally be useful to understand the common trend in the product lifetimes over the years when the penetration of the products is saturated. The ratio could also be used as substitutes of the average of the lifetime distribution that is approximated by a statistical distribution function.

Introduction

Product lifetime extension would contribute to establishing a circular economy and reducing the environmental impacts of mass consumption. Product lifetimes may have been increased recently in general, but understanding the situation with quantitative data is needed in order to evaluate the contribution of product lifetime extension. Approaches for measuring the actual product lifetimes have been well established in past studies (Oguchi et al., 2010); however, product lifetime extension would progress gradually and therefore, it is needed to assess the applicability of each approaches to detecting the change in product lifetimes over time.

The present study observed the historical change in the actual lifetimes of consumer durables in Japan by three different ways; direct observation; model calculation; simple indicator calculation based on stock and sales data of products. The study then discussed the similarities and the dissimilarities in the measured product lifetimes by different approaches and the past trend in actual lifetimes of consumer durables in Japan.

Approaches for measuring actual product lifetimes

According to a review by Oguchi et al. (2010), approaches for estimating actual product lifetime distribution found in literature can be classified into four approaches (Table1). These approaches estimate product lifetime distribution based on the past sales and the number of in-use products or discarded products. The product-age profile of the in-use or discarded products is required for three of the four approaches (approaches 1–3). To apply these approaches to measure the change in the actual product lifetimes of consumer durables over the years, we need to conduct an extensive sample survey on the age profile of in-use or discarded products in each year. It is generally time-consuming and cost-intensive unless such data is readily available by statistics etc. On the other hand, because the approach 4 does not need to know the product-age profile of the in-use products, measuring the change in the actual product lifetimes by this approach is relatively less time-consuming and cost-intensive.

Materials and methods

We observed or estimated the historical change in the actual product lifetimes of consumer durable goods in Japan by different approaches: a direct observation and a model calculation by a simplified estimation method. We also examined the applicability of a simple indicator which can be calculated based on stock and sales data of products. In this study, we selected five types of electrical and electronic equipment: refrigerators, washing machines, room air conditioners, televisions, and mobile phones (including smartphones) and passenger cars as case studies.

Approach	Required data (number of...)			Survey method for primary data (definition of estimated lifetime)
	End-of-life	In-use	Sales	
(1) Calculate discard rate distribution for a certain period	X (for each age)		X (time-series)	- Survey of collected EoL products at facilities - Questionnaire to consumers who discarded products
(2) Calculate survival rate distribution at a certain time point		X (for each age)	X (time-series)	- Questionnaire to consumers to ask the number and product age of in-use products
(3) Calculate failure rate distribution for a certain period		X (for each age, at least two time points)		- Questionnaire to consumers to ask the number and product age of in-use products
(4) Estimate from the total number of in-use products based on mass balance equation		X (only the total number)	X (time-series)	- Questionnaire to consumers to ask the number of in-use products - Use of statistics

Table 1. Approaches for estimating actual product lifetime distribution.

Direct observation of the age profile of the discarded products

We observed the actual lifetimes of the selected product types in Japan on the basis of the data from surveys by mean of direct observation approach.

"Consumer Confidence Survey" by the Cabinet Office of the Japanese government (CAO) surveys annually the average lifetimes of 11 consumer durables including home appliances and electronics by means of questionnaire surveys to consumers. The survey asks consumers the lifetimes of their old products if they had experiences of replacing their products in the survey year. The primary purpose of the survey is to obtain a basic data for understanding the economic trend, but we may also understand the trend in the actual lifetimes of various products in the country.

Another survey has been annually conducted on electrical and electronic equipment by the Association for Electric Home Appliances (AEHA) of Japan (AEHA, 2002-2016). It reports the investigation results of the lifetimes of four types of home appliances: room air conditioners; televisions; refrigerators (including freezers); washing machines, which are collected to collection centers under the Japanese home appliances recycling law.

Regarding passenger cars, Automobile Inspection and Registration Information Association in Japan (AIRIA) publishes annually the average lifetimes of several types of motor vehicles including passenger cars, which are calculated from the complete dataset from the registration system (AIRIA, n.d.).

All of the surveys above report the arithmetic average of the surveyed lifetimes of replaced, collected (discarded), or de-registered products as "average lifetimes."

Model calculation by a simplified method

We calculated the average lifetimes by using the method which was proposed by Oguchi & Fuse (2015) based on the population balance model. This method estimates the product lifetime distribution on the basis of mass-balance of products. The product-age profile of the in-use products is not required, so it is relatively less time-consuming and cost-intensive to investigate the historical change of the product lifetimes.

Assuming that the lifetime distribution (survival rate distribution) of products follows any parametric distribution function, the average of the distribution (average lifetimes) was optimized so that the total number of in-use products calculated from past sales and the survival rate distribution (equation (1)) consists with the observed number.

$$N_t = \Sigma \{S_{t-i} * R_t(i)\} \quad (1)$$

where, N_t is the calculated total number of in-use products at the end of the year t, S_{t-i} is the number of sales in the year t-i, $R_t(i)$ is the survival rate of the products with a product age i year(s) at the end of the year t.

In this study, we assumed the survival rate distribution of products follows the Weibull distribution function with two parameters, which was expressed by equation (2):

$$R(i) = \exp\left[-(i/\mu)^m * \{\Gamma(1+1/m)\}^m\right] \quad (2)$$

where, μ is the average, m is the shape parameter, Γ is the gamma function. The shape parameter value was assumed to be a common value of the product category, i.e. 3.6 for passenger cars (Oguchi & Fuse, 2015) and 2.4 for other products (Oguchi et al. 2006).

The total number of in-use products was calculated for refrigerators, washing machines, room air conditioners, and televisions by multiplying the number of in-use products per household and the number of households in Japan. The number of in-use products per household was obtained from the Consumer Confidence Survey by CAO and the National Survey of Family Income and Expenditure by Statistics Bureau of Japan. The data was used after being smoothed by fitting with the logistic function. The total number of in-use mobile phones were obtained from statistics by Telecommunications Carriers Association of Japan and that of passenger cars was obtained from statistics by AIRIA.

The time-series sales data was obtained from statistics by the Japan Electrical Manufacturers' Association (refrigerators, washing machines), the Japan Refrigeration and Air Conditioning Industry Association (room air conditioners), Japan Electronics and Information Technology Industries Association (televisions, mobile phones), and AIRIA (passenger cars).

A simple indicator for actual product lifetimes based on stock and flow data

We examined the applicability of the ratio of the number of in-use products against the sales in the same year (hereinafter referred as "stock/flow ratio") as a simple indicator. The stock/flow ratio was calculated by equation (3):

$$\text{Stock/flow ratio} = N_t / S_t \quad (3)$$

This ratio could be used as a simple indicator for average product lifetimes especially when the penetration of the products was already saturated because in such a case most of the end-of-life products would be generated by replacement purchases.

In this study, the total number of in-use products and the sales were obtained from the same data sources as the model calculation.

Results and discussion

Figure 1 shows the observed or estimated historical trend of the average lifetimes of the selected product types. The results generally showed an increasing trend, suggesting that the average lifetimes of the selected products have been increasing in Japan over the past few decades.

The investigation results by CAO, however, have remained stable over the years in the case of home appliances: refrigerators, washing machines, room air conditioners, and televisions. The investigation by CAO were based on respondents' memory (the answers to the question "how many years did you use your old products until you replaced it?"), whereas the other results were calculated based on actual data on collected or in-use products. The results suggested that a questionnaire survey to consumers on the discarded products may not provide precise results enough to detect the historical change in the actual product lifetimes.

The investigation by AEHA and the model calculation generally showed similar values and trend of average lifetimes for washing machines and room air conditioners. A significant difference, however, was seen for the results of refrigerators and televisions—longer average lifetimes were observed by the investigation of AEHA.

The investigation by AEHA was conducted on the collected products at the collection centers. The collected products were not necessarily representative for the entire end-of-life products in Japan because products that were not collected through the official home appliances collection scheme in Japan were excluded. For example, the exported secondhand products were excluded (if existed) in their investigation. In general, secondhand products with relatively younger age are exported, so the age distribution of the collected products at the collection center should be biased toward older direction. This could be a reason for the difference. This suggests that the direct observation of the product age of the domestically collected products would not be suitable for investigating the change in product lifetimes, for example, in the case where active export of secondhand products exists. Another possible reason for these differences is the sampling error of the sample surveys of discarded or in-use products.

The stock/flow ratio as a simplified indicator also showed an increasing trend. The calculated stock/flow ratios generally showed similar values to the estimated average lifetimes by the model calculation except for room air conditioners. Because the penetration of room air conditioners has been increasing during the calculation period—the sales includes a certain amount of sales for additional purchase—the values of the simple indicator were a few years smaller than the average lifetimes that were calculated by the population balance principle. Although the penetration has also been increasing in the case of mobile phones, the lifetime of mobile phones was short. Therefore, this effect on the stock/flow ratio was not significant and the ratios showed quite similar values to those by model calculation.

The stock/flow ratio can be calculated only from the stock and sales in a certain year (does not require time-series datasets) and therefore, the ratio can be used as an indicator for understanding the general order and the trend of the change in the product lifetimes over time when the penetration of the products is saturated. The indicator could also be used as the substitute for the average of the lifetime distribution that is approximated by a statistical distribution function.

A significant reduction in the lifetime of televisions was seen around the year 2010. This is the consequence of the transition from analog to digital broadcasting. In Japan, analog terrestrial broadcasting was stopped in July, 2011. We had to replace our old televisions that could not receive analog broadcasting with digital televisions or add external digital tuners by the shutdown date, so a significant number of televisions were replaced, making the lifetime of televisions shorter temporary. All of the measurement approaches examined in this study (except the data by CAO) were able to detect the temporary reduction (shortening) in the lifetimes of televisions due to this event.

The order of the detected reduced lifetime, however, was different by the approaches. The largest reduction was shown by the stock/flow ratio (6-7 years). The stock/flow ratio does not consider the distribution of product lifetimes and therefore, the calculated values were directly influenced by the change in the sales in the year. The sales of televisions increased 2.5 times of the year 2008, which means the stock/flow ratio was reduced to 0.4 (1/2.5) times. So, the ratio may have not reflect the magnitude of the reduction in the actual product lifetimes in this

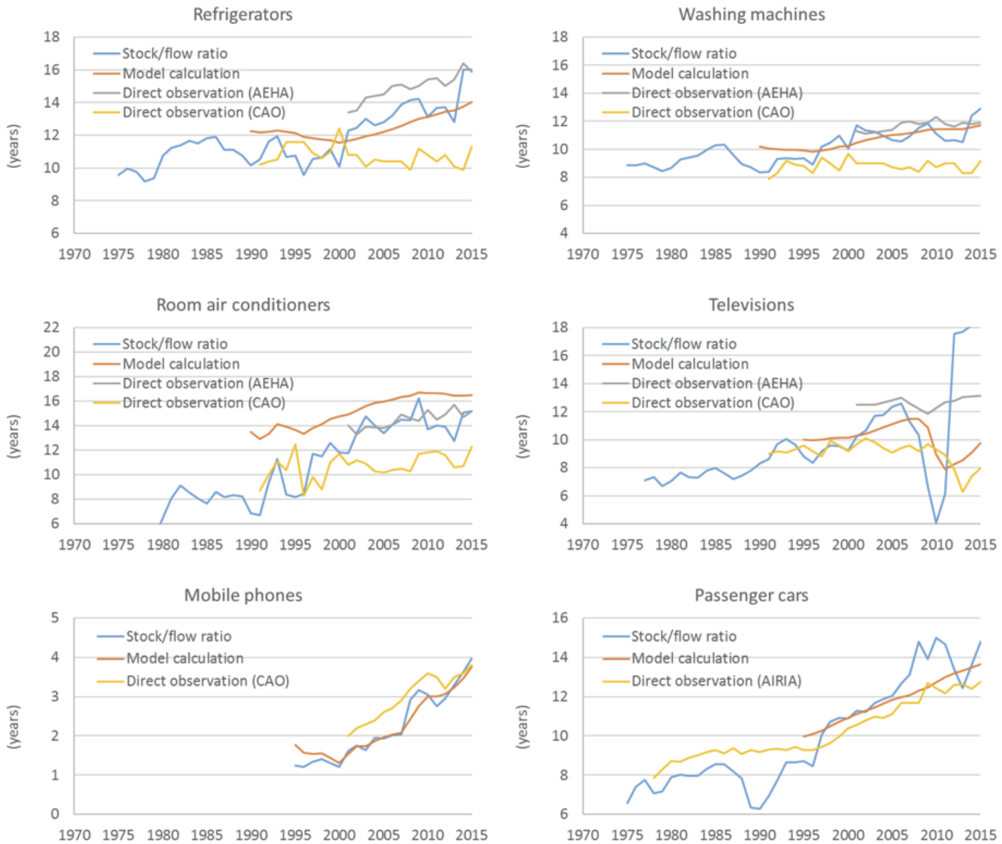

Figure 1. Observed or calculated average lifetimes by different approaches.

case. The stock/flow ratio is useful as a proxy indicator of average lifetimes of products in a steady-state, but cannot measure the temporal change in the product lifetimes resulting from big changes of social systems, economic situation, etc.

The reduction shown by the model calculation was approximately 3 years and that by the reported value by AEHA was approximately 1 year. The model calculation was conducted by assuming the shape parameter of the Weibull distribution function to be a constant value. The shape parameter is not so sensitive to the values of the estimated average lifetime (Oguchi & Fuse, 2015) under normal situation, but the shape parameter may take a significantly different value from normal situation when a big change of social systems happens such as this case. On the other hand, quite a large number of end-of-life televisions were collected at the collection center right before and after the analog broadcasting shutdown, so the product-age profile of the collected products, which were investigated by AEHA, may have been different from the normal situation. Although it is difficult to say which of the model calculation and the investigation by AEHA was more appropriate, at least a few years' reduction in the lifetimes of televisions happened around the event.

Conclusions

The present study observed the historical change in the actual lifetimes of consumer durables in Japan by three different ways; direct observation of the discarded or collected products; model calculation by using the population balance model; calculation of stock/flow ratio as a simple indicator. The average lifetimes of common consumer durables including home appliances, electronics, and passenger cars have been increasing in Japan over the past few decades.

To evaluate the trend of the product lifetimes accurately, product lifetimes need to be observed or estimated based on actual data of discarded, collected, or in-use products. Investigating the product lifetimes based on the questionnaire survey that relies on respondents' memory would not provide precise results enough to detect the historical change in the actual product lifetimes.

Calculating the stock/flow ratio would generally be useful to understand the common trend in the product lifetimes over the years when the penetration of the products is saturated. The ratio could also be used as substitutes of the average of the lifetime distribution that is approximated by a statistical distribution function.

Acknowledgments

The presented work was partly funded by Policy Study for Green Economy, Ministry of the Environment, Japan ("Investigation and Study on the stock of resources that have been accumulated in Japan").

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-324

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Room for change: impact of building-level innovations to facilitate product reuse among residents

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Keywords
Reuse
Give-away
Residential infrastructure
Waste prevention
User participation

Abstract
This article explores the importance of building spaces in residential areas to encourage waste prevention through product reuse. First, a short review is made over five existing spaces that allow residents to leave and take products to be used again by others. Then, the initial experiences of establishing such a space in the HSB Living Lab in Gothenburg are presented to complement the review. In general, the experiences of establishing these rooms for change are positive, with users making use of the space frequently. Aspects such as location and open hours are crucial to make the change-stations convenient for residents to use. Making the space available to a large group of people is important to ensure good product flow and renewal. Even though these spaces enable product exchange between users, it is not always possible to link this exchange to a measurable effect on reduced waste generation or consumption. It is not always true that the items exchanged would have been discarded or purchased if the space to change them was not available. There is an exception when the exchanged items are food, since the food made available for others to take would have been wasted otherwise.

Introduction

Choices people make are influenced by the environment in which they make them (Thaler, Sunstein, & Balz, 2010). Also, convenient infrastructure has been shown to support waste sorting behaviour (Ando & Gosselin, 2005; Miafodzyeva & Brandt, 2013; Porter, Leeming, & Dwyer, 1995). Therefore, it may be expected that convenient infrastructure might support waste prevention activities, such as the reuse of consumer products. Specifically, this article explores the potential benefits of infrastructure that allows leaving or taking products for them to be reused by a different user. Such infrastructures are refered to in this article as change-stations.

To be successful, waste preventing infrastructure should be made available where users would be likely to engage in such activities. Many studies on recycling behaviour support the same premise: the closer to home the better (Dahlén, Berg, Lagerkvist, & Berg, 2009; González-Torre & Adenso-Díaz, 2005). Also, the best place to prevent waste generation is at the source. If the goal is to minimize household waste, it would be necessary to have change-stations in residential areas. Some waste preventing strategies are only possible to achieve if they are implemented among groups larger than individual households or if facilitating infrastructures are made available for individual users (Bekin, Carrigan, & Szmigin, 2007).

Residential buildings with multiple dwellings congregate several households and users to one built infrastructure that can facilitate or hinder waste preventing activities. It is not uncommon to see that people leave books, furniture or diverse artefacts for others to take. If building managers would wish to encourage this behaviour of leaving items for reuse, they could establish formal structures for item exchange. However, there is little research about how such exchange infrastructures are implemented and maintained.

In order to explore the importance of building spaces to encourage waste prevention through reuse, this article presents a short review of cases where infrastructure located in residential areas supports the reuse of products. The review describes briefly how these infrastructures were established and maintained, as well as some experiences and recommendations that have resulted from these cases. After, this article details the initial results of establishing the Swap Cube change-station in the HSB Living Lab in Gothenburg, Sweden.

The HSB Living Lab is a five-storey building with 29 apartments and functions both as a student residence and a research infrastructure (for more about the HSB Living Lab please refer to Chalmers, 2015). Upon residents' requests and management's initiative, it was decided to introduce a space in the building to support waste prevention through re-use, called the Swap Cube. The initial experiences of having the Swap Cube running are used in this article to complement the cases presented in the first section. Together they provide a more detailed description of what to expect when making rooms for change.

Methodology

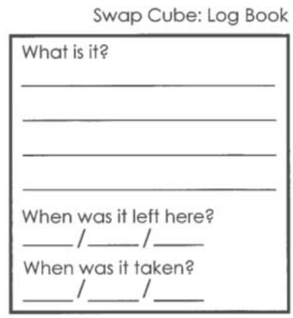
This article is informed by two sources:

1. Case studies: existing change-stations observed by the authors through study visits, interviews and written documentation.
2. Swap Cube: a change-station in the HSB Living Lab established by the authors and followed through direct observation, user surveys and a swap log.

The case studies are five existing change-stations located in residential areas in northern Europe (i.e. Copenhagen, Gothenburg and Berlin). Four cases accept common household items such as clothing, books, toys, kitchen ware, etc. One case, the Solidaric Refrigerator, is dedicated to food. The cases were chosen because the authors have personally been able to visit the sites and collected information from the actors managing the infrastructure. The choice of cases described is not representative in any way, it is merely the result of what cases the authors could visit.

The Swap Cube was launched officially together with the HSB Living Lab, in September 2016. This change-station is always accessible to the tenants of the building. It consists of a wooden frame located in a corner of a common space, furnished with shelves and a clothes hanger (Figure 1). The tenants are asked to document their use of the change-station on a paper log located in the cube (the form is seen in Figure 2).

An initial user survey was done, to evaluate tenants' predisposition and previous experiences regarding swapping, with a follow up survey and user interviews planned as part of a master thesis done during spring 2017. The initial survey consisted of 23 alternative


Swap Cube: Log Book

What is it?

When was it left here?
___/___/___

When was it taken?
___/___/___

Figure 2. Example of a Swap Cupe log form.

questions with space for comments, of which 11 were about swapping. The second survey had 26 questions (with five specifically about the Swap Cube) consisting of both closed and open-ended questions, some of which were multiple choice. Both surveys, the swap log and direct observations are used to inform this article about the results of running the Swap Cube for little less than a year.

Case studies

Change-station on Soender Boulevard, Copenhagen

The authorities of Vestebro, Copenhagen asked Naboskab to help them test a change-station in a well transited intersection of their borough. Naboskab designed the change-station using only recycled material and hired a neighbour to care for the change-station a few hours per week. Initially it was planned that the change-station would operate for 6 months, so the construction was planned accordingly. However, after launched so many people used the station, that there were several requests to keep the change-station working longer

The station is still running strong, with several dozen visitors daily. Given that the station is on the street (Figure 3), it is available to users at any time. Naboskab estimates that about 80% of the users live in the vicinity, divided into four main user groups: families with kids (~30%), elderly people (~15%), socially marginalized citizens (~20%)

Figure 1.Swap Cube in the HSB Living Lab.

Figure 3. Change-station on Soender Boulevard.

and school children (~15%). They estimate also that on average the change-station sees a flow of 150kg of items per weekday and 200kg per day on weekends (Naboskab, 2016).

Neighbourhood recycling station in Hørgården, Copenhagen

Hørgården is a residential area in central Copenhagen, characterized by a large social housing area. In this area, the commune recently redesigned together with the inhabitants, the neighbourhood recycling station. The renewed recycling station now includes, in addition to the recycling containers, an external grilling area, a volunteer bike repair shop and a change-station, which is seen in Figure 4. The change-station is open on Wednesdays and Fridays from 12 to 18 and Sundays from 10 to 16.

The recycling station workers do not maintain the change-station, users are supposed to leave items neatly placed in the space. They do have volunteer youths that help with organizing and keeping the change-station tidy as part of their work training activities. In general, the personnel considers it works well and say it is frequently visited by varied groups of users. No record of the exchanges is kept.

Reuse-house in Hisings Backa, Gothenburg

In Hisings Backa, one of the residential areas run by the housing company Poseidon, they have established what they call a reuse-house. This change-station is administrated by a motivated tenant that keeps it organized and manages the open hours. It is located among the apartment buildings, on the path between the housing area and the nearest bus stop (Figure 5).

This change-room is open a few hours once or twice a week in the evenings, when the tenant that maintains it is present. According to the housing company staff the change-station is fairly used, but has no noticeable effect on the waste volumes generated in the area. They also think the change-station would be used significantly more if the open hours where longer.

Solidaric Refrigerators in Gothenburg

This change-station started as an open refrigerator (as seen in Figure 6) located at the "Transition workshop" (a space that houses several community projects). Now they have two more open refrigerators in other areas of Gothenburg.

Basically, an open refrigerator serves as a change-station for food. The refrigerators are accessible to all public at least three times a week, depending on the open hours of where they are located. The main difference with other change-stations is that most of the items left have been recovered from dumpsters or are donated by one of the collaborating partners. Initially the Solidaric Refrigerator was provisioned with food mainly from dumpster diving , but over time the project managers have established collaborations with some stores, making the collection of their discarded food official. Both cases result in large quantities of food that can be shared with many users.

Food change-stations have higher requirements for hygiene, given that they exchange edible items. Therefore, every open refrigerator has a person responsible for cleaning it out at least once a week. Also, users of the Solidaric Refrigerator are asked to personally evaluate

Figure 4. Change-station in the Neighbourhood recycling station at Hoergården.

Figure 5. Change-station in Hisings Backa.

Figure 6. Solidaric Refrigerator at the Change workshop. © Solikyl.se.

if the food is still in edible condition before taking it, by carefully inspecting and smelling it before consumption.

Kubiz free shop, Weissensee, Berlin

This change-station is located in the cultural and educational center Raoul Wallenberg (KuBiZ), that is dedicated to host projects for social, cultural and infrastructural change. It is open on weekday mornings, as well as between 3 to 7 pm from Tuesday to Thursday.

The shop is designed as a social space where people can book it for meeting or events outside the open hours (as seen in Figure 7). Users are asked not to bring large quantities at once and to bring clean items in good conditions. If there is no room in the shop, then people should take the items back with them. This change-station depends on user donations to pay their rent.

The Swap Cube

The Swap Cube started with some items donated some of the tenants that took the initiative of starting the change-station. The first items donated were mainly clothes, interior decorations and books.

Initial survey

When launching the Swap Cube, the 33 tenants living at the HSB Living Lab at the time received a paper survey. The surveys were distributed by placing them on each floor of the building. Seventeen filled surveys were collected three weeks later.

Most respondents had heard of change-stations or similar infrastructure (10/17 respondents), but only five had used such facilities. Most respondents claimed not to exchange things with friends often (12/17), with one respondent stating that they are very protective of their things. All respondents could imagine themselves using items previously owned by others in the building, with two respondents saying that they see potential problems with swapping with people in the building. Most respondents said that they thought they would take (12/17) and leave (15/17) things in the Swap Cube. Some comments from the respondents that expected not to use the cube were that they had all they needed, or that they rather sell their items. Most respondents said they thought the Swap Cube would make them buy less things (11/17) and even reduce the waste they generate (13/17). Some concerns the respondents noted were that it is not sure they would find what they need, they had special interests and they prefer to have warranty on specific items.

Figure 7. The Umsonstladed (Free shop) at the Kubiz cultural center.

Swap Cube log book

Since established, the Swap Cube has had 65 transactions registered in the log book until the end of May. Of the registered transactions, 27 are marked both when the item was left and taken, 20 are marked only when incoming, and 18 are marked only when taken. Of the items that have both in and out registers, seven where taken on the same day they were donated. The other items vary from spending a couple of days in the change-station to several months.

The items most commonly exchanged where clothes (32 registered items), followed by household items with 13 registered items (e.g. telephone, lamps). Other items exchanged where a few books, some electronics (e.g. mobile chargers, speakers), personal accessories (e.g. jewellery, sunglasses), a desk and a board game. Noticeably, an expensive item, such as an Xbox 360 console, spend almost five months in the Swap Cube without being collected. Some days had increased activity, with single users donating several items simultaneously.

Follow-up survey

After 9 months of the Swap Cube being in operation, a follow up web survey was performed, obtaining fifteen responses. Most respondents had used the Swap Cube (i.e. 12/15), with five respondents only taking things, three only leaving things and four both taking and leaving items. Most respondents said they would like the Swap Cube to continue (i.e. 10/15), with no one directly opposing this.

When asked what has worked well, they commented that it is trustworthy, its location and convenience, it is easy to swap things and they had found some cool stuff. When asked what has not worked well, they commented that they do not get much item renewal, it seems to be a bit inactive, the offer is quite limited and there are not that many people interested in it. One respondent said that it felt too isolated to the tenants of the building, and they would rather see a solution where more people got access to the change-station.

Lessons learned

Location and open hours determine how convenient a change-station is for its users. These two aspects are critical in defining who uses the space and how often. Frequency in use is important to renew the product stock, while the characteristics of the user group will define what type of items are made available. In comparison to the cases reviewed, the swap cube caters to a small group of users, resulting in a stagnated change-station, that would need interventions to renew product stock.

The log form as it is has the practical problem that the description users leave of the items may be too generic or difficult to recognize by the future user taking the item. The authors are aware that there have probably been more interactions than the ones noted, since there are some inconsistencies in the log and with what is observed on display. Therefore, the log should be only considered as a reference of the activity that has taken place.

Conclusion

In general, the experiences of establishing change-stations are positive, with residents making use of the space frequently. Even though these spaces enable exchange, it is not possible always to link this exchange to a measurable effect on reduced consumption or waste generation. It is not always true that the items exchanged would have been discarded or purchased if the space to change them was not available. This connection is clear in the case of the Solidaric Refrigerator, however. Since the food available there would have been wasted otherwise.

There are great possibilities for supporting product reuse among users through building-level innovations. Regardless if products are designed for reuse, the presence of change-stations in residential areas has an immediate effect on users, who promptly engage in exchanging items when convenient infrastructure is available. Therefore, the idea of designing residential spaces to accommodate for product reuse should be promoted among building managers and is a relevant topic to investigate further.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-329

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Understanding the societal, entrepreneurship and economic aspects of developing a circular economy in cities: a case study of coventry in the UK

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Keywords
Circular Economy
Citizen Engagement
Grass Roots
Citizen Driven Innovation
Cities

Abstract
One of the points of agreement emerging from international environmental policy debates is that people's choices, behaviors and lifestyles will play a vital role in achieving sustainable development (Biwei, 2012; Fleischmann, 2016). There is strong evidence of the importance of a working Circular Economy (CE) to address sustainability challenges but there are different accounts and narratives in the CE literature which can cause confusion when trying to define and understand the concept. Urbanisation coupled with the fact that cities are resource inefficient (Agudela-Vera 2012) has given rise to the emergence of Circular Cities such as, Amsterdam but research to date has had a strong emphasis on the "supply side" (business, policy, science) with little attention being paid to the people or "demand side" (social, consumer). It would therefore be helpful to develop a better understanding of the role that citizens and not just City governments can play in a Circular City. To address this the paper uses an illustrative example of Coventry in the UK to examine the strategies and policy actions that drive CE relevant grass roots citizen driven practices and innovations. Through the lens of this example the paper provides insights into the role that citizens could play in developing Circular Cities through citizen driven innovation mechanisms such as social enterprise. The paper concludes that we are lacking sufficient socio-economic evidence of impact on the "demand side" and provides recommendations for further research into the social and citizen driven innovation aspects of CE relevant activities in cities.

Introduction

One of the relatively few points of agreement to have emerged from recent international environmental policy debates is that people's choices, behaviours and lifestyles will play a vital role in achieving sustainable development (Biwei, 2012; Fleischmann et al, 2016). For complex societal challenges, the line between the socio-political, technological and economic context is increasingly blurred (Fitzgerald, 2016). Circular Economy (CE) is focused on supporting sustainable development by addressing flaws in the current linear "take-make-dispose" economy. As an emerging field, the emphasis to date has been on the "supply side" (business, scientific, political). As citizens are an important consideration for achieving sustainable development, we need to balance this with a better understanding of the "demand side" (people society).

With 75% of global natural resources consumed in cities (UNEP-DTIE, 2012), policy and funding support for CE as a solution for urban settings is growing. A recent report (McKinsey 2015) estimated the CE market to be €1.8 trillion by 2030. These factors countered with socio-political and financial pressures on cities to reduce waste, pollution and related environmental concerns means that cities are starting to pay close attention to circular.

Current research and practice on circular in cities focuses on the benefits to be gained from CE frameworks, with little consensus on implementation at city level (Prendeville 2017). Most research examines the roles of government and business, with very few studies engaging citizens beyond this. A deeper understanding is needed of society's potential role within CE to demystify circular for audiences beyond academia, business and government (Hobson & Lynch 2016). This paper reviews what is known about citizens in CE and uses a case example to illustrate the value of focusing on the "demand side" of the problem.

What we know about CE

The Circular economy matters

The Ellen MacArthur Foundation (EMF) acknowledges the roots of CE as dating back to the 1970's, with seven approaches associated with this evolution. To better understand the societal aspects of CE and to pinpoint potential future lines of inquiry a synopsis of each is provided here.

Cradle to Cradle (C2C), Stahel (1976), explores how to achieve radical industrial transformation by switching from a linear cradle to grave pattern to cradle to cradle design (Braungart and McDonough 2002, 2008). C2C favours designing products that have upcycling in mind from the outset. It has gained traction with the emergence of certified C2C products. Regardless of C2C's criticism (Llorach-Massana 2015), it could offer citizens the option to support CE through choosing C2C products in their own building projects.

Stahel's (2006) *Performance Economy*, focuses on labour and small loop manufacturing for regional job creation and reducing CO2 production, but does not elaborate on how the ambitious paradigm shift could be achieved in practice.

The main authors on *Industrial Ecology*, Frosch and Gallopoulos (1989), promote consideration of the local ecosystem when designing closed loop industrial processes. The interdisciplinary routes of this field support engagement with social wellbeing, the local and regional economy. The relevance to circular in cities could be improved upon by extending the focus beyond the role of private to social enterprise and would be timely for the shrinking state, creating demand for non-state actors to address challenges, as experienced by the case study to follow.

Biomimicry looks to nature for environmentally friendly solutions to design challenges, for inspiration and innovation. Benyus (1997) promotes additive manufacturing, a key component of this papers fab lab case study, as a mechanism for realising a biomimicry approach to circular by for example, reducing the need for a supply chain by 3D printing parts in local car garages.

Natural Capitalism (NC) concentrates on the businesses that put the planet at risk by underestimating the true value of natural resources (Lovins and Lovins, 1999). NC identifies the importance of place and location, with one example being local sourcing of food.

Fullerton (2015) presents empowered participation and the role of community and place amongst eight systemic principles of the *regenerative economy*.

Pauli (2009) argues that the green economy lacks significant momentum because it only works for the rich. He proposes a *Blue Economy*, with more focus on the local environment and on valuing resources.

As these competing narratives describe CE from different theoretical perspectives and standpoints, they can be difficult to reconcile. However, it is notable that they give relatively little attention to the social aspects of CE. While some of the authors engage to a limited degree with the role of citizens in CE, others do so to a much lesser extent. Although the social context for CE is messy and complex, greater attention needs to be given to understanding the demand side's role in developing circular cities.

The societal "demand side" of CE

Despite a call for more citizen engagement in CE (Hobson, 2016; Prendeville et al, 2017), very few empirical studies have examined where and why citizens engage in CE. Of the larger studies that do exist, many come from China, so their relevance could be questioned. Notwithstanding these concerns, these studies highlight the need to focus on the role of the citizen (Biwei, 2012; Hobson 2016). This focus aligns with other calls for a wider systems perspective of the problem (Webster, 2013) and for greater attention to the social aspects (Hobson and Lynch 2016), to establish a more inclusive CE culture. Existing examples of CE citizen engagement, such as in citizen innovation spaces; living labs and Digital Fabrication Labs, offer a rich source of insight into the issue.

Following The Helsinki Manifesto (November 2006, Finnish EU Presidency), which supported citizen centred innovation through Living labs (user-centred, open innovation ecosystems based on a systematic user co-creation approach), citizen-driven innovation quickly developed. Strategic policy initiatives and funding streams, emphasising the human and social aspects needed to speed up innovation followed. The role of citizens as the driving force for urban innovation came to the fore (Eskelinen et al 2015), as Steiner et al. (2015: 160-161) explain: *"Combinations of both top-down interventions and citizen-driven innovations will likely lead to more sustainable crises resolution than either approach alone"*

Citizen-driven innovation is most prominent in cities and mostly responds to societal challenges. This is evidenced in the analysis of citizen "prosumption", which reflects the interrelated process of production and consumption (Ritzer, 2014). Such as in citizen engagement with renewable energy and smart grids (Rathnayaka, 2014), where citizens are encouraged to produce energy to reduce their tariffs whilst also supporting their local environment. Increasing knowledge on how to engage more citizens in this type of "prosumption" at scale, could allow ambitions for circular cities to be more easily realised. Taking an in-depth view of specific examples of citizen engagement in circular economy already in operation, is likely to offer useful insights for engaging citizens more widely in CE (http://sustainablefoodcities.org/about).

Over the past decade cities have strived to become more sustainable through implementing policy and investing in smart cities, sustainable cities, eco cities and others. While these approaches represent better governance and tighter legislation, their success has been limited due to a lack of attention to socio-political mechanisms (Prendeville, 2017). Da Jong (2015), for example, excludes circular cities from his study, citing a need for more nuanced and rigorous research to increase confidence that a circular city approach can benefit urban sustainability. Uncertainty about the fit between the "supply" and "demand" sides of CE are at the heart of the problem. Although systemic views of CE acknowledge the role of consumers, these approaches typically take a top-down view that do not fully engage with the social side of circular. More therefore needs to be known about the contributions that citizens can make to circular through different types of grass-roots activity, or of how those contributions fit within the CE approach. The Fab Lab Coventry case, a digital fabrication laboratory that the lead author helped to establish and support, reveals the potential of citizen innovation for CE.

Coventry City and Fab Lab Coventry

An exploratory case study approach was used (Yin, 2009) to provide a review of several community activities, including Fab Lab Coventry. The case builds on a literature review of the recent emergence of circular transition cities. After reviewing the role of citizens within this context, a desk-based investigation was undertaken that explored the underlying socio-economic drivers in the city. The investigation examined the most relevant local strategies and reviewed existing engagement policies and practices. The aim was to understand the factors likely to support the development of CE through community-led grass roots innovation. The researcher also attended community events/workshops, to observe the development of these initiatives, keeping a journal of observations to draw out common themes and recommendations for further investigation and analysis.

Context of Austerity

A main contextual factor emerging from this data gathering, was the severe austerity measures being implemented in the city. As a response to the global financial crisis of 2007, the former UK Conservative led coalition government ushered in a new 'age of austerity' (Cameron 2009). By 2020, Coventry will have suffered a 55 per cent reduction in its grant from government since 2010, equivalent to £120 million a year (Coventry city council 2016). By 2020, the council will only be able to deliver statuary services (Gilbert 2016), leading to the closure and consolidation of libraries and centralisation of services (Hastings et al 2015). This depressing economic climate was the context for establishing a growing number of grass roots community initiatives, such as Fab Lab Coventry.

Coventry Programmes, practices and policies of relevance to citizen driven innovation

Reviewing the City's post austerity measures (see Cultural strategy 2017-2027, Digital Strategy 2017, Local strategic economic plan and Climate Change Strategy to 2020) reveals an ongoing ambition for the city's socio economic growth. Each of the strategies consulted advocates a strong role for citizens in achieving the economic vision, and puts structures, processes and funding in place to support citizen driven innovation. For example, the climate strategy advocates the transfer of green space to local community growing schemes and the cultural strategy celebrates the transfer of city assets, such as tourist attractions, to citizens/community groups. Political leadership for these schemes is provided through Councillor Faye Abbott.

Common, practices, policies and infrastructure in the city that are of relevance to CE include 'proof of concept' funding to support the setup of new social enterprises with an environmental purpose. Examples include volunteers from Coventry Foodbank setting up a community shop to take food waste from local supermarkets and retail it for 10% of the original price to those experiencing food poverty; and a local enterprise looking to fund the upcycle and sale of clothes from local clothes banks. To grow this type of citizen activism, the City Council and Coventry University have worked with the UK Government to establish the city as a nationally accredited Social Enterprise place. Fab Lab Coventry (FLC) was set up with support from this initiative.

FLC is a socially driven digital fabrication laboratory in the heart of the city centre. It was set up in partnership with Coventry University, the University of Warwick and the City Council.

Two thousand local people and organisations co-created the FLC space and operations. FLC opened in an un-rentable shop in the city centre and attracted skilled volunteers, who built the space and made furniture from waste materials. The space opened in August 2016, and by June 2017 was attracting an average of 100 people per week, working on their own projects; learning about new technologies, woodworking, robotics or attending the repair cafés. The FLC repair cafés "(Figure1.)", are attended by people aged 5-70 and have attracted local

Figure 1. Repair café at FLC.

media attention, including being featured on the regional BBC news programme, *Midlands Today.*

While parents and the older population are the most enthusiastic about the repair café, younger participants also enjoy them. They may not be 100% convinced that they should repair toys instead of getting new ones, but they do acknowledge their pleasure at being able to fix their favourite fidget spinners, Lego or toy cars. As one enthusiastic 9-year old attendee explained: *"it's my favourite toy and I can go the fab lab to get it fixed cus they don't sell them in the shop".*

FLC also runs fun social activities to engage citizens in CE. A recent cardboard car race run in collaboration with local arts organisations, promoted a fun way to use recycled cardboard "(Figure.2)". This initiative was a mechanism for encouraging upcycling and use of a local social enterprise called crowrecycling.co.uk.

The role of everyday activism and grass roots innovation in spaces like the community based fab labs offers clear potential to support the development of a circular economy in cities.

Conclusions

This paper has revealed a number of aspects that merit further consideration in building understanding of the development of CE in cities. Firstly, despite widespread agreement that CE matters, it can be difficult to reconcile different narratives about how it is constituted. Secondly, there has been a heavy emphasis on the "supply side" aspects of business, policy, technology and science, with less attention to the "demand side" societal aspects. Thirdly, the illustrative example of Coventry shows an opportunity to involve social entrepreneurs and what we might term CE practitioners. For example, while questions might arise about whether it "fits" CE, FLC represents the type of space that can support circular. This raises questions about how the CE lens could be widened from a "supply side" focus to more proactively encourage the efforts of the grass roots "demand side". The need to engage people in sustainable development is one of few points of agreement within international environmental policy debates (Fleischmann 2016), so this should certainly be factored into a city's transition to CE.

Figure 2. Wear your wheels.

Fourthly, the role of citizens has had little attention within CE. To address this, we need to know more about the role of people, the differing social contexts, and the types of initiatives and roles that citizens play in everyday activism and in driving innovations that might be considered part of a CE framework. Citizen-driven innovation in the context of austerity has grown in Coventry out of necessity, but this may not translate to other countries that have a stronger welfare provision.

This cross-national dimension also merits further investigation. Social enterprises and participatory spaces such as FLC might be part of what is needed to achieve CE in cities. However, a better understanding is needed to unpick their potential role. Further empirical studies should be commissioned to explore the role of place within CE, building on work in other contexts (e.g. O'Connor 2010).

Finally, reflecting on the potential role of citizens within CE and on mechanisms to achieve wider societal engagement such as smart grids, cities digital fabrication labs and repair cafes, whether citizens want to play a role in CE should be considered. The extent to which citizens need to know more about CE is linked to this question.

What is clear from the literature and illustrative study in Coventry is that to support cities on their journey towards the next phase of CE, more research is needed to consider the "demand side" and to improve our understanding of socio-political factors, citizen empowered participation and activism.

Acknowledgments

The author would like to thank Coventry City Council, the City University Initiative and Fab Lab Coventry team for their collaboration.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-334

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Exploration of the ways of empowering people in the design process through product personalization for prolonged product lifetimes

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Keywords
Product personalization
Localization
Design for sustainability
Research through design
Generative research

Abstract
Product personalization has many potentials in extending product lifetimes and sustainable consumption, through strengthening the emotional bond between people and their products. In addition, production and post-use of products need to be considered in the design process to develop design solutions in line with sustainability principles. Product personalization is defined in the study as, a process during which a product's aesthetic and functional attributes are defined, adapted or modified by the user during design, use and post-use stages of the product lifespan. To increase a product's personal relevance to its user, during the process of personalization, user is involved as co-designer and co-maker of the product. In this study, product personalization is discussed within the local context via empowering local skills and knowledge and enabling the use of local materials and production techniques. The ways of enabling people in the design process through product personalization are explored via research through design approach. Firstly, a lighting design exploration is developed based on the design considerations emerge from the personalization and sustainability literature, and an online survey exploring people's reasons and methods of personalization. This design exploration is further developed through three generative sessions during which the participants personalize the design exploration, record and share their experiences in the personalization process, and thus theoretical ideas are refined. The results of the study reveal that, people's needs for personalization, their skills and motivation levels and ease of re-personalization during use phase need to be considered during design process, and these design considerations are interrelated.

Introduction

Prolonging product lifetimes is crucial for sustainability and design, since production of new products requires new resources and energy, and premature or rapid product replacement increases waste, which has environmental, social and economic implications. Product personalization is one of the strategies proposed for a long-lasting person-product relationship, since it strengthens the emotional bond between the person and the product (Niinimaki and Hassi, 2011; Fuad-Luke, 2010; Van Nes, 2010; Mugge et. al., 2005; Chapman, 2005; Cooper, 2000). When this bond is strong, person's attachment to the product more likely postpones product replacement through enabling behaviors such as repair, care and maintenance (Schifferstein & Pelgrim, 2008). When personalized, a product gains a personal touch, and may represent its owner's personal accomplishment and identity (Mugge et. al. 2005). In addition, person's creative and physical involvement in design process embeds personal stories into the product making it unique for its owner (Fuad-Luke, 2009). In this sense, enabling people to personalize their products has many potentials for longevity, as they may become irreplaceable for their owners.

Blom (2000) defines personalization as changing a system's aesthetic or functional attributes to increase its personal relevance. In this study, product personalization means defining, adapting or modifying a product's aesthetic and functional attributes during design, use and post-use stages to increase its personal relevance, and user is the co-designer and co-maker of the process.

While personalization may contribute to sustainable consumption in terms of product attachment, the production should also be in line with sustainability, since both efficiency and sufficiency approaches should be considered to address short product lifetimes (Cooper, 2005). In this sense, a more localized production and service system predominantly depending on local materials, resources, production techniques and post-use services is crucial in empowering local skills and the capabilities of people, production at various production levels (e.g. mass, batch and craft), and more flexible, adaptable and upgradable products tailored to diverse local needs and tastes (Doğan and Walker, 2008). Design for personalization and sustainability can be the key to achieve this.

Although many contemporary products do not enable personalization, people can personalize products in a range of practices such as mass-customization, unique customization, Do-It-Yourself (DIY) and open design. However, customization practices do not guarantee emotional attachment, since selecting from predefined options may not be enough to make a product personal (Norman, 2004). Their implications for sustainability are also questionable, since the main concern is consumption (Doğan and Walker, 2008). Similarly, sustainability may not be the main focus of DIY and open design, although people are more actively and creatively involved in these practices. Besides, researchers propose approaches enabling product personalization such as half-way design (Fuad-Luke, 2009) and locally tailored design explorations (Walker, 2006), where sustainability is the main focus. However, the implications of personalization at the local context for sustainability with a focus on people's interaction with products enabling this adaptation have not been widely researched. This study aims to fill this gap, and more specifically, explores the implications of product personalization for sustainability through the development of lighting design explorations that can be personalized, locally produced, maintained and upgraded through generative sessions.

Methodology

This study adopts research through design approach, during which design considerations emerged from literature review and an online survey led to the development of a lighting design exploration. This has been developed further through three generative sessions during which participants personalized it. In this process, theory and design mutually inform each other, and generative research approach is used to refine and develop them further. Figure 1 presents the research procedure.

Design considerations

In the study, product personalization is explored through lighting category, since it is convenient in exploring local skills, use of local materials and production techniques, and easier to personalize compared to other categories (e.g. furniture, electronic products, etc.).

For the initial design exploration, design considerations were derived from the dimensions of product personalization (Mugge et. al., 2009a), sustainability literature and the online survey. Among the personalization dimensions listed by Mugge et. al. (2009a), *mental and physical effort, flexibility* and the *goals of personalization* are prominent for this study. The *mental and physical* effort invested during personalization is effective in strengthening person-product relationship (Mugge et. al., 2009b). However, too much mental effort during the personalization process may increase task complexity, and thus Mugge et. al. (2009a) propose to determine the personalization options considering the target group's skills and motivation. *Flexibility* is the product's flexibility for personalization for several times, and Mugge et. al. (2009a) indicate that, products that are less susceptible to fashion changes can be created through this. If personalization takes place both in the design and use phases or post-use phase, the product can be adapted to changing needs and tastes, which may prolong product lifetime. The *goals of personalization* are defined as utility-related and appearance-related goals, which may be valuable for understanding people's personalization needs. Mugge et. al. (2009b) suggest that, personalizing a product's aesthetic features, rather than its functionality, makes a person's identity more visible to others, strengthening person-product relationship. In the design process, user's active mental and physical involvement, the integration of local skills into the design exploration and local production with locally available materials were also considered.

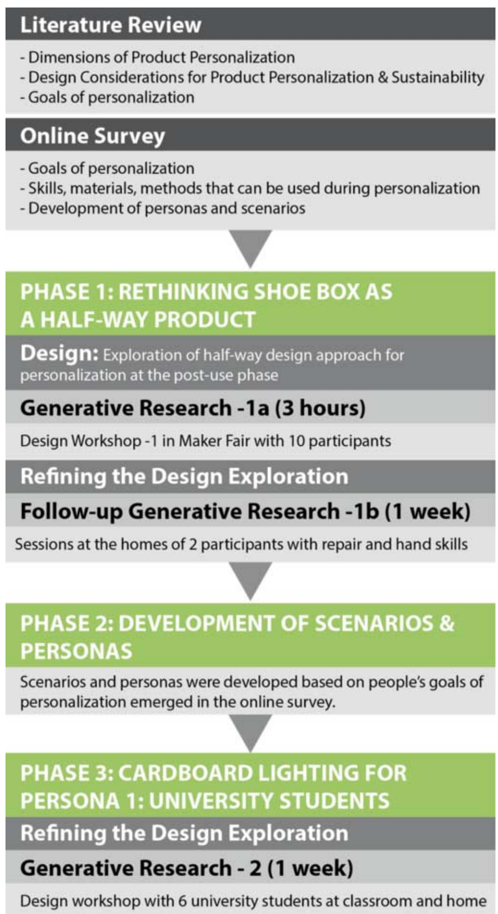

Figure 1. Research Procedure.

Online survey

In the study, how and why people personalize their products was explored through an online questionnaire. The questions included personalized product categories, methods and reasons of personalization and product parts and materials used during personalization. Through criterion sampling, only people who personalized their products participated in the research. 17 people provided 42 personalized products. Participants' responses were analyzed based on the dimensions of personalization through content analysis.

The local skills that could be enabled during design process emerged as sewing, glass painting, wood ageing, wet felt and patchwork. The methods of personalization involve re-using, integrating various products and/or parts, and surface treatment. The most significant outcome of this study was people's goals of personalization (Figure 6) for understanding people's personalization needs and generate design scenarios and personas in Phase 2.

Phase 1: Rethinking shoe box as a half-way product

This phase explored how a half-way product enabling personalization could be designed, the type of design details needed for personalization, and how the generative session procedure should be.

Development of the Design Exploration

Since the reuse of cardboard boxes was one of the most common ways of personalization in the online survey, reusing a shoe box was considered in the exploration. To enable personalization, holes were drilled on the edges of the boxes to help people design the shading via either passing ropes through the holes or attaching materials to the holes using metal rings, and electrical parts were attached on the boxes (Figure 2).

Phase 1a: Design Workshop

This phase aims to evaluate and improve the design exploration through analyzing the products personalized by people, and gain insight into the generative session setup. To recruit people with high motivation for personalization, a maker fair was selected as the research setting. 10 people with different skills and at different ages (between 9-40) participated in the workshop. In addition to shoe boxes, various textiles, ropes and ribbons, beads, stapler and metal rings for joining the parts, and scissors, rulers, pens, cutters and punchers were provided. The participants were asked on the lighting's purpose and the context of use, their thoughts about the personalized product, and the problems they encountered during this process.

Phase 1a: Results

Figure 3 presents the personalized examples. Since the material was re-used cardboard, people spent time to cover its defects, and some of them also covered the holes or only outer surface of the boxes. Only two participants used the holes to create a shading. This would imply that, the part to be personalized was not clearly defined. In addition, the duration was short to fully investigate the personalization process and people might be affected by each other's process.

Considering these findings, the body holding the bulb and the shading to be personalized were separated. In this way, the participants could more focus on the parts to be personalized, which were two box covers with holes and apertures (Figure 4). These covers were placed at the front and back sides of the body. Moreover, new cardboard was used, the socket was placed in a housing with properly managing the cable to improve it aesthetically.

Figure 2. Half-way design exploration.

Figure 3. Personalized examples.

Figure 4. Personalized examples.

Figure 5. Personalized design explorations.

Phase 1b: Follow-up generative session

In this phase, the effectiveness of the improved design details and the research procedure were evaluated. The generative sessions which lasted one week were conducted at the homes of one male and one female participants at the age of 60, who have repair and hand skills respectively. The participants were asked to personalize the design explorations using the materials available in their home environments. The participants used diaries and took photographs to document their process followed by semi-structured interviews.

Phase 1b: Results

Figure 5 shows the personalized design explorations. The holes were used in only one of the covers to create a shading by Participant 1 who made aesthetic interventions on the exploration. Participant 2 with repair skills made functional and aesthetic interventions through integrating mass-produced re-used parts and using the holes for decorative purposes.

Although the participants enjoyed personalization process and the design exploration enabled them to integrate their skills, they did not prefer to use these personalized explorations at home due to their home-made look. In addition, the holes would only allow the participants to insert ropes, and in order to attach sheet materials, they had to use adhesives, which decreased the flexibility of personalization. Besides, the structural variety was limited, which might be preferable for people with repair skills such as Participant 2. The results looked more improvised, since this phase lacked a defined scenario for personalization such as enabling specific skills. To address this, design scenarios and personas were generated based on the people's personalization goals.

Phase 2: Development of personas and design scenarios

People's personalization goals and the products in the online survey were analyzed based on the product lifespan phase that personalization occurs (Figure 6) to understand the personalization process more clearly. This analysis revealed that certain groups of people had similar goals for personalization.

Based on this, two design scenarios and personas were developed:

Figure 6. Goals of personalization.

- Personalization in the post-use phase due to cost constraints for university students with limited income and staying in a shared house.
- Personalization through enabling a craft skill of people attending a craft course and being interested in DIY. In the following section, design exploration developed for the first scenario along with the generative session are explained.

Phase 3: Cardboard Lighting for Persona 1

The important design considerations for this scenario were enabling simple interventions without too much mental and physical effort and/or specific skills, since university students may not prefer spending too much time and effort to engage in such a process, and they may not have expertise in making things. Enabling the reuse of material and/parts and designing an affordable product from available materials (e.g. cardboard) were considered important for this scenario. The number of surfaces to be personalized was increased to increase the level of self-expression. Two design details were developed for creating a shading to explore the potential of various details in enabling personalization. Sheet materials such as paper, fabric, etc. could be inserted on *shading A* through cutting materials using a cardboard template, and inserting these through the slots on the shading. *Shading B* enables inserting ropes through the holes. Binding

Figure 7. Initial toolkit for Scenario 1.

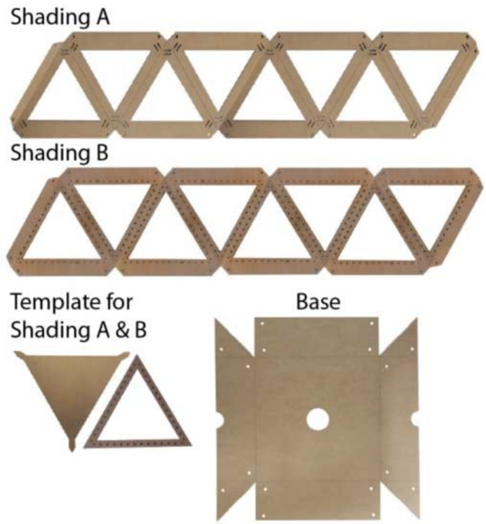

Figure 8. Final toolkit for Scenario 1.

screws were used for combining the shadings and the base. The initial design exploration (Figure 7) consisted of separate rhombic shadings; however, it required too many screws, and physical and mental effort. Thus, the design exploration was simplified as in Figure 8.

Phase 3: Design Workshop for Scenario 1

In this phase, the effectiveness of the improved design details along with revised research procedure were incorporated. It involved two phases; a half-day design workshop in a classroom and 1-week personalization and use phase at home setting. 6 university students sharing their homes with their friends participated in the study. In workshop, the students were provided with the generative toolkit, diaries and materials for personalization such as old magazines, fabrics and ropes. During that, they became familiarized with the toolkit, and then, they were asked to personalize the design exploration using the materials available at their homes. At the end of one week, they brought back the personalized designs, the diaries and the photographs of their process, and semi-structured follow-up interviews were conducted.

Figure 9. Examples of personalized products.

Phase 3: Results

Figure 9 shows the personalized product examples. All participants incorporated reused or repurposed materials for shadings. Although the shadings were all different, the structures were the same for all. A balance between task complexity and structural variety can be explored in the subsequent phases. Most students considered color and pattern harmony between the shadings and the cardboard structure. All students could easily personalize Shading A, while having difficulty in personalizing Shading B, since the hole size was limited, and the procedure was time consuming. In addition, the photographs revealed that, they explored different shadings on Shading A, while personalizing Shading B only once. Some students attached personally meaningful things on the lighting such as a souvenir and a part of pillow case from the childhood. In general, changing the shadings during use phase appeared to be difficult. In the subsequent phases, ease of re-personalization needs to be considered. The research procedure should be rethought, as the students were limited with the materials provided in the half-day workshop. For future workshops, no material could be provided to not to affect the creativity of the participants. Although the use phase could be explored to a certain extent, the procedure could be extended to see the changes (if any) that the participants make during that phase over the long term.

Conclusions

In the study, the ways of empowering people in the design process with product personalization was explored through research through design process. Design for product personalization in line with sustainability criteria requires the integration of localization in the design process (Ozan and Doğan, 2014). Therefore, designers need to consider both dimensions of product personalization (Mugge et. al., 2009a) and the use of local skills, materials, production techniques, and post-use services in the design process. In addition, people's personalization goals and practices provide insights for understanding their needs. All the design explorations in the study required certain level of mental and physical effort. As Mugge et. al. (2009a) stated, required effort and task complexity needs to be balanced according to the skills and motivations of the target group. For instance, the students did not explore different shadings with Shading B, since it was time consuming to personalize it. This may affect the flexibility of personalization, since people may not want to personalize a product for the second time, when the personalization task is complex. Moreover, ease of re-personalization in the use phase is a significant criterion for longevity, since this enables people to adapt a product to their changing needs and tastes. This requires design details enabling ease of attachment and detachment. The online survey reveals that, people can personalize products for more than one reason. For instance, when a product is personalized by reusing a material which is also meaningful to its owner, repurposing and keeping memories alive would come together. To this end, designers could consider the combination of personalization goals of people, while designing for personalization. The scenarios in the study highlight specific design considerations for sustainability such as the use of materials in the post-use phase, local skills, etc. The improvised and fresh outcomes in Phase 1 and 2 reveal that, integrating these considerations into design process becomes more meaningful, when the target group is selected accordingly. Certainly, longer studies should be conducted to observe people's experiences with the evolving and adaptable design exploration in the use phase, and to see the implications of personalization for product lifetime over a long term. People's personalization experiences in the use phase would eventually reveal new design considerations for designing for product personalization in line with sustainability principles.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-340

Towards a typology of waste in fashion practice: an Australian perspective

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Keywords
Waste
Fashion design
Textiles
Australia

Abstract
Waste in fashion is a material problem as well as a cultural condition. In this paper we offer a cultural perspective on waste transformation in fashion practices: what happens to waste, rather than where it goes. We propose states of transformation of waste: disguise, elevation and enchantment. These states are not a hierarchy but rather a typology to consider the kinds of material and cultural transformations that waste undergoes when revalorised through fashion practice. The study centres on the Australian context, and seeks to examine the ways in which Australian fashion retailers, designers, and community groups are engaging with clothing and textile waste. We identified forty-seven initiatives and explored their approaches to waste transformation. Through selected vignettes, this paper examines both the material processes and symbolic meaning behind the approach and its messaging, and offers reflections on the ideas of waste that emerge. Selected examples include large fashion retailers, independent and experimental fashion practitioners, and grassroots campaigns by local charities. Looking beyond the practical approaches to waste management, such 'reduce, reuse, recycle,' or the waste hierarchy, we explore ways in which these practices may 'disguise' waste, 'elevate' waste, or 'enchant' waste. Through this analysis, we argue for a perception of waste beyond that of inevitable by-product of the industry, towards waste recast as a potent force of loss and renewal.

Introduction

Drawing from various disciplines, including material culture studies, fashion theory, and anthropology, this paper develops a typology of waste in fashion practice in order to conceptualise waste as both a cultural and material force. By using the term 'fashion practices' we seek to accommodate not only production and design practices, but practices by fashion's wearers. This study extends our prior research proposing a waste typology (Binotto & Payne, 2017) through applying these ideas to the Australian context. In order to examine waste within Australian fashion practices, we drew upon multiple sources including magazines, newspaper articles, reports, social media and retailer websites in order to identify ways in which waste is utilized and represented (see Appendix 1, Table 4). These examples we assembled into vignettes of fashion practice: examining communication of waste among retailers, independent practitioners, community groups, and makers, with full lists provided in Appendix 1, Tables 1-3. The reflections on practice draw on theories from Bennett (2001), Hawkins (2006) and others to examine how these practices may 'disguise', 'elevate', or 'enchant' waste.

Defining waste and waste making in fashion

Waste

The term 'waste' encompasses a range of meanings. Put simply 'waste' refers to "discarded, expelled, or excess matter" (Hawkins, 2006, p. viii). 'Waste' can denote a loss of value in material, practical, or symbolic terms; things can deteriorate, become useless, or lose significance. Hence determining something to be 'waste' involves making value judgements according to notions of order, "that change historically and differ from one culture or group to the next" (Hauser, 2002, p. 40). 'Waste' is therefore a state that things can move in and out of depending on context and according to who is judging. In this understanding, following anthropologist Mary Douglas (1966), the state of 'waste' is a category of judgment within a system of classification intended to establish order. Douglas considered it the nature of society to create categories for things according to systems of order, with 'waste' (though Douglas used the term 'dirt') being a category for matter that is "out of place" (1966, p. 36). Waste as matter "out of place" is therefore an inconvenience: it lingers, no longer needed or wanted. Waste needs to go or be put somewhere.

Fashion as waste making

Waste-making is central to the workings of the modern fashion system - from design development to production, consumption and disposal – and waste-making keeps the system in motion, relying on new to replace old (see Calefato, 2004, p. 123). Although no biological or human-designed system can exist without waste (Moser, 2002, p. 102), the contemporary fashion system is predicated on its production. Stylistic changes and the desire for newness keeps the fashion system in motion, with aesthetic devaluing of garments occurring as they are replaced by new trends and styles, particularly so in the era of fast fashion (Entwistle, 2009). In this context 'waste' is linked to practices of excess and abundance - wasteful behaviour - and is particularly significant to the problem of waste in contemporary first-world consumer societies.

Different types of waste may be created through fashion design process, whether energy expenditure, pollution and depletion of finite resources for fibre production and manufacture, textile scraps, offcuts and overproduction of stock, or prematurely discarded items that end up in landfill. As discussed elsewhere, waste may be nourishing, not only polluting, as fashion's creative excess can be harnessed and transformed into fresh ideas, and discarded clothing can be made new by wearers' revalorization (Payne, 2012).

Given the large volumes of post-consumer waste, repurposing this waste in fashion practice appears as the pragmatic, sustainable approach for designers. Recycled goods use less water and other inputs, and reused clothing can reduce energy by between 60 and 90 kWh per kilogram of fibre (Woolridge et al, 2006). That said, the scale of garment consumption and disposal is so far beyond the ability of recyclers to keep pace that recycling and recapturing waste is no long-term solution, but may simply "appease the 'green' conscience of another consumer" (Boscagli, 2014, p. 257). Rather, fashion's waste problem is systemic and related to wider economic goals that are incompatible with sustainability (Fletcher, 2011), and therefore profound shifts in thinking are required of individuals, industries and societies. However, in presenting a cultural typology of waste, we focus less on the functional aspects of utilizing waste, important though this is, and more on the social transformation that the waste undergoes. We propose three states that demonstrate what happens to waste when transformed by fashion practice, and in the following sections we discuss these with examples from waste in fashion practices in Australia.

Fashion and waste thinking

Australia and fashion's waste

Issues of overconsumption and textile waste are common to many developed, high consuming nations. However, in Australia they are thrown into stark relief. Australia has a small population over a large land mass, a hollowed-out manufacturing base and a high consuming, first world customer base seduced by low-cost imported fast fashion products.

Australians discard an estimated $140 million worth of clothes each year, with an average lifetime of three months per item (Ragtrader, 2014). Over 500,000 tonnes of textiles are annually sent to landfill (ABS, 2013). Fast fashion revenue in Australia rose 21.5% annually 2012-17, as since 2011 the overseas retailers such as H&M and Zara arrived in what was hitherto a market ignored by global retailers (Magner, 2017). With the increased speed of fashion production is a commensurate increase in textile waste to landfill. As reported by Leggatt-Cook et al (2017), Australian charities take the burden of the bulk of the waste or discarded clothing. They are struggling under the challenges of poor quality donations with high synthetic fibre content, and the traditional cotton ragging is growing more difficult. A portion of donated clothing goes to landfill, but much is also exported offshore (Press, 2017).

Within this context, post-consumer textile waste is recognised as a challenge and receiving increasing attention from industry, government and the media, for example, the War on Waste television show (2017). Despite growing public awareness, collaborations to promote garment durability such as the Sustainable Clothing Action Plan (SCAP) in the UK are not present in Australia. Instead, Australian charities and municipal councils are at the coalface of managing increasing volumes of textile waste. Although practices engaging with waste in fashion remain niche, we identified many examples of Australian initiatives (see Appendix 1, Tables 1-3) and below we describe several of these.

Disguising waste

One of the most common approaches to transforming waste is through utilising textiles developed from recycled feedstocks. With fabrics from recycled fibres, the fabric looks new and feels new, and it is only the communication around the product that reveals it as being made from waste: whether waste fabric, waste bottles, waste nylon fishing nets. This production method disguises the waste so that it may pass for a 'new' product. This mode of recycling can be seen as having a 'disguise' and a 'reveal', reminiscent of a magician's conjuring trick in which the new is revealed to be the old. The consumer is confounded to think that the puffer jacket was once coffee grounds, or that the swimsuit was once a nylon fishing net. In recycling of this nature the waste is captured and utilised, revalorised, but it is only through the storytelling around the object that its material origins are revealed. Yet as Boscagli (2014, p. 258) notes, industrial recycling of this kind may "alienate the object from its temporal and human context, its political economy, and its past."

Australian independent designers and mass-market retailers alike are increasingly including disguised recycled materials in their product lines. At the mass-market level surf brand Billabong's Recycler board shorts are made from recycled plastic water bottles, more than 80,000 of which have been redirected over from going into the ocean or landfill (Billabong, 2017). Footwear brand Kustom uses recycled rubber off-cuts for the soles of limited edition boots created in collaboration with conservation group Sea Shepherd. In these examples both board shorts and boots show no visual clues to their origin. Another approach to 'disguise' is that of using dead stock and pre-consumer waste offcuts, an approach taken by The Social Studio and many others. These fashion collections are produced in limited runs or as one-off designs. Again, the garments appear new, and only through the brand's communication is the clothing revealed as being made from industry dead stock or end-of-roll fabric.

Independent designer Rachael Cassar creates couture pieces from the fabric of secondhand garments through a process of deconstruction, redesigning and reconstruction. Through the creation of one-off, highly embellished pieces that are not trend-based, Cassar gives old and unwanted materials a new life and long-term value. Though valuing the humble origins of her materials Cassar's upcycling methods, which include over dyeing, can also disguise their provenance. Drawing from Lucy Norris (2005, p.101) who suggests the transformative value of cloth and second-hand clothing lies in the "ambiguities of its material properties, its colour, its strength and fragility, its capacity to absorb, to reflect, to be cut and restitch[ed]", Cassar takes advantage of the materiality of old clothes and fabric employing processes which disguise and transform in order to create unique showpieces with a story.

The notion of disguise becomes more ambiguous in the second-hand markets and vintage clothing shops in which donated or end of season clothes can be transformed back into fashionable attire, becoming 'as new'. Strategies of presentation and display of second-hand goods can work to create value in different ways and according to how the experience of shopping is valued for the consumer (Gregson & Crewe, 2003). Charity stores such as the Salvos style second hand clothing into on-trend looks, producing photoshoots and styling 'how tos' to promote the aesthetic revalorization of the wasted garments.

Elevating waste

A second stream of 'what happens' to waste can be seen when the waste is transformed into a new item, but its material origins as waste remain visible. The wasted object or item may be recontextualised, without changing its form, or it may be upcycled into a new object in a way that celebrates its past life. These practices 'elevate' rather than 'disguise' waste. Visible traces of a wasted or even abject item transformed provide the biographical insight that elevates waste, giving a value to the new product as well as revaluing the waste that was transformed.

The deconstruction of old clothes into new fashion has a long lineage in fashion design practice (Gill, 1998). In the Australian context, bikini designer Paula Stafford produced bikinis made from tablecloths and carpet in the 1950s (King, 2013), and in the 1970s designer Jenny Bannister reworked old khaki uniforms, in two of many examples. The upcycled design aesthetic, in which shapes or elements of the original garment are evident, is integral to the value of the new product. This kind of visible transformation is also a magic of designer conjuring. However, upcycled garments may not always be more valuable or successful than the original reclaimed garments. The elevation of the waste garments occurs through the cleverness in execution and the aesthetic success of the transformation: the success of which is highly subjective.

In what has been a long term global trend, many independent designers capture waste streams of pre or post-consumer textile waste, however it is those using post-consumer waste that are mostly likely to elevate the waste through transformation. Australian examples include Nawato, using mending and patchwork strategies to embellish and deconstruct denim jeans, or Studio Mücke, deconstructing men's shirts to create womenswear. In Author 2's own work for label Maison Briz Vegas, secondhand t-shirts are collected from flea markets and op-shops, dyed, unpicked and patched into lengths of fabric that is re-cut and sewn into new garments that indicate a former life. Maison Briz Vegas also transforms generic consumer waste such as jar lids, plastic bags and plastic bottles into garment embellishments, though importantly the items' origins as rubbish remains evident.

The work of Sydney-based Seljak Brand is an example of the elevation of pre-consumer waste. Seljak Brand produces blankets made from recycled off-cuts from a wool mill in Tasmania. Off-cuts of Australian merino wool, alpaca, mohair and polyester as well as old blankets are shredded and re-spun into yarn that is woven into new blankets. Like the notions of 'disguise' discussed earlier, Seljak blankets are designed to be luxurious, yet to highlight the many fibres that went into their creation, with the mottled flecks of different coloured original fibre showcased in the new products, with a blanket stitch chosen to highlight the colours.

Waste can be elevated simply by context and representation. The setting, such as a curated secondhand boutique, may elevate items that were once waste, as old clothes are returned into a fresh commodity cycle with new economic and aesthetic value (Gregson & Crewe, 2003). Outlined by Gregson and Crewe, "representational strategies of looking (and buying)" (2003, p. 54) are often associated with particular retail and display practices that can within second-hand exchange these strategies can "provide the conditions within which value itself emerges". (2003, p. 18) Australian projects such as SWOP Clothing Exchange shops, Suitcase Rummage, the Garage Sale Trail, and the Brisbane Revive festivals each display wasted clothing in ways that elevate it: old torn jeans, or faded brand t-shirts acquire a vintage aura in the right setting. Additionally, the communication and promotion around these shops and events work to elevate waste by tapping into the delight of treasure and bargain hunting.

Enchanting waste

The examples of disguise and elevate are two approaches to consider how waste may be revalorized and represented in fashion practice, and in this final section we propose a third way. Engagement with the material world of waste can be intimate, sensorial and profound (Edensor, 2005), invoke a range of emotional and somatic reactions (Hawkins, 2006), and spark moments of presence and wonder: an 'enchantment' (Bennett, 2001). Bennett (2001, p. 5) describes 'enchantment' as a mood of "fullness, plenitude, or liveliness" that comes with "active engagement with objects of sensuous experience; it is a state of interactive fascination" and can result from a multitude of sites, encounters or entities "that provoke joyful attachment" (Bennett, 2001, p. 4). In the context of fashion practice, Bennett's notion of 'enchantment' could come in the act or process of waste thinking / making with waste. The feelings that may be sparked by an engagement with and connection to waste may in turn challenge and transform understandings of waste and prompt other practices, possibly what Bennett (2001, p. 10) terms an "ethic of generosity".

Object Therapy (2016-2017) is an ongoing project and traveling exhibition that explores the transformation of broken objects through creative repair. Community participation is central to the project as members offered their own broken objects for repair by designers and artists. A video accompanying the exhibition features the owners relaying the story behind their broken object, discussing their reactions to the 'fixed' incarnation and contemplating the transformation of their object. These responses suggest wasted and transformed objects have an affective power that can prompt consideration of the meanings of waste and possibly spark a new or different relationship with waste. Following Bennett, Hawkins suggests enchantment might offer ideas of "how we might come to live differently with things" (Hawkins, 2006, p. 76). Alongside the exhibition Object Therapy hosts public repair workshops that attempt to provide a space of engagement that may spark new relationships with waste.

Currently the fashion industry is not only responding to waste created by its own production and consumption system but also with other forms of consumer waste. As such other waste stories can be told through fashion practice, for example the recycling of plastic water bottles into fabric tells of a throwaway society and polluted oceans. Thus it is not just fashion's waste but also other forms of waste that can be addressed through fashion practice. As Bennett proposes, encounters with wasted objects can startle and provoke an affect (2010, p. 4) and designers may be motivated by the poignancy of visible waste and a desire to rescue it. The rescue work itself may hold enchantment for designers, and the rescue story may also for viewers and consumers. For the designers of Maison Briz Vegas moments of enchantment come from the processes of gleaning at sites such as flea markets and op-shops, as well as the play, care and transformation involved in the design and making process.

Drawing from Rachael Cassar's reflections on practice we consider her process and relationship with waste materials as a form of enchantment. Cassar describes using her hands to create as the aspect of fashion practice that matters most to her (Black, 2012). The sensory processes involved in creating and sculpting, as well as the problem solving that accompanies the limitations of waste items provides inspiration and joy for Cassar. While Cassar's methods of transforming old fabric and secondhand clothing may work to 'disguise' their origins, the process and engagement with materials may bring about 'enchantment'.

These ideas of enchantment may overlap with the notions of 'disguise' and 'elevation' described above. All three ideas are about 'what happens to waste', but the notion of enchantment goes beyond the transformation of the physical waste to encompass the moments of "delight and disturbance" (Bennett, 2010, p. xi) that waste can provoke in designers and consumers, and prompt meditation, reflection, discovery.

Conclusions

In this paper we have examined a range of ways waste is transformed through fashion practices, drawing upon illustrations from the Australian context. Pragmatically, the sheer volume of textile waste overwhelms charities and textile recyclers. The two different modes of waste transformation through fashion practice, 'disguise' and 'elevation,' are methods that reduce the environmental burden of fashion production, consumption and disposal. Reclaiming or reusing waste reduces the demand for virgin resources to create new products, and prolongs the useful life of products otherwise headed for landfill. These modes of transformation have functional benefits, however there is another state that waste occupies that may not have quantifiable environmental benefits but can play an important role in prompting reflection on issues of waste. Waste is a cultural force that may prompt moments of enchantment and reflection through fashion practices. This typology of waste is a prism through which to examine issues surrounding fashion product lifetimes and ways in which practitioners may engage with waste. Although this paper has provided an Australian perspective on waste in fashion practice, the typology established could be applied to any locality and mode of design practice.

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Appendix 1

Tables 1-4. List of analysed Australian fashion waste initiatives and search methodology.

Table 1. Independent labels (24).

Name	Utilising waste	URLs
Aarli	Indigenous upcycled clothing	https://pozible.com/project/189822/rewards
ALAS	Recycled Polyester in active wear	https://alasthelabel.com/pages/our-fabrics
Baaby swimwear	Recycled Nylon swimwear	https://wellmadeclothes.com.au/designers/baaby
Belmore shoes	Minimal waste shoes	https://wellmadeclothes.com.au/designers/belmore
Don Pozzano	Upcycled menswear	https://www.etsy.com/au/shop/urbandon
Dis/Owned	Post-consumer clothing	http://www.disowned.com.au
Edition	Zero Waste clothing	http://www.editionalicesutton.com/about.html
Hanny-D Creations	Upcycled clothing	http://www.abc.net.au/news/2015-07-21/upcycled-the-art-of-turning-old-clothes-into-new-fashion/6635700
Her Swimwear	Recycled Nylon and Recyled Polyester	https://wellmadeclothes.com.au/designers/her-swimwear
Jenny Bannister	Upcycled clothing	http://www.smh.com.au/lifestyle/fashion/sustainable-style-meet-the-queen-of-australian-upcycling-20160906-gra5i0.html
Kit Willow - kitX	Recycled Polyester textiles, Reclaimed Horn buttons	http://www.abc.net.au/news/2017-05-17/sustainable-brands-at-australian-fashion-week-2017/8532358
Liar the label	Recycled Polyester swimwear	https://liarthelabel.com.au/about/
Maison Briz Vegas	Upcycled post-consumer clothing and rubbish	http://thefashionarchives.org/?tfaqanda=maison-briz-vegas
Nawato	Upcycled clothing	https://www.nawato.com/pages/about-us
NICO underwear	Recycled Cotton and Recycled Nylon underwear	https://nicounderwear.com/pages/recycled-cotton
ReWright	Upcycled clothing	http://www.upcycleclothing.com.au
Seljak Brand	Recycled Wool, Alpaca, Mohair and Polyester (pre-consumer factory waste)	https://www.seljakbrand.com.au
Sinerji	Recycled polyester	http://www.sinerji.com.au/product.php?id_product=290
Social Outfit	Upcycled pre-consumer textile remnants	https://thesocialoutfit.org/pages/mission
Social Studio	Upcycled pre-consumer textile remnants	http://www.thesocialstudio.org/fashion/
Studio Mücke	Upcycled post-consumer shirts and sweaters	http://www.mucke.com.au/home
Thoreau	Reclaimed Italian designer fabric	http://www.ragtrader.com.au/news/designer-tackles-10-of-all-greenhouse-emissions
Two threads	Upcycled clothing	http://www.twothreads.com.au/website/home.html
Upcycle studio	Upcycled products	https://www.upcyclestudio.com.au

Table 2. Mass-market retailers (11).

Name	Utilising waste	URLs
Billabong	Recycled polyester in board shorts	http://www.billabongbiz.com/phoenix.zhtml?c=154279&p=irol-socialcompliance
Country Road	Take-back and donation schemes	https://www.countryroad.com.au/fashion-trade
First Base Activewear	80% Recycled Nylon	http://www.ragtrader.com.au/news/urban-outfitters-asos-revolve-snap-up-activewear#EyAKwps6Ygi1cbHY.99
Gorman	Recycled cotton	http://www.gormanshop.com.au/dawn-jumper.html
Jeanswest	Recycled cotton	http://www.jeanswest.com.au/en-au/
Lorna Jane	Activewear take-back and donation scheme	https://www.lornajane.com.au/swap-shop
Kathmandu	Recycled cotton (pre-consumer waste); Recycled Polyester;	http://www.kathmandu.com.au/corporate-responsibility/sustainability/recycolor-made-with-recycled-cotton http://www.kathmandu.com.au/corporate-responsibility/sustainability/repreve-recycled-polyester
Kustom	Recycled rubber off-cuts in boots	https://www.kustomfootwear.com.au/shop/product/shoes/sea-shepherd-combat-boot-army-black?color=ACK
Mountain Designs	Recycled coffee grounds into performance textiles	http://www.ragtrader.com.au/news/what-the-frappe#8ik5B6KrjgVMEO4X.99
One Teaspoon	Recycled Cotton and Recycled Polyester; Recycled Denim jeans Recycled Polyester swimwear	http://www.ragtrader.com.au/news/urban-outfitters-asos-revolve-snap-up-activewear#EyAKwps6Ygi1cbHY.99 https://liarthelabel.com.au/about/
Trenery	Recycled cotton, polyester	https://www.trenery.com.au/thestylefile/ecodown-april-2017.html

Table 3. Charities and community groups (12).

Name	Utilising waste	URLs
Bower Reuse and Repair Centre	Post-consumer waste repairs	https://australiandesigncentre.com/object-therapy/
Endeavour Foundation	Post-consumer waste sales	https://www.endeavour.com.au/shop-with-us/recycled-clothing-stores
Garage Sale Trail	Post-consumer waste sales	https://www.garagesaletrail.com.au
Lifeline (Uniting Care)	Post-consumer waste sales	https://uccommunity.org.au/lifeline-rag-sales https://uccommunity.org.au/lifeline-shops
Object Therapy	Post-consumer waste repairs and education	http://www.hotel-hotel.com.au/fixandmake/events/object-therapy/ https://australiandesigncentre.com/object-therapy/
Salvos (The Salvation Army)	Post-consumer waste sales	http://salvosstores.salvos.org.au/about-us/fashion-with-a-conscience/street-boutique/ http://www.ragtrader.com.au/news/salvos-tackles-industry-issue
State Library Queensland (SLQ) upcycling workshops	Post-consumer waste repairs and education	http://blogs.slq.qld.gov.au/indigenous-voices/2016/04/11/kreative-kuril-workshop-upcycled-fashion/
Suitcase Rummage	Post-consumer waste sales	http://suitcaserummage.com.au
SWOP	Post-consumer clothing swap	http://www.swop.net.au/
The Clothing Exchange	Post-consumer clothing swap	http://www.clothingexchange.com.au
Textile Beat	Post-consumer waste repairs and education	http://textilebeat.com/
Vinnies (St Vincent de Pauls)	Post-consumer waste sales	https://www.vinnies.org.au/shops

Table 4. Methodology details.

Search engine terms	Conducted advanced Google searches of Australian region, in past five years, using search terms such as [waste fashion] ["recycled fashion"] [repair fashion clothing] [upcycled fashion] ["recycled polyester"]
Magazines	Conducted in site searches of independent fashion magazines Peppermint and Frankie, and fashion industry magazine Ragtrader
Retailer in site searches	Conducted in site searches of twenty-six mass-market Australian retailers, based on retail presence, using search terms [waste] and [recycled]. We excluded global brands headquartered offshore.

Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-347

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Product policy and material scarcity challenges: the essential role of government in the past and lessons for today

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Abstract

Materials are important in economies, business, innovation activity and products, and they have quickly become essential to maintain and improve our quality of life. The world faces problems concerning material supply, but these concerns are not translated into product design activity, even though history shows that product design policy can play an important role in finding solutions to materials problems. This paper has a focus on the role of governmental policy in ensuring material availability to the state.

The case of British WWII Utility Furniture scheme is one where consumer products were designed and developed as a response to severe material shortages. This action is set in the context of wartime conditions where the products were designed, manufactured, used and often reused over a long lifetime, under very stringent governmental control.

The control came from the government ministries but was designed and manufactured by the private sector. The furniture scheme was brought in to allow workers to have a furnished home to live in, eat and rest to allow them to work to help win the war.

Drawing on policy lessons from the wartime cases this paper makes a comparison of the WWII British approach with a European 21st century action plan for the circular economy, which raises important questions for policy development.

Introduction

Material shortage has been a challenge ever since mankind first started making things (Tilton, 2003, Ashby, 2013, Ashby et al, 2016). It is only the contexts, technologies and materials that change in each case. Today materials are just as important in economies, business, innovation activity and products, and they are essential to maintain and improve quality of life. In turn how we select, extract, process, use and deal with materials has profound implications for all life on earth. The world faces material supply problems today, but these concerns are not widely acted upon, even though history shows that product design policy changes can play an important role in finding solutions to materials problems (Peck et al, 2010), (De Rijk, 2009). This paper has a focus on the role of governmental policy in the supply of products and thus ensuring material availability.

A number of writers have linked product design and the use of materials, and examples include Victor Papanek (1972), Clive Dilnot (1982) and Victor Margolin (1988, 1989, 1997). In the combined fields of critical materials (material scarcity) and product design, there are however, no published works exploring historic policy responses and relating those past responses to current and future scenarios. The majority of publications on the topic of critical materials assess current situations and project proposals forward in time. Very few look back for policy lessons from past responses.

The case of British WWII Utility Furniture is one where civilian products were designed and developed as a response to severe material shortages. This case is set in the context of an exceptional period of political, economic, social and cultural wartime conditions where the products were designed, manufactured, used, and often reused, over a long lifetime. The scheme was conducted under very strict governmental control.

This paper draws on policy lessons from the wartime cases and makes a comparison with a European 21st century action plan for the circular economy, which raises important questions for policy development going forwards.

This paper does not seek to propose that events and actions, in a wartime material shortage situation from 70+ years ago, will provide an exact blueprint for product design policy actions required in the 21st century. For example many of the critical materials of today were not in industrial use in WWII and also many of the technologies of today did not exist then. What is proposed is that, given a particular set of materials challenges, the British found a product design policy response that 'worked' in resolving their material scarcity / supply problems. Re-visiting their response may help in the search for solutions today.

This paper is a development of the utility furniture aspect of the TU Delft PhD thesis of David Peck (Peck, 2016). Peck's thesis did not focus on the policy aspects and this paper addresses that gap.

In research peck conducted, the 20th century was selected as the time frame in which to find suitable cases. A combination of clear materials scarcity and a distinct product design change, were sought. Peck highlighted that product design aspects as a response to materials scarcity, have not been well documented.

WWII provides a wider choice of suitable cases. Importantly product design (including policy approaches) had developed and played a clear role in solving scarcity problems (Postan, 1952, Edgerton, 2011; Reimer & Pinch, 2013; Broadberry & Howlett, 2014). In addition materials and product controls were more far reaching and adhered to much more rigorously in Britain, than in the other democratic allied nations (Broadberry & Howlett, 2014).

Peck selected five cases, one of which was the Utility Furniture Scheme, see figure 1. This case represents the furniture designed and manufactured during the war years and into the post war period.

British furniture production controls via the Utility Furniture Scheme regulated scarce materials and labour in WWII Britain, through governmental controlled rationing and statutory designs. The British Board of trade introduced the Utility Furniture Scheme in 1943. The aim was to produce new furniture using as little power, labour and material as possible, and it only to be supplied to those who needed it most. The scheme was direct governmental intervention to control the furniture market in order to control quality, prices and address supply shortages. A labelling scheme to show the product conformed to the scheme, using the CC41 logo, was applied to all items of furniture. Prices were fixed low to allow all income groups to obtain furniture when needed. The products were purchase tax exempt. Profits for producers and retailers were fixed. All stages of the supply chain were recorded and audited. Production required a licence and production was allocated in designated geographic locations to limit transportation distances. Batch production methods were used, the design 'de-skilled' the production and division of labour was deployed. All designs has a unique government approved specification number. Large runs were encouraged. Durability and ease of repair were important. A buying permit giving access to limited coupons were issued to those who could prove a furniture need (bombed out, just married, new baby, etc.) allowing a limited amount to be purchased in any given period.

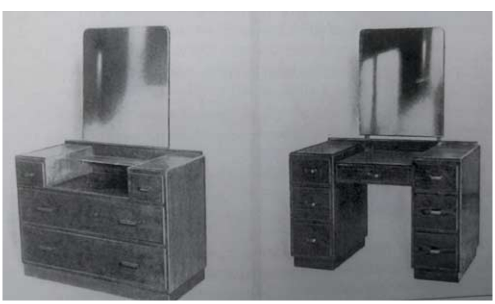


Figure 1. Examples of Utility Furniture, dressing table designs from the second Utility Furniture Catalogue published in 1947. Attfield, 1999.

The government appointed group conducting the furniture research and approving designs later became the Council of Industrial Design. The designs did not have any features which 'wasted' material of 'unneeded' style such as carvings or mouldings. The designs conformed to a British style of modernism, see figure 2. Whilst the public had mixed views on the whole utility furniture scheme, the scheme was a success in making the best use of scarce resources whilst providing furniture to those who had need, across the nation as efficiently and economically as possible.

Utility furniture scheme: governmental policy in response to resource scarcity.

As the international threats increased through the late 1930's, British governmental thinking changed to reflect the new material requirements of a modern war. In this period more detailed plans for raw materials supply requirements were made. Preparations included the final detailed planning for future actions to secure strategic materials.

The demands for materials in the early phases of a possible war, were expected to be very high. In addition allowance had to be made for considerable dislocation in European supplies (Postan, 1952), (Hancock and Gowing, 1949).

A new Ministry of Supply started operations in August 1939, one month before hostilities broke out, and took

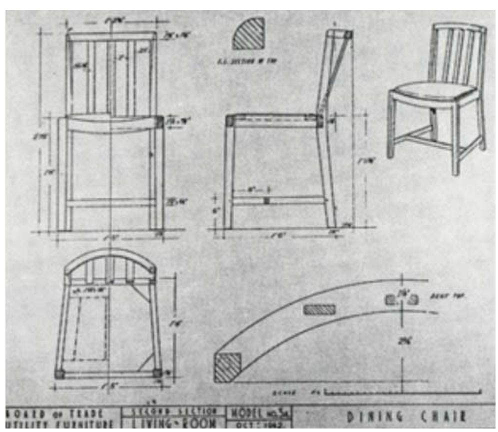


Figure 2 Government approved technical drawing detailing materials permitted, parts permitted and the appearance of the finished product.

over the 'Production, Contracts and Inspectorate' branches of the War Office. This aspect means that product 'Research and Design' came under the ministry of supply. Amongst the plans worked out in the last year of peace, were various schemes for reorganising materials supply to match the expected changes in international materials supply, to develop domestic (home produced) supplies of timber and iron ore, to plan carefully the use of scarce materials and to develop their substitution by other materials. Production would be based on a system of priorities (Postan, 1952) with the higher the war production priority, the greater allocation of material. At this stage, the production of domestic furniture was very low down the list of priorities.

When the war broke out, 56% of Britain's hardwood came from continental Europe, a source which was soon to be lost (Mills, 2008).

One of the control mechanisms deployed was statutory (legal) powers to control prices and to lay down conditions of material purchase, product sale and product use. This action can be seen in the utility furniture case. Compulsory government controls were imposed on most materials.

To a certain extent material prices were of low importance. Britain would pay if a material could be supplied. The effect of material supply on the economic performance of Britain was of interest only in that it effected the war effort. Economics as usual (peacetime economics) were suspended.

In 1940 the unrestricted allocation of timber for civilian furniture, which was deemed a non-essential product, was discontinued. A Timber Supplies Committee was set up to explore the problem of replacing furniture, damaged through the bombing of towns and cities. This Committee made a small timber allocation for the manufacture of specified products. This was in response to the upwardly spiralling prices of second hand furniture, which was quickly being bought by bombed out families (National Archives). Such spiralling prices fuelled a growing black market and the authorities were keen to show they were in control of all aspects of the 'home front'.

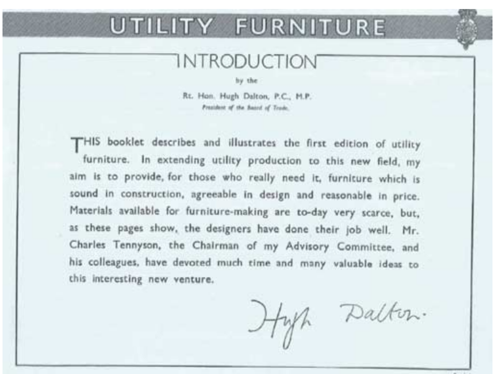
It was during this period of severe scarcity, which saw a reduction in timber material supplies of over 50%, the Utility Furniture Scheme was launched. The scheme was introduced by the Board of Trade at the end of 1942. Under this scheme restrictions including the introduction of standard designs – the Utility Furniture Scheme Design, where the supply of timber was for the production of the designated, approved, design only. In addition there was also the zoning or regionalisation of supply, in order to reduce fuel used for transporting products. The Board of Trade selected the firms to make Utility Furniture, and allocated production volumes and timings to them, together with the raw materials.

The first range of Utility Furniture products became available in 1943 and the scheme formally ceased in 1952. For 6 years 1943 – 1948 the design of furniture was very tightly controlled and manufacturing firms had no freedom to adapt the limited range of designated designs at all (Pinch and Reimer, 2013), (Dover 1991).

Hugh Dalton, President of the Board of Trade appointed a Utility Furniture Advisory Committee (UFAC). This committee advised on both design and manufacture, had 9 people on it, with a mix of societal backgrounds, from research and industry. There was a call for submissions from private sector company designers to meet the utility furniture requirements.

The designers selected were Edwin Clinch and H.T. Cutler, both from the furniture design and production area of High Wycombe near London. In January 1943 the first catalogue was produced which outlined the furniture which would be on offer. This catalogue remained in place for the next 3 years, and two pages of the catalogue are shown in figure 3 below.

By February 1943 25,000 units of Utility Furniture had been sold. The Utility Furniture scheme was such a success that demand remained high and unit production increased (Mills, 2008).


UTILITY FURNITURE

INTRODUCTION

by the

Rt. Hon. Hugh Dalton, P.C., M.P.

President of the Board of Trade.

THIS booklet describes and illustrates the first edition of utility furniture. In extending utility production to this new field, my aim is to provide, for those who really need it, furniture which is sound in construction, agreeable in design and reasonable in price. Materials available for furniture-making are to-day very scarce, but, as these pages show, the designers have done their job well. Mr. Charles Tennyson, the Chairman of my Advisory Committee, and his colleagues, have devoted much time and many valuable ideas to this interesting new venture.

Hugh Dalton.

Figure 3. Pages from the first Utility Furniture Scheme catalogue, 1943 (Mills, 2008)

The WWII British product strategies for dealing with materials scarcity show that extensive systemic changes, including fundamental design change of all products, can address raw materials reductions of over 50%. The British product policy approaches played a significant part in Britain limiting the adverse effects of materials shortages, whilst providing for the needs of society.

Today, the world faces materials problems, which also require significant changes. This challenge is explained below.

21st century materials problems: material criticality

From the start of the 21st century there have been growing concerns over the increasing demand-supply of materials (Peck & Bakker, 2012), (CRM-Innonet 2014), (Bakker et al 2014), (Abraham, 2015), (Peck et al, 2015). At the same time, an awareness of the interconnectedness with energy challenges and climate change, is emerging (EU, 2014, 2015, 2016) (Köhler et al, 2013). Currently most materials analysis have a focus on two factors; the risk of supply disruption and the importance to the economy (Graedel T E, et al, 2009, 2012, 2013). A combination of these two factors produces the definition of 'critical materials'. This methodological approach can be shown graphically and is shown in figure 4.

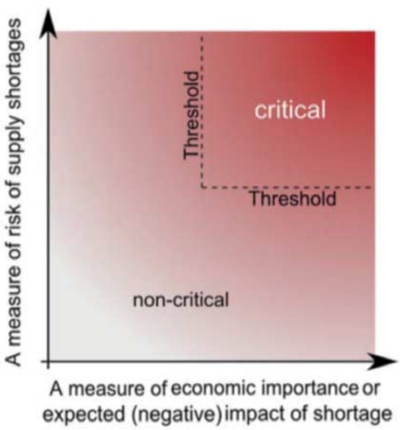


Figure 4. The two factors which determine if a material is critical; economic importance against supply risk (Sievers et al 2012).

Similar approaches, to determine if a material is critical or not, were developed over the period 2008-12 in a number of countries, e.g. EU, USA, UK, NL, (Peligrini, 2014). This approach was used to develop the graph in the 2014 EU report, as shown in figure 5. This two axis basis, supply risk against economic importance, is the core of most post 2008 definitions of critical materials.

EU policy on materials

In order to address the complex and interrelated challenges described above, the European Commission has developed a policy in 2008, called the EU Raw Materials Initiative (EU RMI, 2008). Part of the work is an on-going assessment of which materials are critical. The RMI is the main European Union strategy for raw materials. The RMI has been developed based on three pillars (EU RMI, 2008), (EU manifesto, 2012):

1. Ensuring a level playing field in access to resources in third countries
2. Fostering sustainable supply of raw materials from European sources
3. Boosting resource efficiency and promoting recycling.

In conjunction with the RMI the EU has developed a plan called Closing the loop – An EU action plan for the circular economy (EU closing the loop, 2015). This plan outlines a transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible and the generation of waste minimised. A range of policy actions are proposed

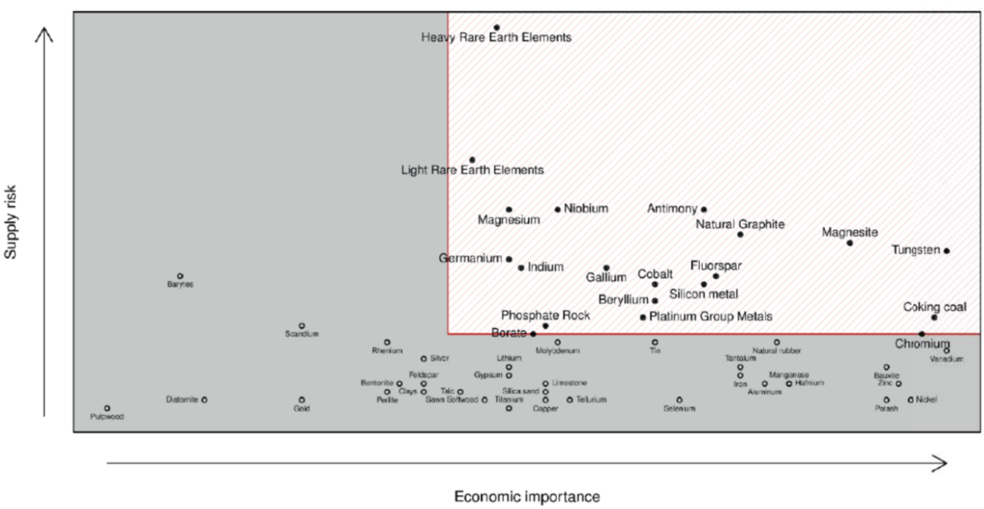


Figure 5. The two axis – economic importance against supply risk to determine criticality of a material. The EU 2014 critical list is shown (due for update in 2017), (Peligrini, 2014).

and includes incorpration of critical materals aspects. A number of policy actions are outlined in the circular plan (shown in fig 6 in the next section). One EU member state, The Netherlands, has announced that it will reduce primary materials use by 50% by 2030 as a response to the EU action plan (Netherlands Government, 2016)

Comparison of WWII and circular action plan today

This section takes the British 1943 utility furniture policy actions and the 2017 critical materials / circular economy policy actions (EU circular action plan) and compares them. The figure 6 below shows this comparison.

Conclusion

The differences in materials, technologies and circumstances between the two periods are significant and cannot be ignored. That having been said there are many features of the two policy approaches which have significant parallels.

What does appear is the parallels between the two policy approaches are significant. Equally the differences are most profound in particular in relation to the societal aspects.

This appraisal only represents a first step in understanding the potential use of looking back in history to help develop the circular economy action plan going forwards.

In the case of the Netherlands, which has announced a reduction of primary material use of 50% by 2030, it is interesting that Britain also had over a 50% reduction in material supplies.

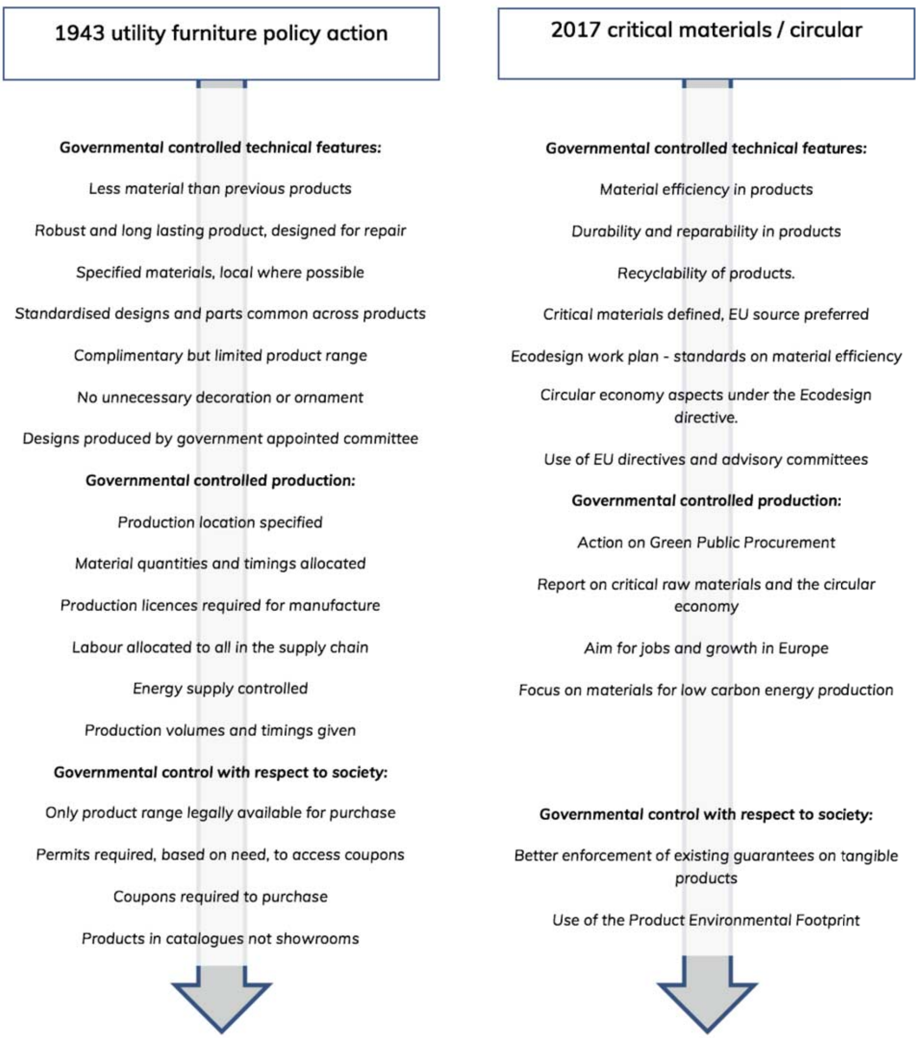


Figure 6 Comparison of 1943 utility furniture policy actions and the 2017 critical materials / circular economy policy actions

The question this paper raises is if Europe does not want all of the policy strategies used by the British in WWII (rationing, price controls, control of industry, full state control, etc.) then can the current circular economy approach work, given the policy framework in place? What is acceptable to European society versus what action is needed? These questions need to answered in further research.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-353

Considering optimal lifetimes for LED lamps: a mixed approach and policy implications

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Keywords
Durability
Lifetime
LEDs
Life cycle assessment
Life cycle cost

Abstract
Ecodesign policy for energy-using products so far has tended to focus on the energy efficiency requirements, but there is increasing interest in durability requirements as well. This exploratory study analyses whether and when long lifetimes are preferable when considering the trade-offs between durability and other important parameters such as costs and environmental impacts, examining the case of LED lamps. This is an interesting product group to examine because of the improving lumen efficiency of the technology as well as the increasing emphasis on lifetimes by both producers and policymakers. This research integrates both economic and environmental approaches to examine optimal lifetimes in the case of LED lamps. The first part of the research utilised an optimised least lifecycle cost (LCC) model of LED household lamps for sale in a Swedish online market, finding that optimal lifetimes were in the range of 25000-30000 hours for these lamps. However, this modelling did not consider dynamic factors such as changing prices and efficiencies. This study took the case of 800 lumen lamps to consider these factors, utilising both LCC scenarios, varying lifetime, purchase prices, energy cost and efficiency as well as LCA scenarios, varying electricity mix and lifetimes. The mixed approach demonstrates that different conclusions can be reached depending on the approach and the assumptions used. The merits and possible future improvements of these approaches for approximating optimal lifetimes of LED lamps are discussed based on preliminary findings. Lastly, the implications of the findings for further development of durability requirements and other policies are briefly discussed.

Introduction

Durability refers to the "ability of a product to perform its function at the anticipated performance level over a given period (number of cycles/uses/hours), under the expected conditions of use and under foreseeable actions" (Boulos et al., 2015). Mandatory eco-design durability requirements have been set for lighting products through EU Ecodesign regulation and it is expected that more product groups will follow in the future (Maitre-Ekern & Dalhammar, 2016). EU Regulation 1194/2012 prescribes standard testing for light-emitting diodes (LEDs) for 6000 hours, requiring that at least 90% of the samples have survived (i.e. survival factor) and maintained at least 80% of their average initial light output (i.e. lumen maintenance).

Several manufacturers are promoting the long life of LED lamps as a valuable attribute to consumers, with some claiming lifetimes exceeding 50000 hours. However, a key question is whether long lifetimes are optimal for these products. This question can be considered both from an economic approach (i.e. lifecycle cost (LCC)) and from an environmental approach (i.e. life cycle assessment (LCA)). These approaches have been used in past research on the question of optimal lifetimes for electronics and appliances (see e.g. Bakker, et al., 2014; EU Commission, 2015; Prakash, et al., 2015; VHK, 2014); however, often research has taken either an LCC or an LCA approach, but it is important to consider both in considering sustainability of the products (Tähkämö, 2013).

This exploratory research integrates both economic and environmental approaches to examine optimal lifetimes in the case of LED lamps. LED lamps for sale online in Sweden were examined in the first part of the research to model the optimal durability of these lamps, assuming factors such as energy use and price were also optimised. More dynamic LCC scenarios were developed for a subset of the market (~800 lumen lamps) in which the LCC was calculated for different case scenarios assuming different improvements in efficiency, price, and the price of electricity, similar to the case study approach used by Boulos et al. (2015). Lastly, an LCA approach developed scenarios for an 800 lumen LED lamp modelled in previous research (Scholand & Dillon, 2012), considering different lifetimes, improving efficiency and different electricity mixes. It should be noted that results presented here are preliminary as ongoing research aims to integrate more current data and refine the modelling approaches.

Lifetimes on the market

LED lamps on the market in Sweden in December 2016 were examined in the first part of the research using web-scraped data from online market webpages (e.g. Pricerunner.se for household replacement lamps). Table 1 below outlines the range of key characteristics for LED lamps in this market.

Lifetime (h)	AVG: 21000 Range: 10000-50000
Price (€/piece)	AVG: 14.4 € Range: 0.9-99 €
Luminous flux (lm)	AVG: 498 Range: 8-2200
Luminous efficacy (lm/W)	AVG: 75 Range: 16-128
Correlated colour temperature (K)*	AVG: 2800 Range: 1800-6500

Table 1. Characteristics of LED lamp Swedish online market data

**Correlated colour temperature (CCT) illustrates the colour of the light, so that CCT around 3000K is perceived as warm white, 3500-5000K as neutral white, and >5000K as cool white light.*

Life cycle cost approach

The starting point for calculating LCC, aligned with the Ecodesign performance standards, is the following formula:

$$LCC=P_P+PWF \cdot P_E \cdot UEC \quad (S1)$$

Where PP is the purchase price (€/lamp), PWF is the present worth factor, PE is the price of electricity (€/kWh), and UEC is the annual unit energy use (kWh). End of life costs are often excluded from LCC calculations, particularly if the cost of end of life management is part of the purchase price, as in extended producer responsibility schemes (i.e. the case in the EU) (Siderius, 2013).

Optimal durability the market

The first part of this research explored optimal lifetimes for the LED lamp dataset through theoretical modelling (see Richter, Van Buskirk, & Dalhammar, 2017). In the LCC equation introduced above, lifetime is related to PWF, which can be defined as:

$$PWF = \frac{1-(1+i)^{-L}}{i} \quad (S2)$$

Where i is the interest or discount rate and L is the product lifetime (in hours) (Van Buskirk, et al., 2014). The relationship between LCC and PWF can be expressed in the following manner in which the PWF is singled out from the rest of the equation:

$$\frac{LCC}{PWF} = \frac{P_P}{PWF} + P_E \cdot UEC \quad (S3)$$

The optimum relationship between LCC, price and PWF can then be explored by calculating the price regression coefficients, which were used to calculate price as a function of lifetime. The results of the Richter et al. (2017) study (Figure 1) indicated that, considering the relationship between purchase price and lifetimes, optimal lifetimes are generally around 25000 hours - longer than the range of lifetimes available on the market and certainly longer than the minimum lifetimes required in the Ecodesign standards for lighting (i.e. 6000 hours). Factors such as intensity of use and discount rates (DR) can be influential, but the main finding remains intact (even with a higher DR of 9%, optimal durability was still over 20000 hours for all intensity of use scenarios).

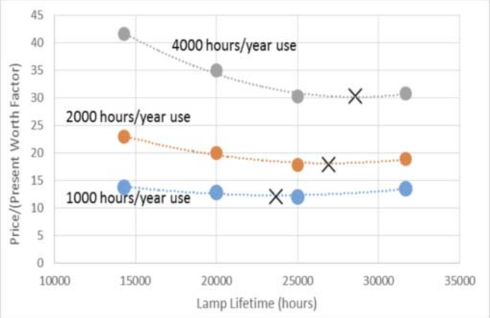

Figure 1. Model approximating optimum lifetimes (marked with x), assuming 6% DR. Source: (Richter et al., 2017)

Optimal durability: ~800 lm case scenarios

The method above can be useful for assessing durability in the entire market and assessing LCC in a real time market. However, it focusses only on durability and price, and does not consider dynamic factors such as improving efficiency of replacement lamps. To illustrate this, we examined a subset of data for 800 lumen LED lamps (±25 lm) with a CCT of 2700-3000K. The choice of 800 lumen lamps also aligns with the LCA presented in the next section.

The LCC was calculated with a simplified method in which the discount rate was equal to the rise of electricity prices (a method used by Siderius, 2013), and thus the PWF simplifies in the equation S1 above to the lifetime. This simplification allowed for exploration of the variables of increasing efficiency of LED technology, decreasing purchase price, and high or low electricity prices. The LCC for the 10000 hour, 20000 hour and 30000 hour lamps are compared (normalized to the 30000 hours, i.e. 3 x 10000h lamps, and 1.5 x 20000h lamps are needed for 30000 hours).

In this simplified LCC calculation, the intensity of use does not affect the LCC but would affect the length of the

Lifetime (h)	10000 (n=3)	20000 (n=10)	30000 (n=3)
Price (€)	AVG: 14.97 Range: 11-19.3	AVG: 18.94 Range: 8.2-34.5	AVG: 19.02 Range: 12.5-25.6
Efficiency (lm/W)	AVG: 105.1 Range: 84.8-115.1	AVG: 81.1 Range: 80.6-82.5	AVG: 84.2 Range: 80.6-90

Table 2. Characteristics of ~800 lumen LED lamp Swedish online market data.

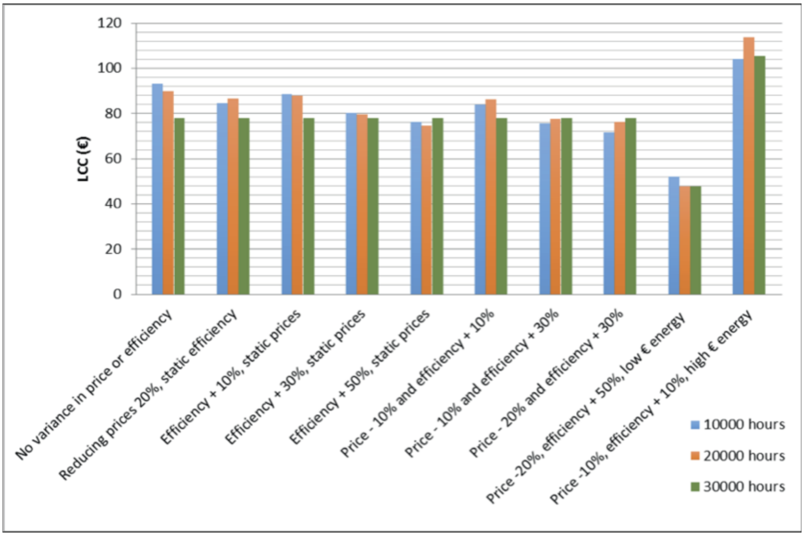

Figure 2. LCC case scenarios for ~800 lumen LED lamps on Swedish market

replacement cycles. The scenarios presented in Figure 2 assume a replacement every 10 years for a 10000 hour lamp operating at 1000 hours per year (approximately 2.7 hours/day). In reality, some lamps in a household could be used much more intensely than this. More intense use, e.g. 4000 hours, would result in shorter replacement cycles, e.g. 2.5 years for 10000 hour lamps. Shorter replacement cycles, would have implications for how much improvement in price or efficiency is realized in that time.

In scenarios where there are either significant efficiency improvements (i.e. efficiency doubled) or both price decreases and efficiency improvements, shorter life LED lamps that can take advantage of the learning curves and efficiency improvements in the replacement lamps, are preferred for least life cycle costs (LLCC).

The LCC scenarios were also sensitive to the price of electricity. The EU average (0.205€/kWh for 2016 according to Eurostat data) was the default assumption; however, in low cost energy contexts (e.g. Bulgaria at 0.09€/kWh), longer lifetimes would be preferable for LLCC, even with lower purchase prices and improving efficiency of replacements. High energy prices (e.g. 0.3€ in Denmark) also had implications in which the gains of spreading the purchase price over a longer lifetime were a trade off with the gains of saving costs of electricity, yielding the 20000h lamps as the LLCC option.

Life cycle assessment approach

Tähkämö (2013) found that for downlight LED luminaire, extending the lifetime of the luminaire lowered the overall environmental impacts (particularly for impact categories related to waste and resources, but also to a lesser extent in energy impact categories). In that study, shorter lifetimes also raised the relative significance of the manufacturing stage compared to the use stage (about 45% in a 15000h lifetime compared to just above 20% of a 50000h lifetime). However, previous LCAs for lighting focused more on comparison between lighting technologies (i.e. incandescent, fluorescent, LED) than between characteristics of the same technology, and as such, have not explicitly compared the environmental impacts considering varying lifetimes and improving efficiencies between lamps with the same technology.

Optimal durability: ~800 lm case scenarios

The LCA in this study constructs scenario cases for short (12500h) and long (25000h) lifetimes of LED lamps, considering a range of key environmental impact indicators, similar to the approach by previous studies of other product groups (Ardente & Mathieux, 2014; Boulos et al., 2015). The base case data is from the Department of Energy 2012 LCA (Scholand & Dillon, 2012 - "DOE 2012 LCA"), which considered an 806-lumen lamp and functional unit of 20 million lumen-hours. The LCA was modelled in SimaPro using Ecoinvent database and the 2012 DOE LCA report data.

While the DOE report also used Ecoinvent, it used an earlier version so direct comparisons should not be made as some unit processes have been updated. In addition, the LED market data from the LCC study indicates there is already efficiency improvements from the lamp considered in the DOE report. It is also known that components such as aluminium heat sinks have developed (e.g. decreased in mass) significantly since that study. Therefore, the LCA study presented here should only be considered exploratory while the approach is further developed with more current data. The choice to model the same LED lamp type as the DOE 2012 LCA was made because the report is currently the most comprehensive data publically available for household replacement LED lamps.

The DOE 2012 LCA considered a lamp with a relatively long (25000h) lifetime, so the comparison was made with a scenario in which the lifetime was assumed to be half this (12500h), thus requiring two lamps for the same functional unit. The replacement lamp for the 12500 lamp was assumed to be twice as efficient as the original 12.5w lamp (i.e. 6.25w). The material composition was assumed to be the same, but in reality, the replacement lamp would also have material changes. The scenarios were modelled with the EU energy mix (with approximately half of production from thermal sources) and the Norwegian mix (with primarily hydroelectricity).

Figure 3 shows that, with the EU average electricity mix, the longer life LED lamp (blue) has more significant impacts in energy related categories while the shorter life lamp (red) has relatively higher impacts in the toxicity and metal depletion environmental impact categories – highlighting possible trade-offs between different types of environmental impacts. The scenarios with the less carbon intensive Norwegian electricity mix (green and purple) do not show the same trade-offs, with the longer life LED lamp having relatively less impact compared to the more efficient short life scenario in all environmental impact categories, with the exception of water depletion due to hydroelectricity generation.

Discussion and conclusions

These initial findings indicate that in certain contexts, longer life LEDs can have both cost and environmental benefits, but this is not true in all cases. From the LCC perspective, if prices continue to fall and efficiency continues to improve rapidly, least life cycle costs may be found through shorter life LED lamps, particularly in the context of average-high contexts (0.205-0.3€/kWh). Interestingly, in the subset of data used for the cases (the 800 lumen lamps), the more efficient products tended to have a lower lifetime than the durable products (this was influenced by the low number of lamps in the data). This was observed on the dataset as whole, but less pronounced. Testing the LCC approach on another subset or developing a generalized case from the market dataset could also strengthen the findings.

It is worth noting in the 800 lumen subset, as well as the entire dataset, that there is a range of prices and efficiencies, which means that the actual LCC for consumers can be quite different, depending on their purchase choices. This highlights the importance of information and that policy requirements for durability may already appropriate in certain scenarios.

In further developing the LCC scenarios, the projected outlook of the LED lamp market could be more thoroughly researched to match the theoretical scenarios to likely projections. For example, the U.S. Energy Information Administration projects LED lamp prices to continue decrease in price and increase in efficiency, close to the improving price and efficiency scenarios in the cases, though this trend is projected to slow as soon as 2020 and the market is projected to reach maturity by 2030 (U.S. EIA, 2014). This would mean that longer lifetimes could be motivated from an LCC perspective in the near future. Already there are lamps currently on the market starting to approach the limit projected for the market in the U.S. EIA's projection (200 lumens/watt – see (Philips Lighting, 2017). However, other projections were not researched in this study and may show different scenarios, including the possibility of new LED laser technology (Maloney, 2016).

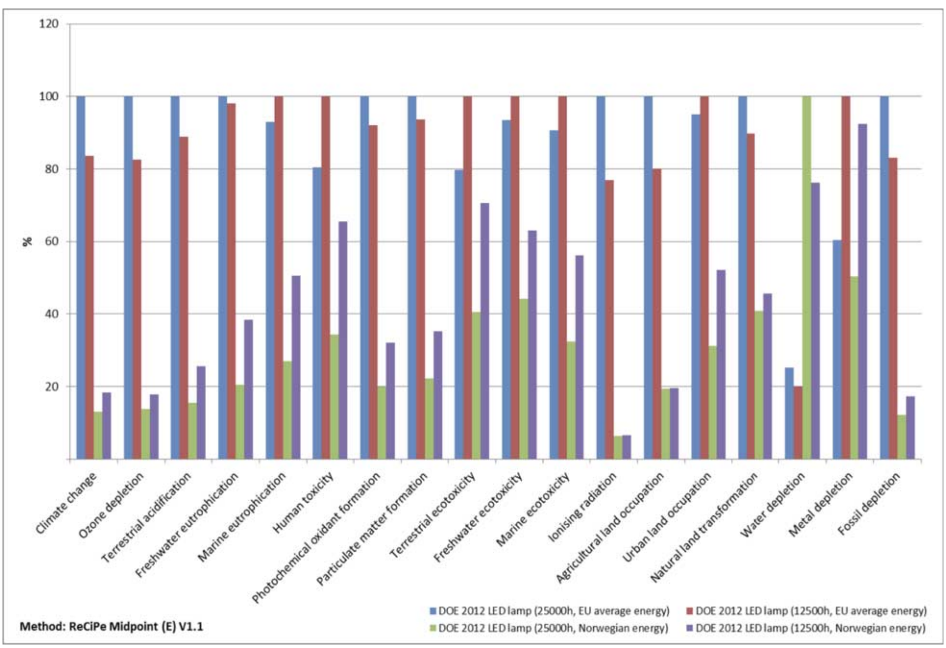

Figure 3. Comparative environmental impacts of LCA scenarios.

The LCA approach indicated that with an average EU electricity mix, there may be trade-offs between energy and material environmental impacts. Development of the approach and scenarios with more current product data and sensitivity analysis of using different impact indicator methods could further elaborate the scenarios. There is also a need to further explore scenarios with different electricity mixes, as the findings suggest that more durable LED products are preferable in contexts with less thermally sourced electricity generation. Lastly, whether decreasing mass and material changes to LED lamps in the replacement scenarios could influence the results also needs to be investigated.

Policy options for LED lamp durability

Producers are already promoting durability as an attribute of LEDs, so some consumer protection may already exist in consumer law if LED products fall short of lifetime claims (Stone, 2015). While use of the term "energy –efficient" is defined by Ecodesign regulations for lighting, it remains to be seen whether the term "long life" will also be included. Mandatory warranties could be another policy approach to increase consumer confidence and ensure stated claims about lifetime, but may be more complicated for the consumer than mandatory requirements. There are also questions about whether and how lifetime information could be integrated into labelling requirements to highlight durability to consumers.

While current Ecodesign requirements are based on 6000 hours, this study revealed that in some contexts and scenarios it may already be, or soon will be, relevant to consider policies to ensure longer lifetimes for LEDs. Testing lamp durability involves several parameters and accelerated tests are currently being developed (see Narendran, et al., 2016) that could make lifetime and durability tests more feasible. Improved testing procedures could in turn enable mandatory requirements on durability. The question would be the timing, design, and stringency of such requirements to coincide with the maturing of the LED lamp market.

Acknowledgments

This research was funded by the Swedish energy Agency (Grant 36936-1).

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-358

Additive manufacturing for circular product design: a literature review from a design perspective

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Keywords
Circular product design
Additive manufacturing
3D printing
Circular economy
Sustainability

Abstract
Circular product design is a relatively new approach to design suitable strategies to realize circular products. Additive manufacturing (AM) is seen as a promising enabling production process. It has digital and additive characteristics, which makes AM different from conventional production techniques. However, it is yet unclear how this technique can contribute to circular product design in practice. In this paper, a literature review is placed in context, i.e. the results of a literature review on sustainability opportunities in AM are compared to five typical design cases in a design review.

The outcomes of the literature study reveal the aspects of the digital and additive characteristics of AM, that lead to potential sustainability opportunities. We compared these aspects to the circular design strategies as described by Bakker et al. (2014) and Bocken et al. (2016) in the context of the five selected design projects. Each project is described in terms of circular design strategies and how these were achieved through additive manufacturing.

Using design practice to reflect on the outcomes of the literature review resulted in a better understanding of the potential of additive manufacturing for circular product design. The relation between the sustainability aspects of AM and the circular design strategies were made explicit. AM seems to be especially suitable to customize parts to fit existing products and to contribute to new opportunities regarding material recycling. These findings deserve further exploration in order to understand the motives for implementation in circular product design.

Introduction

Circular product design aims to preserve the economic and environmental value of materials for as long as possible by keeping them in the economic system, either by lengthening their life within products or by 'looping' them back into the system for reuse (den Hollander et al., 2017). This is a relatively new approach to design suitable strategies to realize circular products (Bakker et al., 2014; Bocken et al., 2016).

Additive manufacturing (AM), being a rapidly growing and emerging technique, is seen as a promising enabling production process for the circular economy (Despeisse et al., 2017; Esmaeilian et al., 2016; Huang et al., 2015). It is different from conventional production techniques, like injection moulding or milling, through its digital and additive characteristics. Although literature describes many potential sustainability advantages of additive manufacturing, it is yet unclear how this technique can contribute to circular product design in practice.

We are particularly interested in the way in which designers can use AM to fulfil circular design requirements. Therefore, in this paper a literature review is performed concerning the sustainability aspects of additive manufacturing. The outcomes are compared to circular design strategies in the context of some typical AM product design projects. We will discuss how the additive manufacturing opportunities described in literature can be used in design practice to realize circular product design and move towards a circular economy.

Method

In this paper the state of the art of the field is studied as a foundation for research through design (Horváth, 2008; Koskinen et al., 2011; Stappers, 2007). Therefore, a literature review is placed in context, i.e. the results of the literature review on sustainability opportunities in AM are compared to five typical design cases in a design review.

The literature review is based on the rigorous and evidence focused methodology of Hagen-Zanker & Mallett, (2012). Relevant literature related to AM, circularity or sustainability and product design was collected. Literature was obtained through addition of search strings in Google scholar and snowballing. Search strings consisted of "circular product design" and ("additive manufacturing" OR "3d print*"); "circular economy" and ("additive manufacturing" OR "3d print*") and "product design";

"sustainable design" and ("additive manufacturing" OR "3d print*"). As this study focusses on circular product design, articles and documents focussing on circular business models were considered out of scope. It should be noted that research into the sustainability potential of additive manufacturing is an emerging field and, although rapidly expanding, not yet mature. Many papers are exploratory and propositional in character, often relying on (grey) literature and with only few empirical studies.

The design review describes five product design cases. The projects were selected based on the following criteria: 1) The cases show how 3D printing is implemented by professional designers and 2) how they gave shape to their sustainability ambitions. 3) All projects are conceptual consumer products, which are 4) not older than 5 years (made between 2012-2016), and 5) presented at design related exhibitions, hence fulfilling a pioneering and model role.

Results literature review

The literature study confirms that the digital and additive characteristics of additive manufacturing enable aspects that are considered to support sustainability. Table 1 outlines AM-related aspects resulting from these characteristics and their potential sustainability opportunities as described in literature.

The AM-aspects do not show a clear hierarchy and also in the relation to sustainability opportunities different papers have varying interpretations. Therefore, some of the aspects appear both in the first and second column. For example, "small scale" production is seen by some as an AM-aspect that enables customization and local production, but others consider it a sustainability opportunity that can be enabled through "absence of specialized tooling". Likewise, some consider local production as an AM-aspect enabling several sustainability opportunities, while others consider it as a sustainability opportunity being enabled through e.g. on demand production.

Aspects of additive manufacturing	Could result in sustainability opportunities	Literature
Design for customization and personalization	Extended product life through increased product desirability and attachment	Diegel et al., 2016; Diegel, 2010; Ford & Despeisse, 2016; Kondoh et al., 2017; Loy et al., 2016; Loy & Tatham, 2016; Nagarajan et al., 2016
Design for co-creation	Minimization of environmental impact (co-creation of sustainable solutions)	Kohtala, 2015; Reay & Withell, 2011
	Creation of individual meaning, leading to product attachment	Loy & Tatham, 2016
On-demand production	(in-situ) repair (production of spare parts)	Diegel et al., 2016; Ford & Despeisse, 2016; Mani et al., 2014; Matsumoto et al., 2016a; Mcintyre et al., 2016; Prendeville et al., 2016; Van Wijk & Van Wijk, 2015
	Supporting local production	Chen et al., 2015; Esmaeilian et al., 2016; Ford & Despeisse, 2016; Mcintyre et al., 2016; Singh Srai et al., 2016
	Reducing inventories (only producing when needed)	Esmaeilian et al., 2016; Huang et al., 2015; Kai et al., 2016; Loy & Tatham, 2016; Olson, 2013
	Digital storage (reducing inventories, eliminating storage)	Ford & Despeisse, 2016; Mohr & Khan, 2015
Small scale production	Supporting customization and personalization	Ford et al., 2015; Gebler et al., 2014; Hao et al., 2010; Huang et al., 2013
	Supporting local production	Despeisse et al., 2017; Kohtala, 2015
Local production (distributed manufacturing)	Localised repair (eliminating supply chains and logistics)	Despeisse et al., 2017; Ford & Despeisse, 2016; Freitas et al., 2016; Mançanares et al., 2015; Mcintyre et al., 2016; Van Wijk & Van Wijk, 2015
	Efficient use and/or recycling of local material	Despeisse et al., 2017; Kobayashi, 2016; Kreiger et al., 2014; Loy et al., 2016
	Shortened supply chain and reduced transport	Chen et al., 2015; Ford & Despeisse, 2016; Freitas et al., 2016; Gebler et al., 2014; Hao et al., 2010; Huang et al., 2013; Mançanares et al., 2015; Prendeville et al., 2016
	Empowerment of local communities	Chen et al., 2015; Ford & Despeisse, 2016; Loy et al., 2016; Prendeville et al., 2016
Absence of specialized tooling, i.e. no moulds required	Supporting small scale/customized production	Chen et al., 2015; Despeisse & Ford, 2015; Huang et al., 2015; Kondoh et al., 2017
	Less resources spent on fabrication (no mould, etc.)	Chen et al., 2015; Hao et al., 2010; Kondoh et al., 2017
Increased design flexibility enabling design for optimized geometries and/or lightweight products	Optimized material usage	Ford & Despeisse, 2016; Mançanares et al., 2015; Nagarajan et al., 2016
	Assembly simplification (fewer parts, materials)	Ford & Despeisse, 2016; Huang et al., 2013
	Increased product functionality	Nagarajan et al., 2016
	Supporting repair (e.g. less expensive, add on new material on existing surfaces)	Bertling et al., 2014; Diegel et al., 2016; Ellen MacArthur Foundation, 2013; Matsumoto et al., 2016b; Tang et al., 2016
	Reduced energy consumption	Ford & Despeisse, 2016; Hao et al., 2010; Kondoh et al., 2017; Mançanares et al., 2015; Mani et al., 2014; Nagarajan et al., 2016

Table 1. Aspects of AM that are considered to result in sustainable opportunities as obtained from the literature review. The appearance of Ford and Despeisse in the references is striking, which results from their work that describes overviews of AM and sustainability, as well as circular economy.

In addition to the sustainability opportunities outlined in Table 1, also challenges and uncertainties are noted. The additive character of AM allows for fabrication of complex parts, unable to be created in different ways (Lipson, 2012), resulting in optimized geometries and lightweight components. This is achieved through layer-by-layer building, instead of subtracting material, and is therefore expected to reduce production waste (e.g. Diegel, 2010; Ford & Despeisse, 2016; Kondoh et al., 2016). However this is criticized by others, because of the need for support material (Almeida & Correia, 2016; Bertling et al., 2014).

Another possible drawback of additive manufacturing is the high energy demand, when compared to conventional production processes. Although some life cycle analysis studies can be found concerning this topic, literature is too limited to draw firm conclusions, since the outcome depends heavily on the way of usage (Faludi et al., 2015; Huang et al., 2013). Pre-heating and the processing of raw materials are mentioned as energy intensive activities. However, AM is also mentioned as less energy intensive for small production volumes and in case of shortened supply chains (Almeida & Correia, 2016; Diegel et al., 2016; Freitas et al., 2016; Prendeville et al., 2016)

Repair reappears several times in table 1, as it is widely recognized in literature that additive manufacturing can support repair of products. Through local and on-demand production repair is thought to become more accessible and cheaper, e.g. no stock of spare-parts is needed because of digital storage. However, component certification and liability issues are currently a drawback for acceptance of AM in repair (Ford & Despeisse, 2016). This is not only the case for the production of spare parts,

but also for new parts, e.g. local printing and co-creation lead to new questions about product liability and intellectual property (Diegel et al., 2016).

Design review

In this section we will compare the potential contribution of additive manufacturing in sustainable product design, as discussed above, to the circular design strategies as described by Bakker et al. (2014) and Bocken et al. (2016). A summary of the strategies can be found in figure 1.

This comparison of literature review and circular design strategies is placed in context by the five selected design projects. Below, each case is described in terms of circular design strategies and how these were applied through additive manufacturing.

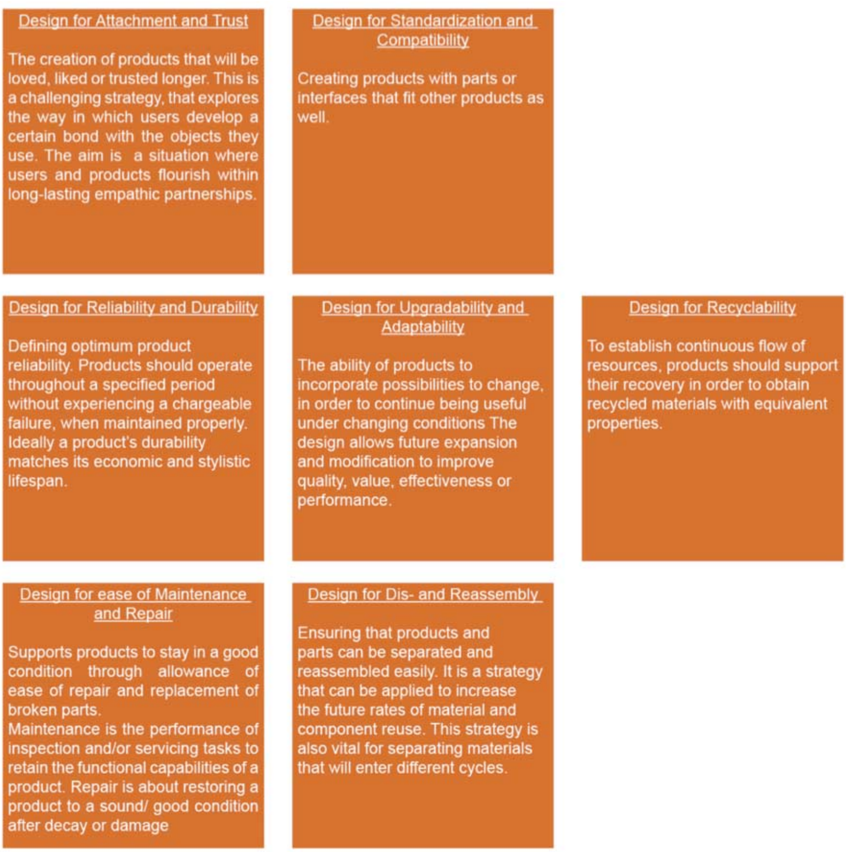

Figure 1. Circular design strategies (Bakker et al., 2014; Bocken et al., 2016).

1. "Project RE_": Samuel Bernier (2012)

Project RE_ explores 3D printing as do-it-yourself tool for reuse of products. Samuel Bernier expands the functionality of used cans and jars through the addition of customized lids. Fourteen new objects were designed, e.g. piggybank, pencil holder, orange press (figure 2)(Bernier, 2012). Additive manufacturing enabled this project for several reasons. Direct fabrication from the CAD model allows for adaptation to the different packaging materials through small-scale production and the absence of specialized tooling. In this way the circular design strategy for adaptability and upgradability is adopted. Following the open-source character of 3D printing (Kohtala, 2016; Tymrak et al., 2014; Van Wijk & Van Wijk, 2015), Bernier shares his files online, allowing his customers to adjust and print the objects themselves, leading to design for attachment and trust, i.e. the person-product relationship is strengthened through effort investment during the personalisation process (Mugge et al., 2009).

2. "Screw it": David Graas (2013)

David Graas designed connectors that transform old PET bottles and their lids into e.g. a vase (figure 3) (Graas, 2013). Although "Project Re_" and "Screw it" both increase longevity of packaging, AM is used in different ways. Graas uses additive manufacturing primarily as production technique to enable small-scale production. Due to the absence of specialized tooling, investment cost are reduced and this lowers the barrier to bring products to the market (Chen et al., 2015; Despeisse et al., 2017; Tang et al., 2016). Besides this, the stock is digital and products are only produced on-demand when ordered, eliminating inventory and reducing investment costs. The connectors are designed for standardization and compatibility, as well as dis- and reassembly, allowing different kind of PET bottles to finish the product. When screwed into the connectors the bottles are upgraded into a new and longer lasting product.

3. "Value added repair": Marcel den Hollander and Conny Bakker (2015)

In this project the lifespan of existing products is increased through repair, using the flexible design aspect of additive manufacturing. The design flexibility allows the creation of a component that fits the broken product, but also to adapt it. The central idea is that through customization of the broken part, a repair cannot only restore the product, but can add value in addition (figure 4). The improvement of the old product, by introducing extra functionalities, adds an extra dimension to repair. It supports design for "attachment and trust" and "upgradability and adaptability" can only be realized, because of absence of specialized tooling and small scale and local production.

Figure 2. Objects belonging to "Project RE_" from Samuel Bernier

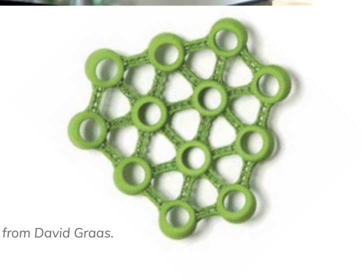

Figure 3. The "Screw it" vase from David Graas.

Figure 4. Some examples of "Value added repair" from Marcel Den Hollander and Conny Bakker.

4. "BIOMIMICRY soft seating": Lilian van Daal (2014)

Van Daal designed a seat fabricated in one print, but expressing different material properties through different local structures (figure 5) (Daal, 2014). The chair is a good example of the design abilities of additive manufacturing to support design for recyclability. It represents the ability of AM to create complex shapes, leading to several benefits. In this case the variation of local structures makes 'assembly of parts' redundant; the seat is fabricated with only one material, enhancing not only recycling, but also simplifying the supply chain (Despeisse et al., 2017; Prendeville et al., 2016). This augments the ability of local recycling, which can lead to avoidance of information loss and a higher efficiency rate. Kreiger et al. (2014) found that distributed recycling could save up to 80% embodied energy for HDPE filament in areas with a low-density population.

Figure 5. "BIOMIMICRY soft seating" from Lilian van Daal.

5. "Standard Products": Jesse Kirschner and Jesse Howard (2016)

In "Standard Products" joints are 3D printed to create furniture from wood (e.g. stool, cupboard) (figure 6) (Kirschner & Howard, 2016). This project shows the ability of AM to combine design for standardization with design for adaptability. Several standard designs are offered, but through the digital customization, joints can be adjusted to local standards or personal preferences. For example, customers can adjust their product online from a stool into a bench and order the joints on-demand. By simply dis- and reassembling of parts, a better suiting piece of furniture is created and thus the lifespan can be increased. In addition, users can choose whether they prefer the digital file, the printed joints or the complete product (figure 6). In other words, they can decide on the degree of co-creation and local production. Through the availability of the digital files of the joints, parts can easily be replaced and products repaired when broken.

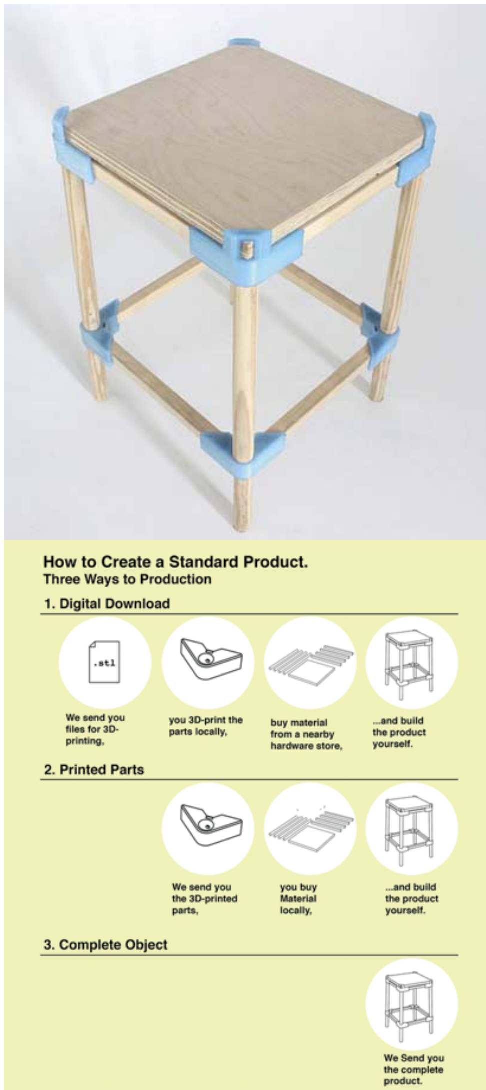

Figure 6. The stool of "Standard Products" from Jesse Kirschner and Jesse Howard.

Discussion and conclusion

Using design practice to reflect on the outcomes of the literature review resulted in a better understanding of the potential of additive manufacturing in relation to circular design strategies. In general, "Project Re", "Screw it" and "Value added repair" are good examples of product life extension of existing products. Parts are added to these products with additive manufacturing, increasing their value. "Standard products" is also an example of product life extension, but seems to be especially designed for it: i.e. instead of adding parts, the design itself consists of values supporting circular product solutions. "BIOMIMICRY soft seating" shows the potential of AM to create products that allow to close the loop through recycling.

In the literature review a number of specific AM-aspects were identified that contribute to sustainability. Table 2 outlines which AM-aspects support a particular circular design strategy based on the insights of this design review. Table 2 shows that design for "ease of maintenance and repair" and "upgradability and adaptability" are well supported by the AM aspects. Literature widely

Sustainable aspects of AM / Circular design strategies	Design for customization and personalization	Design for co-creation	On-demand production	Small scale production	Local production	Absence of specialized tooling	Flexible design
Design for attachment and trust	3	1		1	1		
Design for reliability and durability							
Design for ease of maintenance and repair	3		5	3,5	3,5	3	3
Design for upgradability and	3,5	5	5	1,3	3,5	1,3	3
Design for standardization and compatibility							
Design for dis-and reassembly							
Design for recyclability					4		4

Table 2. Connection between circular design strategies and AM aspects. Numbers correspond with cases.

recognizes the suitability of AM for repair and this is confirmed by the design cases. Also, the relation with design for "attachment and trust", which is related to personalisation and customization, can be expected. This is mainly considered from the product-user interaction. However, the design cases show that customization is also valuable on product level, i.e. a component can perfectly fit an existing product. The suitability of AM for design for upgradability and adaptability is an interesting outcome, because it enables to extend the life of existing products, as shown by most of the discussed design cases.

Design for recyclability is mainly illustrated by "BIOMIMICRY soft seating" and shows an innovative use of additive manufacturing. This case demonstrates that different mechanical properties can be obtained with a single material, thus revealing opportunities within the relation between materials and products.

However, not all circular design strategies are supported by AM in the five cases. Design for "reliability and durability", "standardization and compatibility" and "dis- and reassembly" are not achieved through directly exploiting one or more of the identified AM aspects. A possible explanation is that these strategies depend highly on design and/or production. "Screw it", for example, evidently supports standardization and compatibility, as well as dis- and reassembly, but this is due to the design as such and not to the specifics of additive manufacturing. The advantages of AM that realize the design do not necessarily contribute to the realization of the circular design strategies; they could have been realized through other manufacturing methods as well. However, the five design cases are not exhaustive, therefore this needs further exploration.

Concluding, this study clearly shows the potential of AM for circular product design. The findings in table 2 deserve further exploration in order to understand the motives for implementation in circular product design. Investigating the strategies through design explorations combined with empirical research seems to be a promising route, because it allows to go beyond analysis, not only gaining knowledge, but also exploring tools for implementation.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-365

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Promoting circular innovation through innovation networks: the case of cradle to cradle certified products

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Keywords
Circular economy
Circular design
Cradle to cradle
Sustainability-oriented innovation
Innovation networks
Life cycle thinking

Abstract
As advancement of sustainability-oriented innovation, circular innovation addresses not only the lacking environmental challenge integration but adopts a life cycle perspective. As a product design concept for the circular economy, Cradle to Cradle promotes closed biological and technical loops. We make use of the promotor network theory for understanding how companies collaborate in an innovation network for overcoming innovation barriers and successfully developing circular products. By conducting a longitudinal in-depth case study on a cradle to cradle pioneer company in the consumables industry, we find that cradle to cradle innovators collaborate tightly on the company, supplier and linking levels. Furthermore, these companies are characterised by excellent communication structures between the various promoters in the innovation network.

Introduction
Today's linear economic system fails to account for resources scarcity, the allocation of waste in the ecosystem, and environmental pollution more broadly thus threatening the livelihood of future generations. In the last decades several concepts have been developed that aim at decoupling economic growth from environmental pressure, such as Stahel's loop economy (Stahel, 1984; Stahel, 2010), biomimicry (Benyus, 2008), the blue economy (Pauli, 2012), and cradle to cradle (Braungart, McDonough, & Bollinger, 2007). The Ellen MacArthur foundation (2013) integrated these overlapping perspectives under the umbrella term of circular economy (see also Blomsma & Brennan, 2017) . For systematically basing and advancing the scientific debate on the circular economy, several authors conducted literature reviews and identified innovation and collaboration as critical elements for implementing the circular economy (Blomsma & Brennan, 2017; Geissdoerfer et al., 2017; Ghisellini, Cialani, & Ulgiati, 2016; Lieder & Rashid, 2016). Geissdoerfer et al., (2017). Innovation and collaboration go hand in hand, as circular innovation, endeavours need a close collaboration with company external parties to fulfil the criteria for closed loops products.

In order to systematically understand the immanent collaboration structures of circular innovation processes and how company level barriers to circular innovation can be overcome, this paper suggests applying the theory of promotor networks (Fichter, 2009) on cradle to cradle innovation. This aims at answering the research question: How do companies collaborate in an innovation network for successfully developing circular products?

In the remainder of this paper, we first concisely review literature on circular innovation before we present our theoretical lens 'promotor networks'. Afterwards, we apply it to analyse a longitudinal single case study on a successful cradle to cradle pioneer company in the consumables industry.

Literature Review: Circular Innovation
Coming from an innovation management perspective, Hansen et al. (2009) specified sustainability-oriented innovation as based on the full product life cycle from resource extraction to end-of-life. In more recent advances under the label of 'circular' innovation, Bocken et al. (2016) have emphasized the importance of closing these life cycles. One very recent branch of circular innovation studies looks at the phenomenon of cradle to cradle (Braungart et al., 2007) – a product design concept that has been formalised into what can be considered the first product certification standard for the circular economy. The product certification standard supports companies when implementing circular innovation by making the concept tangible. Cradle to cradle differentiates between biological and technical loops. Products with inherent dissipative losses (materials of consumption) shall be designed for being biodegradable; other products (materials of service) shall be designed for continuous and safe cycling without material downgrading (Braungart et al., 2007). Thus, the product certification not only certifies

the materials that can be cycled, but also focuses on health effects of the materials by banning hazardous substances (further certification criteria are water stewardship, use of renewable energies, and social fairness, but are not investigated in detail here). The standard also differs from other product certifications by its five-level certification system ranging from 'basic' to 'platinum' stimulating companies' level of ambition and animating for continuous improvements.

First studies show that the strict specifications and the resulting necessary collaboration with value chain partners make circular innovation processes very complex (Drabe & Herstatt, 2016; Smits, Drabe, & Herstatt, 2016). These studies discovered that interactions between individuals and groups in and outside the firm are important to connect disparate "knowledge assets" (Staber, 2004). Taking into account the close collaboration for developing cradle to cradle products, the circular innovation environment can be understood as an innovation network with the joint goal of developing cradle to cradle certified products. However, as developing or changing suppliers and business models, product developers of circular products often do not have the authority for deciding to implement closed loop production systems (Bakker et al., 2010). This is an important barrier to circular innovation. In the following sections, we will first explain the promotor roles, who push forward circular innovation in the company and its innovation network, and consecutively analyse the case of a successful cradle to cradle pioneer company with regard to the promotor roles

Theoretical Perspective: Promotor Networks

Originally introduced by Witte (1973), Fichter merged the promotor concept into the discussion on open innovation in the sustainability context by combining both concepts in a multi-level concept of innovation systems (Fichter, 2009). According to the promotor theory, companies need different types of promotors in their innovation processes to overcome innovation barriers. Promotors are defined as 'individuals who actively and intensively support the innovation process' (Witte, 1973, p.15). There are four types of promotors, which contribute to the innovation process by different competences:

- Power promotor: hierarchical power
- Expert promotor: expert knowledge
- Process promotor: organizational knowledge
- Relationship promotor: relationships inside and outside the company.

These promotors can even be combined in one person – the universal promotor (Fichter, 2009). In a successful innovation process, all types of promotors work together closely. The promotors aim at helping a specific innovation to a break through (Fichter, 2009). These promotors must not necessarily be part only of the focal firm (company level) but also act within the company's innovation network on the value chain as well as the framing and linking levels (Fichter, 2009). The latter spans firms that facilitate other firms' innovation (Winch & Courtney, 2007).

We are going to apply this framework for analysing the power structures that promote circular innovation and to understand success factors that help to overcome innovation barriers.

Methodology

We will answer the research question by an abductive longitudinal case study. Case study research leads to propositions deeply grounded in empirical evidence, thus providing a strong basis for theory building (Eisenhardt & Graebner, 2007; Yin, 2014). Therefore, this approach is particularly suitable for analysing newly emerged phenomena such as circular innovation. Our study focuses on a large family-owned environmental pioneer in the consumer goods industry (in the following 'Consumables Ltd.') that optimises its products for the biological and technical loops. We chose Consumables Ltd. due to its catering to both loops, its long legacy of environmental innovation and its respective market positioning as eco-pioneer.

Well-grounded on desk research we are currently conducting semi-structured interviews with internal and external experts of the firm involved in the innovation process. Following the strategy of interviewing a broad set of actors, we started with the Cradle to Cradle Officer. Afterwards, we questioned the experts in the departments and consecutively a member of the management board, followed by relevant external agents, such as EPEA (Environmental Protection and Encouragement Agency), selected suppliers, and value chain partners (see Figure 1).

This allows us to capture the whole innovation network. This method, based on data triangulation (Yin, 2014), allows profound insights into all facets and stages of the innovation process. We follow a recursive process of data generation and analysis (Charmaz, 2014) and are currently at the progressed beginning of the interview and analysis phase. Table 1 provides an overview of the current research status.

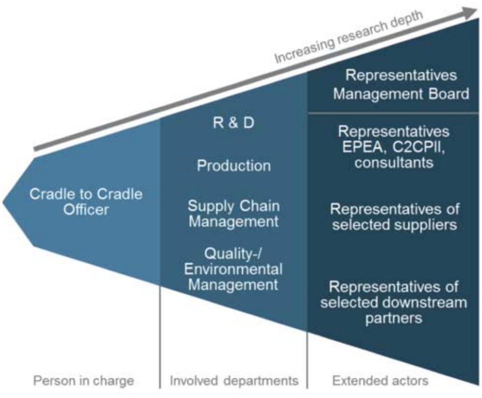

Figure 1. Interview strategy.

Data Categories	Consumables Ltd.
Interviews	**4 (8)**
Focal firm	3 (5)
Assessor, certification body, consultants	1 (1)
Suppliers and partners	1 (2)
Site visits	**2 (2)**
Publicly available information	**20 (20)**
Corporate documents (e.g. sustainability reports, environmental policy)	4 (4)
Press releases	6 (6)
Press articles	10 (10)
x = conducted, (x) = planned	

Table 1. Data collection status.

The interviews are transcribed, coded, and analysed using the software for qualitative text analysis, MAXQDA. The derived tentative theoretical categories will be presented in the following sections.

Preliminary Findings

Consumables Ltd. has been considered as an eco-pioneer in the chemical industry as early as the 1980s. They specialised in products, which, after their application, are fully biodegradable in the water system. When starting their cradle to cradle project in 2012 they had already optimised the formulation of the products, but as they are taking a holistic approach, they went on with optimizing the packaging of their products, too. In the course of developing the core product and packaging consistent with the cradle to cradle philosophy, an extensive innovation network has developed. Figure 2 depicts the innovation network on three levels: organisation, value chain network, and overarching linkages. It includes the different promotor types that we identified within the case study and their relationships.

Company Level

At the company level, three promotors were significantly driving the cradle to cradle project. First, the Head of Product Development served as an expert promoter. He joined the company with previous experience in developing products optimised for the biological cycle. Consequently, he applied this thinking to the products of Consumables Ltd. and started to demand detailed material passports from the suppliers. In 2011, he introduced the cradle to cradle concept to the company at a point of time when the CEO was looking for concepts on sustainable packaging which, given his scepticism due to food competition, would not use bio plastics. Cradle to Cradle would allow the company to argue the use of renewable materials for their core products, which are products of consumption that will be dissolved in water and therefore need to be biodegradable. At the same time, they can reason for the use of recycled plastic from the public collection system for the packaging. The CEO became a strong supporter of cradle to cradle in the company and acted as a power promotor. He entrusted the Head of Product Development to have a product certified as a trial. “Without our CEO Cradle to Cradle would not have been possible” (Sustainability Manager, Consumables Ltd.). Short before the Cradle to Cradle kick-off meeting took place, the company additionally hired a Head of Packing Development, who developed into an expert promotor himself.

Consecutively, the Head of Product Development had the first product and production site assessed by EPEA. They had their first product cradle to cradle certified in 2013. The cleaning product itself reached the material health Platinum level straight away, the overall cradle to cradle score summed up to gold. Although not having been part of their core value creation so far, the packaging managed to get the bronze certification. A success factor was the fast and direct communication with the CEO. On the one hand, he supported and challenged his experts by leaving them room for innovation and accepting intermediate steps to get to the market quickly and, on the other hand, challenging them regarding the progress in regular

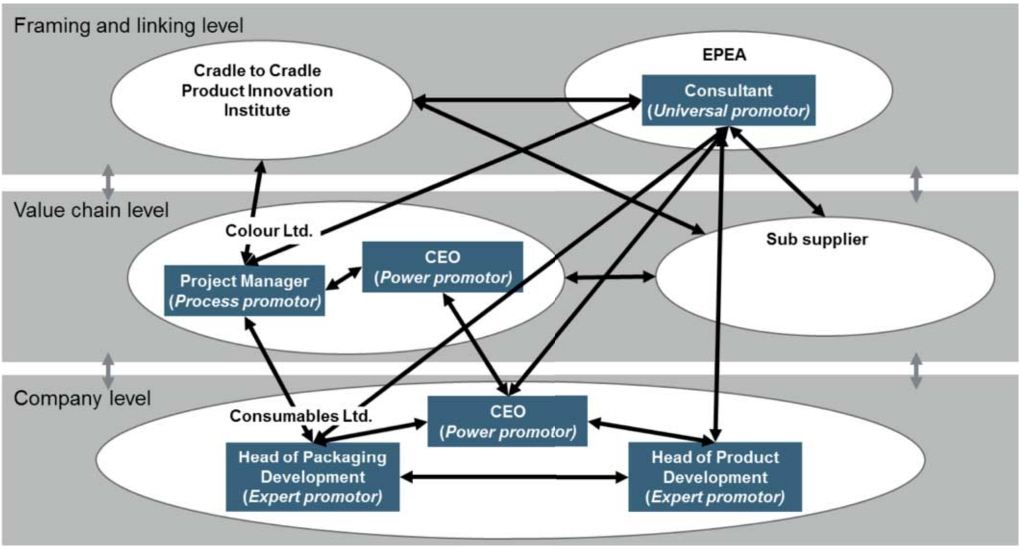

Figure 2. Preliminary framework: Cradle to cradle innovation network with promotors (based on Fichter, 2009).

meetings. He also backed them against team members with a more reactive stance towards environmental management. Especially the communication ties between the expert promotor Head of Packaging Development and the CEO of Consumables Ltd. were strong and direct. Whereas the expert promotor Head of Product Development developed tight linkages with EPEA.\

Value chain level

An important supplier to Consumables Ltd. in the area of packaging is Colour Ltd., supplying the inks for the labels of the packaging. They had already been contacted by EPEA a couple of years before if they were interested in developing a gold-level printing colour, but there was not much commitment then. Later, in 2014, with Consumables Ltd. as a prospective customer, EPEA convinced a project manager at Colours Ltd. of the demand and future profitability of cradle to cradle colours. The project manager used his direct contact with the CEO of Colour Ltd. to get permission for the cradle to cradle colour development project. “I knew that the second hierarchy level would kill the project right away again, so I directly asked our CEO for permission.” (Project Manager, Colour Ltd.) Thus playing the role of a process promotor. Without the joint initiative on all three levels by the universal promotor, the expert promotor (Head of Packaging Development) and the process promotor, the project would not have been conducted. During the joint development process, strong ties and trust have developed.

Framing and linking level

On the framing and linking level, we locate the innovation intermediary EPEA. Its Managing Director, also working as an operative consultant, acts as universal promotor. He disposes over cradle to cradle expert knowledge, has the process knowledge on how to conduct all necessary assessments and the certification, and has direct influence on the EPEA headquarter. Furthermore, he has important relationship knowledge as he is well connected in many companies in the cradle to cradle sphere, so that he can broker knowledge and bridge the needs of companies through matchmaking. His persistence and commitment was central to the development of the strong ties within the network. Based on the successful first certification, Consumer Ltd. further opened up their innovation process to integrate an EPEA representative early on in the innovation project. The universal promotor and the expert promoter (Head of Product Development) developed even a weekly call for pushing forward cradle to cradle innovation.

Discussion

We find that successful cradle to cradle innovators are characterised by excellent communication structures between the various promoters in the innovation network. The innovation network is characterised by close relationships between the actors and open and direct communication. The power promotors play a central role in levelling out the way for circular innovation and pushing forward innovation projects that would otherwise risk to be stopped at a middle management level. A process promoter can overcome such barriers. The expert promotors developed their existing suppliers or developed new ones together with the intermediary organisation’s universal promoter. They were given the support of the top management, who had a very strong interest in improving the environmental performance of their products. Leaving the experts free rein, the permission to develop the supply network, and the frequent milestone meetings facilitated swift decision-making and relatively fast market entry.

Overall, all promotors, through their tight collaboration, jointly contribute to overcoming company-internal innovation barriers and set aside structural constraints through their network integration.

Conclusions

Applying the promotor networks framework to cradle to cradle allowed us to get a better understanding of a circular product innovation processes. With regard to its linkages to its external partners and the roles that facilitated circular innovations in form of improved cradle to cradle products. We contribute to understanding how promotors manage to overcome innovation barriers. Our findings imply that companies wishing to implement successfully circular innovation need to build up a strong network with their suppliers and partners on the framing and linking level that are characterised by a long-term orientation, trust, and open communication.

Acknowledgments

This paper is a work in progress; hence, the findings presented above are to be considered preliminary. We would like to thank all interviewees for their collaboration and provision of valuable insights. The study is part of a larger research initiative at the Institute for Integrated Quality Design (IQD), which is jointly funded by Quality Austria (Quality Austria - Trainings, Zertifizierungs und Begutachtungs GmbH, Vienna), the State of Upper Austria and Johannes Kepler University (JKU) Linz, for which we are very grateful.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-370

PLATE conference
Delft University of Technology
8-10 November 2017

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Sustainable business model experimentation practices: evidence from three start-ups

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Keywords
Sustainable business model
Experimentation
Circular Economy
Start-up.

Abstract
With a growing world population, resource use, and the effects of climate change, it is apparent that our current 'take-make-dispose' economy cannot be sustained. Sustainable business model innovation integrates sustainability objectives into business models to achieve a positive impact on society and/or the environment in combination with pursuing profit. Experimentation capabilities are essential for implementation, but established companies struggle with execution. Start-ups are more acquainted with a trial and error approach in which assumptions are gradually validated or adapted to market needs. To contribute to the shift towards sustainable business models, this paper explores how start-ups develop sustainable business model experiments and which elements of the sustainable business model canvas are tested through experimentation. Three start-ups were followed in their experimentation journey to develop profitable sustainable business models. Results indicate that 1) experiments always concerned the value proposition and another building block of the business model with a high-risk profile 2) start-ups use easy accessible resources to execute experiments in a fast paced and iterative manner 3) decisions of continuation of business model ideas were based on the outcomes of experiments in relation to the purpose of the company. In addition, this paper provides examples of experimentation practices of these start-ups to give hands-on examples how sustainable business model experimentation can be developed.

Introduction

With a growing world population, increases in resource use, and the widespread effects of climate change (IPCC, 2014), it is evident that our current 'take-make-dispose' economy cannot be sustained. By changing the way in which companies operate, businesses can play a crucial role in the transition towards sustainable development (Loorbach & Wijsman, 2013).

Sustainable business model innovation is an emerging field of research attempting to integrate sustainability objectives into business models and achieve a positive impact on society and/or the environment in combination with the pursuit of profit (Schaltegger et al., 2015; Stubbs & Cocklin, 2008; Tyl et al., 2015).

Adopting new business models can create a competitive advantage. Experimentation is key for their discovery and development, as business models often cannot be fully anticipated in advance (McGrath, 2009). In these experiments, business ideas are treated as assumptions to be gradually validated or adapted to market needs with a trial and error approach (Blank, 2013; Ries, 2011).

Recent work of Weissbrod and Bocken (2017) show that an experimentation capability is essential to sustainable business modelling. Their study also shows that established companies struggle with execution of such experiments (Weissbrod & Bocken, 2017). As 'Lean-startup' practices spread, conventional wisdom about entrepreneurship is turned on its head as new ventures are following principles of failing fast and continually learning (Blank, 2013; Ries, 2011). To contribute to the shift towards sustainable business models, this paper explores how start-ups develop sustainable business model experiments and which elements of the sustainable business model canvas are tested through experimentation.

Methodology

Three start-ups with a sustainability-related business mission were followed in action research. In contrast to existing companies that execute a certain business model, these companies looked for a successful one, as the definition of 'start-up' by Blank (2013) describes. In action research practitioners and researchers act together in an iterative process, which includes problem diagnosis, action intervention and reflective learning in a systematic and documented way (Avison et al., 1991; Swann, 2002).

Data collection was performed by working with three companies to define/validate specific elements of their sustainable business model in real situations. Project activities consisted of: framing the project scope, gathering insights of stakeholders, co-create sessions on how to enhance the sustainable business model, identifying riskiest assumptions of these business ideas, executing an experiment to validate these assumptions, adapting business ideas based on outcomes and reflecting on the experimentation process.

Common patterns in the experimentation process were discovered through framework analysis - a generative approach grounded in qualitative data that allows for systematic analysis and comparison of multiple cases (Srivastava & Thomson, 2009). Findings were analyzed by the authors in relation to the building blocks of the SBMC (Figure 2).

Results

Case 1: THANKS

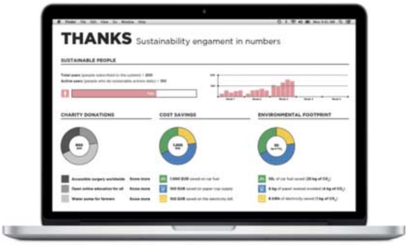

Figure 1. THANKS: a tool for a sustainable office culture © THANKS, 2016

Project framework: THANKS
THANKS is a new venture started in 2014 at Delft University of Technology within the framework of the Climate-KIC Netherlands (Figure 1). Background research revealed a market opportunity for energy saving solutions centred on sustainable behavioural change within large office buildings. The objective of THANKS was to develop a business model to encourage energy saving actions at the workplace.

Tested element of business model
THANKS' primary focus was to define a value proposition and frame the customer segment with more specificity. For THANKS the riskiest assumptions were as follows: first whether companies are interested in a solution based on behavioural change; and second whether employees could be nudged to save energy in the office. The customer segment building block was tested in relation to the value proposition.

Experiment and required resources
The experimentation process (Figure 4) took shape as a set of interrelated activities spread across three main iterations.

The first iteration entailed: interviewing the energy manager of a company; creating booklets to gather feedback from 20 office workers; a day of ethnographic observations into an office space; and a creative session with 10 office workers. Insights from these activities were combined into a new idea during a brainstorm session: to engage employees with the sustainability strategy of the company allowing them to make a small donation every time they made an energy saving action.

The second iteration entailed rapid service prototyping (Figure 3). Signs with energy saving reminders were placed in strategic locations (e.g. next to light switches). By scanning a QR code, office workers we redirected to a landing page where they could make a €1 donation on behalf of the company. The test was run with 10 office workers for 10 days. The amount of donations was used as an engagement metric: 87 out of the 100 possible Euros were donated. 10 follow up interviews provided feedback on energy saving potential. Parallel interviews with CSR managers of 2 international companies validated relevance for the customer. Insights from these activities were embedded into an updated prototype with adjusted features: broader focus on sustainable actions, a tangible donation experience for office workers, and impact feedback to the company.

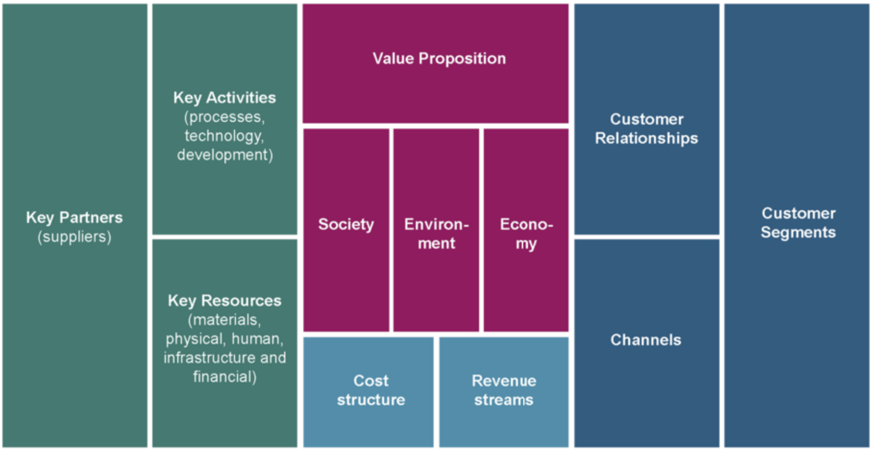

Figure 2. Sustainable Business Model Canvas (Bocken, 2015 building on Osterwalder & Pigneur, 2010)

The third iteration entailed rapid service prototyping (Figure 3). By putting tokens associated with different actions inside a piggy bank placed on their desk, office workers could donate money to a charity of their choice. Counting tokens at the end of the test provided immediate impact feedback to the company (e.g., kg of paper waste saved by reusing cups). The test was run with 4 office workers for 20 days. 68/100 Euros were donated. Parallel interviews with CSR managers of 5 international companies validated relevance for the customer.

Outcome of experiment

The positive outcome of the experimentation process enabled the definition of a preliminary business model around the value proposition and the defined customer segment. A first business plan was drafted. This was crucial to raise funds to build a digital prototype to be used by THANKS in the first pilots.

Figure 3. THANKS Rapid prototyping, second iteration © THANKS, 2016

Case 2: Mud Jeans

Figure 5. Mud Jeans: The first circular jeans company © Mud Jeans, 2016

Project framework: Mud Jeans

Mud Jeans is a Dutch denim company that introduced an innovative leasing business model for jeans in 2013 (Figure 5). Lease-a-jeans offers users the opportunity to lease a jeans for €7,50 a month and a one-time subscription fee of €20,00. After one year, lease-a-jeans members can return the jeans and switch to a new pair. The returned pair is upcycled to vintage jeans or recycled as a resource for new denim. The objective of this project was to create a stronger proposition for leasing jeans to appeal to more customers. Figure 6 shows the step-wise process taken for Mud Jeans.

Tested element of business model

Mud Jeans assumed that foremost, leasing jeans offers guilt-free consumption. During a workshop four other value propositions were developed (Figure 7).

For Mud Jeans the riskiest assumption was that customers would be willing to lease jeans instead of purchasing jeans to offer guilt-free consumption. The customer relation building block was tested in relation to the value proposition.

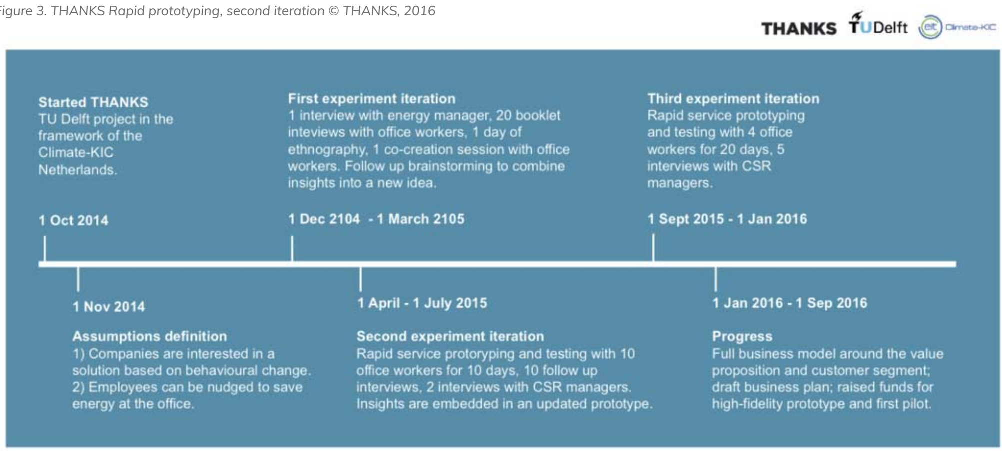

Figure 4. Overview of experimentation activities of THANKS from 1 Oct 2014 to 1 Sep 2016

Figure 6. Overview of experimentation activities of Mud Jeans from 18 February 2016 to 7 July 2016.

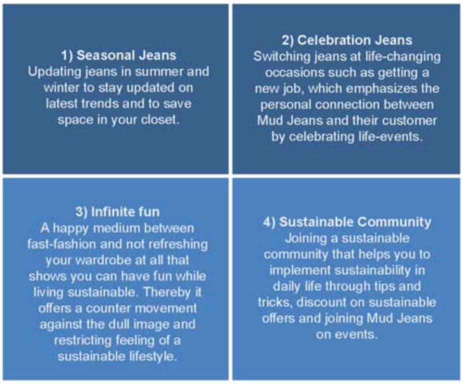

Figure 7. Four value propositions for leasing jeans.

Experiment and required resources

Mud Jeans set up a Facebook campaign and published this to potential customers to measure the click-through-rate on the advertisements which contained descriptions of the value proposition. In this way, costs were kept below €200.

Outcome of experiment

Mud Jeans decided to only test ideas that suited their purpose of becoming a circular company that reduces waste. Ideas that stimulate seasonal or special event purchases were not tested. Ideas that were related to expressing a sustainable lifestyle by wearing Mud Jeans were proposed to potential customers (Figures 8 and 9).

Both ads scored higher (sustainable community: 1.49%; Infinite fun: 1.17%) than the industry average CTR of textile ads (0.254% according to LINCHPINSEO) and previous ads of Mud Jeans about leasing jeans (1.02% and 1.11%). Mud Jeans decided to combine the proposition to make it suit their own believes. Results were incorporated in the brand book of Mud Jeans to further clarify what Mud Jeans stands for and what they should communicate to (potential) customers. Due to time constraints actual conversion was not tested.

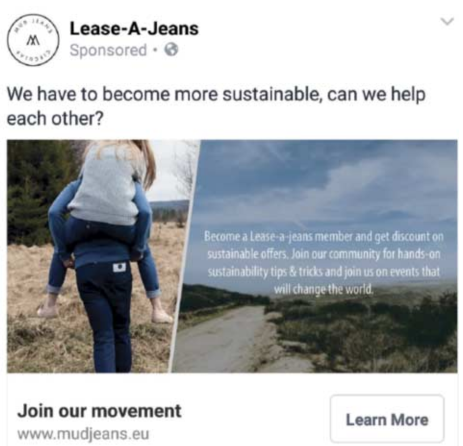

Figure 8. Facebook ad campaign 'Sustainable community' to test value propositions for leasing jeans © Innoboost, 2016

Figure 9. Facebook ad campaign 'Infinite fun' to test value propositions for leasing jeans © Innoboost, 2016

Case 3: Peerby

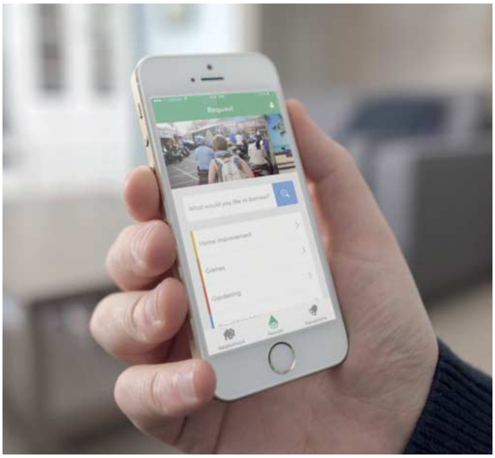

Figure 10. Peerby: Pioneer in the sharing economy © Peerby, 2017

Project framework: Peerby
Peerby offers a platform where neighbours can borrow or rent items from each other to stimulate the sharing economy (Figure 10). The objective was to find a business model to generate additional revenue streams (Figure 11 shows the experimentation activities).

Tested element of business model
First community members were asked questions about the existing platform and how more value could be added. Community members were satisfied with the current design. To generate additional revenue streams project members reflected on unique resources and capabilities of the company and questioned which new customers segments would be interested in these assets.

Business ideas and new customer sections were selected based on 1) coherence with Peerby's mission to shift away from the throw-away culture and excessive consumption 2) Business potential 3) scalability. This led to a focus on retailers. For Peerby the riskiest assumption was that retailers could be considered as an additional customer segment when adding new features to the platform. In this case, the customer segment was tested in relation the value proposition building block.

Experiment and required resources
Through a co-creation session with an ex-retailer from their own network, the value proposition was sharpened by brainstorming how key assets could become more valuable. The ex-retailer openly shared his considerations.

Outcome of experiment
After Peerby proposed value propositions to an ex-retailer business model, ideas changed to better meet the retailers' needs. After analyzing the impact of these ideas in more detail, Peerby decided not to continue with these as they counteract their purpose by stimulating sales of products, while Peerby is committed to enhance the sharing economy to offer an alternative for excessive consumption.

Overview of experimentation practices
Table 1 summarizes the experimentation practices for each of the cases.

It shows that for each type of practice, specific capabilities and resources are needed, which range widely from interview skills to physical prototyping.

Discussion and Conclusions
To contribute to the shift towards sustainable business models, this paper explored how start-ups develop sustainable business model experiments and which elements of the sustainable business model canvas are tested through experimentation.

First, it was found that fast-paced experiments gave meaningful and low-resource insights on how to adapt business models to better suit customer needs while strengthening the original sustainability purpose or strategy of the start-up.

Second, experiments for sustainable business model design and validation are always concerned with the

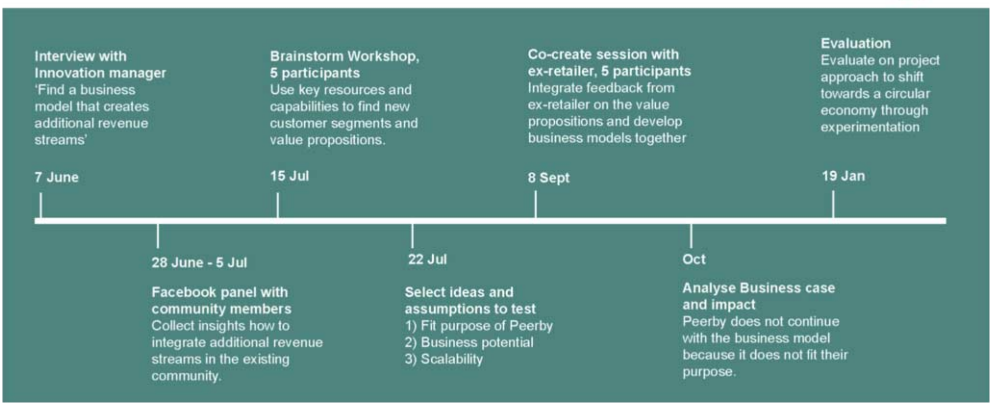

Figure 11. Overview of experimentation activities of Peerby from 7 June to 30 October.

Experimentation practices	Resources and capabilities	Outcomes	Case example
Conversational interview	Interviewer and interviewee	Insights in what is important to the stakeholder and their considerations	THANKS Mud Jeans Peerby
Booklet interview	Interviewer and interviewee; booklet design	In-depth insight in the stakeholders by discussing what is written down	THANKS
Ethnographic observation	Social researcher, notebook, photo / video camera	Real-life reactions and interactions of the customers to feed into experiment design	THANKS
Co-create session	Invite stakeholder who discusses considerations openly	1) Ideas that match the visions of involved stakeholders 2) Coherent vision	Peerby
Brainstorming	Multidisciplinary team and perspective outside the company	Ideas that fit the visions of people from different expertise's	THANKS Mud Jeans Peerby
Facebook A/B Test	Budget for ad campaign. Content-writer for ads	Indication of what resonates better with customers through number of clicks	Mud Jeans
Rapid Service Prototyping	Physical and/or digital prototype (e.g. paper signs, web landing page)	Customer feedback through interactions with the prototype	THANKS

Table 1. Overview of experimentation practices in the three case-studies and accompanied resources and capabilities

value proposition (which echoes existing literature, e.g. Osterwalder et al., 2014), but in relation to another building block of the business model, which is essential for implementing that value proposition. The selection of the building blocks appears to depend on two factors: the level of certainty about particular aspects of the business (e.g., clarity on future revenue streams or customer segments) and assumption the company perceives as riskiest (e.g. customer, channels). Experimentation can start with the most uncertain or riskiest assumptions.

Third, experiments allowed for minimization of cost and perceived risks for companies engaging in sustainable business model design and validation. In order to achieve this, experiments were conducted with a customer centric approach in line with Blank (2013) and Ries (2011) aiming to generate new business opportunities, fast paced and iteratively, and using easily accessible resources.

Fourth, deciding to continue with the business model idea is based on outcomes of experiments in relation to the purpose of the company. All three sustainability-driven start-ups have a clear purpose for their business and evaluated ideas based on the fit with their mission and vision.

Finally, we identified experimentation practices that can support sustainable business model experimentation. These include: conversational interview, booklet interview, ethnographic observation, co-creation session, brainstorming, A/B test, focus group, rapid service prototyping (physical and digital) and Facebook testing. These practices, which can be broadly categorized as design thinking type of activities and stakeholder interactions, have proven to be crucial in strengthening the business proposition allowing to progressively create an overlap between sustainability objectives and market needs (Keskin et al., 2013; Keskin 2015).

While tested in start-ups, we believe that experimentation can also help established companies 'stuck' in existing business models (Weissbrod and Bocken, 2017). For instance, co-creation (Table 1) is a key experimentation practice because it creates a sense of shared ownership, which is key to push innovation forward in a large and slow corporate context (Gardien et al., 2015). Further research is necessary to experience how the internal organization of established companies react to experimentation practices that are similar to the described cases.

Acknowledgments

We are grateful for the participation of THANKS, Mud Jeans and Peerby. A special thanks to Danique Gunning and Bert van Son of Mud Jeans; Selman Aqiqi, Sjors Boelaars, Anna Noyons and Daan Weddepohl of Peerby. Without their openness and dedication this publication would not have been possible. Moreover, we would like to thank Innoboost for executing the projects in collaboration with the case-companies; in particular: Christiaan Kraaijenhagen, Edward Hissink, Sandra Horlings, Robbert Cornelissen, Claire Hornn, Nicole Brouwer and Wouter Verduyn.

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Product Lifetimes And The Environment 2017 - Conference Proceedings C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-377

PLATE conference
Delft University of Technology
8-10 November 2017

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Management of material cyclicity potential: example of electrical and electronic products

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Keywords

Material cyclicity potential
Electrical and electronic products
Management strategy

Abbreviations

EEP - electrical and electronic products
UEEP - used electrical and electronic products
MCP - material cyclicity potential
MMT - material multiple turnover

Abstract

This study is aimed at justification of the theoretical foundations of management of material cyclicity potential (MCP), including materials used in electrical and electronic products (EEP). In our opinion, the "cyclicity" of material should be studied from the perspective of the potential of materials to be multiply used. Such an approach allows to identify all possible forms of MCP manifestation in space and time. We suppose that the process of increasing of MCP starts with the design of the cycle of material multiple turnover (MMT) by forming an optimal range of products within which certain material sequentially turns, and continuous with the forming of MCP within adjacent product life cycles (located next in the specified range). The priority in the turnover sequence should be given to those products that are characterized by minimum change in the material quality parameters at the output of the turn. So, the focus on "cycle of MMT" rather than "product life cycle" is important for ensuring the maximum number of turns of material because it highlights that one deals with a range of products in which the same material is sequentially used, throughout their lifecycles, rather than only with one product. The suggested approach to closing material cycles is based on the concept of MCP, and unlike existing approaches, it provides the moving of certain material along a specified path – an optimal range of products thereby forming a cycle of MMT with maximum number of turns. This path obviously can be adjusted with each subsequent turn of material because a new products and technologies are being continuously designed. In the context of the circular economy, the proposed theoretically-methodical design of sustainable use of materials is intended for the rational allocation of new and circulating materials in an economic system.

Introduction

Introduction of life-cycle thinking into waste policy is one of the actions of Thematic Strategy on the prevention and recycling of waste [Communication, 2005]. Life-cycle thinking looks at environmental impacts throughout the entire product life cycle, from extraction of resources to their disposal phase [Communication, 2005; Report, 2011]. The Thematic Strategy on the prevention and recycling of waste and the Strategy on the Sustainable Use of Natural Resources are some of the seven thematic strategies programmed by the Sixth Environmental Action Plan [Decision No 1600/2002/EC], the first ended in July 2012, but a lot of measures launched under this programme continue to be implemented. The Seventh General Union Environment Action Programme to 2020 "Living well, within the limits of our planet" has been approved since 2013 [Decision No 1386/2013/EU], where a new broader meaning appears in the formulation of tasks concerning the management of resources and waste – "to move towards a lifecycle-driven "circular" economy, with a cascading use of resources and residual waste that is close to zero". This strategic task was reflected after several years in the "Closing the loop – An EU action plan for the Circular Economy". In order to close the loop of product lifecycles the document outlined an action plan to provide cyclical economy at each stage of the chain of value creation [Communication, 2015; Report, 2016]. Special attention is paid to electrical and electronic products (EEP) among a set of products in "Closing the loop – An EU action plan for the Circular Economy".

To our opinion "to close the loop of product lifecycles" does not sound quite right, because the product life cycle cannot be described itself as a circle. In a circle, or rather spiral, the material/substance can circulate which is sequentially used in a range of products, forming a cycle of material multiple turnover (MMT). In our opinion, without neglecting the possibilities of MCP increasing within the product life cycle, the ranking of products for determining the sequence of use of specific material is of great importance for increasing the number of turns of material in economic system and formation of demand for "material of the jth turn". So, relying upon the objective necessity of increasing MCP within a cycle of MMT, the approaches to formation of fundamentally new strategies for the sustainable management of material cyclicity potential, including the materials used in EEP, should be developed.

The concept of 'zero waste'

The concept of "zero waste" has become the most popular in the scientific community among a set of different concepts in the field of resource and waste management. By the content of this concept, all types of wastes are considered as potential resources [Murray, 2002], that is caused by the possibility of their involvement into one of two cycles: biological or technogenic. The concept of "zero waste" in terms of technogenic cycles is a further interpretation of the concept of resource cycles [Komar, 1975], industrial metabolism [Ayres et al., 1989], anthroposphere metabolism, city's metabolism [Baccini & Brunner, 1999; Baccini, 1997].

The study of issues on the accepting the concept by scientists and its application in practice certify that it is still at the phase of development [Zaman 2014; Zaman & Lehman, 2011]. Scientists offer different models, approaches, mechanisms to achieve the state of "zero waste". Experts in the field of waste management treat this approach in different ways, offering strategies that differ by their content to achieve "zero waste" in cities and regions. As of today, "zero waste" strategy is aimed at "zero landfills" by removing waste from landfills [Zaman, 2014].

To get closer to "zero landfill" the existing strategies of the EU Member States are developed in accordance with the tasks of the waste management hierarchy [Guidelines, 2013], that actually is their cornerstone. Gradual upward movement in the hierarchy to the higher priority directions, which are connected with the minimization of waste generation (reduce, reuse and recycle), occurs due to rethinking of the need for the product, need to redesign to minimizing waste potential, to extending its use phase [Guidelines, 2013].

Theoretical basis for the development of multilevel strategies for materials cyclicity

The cycle of material multiple turnover: the essence and structure

The scheme of cyclic (repeated) use of the material provides the production of a product from the material obtained from the previous product and which can be recovered and used further in the production of the next product. Relying upon this, in order to increase the number of turnover of specific material in the economic system, in our opinion, it is necessary to form the optimal range of products. We will consider the optimal range of products for MMT as the sequence of products, selected and arranged according to the change of the quality characteristics of the material for its each subsequent turnover. Such range can be formed by modeling the process of MMT on the basis of selecting the most acceptable products from point of view of the minimal loss of initial value of specific material. The optimal range of products, for which the same material is used, forms a cycle of MMT (Figure 1).

The cycle of MMT is defined as the material life cycle in part of its multiple use. Material that is used in production for the first time (primary material), will be nominally defined as "material of the 1st turn", the material that is used in production for the jth time will be nominally defined as "material of jth turn". If we consider the structure of the cycle of MMT that is formed according to the optimal range of products, then the jth turn of material covers the life cycle of ith product of this range. Hence, since the cyclicity of material use implies its turnover in the production of a certain range of products, it is important to analyze the life cycles of adjacent products (located next in range), instead of the life cycle of only one product.

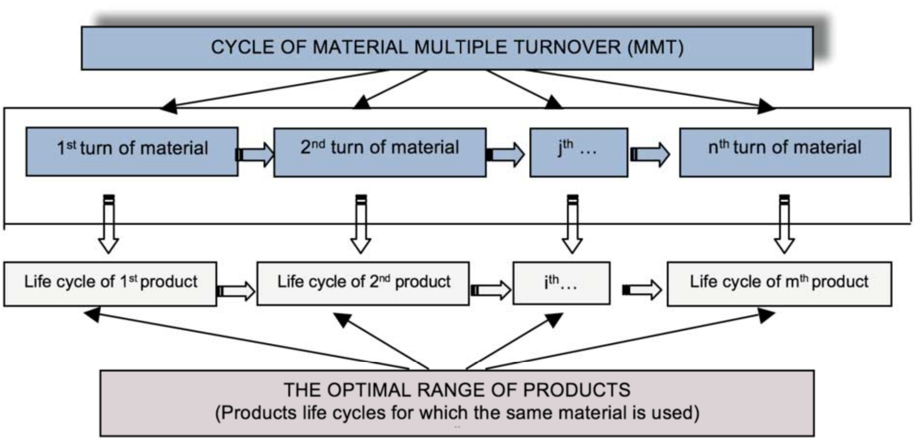

Figure 1. Structure of the cycle of material multiple turnover.

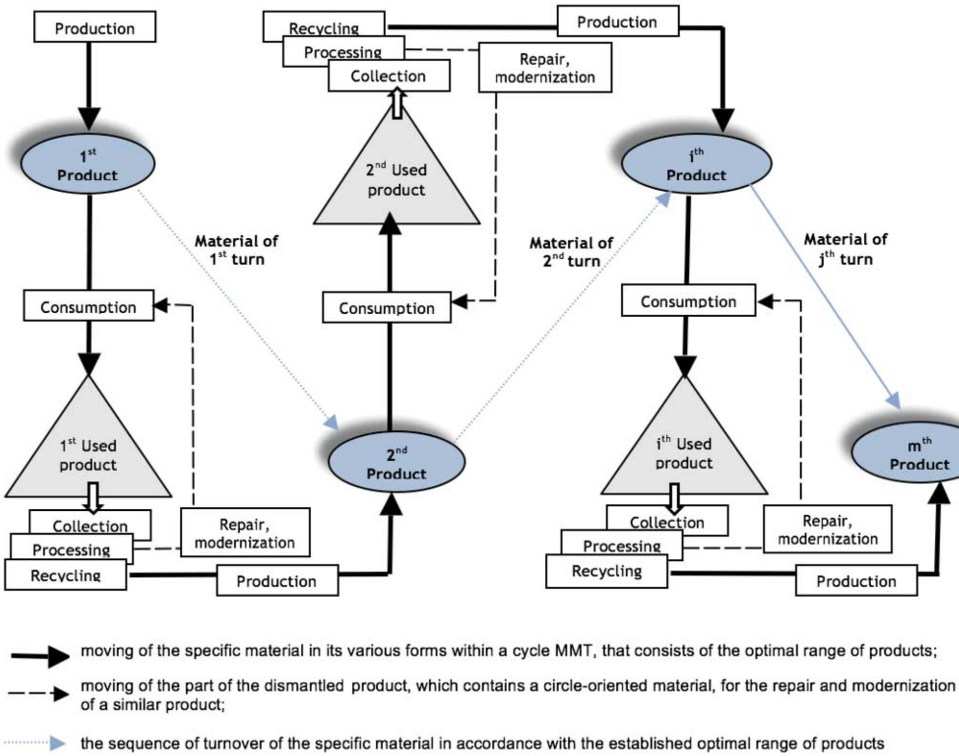

Figure 2. Turnover of specific material within the optimal range of products.

Figure 2 shows the sequence of turnover of the specific material according to the optimal range of m products. This scheme significantly expands the scope of increasing and using the MCP, as it represents its entire lifecycle in terms of multiple use as well as the life cycles of all adjacent products.

Cyclicity of material and the need for management of the MCP

Taking into account the above, we define the cyclicity of material as its acquired characteristic to be multiply used in the economic system, which is formed during the life cycles of adjacent products as elements of the cycle of MMT. Cyclicity, as the acquired characteristic of material, appears due to the increasing and using of MCP, which by-turn requires appropriate management of these processes.

Relying on the essential content of the terms 'potential' [Zavadsky et al., 2006; Balatsky et al., 2010] and 'management of potential' [Balatsky et al., 2010; Telizhenko et al., 2006; Dolzhansky et al., 2006], we consider the material cyclicity potential as multilevel, integrated and the dynamic complex of all kinds of explicit opportunities, unused / partially used reserves and available resources, including the prospects for their increase, which are used / can be used to ensure multiple turnover of material in the economic system.

In its turn, the management of MCP is defined as a set of principles, methods, mechanisms, means and forms of continuous targeted impact on the processes of formation, allocation and use of MCP that provides the keeping of the materials value in the economic system as long as possible. Next, we will determine the content of these processes, which, in fact, are mutually dependent from the point of view of mutual influence.

Thus, "the formation of MCP" will be interpreted as a process of identifying and creating opportunities / preconditions and necessary resources to provide the cyclicity of specific material within the system "resource – product – used product – resource` – product`", structuring and arranging the opportunities and available resources in compliance with the profile of actions of all participants of this system, as well as identifying the implicit opportunities for potential growth in the future.

"The allocation of MCP" we consider as the process of optimal allocation of available resources to ensure the cyclicity on the basis of the minimum loss of the original value of specific material. The material that is to be allocated makes jth turn and goes to the next (jth+1) turn in accordance with the modeled optimal range of products within the cycle of MMT.

We will determine the process of "using the cyclicity potential" as the involvement of specific material to the production of ith product according to the modeled optimal range of products within the cycle of MMT.

Suggested approach to closing material cycles is based on the formation and maximum use of MCP, and unlike existing approaches it provides the moving of certain material along a specified path – the optimal range of products thereby forming a cycle of MMT with maximum number of turns.

Central principles of MCP management

Let's consider the content of the main principles of MCP management.

1. The principle of modeling the cycle of MMT. The basis of this principle is the establishment of the optimal range of products for cyclicity of specific material in accordance with the change in the quality characteristics of the material as a result of each turn. This principle consists in the arranging of products based on the maximum possible turnover of specific material by modeling the process of its circle-oriented use.

2. The principle of evaluating the life cycles of adjacent products rather than evaluating the life cycle of a single product. Since the material cyclicity consists in its multiple use, it is important to analyze the life cycles of adjacent products that are the part of a cycle of MMT. Expanding the scope of evaluation in such way allows us to connect the processes of forming the MCP with the processes of its further use.

3. The principle of fair allocation of the material cyclicity potential. It is necessary to allocate the cyclicity potential reasoning from the minimum loss of the material original value with each subsequent turn.

4. The principle of continuous increasing of MCP. The essence of this principle is to identify the organizational, technical, technological, economic and other opportunities for their further implementation, as well as the continuous search and use of available reserves to increase the level of materials cyclicity in the chain "resource – product – used product – resource` – product`".

5. The principle of maximum use of the available MCP. The content of the principle consists in the direct maximal use of material, obtained from the jth turn, in the production of ith product in accordance with the established optimal range of products within the MMT cycle.

The multi-level strategies for cyclicity of materials used in EEP

Materials cyclicity providing for EEP

For certain materials and substances used in electrical and electronic equipment, a cycle of MMT can be designed by forming the optimal range of these products. This range is established on the basis of the analysis of two factors, i.e. the technical requirements for the material while product producing and quality characteristics of the material at the output of turnover. That is, each next product of the range is selected by the criterion of minimal loss of original value of material in the result of turnover through the life cycle of this product. In other words, the ranking of EEP for determining the sequence of use of same material is conducted, and the priority in the turnover sequence will be given to those products that are characterized by minimum change in the material quality parameters at the end of the turn.

Modeling of the cycle of multiple turnover of a specific material or substance for these products is a key aspect of MCP management.

Diversification of MCP management

To date, modern European policy in the field of the environment has several strategic benchmarks, namely waste prevention and recycling, sustainable use of resources, integrated product policy, sustainable consumption and production [European, Environment]. It is important to note that each of four mentioned benchmarks is aimed, in a certain sense, at increasing and using the cyclicity potential of materials and substances used in certain products.

The multi-direction peculiarity of MCP increasing processe causes the need for diversification of its management. At the same time, the diversification of management, we consider as the multilevelness, the diversity of management objects, as well as the multi-version of forms and methods for achieving a set of tasks. The possibility of allocation the tasks among the participants of the system "resource – product – used product – resource` – product`" is objective precondition for diversification of MCP management.

The multilevel strategies for EEP materials cyclicity providing

Multilevel approach to the MCP management consists in the implementation of this process at the levels of individual, organization and region. Each of these levels includes the managing by the corresponding objects. To form the rational behavior of all participants of the system "resource – product – used product – resource` – product`" it is essential to develop a strategy for providing materials cyclicity of EEP, which covers all mentioned levels.

Conclusions

The implementation of "to move towards a lifecycle-driven circular economy" for EEP through "closing the loop of product lifecycles" sounds quiet respectably. But if we are talking about product lifecycle, it is not the loop, but rather cycle as a set of subsequent stages. Besides, if "circular economy" we consider as "closing the loop", it more likely relates to material lifecycle, but not to product lifecycle. And if nevertheless we emphasis material, which circulates in economy, then it is a spiral rather than a cycle, because the material is subsequently used in a number of different products, forming a cycle of its multiple turnover. In our opinion, the cyclicity of the material, i.e. its ability of moving on spiral, is, in fact, its acquired characteristic, that occurs due to the increasing of MCP at the stages of life cycle of adjacent products, not a single product. A range of products, within which the material turns, forms a cycle of MMT. Modeling of the optimal range of products thereby forming the cycle of multiple turnover of certain material will allow the keeping of its value in the economic system as long as possible.

Unlike the existing approaches to closing material cycles, the suggested approach provides the moving of certain material along a specified path – the optimal range of products thereby forming a cycle of MMT with maximum number of turns, and this path can be adjusted with each subsequent turn of material in view of the fact that new products and technologies are being continuously designed.

In our opinion to increase MCP of products, including EEP, the fundamentally new strategy should be developed, such as "The sustainable management of MCP", that is based on the above proposed principles. At the same time the strategy of sustainable management of material cyclicity potential should be multi-level, i.e. the activities should be allocated and simultaneously oriented at all levels of management: level of individual, organization and region.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-382

Consumer complaint deadlines and product durability: the role of law and regulation

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Keywords
Durability
Consumer complaints
Legal guarantees
Commercial guarantees

Abstract

Under Norwegian law, the consumer has a right to complain about a product up to five years after purchase, if the product has an average life expectancy of more than two years. This means that producers' liability in Norway is valid for a longer period than in most of the EU, where the consumers' right to redress expires after two years. SIFO is doing a project for the Norwegian Ministry of Consumer Affairs (BLD), in order to assess if this difference in consumer protection influences product durability in the Norwegian market. Is there a correlation between liability period and product life span, and if so, to what degree? One hypothesis might be that the size of the market is too small (with only 5 million inhabitants) for importers and producers to take national regulation of this sort into account. In order to address these questions, we intend to perform three empirical work packages: (1) A check on how many cases handled by the Norwegian Consumer Council that the complaining consumer could not have raised if the country had had a two-year liability; (2) A survey on consumers' knowledge of their rights; and (3) Informant or stakeholder interviews with a number of importers and producers to figure out if they put extra emphasis on durability in the Norwegian market as a result of the five year liability. We will also build on previous research into product durability, performed at the institute since the late seventies.

Introduction: The societal relevance of the liability period

Producers' liability in Norway is valid for a longer period - five years for products meant to last - than in most of the EU, where the consumers' right to redress expire after two years. A reduction of the liability period will weaken the consumer protection in the market and transfer power from the customer to the producer/importer/seller. Thus, the balance of power changes some degrees to the consumers' disadvantage.

Under the concern for a (relatively) long liability period also lies an ambition to influence what we might call the product culture of society, beyond a value-for-money perspective. We wish to contribute to a development in the direction of longer lasting and more repairable products. While the original critique of low product quality/durability; especially the phenomenon of planned obsolescence, was based on 'moral' concern, the focus since the report from the World Commission (1987) has been on sustainability. We claim that longer product life is a potentially important contribution to a more sustainable Europe and that the liability period, and the knowledge of this among consumers and retailers etc. will influence product life.

SIFO's (and its predecessor FMD's) research in this field has been based on environmental concern (Dahl 1977, Dahl 1980, Nord 1980, Lange & Kristiansen 1996, Throne-Holst o& Lange 1996, Strandbakken 1997, Tufte 1999, Klepp 2001, Strandbakken 2007). So has other Norwegian research (Hille 1993, Meissner, Brun & Stueland-Larsen 1997), like most of the international (Lund & Denney 1978, DeBell & Dardis 1979, Antonides 1990, Cooper 1994, Gärling, Marell & Davidsson 1995, Granberg 1996, Heiskanen 1996, Marell 1996, Wärneryd 1996, Granberg 1997, Cooper & Evans 2000, Cooper 2004, Cooper 2005, Cooper red. 2010). Relevant to this theme is also second-hand markets, flea markets and so on (Stroeker 1995, Briel 1999, Burns 2010, Hebrok & Asdal 2013, Vittersø & Heidenstrøm 2016).

What are the environmental aspects of product durability? Increased life span for products leads to reduced energy consumption, reduced pollution and reduced materials consumption.

Energy consumption. With fewer units produced (globally) we use less energy for materials extraction, less energy for transport of raw materials, less energy for transport of materials to manufacturer, less energy for making products, less energy for transport to retailer, less energy for transport to consumer, less energy for transport to landfill, and finally less energy for destruction, for disassembly, for partial re-use or materials recycling. Here, the calculation might be slightly influenced by a possible energy gain by incineration (however, even if products like furniture give some energy at the end of their lifespan, this is not energy that we need to rush to exploit).

Pollution. In the extraction phase and the production phase, in addition to the transportation between phases we will see less pollution because of a smaller product volume (that is: production volume). In the disposal phase, we will produce less waste, which also is a big polluter.

Materials consumption. Increased product life leads to less use of resources like cotton, wood, oil, metals etc. Here the real environmental gain actually comes from reduced pollution and reduced energy use. The concern over resource depletion is probably largely mistaken (with a few notable exceptions, like phosphorus). Locally, however, wood might be a scarce resource, and we know that production of cotton is problematic for local freshwater resources.

It has sometimes been claimed that long product life may be a constraining factor, keeping new and environmentally improved products out. This argument, which we believe is mainly mistaken (Hille 1993, Heiskanen 1996, Strandbakken 2007), would – even if it should have been correct, only be valid for products that are polluting or using energy in the use phase, like vehicles, washing machines, cold appliances and car tyres. However, this is not the place to prod further into these questions.

The argument for a relatively long redress period is that this will motivate producers and importers to prioritize quality, longevity, perhaps also reparability (Sweden has recently introduced tax reductions for repair of products).

Research questions

First, we wanted to assess the volume of consumer complaints handled by the Norwegian Consumer Council and/or the Consumer Disputes Commission that referred to or was based on a longer redress period than two years. How many cases per year, the development of the volume over years and what products that were subject to complaints beyond the two-year period.

Second, we wanted to assess the Norwegian consumers' knowledge of and familiarity with questions of law based rights to complain and producers' guarantees.

Third, we wanted to have the views, opinions and interests of some relevant stakeholders on questions of product durability, quality and redress periods. Do importers and producers change their policy and market more durable products in countries with a longer redress period?

All these undertakings were supposed to shed some light on the relationship between law and regulation on one hand, and product durability on the other.

Consumer complaints beyond the two year redress period

The Norwegian Consumer Council received 43 000 complaints between January 2012 and December 2016. We have had access to this vast material, where cases are registered by date of purchase (this information is often missing, however), date of complaint and type of product (or service).

For the practical problems and challenges that had to be met for an effective utilization of this material, we refer to the Appendix; Methodological aspects. We have not been able to check if the complaints were decided in favour of the consumer or not.

It is necessary, however, to put these complaints into a societal context. According to the Norwegian Consumer Council, based on a report from 2013, more than 90 % of the consumers complain only at the point of purchase, that is the shop. A bit more than 50 % of the consumers claim that they in the course of a year have bought items that they needed to complain about. 72 % of them actually made a complaint and, as mentioned, 91 % complained in the shop only. Of the complainers, 82 % had their case dealt within the shop (the complaint was accepted by the retailer), 7 % was rejected and 8 % dropped the case. Six out of ten were satisfied by the way the retailer treated them, while a bit less than three out of ten were dissatisfied (27 %).

This only to emphasize that the formal complaints to the Consumer Council is only the tip of the iceberg. This tip is, in our view, an important one because it «disciplines» the market. Both consumers and retailers know that there is a potential next level, if they fail to solve the disputes peacefully. In this context, consumer and retailer awareness of consumer rights and redress periods etc. is an important part of the product culture of a society, probably even a precondition for a functioning market. I have heard stories where a customer took a faulty coffee machine back to the store after 4 ½ years, and was immediately handled a new one over the counter.

For the year 2011, the archive is inadequate, lacking date of complaint.

For 2012, 5157 cases were registered. We checked 10 % (randomly selected) of the cases, and among 515 cases, we found 16 where the time span between purchase and complaint were longer than two years. This gives an estimate of 160 cases in the total sample. Most common products were cars, white goods, consumer electronics and furniture.

For 2013, 5853 cases were registered. Among 585 checked cases, we found 24 with a time span over two years, but less than five (here we also found three cases where consumers had complained after 10 and 13 years!). This gives an estimate of 240 cases that year. Cars and consumer electronics (TV, PC, "computer" and MacBook) dominated; half the cases belonged to these categories, two cases concerned white goods, the rest were one of a kind cases.

For 2014, 7353 cases were registered. Among the 735 checked cases, we found 39 complaints between two and five years. Again, car complaints were most frequent (10 cases), together with white goods/larger kitchen appliances (also 10), followed by furniture and consumer electronics (both product categories with 6 cases).

2015 registered a total of 8416 complaints. In our 841 checked cases we found 39 between two and five years; which gives an estimated 390 cases totally. 14 cases concerned cars, 8 concerned computers and computer equipment, followed by white goods (3), furniture (3) and cell phones (2).

For 2016, 9653 cases were registered. The 965 cases in our 10 % selection yielded 60 cases, giving an estimate of 600 cases of consumer complaints referring to a redress period of more than two years. As usual, cars dominate (10 cases, plus 3 for other types of vehicles). This year, interestingly, as many as 8 cases concerned cell phones (we do not know how many of these were smartphones), and 6 were about consumer electronics. The development of the number of cases and complaints are summarized in table 1.

Year	Total number of cases	Complaints
2012	5157	160
2013	5853	240
2014	7353	390
2015	8416	390
2016	9653	600

Table 1. Development 2012-2016.

The simple main tendency is that the number of cases based on a redress period of more than two years increases. So does the total number of complaints, but the 2+ complaints increase more than the total number (except between 2014 and 15). This indicates that the five-year redress is an important part of Norwegian consumer law.

Consumers' knowledge of and familiarity with legal and commercial guarantees

A Norwegian nationwide survey was conducted in spring 2017 by SIFO Consumption Research Norway for the Norwegian Ministry for Consumer Affairs (Strandbakken & Bøyum 2017). A set of questions probed Norwegian consumers' knowledge of the difference between legal and commercial guarantees. This was done by asking respondents to decide if a set of statements were correct or incorrect.

The first statement was *"Legal guarantee is legally established, while commercial guarantee is given voluntarily by the retailer"*. For reasons of language/wording, this is not a stupid question (a question containing the correct answer) in Norwegian… 53 % gave the right answer, 29 % gave the wrong one and 18 % did not know or not answer.

The second *was "Commercial guarantees offer more than legal guarantees (rights beyond what is offered by law)"*. The correct answer here is that the statement is "correct". A manufacturers guarantee or warranty has to promise more than what the law demands. 55 % gave the correct answer (which is actually 10 % less than the percentage who gave the correct answer to the same question I 1998), 21 % gave the wrong answer and 24 % did not know or did not answer.

The third statement was: *"Commercial guarantee is offered for a limited period, while a legal guarantee is unlimited"*. Here, obviously, the correct answer is "wrong". 61% gave the correct answer, 20 % gave the wrong answer and 19 % did not know/answer.

Two direct questions on redress and legal guarantees were asked; the first about the consumer's rights if a refrigerator should break down one and a half year after purchase, the second about the consumer's rights if a cell phone/smart phone breaks down after three and a half year. 63 % chose the correct alternative for the refrigerator after 1 ½ year; that he was entitled to free repair, on the condition that he had not caused the damage himself. On the question on smart phones breakdown after 3 ½ year the answers were more disappointing, however. Here only 43 % of the male respondents, and as few as 25 % of the female knew that they had rights to repair (or being offered a new product if repair was not possible). This proves that the five year redress is not well enough known among Norwegian consumers, after all (or that smart phone retailers have managed to confuse consumers with their generous one year commercial guarantee).

Stakeholder views

We sent a small battery of questions to a set of importers, retailers and producers of white goods, consumer electronics and furniture; questions about product durability/quality, if reduced sales might be a problem because of longer durability, if they adjusted their product range to countries with different redress periods etc. In addition we asked if their policy would change if the redress period was changed (i.e. reduced to two year for the whole EU/EES region) and if they offered commercial guarantees on top of the legal ones.

We mainly managed to get in touch with "up-market" actors, and this might give a bias in the results.

Respondents/informants were unanimous in their views on country wise adjustments. "*Absolutely not*!". *"The Norwegian market is one thousandth of the global market. We do not produce separately for Norway, so the answer is no*". They were also very clear that they preferred equal rules all over Europe, because different regulations (i.e. different redress periods) caused a lot of extra work.

Two comments: it is still possible that the Norwegian market, because of wealthy consumers, mainly has received expensive and high quality products; resulting in a different product portfolio than countries, without the five year redress being the cause. And, these stakeholders' preference for equal rules does not necessarily mean that they are opposed to a longer redress period. On the contrary, the stakeholders we interviewed would probably benefit from a longer redress, because it would mean trouble to their low quality/low price competitors.

Conclusions

An increased life span for consumer durables will lead to reduces energy consumption, reduced pollution and reduced materials extraction. Hence, we claim that lower exchange rates will benefit the environment.

It might be difficult for large consumer groups to complain when they do not know their rights, or misunderstand them. It seems as if the five-year redress period for durables is not well enough known among consumers. That said, more than half the respondents (on some questions much more) answers the knowledge questions correctly.

It is not necessarily the number of cases treated in the Consumer Council or the Consumer Disputes Commission that is crucial. The awareness among business and consumers is important because nine out of ten cases are dealt within the shop.

We observe a rising number of consumer complaints in Norway based on the five-year redress, from fewer than 200 to more than 600 in four years. Vehicles, furniture and white goods are large categories, but the category with the largest increase is "brown goods"; PCs, laptops and, most notably, cell phones/smart phones.

Our stakeholders support a common legislation for Europe, and regard i.e. the Norwegian market as too small to introduce product adjustments.

However, it is still possible that the Norwegian market, because of its wealthy consumers, mainly has received expensive and high quality products.

Acknowledgments

This paper is based on a project on legal guarantees, financed by the Norwegian Ministry of Consumer Affairs.

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Appendix

Methodological aspects

We analyze a year, for instance 2014, by taking the XL-file and formatting it as printable. That year's 7353 cases are presented with one line each; registering what product or service the complaint is about, the date of purchase (often missing, however) and the date of complaint. In printable form, the 2014 archive covers 78 pages. Since the Consumer Council numbers their cases successively, we decided that by picking 8 random pages between 1 and 78 we would be able to cover 735 cases. The number of cases that we identified on these 8 pages that had a period between purchase and complaint that exceeded 2 years, were counted and registered, excluding services. To give an estimate for the year, we multiply by ten.

This approach was used for all the years.

Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-387

Do ecolabels extend product service times? An analysis of the product group specific criteria of the European Union and Nordic ecolabels

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Keywords
Ecolabel
Product Service Time Extension
Durability
Reparability

Abstract
Ecolabels are an established means of guiding consumer choices towards product and service options with better environmental performance. The life cycle approach based award criteria of ISO Type I product-specific ecolabels aim to steer the product into the market in an environmentally less harmful direction. In this paper, we present an analysis of Product Group Specific Criteria Documents of two ISO Type I Ecolabelling Schemes: the Nordic Ecolabel and the EU Ecolabel. The examination of the product group specific criteria documents indicates that requirements on durability, upgradability and reparability can well be set, and are already included in ecolabel requirements. While durability is already present the criteria for a variety of different product groups, upgradability and reparability are currently required for fewer products, such as computers and televisions mentioned above. Future revisions of product-specific criteria set present an opportunity to apply circular economy relevant requirements on upgradability and reparability in a broader suite of product groups. Further research on product life spans of ecolabelled products is needed.

Introduction

The current model of consumption and production, where items are produced from extracted natural resources, used for a short time and thrown away, cannot be sustained in the long run. Product life spans have decreased steadily and simultaneously material flows through society have been increasing (Bakker et al. 2014). By minimising matter and energy flow in the system, environmental deterioration can be minimised without restricting economic growth or social or technical progress (Stahel, 1982 in Lieder and Rashid 2016:37). The Circular Economy discourse has been developing in recent years as a response to resource scarcity and the limitations of the Earth's carrying capacity. It proposes a model for minimising the use of virgin materials for economic activity (Skou Andersen (2007), p.133), and for maintaining the value of natural resources contained in consumable items (e.g., Ghisellini et al. 2016 and Franklin-Johnson et al. 2016).

The conceptual starting point introduced by Pearce and Turner (1990) is that a Circular Economy, as opposed to an open-ended economy, aims to minimise residues from economic activity. Value is created by increasing the amount of time during which a resource provides value (Franklin-Johnson et al. 2016:592). In addition to designing for material circulation, the physical and use life time of products plays an important role in reducing the material throughput in society and is a factor in Circular Economy. Recent circular economy literature refers to longer lasting or durable products (Allwood et al. 2011, in Lieder and Rashid 2016:44) resource longevity (Franklin-Johnson et al. 2016), and multiple life cycles products, implemented through e.g., remanufacturing and reuse (Asif et al. 2015:1265).

Durability, reparability, and upgradability of products are considered as factors that extend a product's service time (Ellen MacArthur Foundation, EC 2015). Reparability is understood as "product design that allows maintaining the product function, including easy access to parts, fault diagnostics, part inter-changeability, identification of components and leads as well as information on repair (Ellen MacArthur Foundation Circular Economy Toolkit). Upgradability is defined as the ability of a product to continue being useful by improving the quality, value, and effectiveness or performance (Bocken et al. (2016):311). Multi-functionality is seen as product features by which the product serves several uses, which is a factor that can increase the use of a product during its lifetime. This paper analyses the existence of these factors on ecolabel requirements.

Ecolabels can act as a market pull for sustainable products (e.g. Cordella & Hidalgo 2016: 65) and thereby evidently have the potential to steer the market towards greener products. So-called ISO Type I ecolabels set a standard for environmentally preferable products, which are identified by considering the environmental impacts throughout the product life cycle (ISO14024:1999). Each product group is associated with a set of requirements for an eco-label applicant, to differentiate between the better performing products. The criteria are revised periodically which creates a stepwise push towards sustainability.

The aim of this research is to analyse how the Product-Group-Specific Criteria of the Nordic Swan Ecolabel and the EU Ecolabel promote Extended Product Service Times. The following publicly available documents were analysed for this research: (a) 46 Product Group specific Criteria Documents of the Nordic Swan Ecolabel; and (b) 29 Product group specific criteria documents of the EU Ecolabel Flower.

Results

Table 1 below shows the extent to which the EU Ecolabel and the Nordic Swan include award criteria requirements on durability, reparability, upgradability and multi-functionality.

The EU Ecolabel has requirements on durability and reparability. The product groups that generally have requirements on durability also have requirements on reparability. The criteria for Flushing Toilets, Water Based Heaters, Imaging Equipment, Computers, Televisions, Furniture and Mattresses have an obligatory warranty or guarantee period, which ranges from 2 to 10 years depending on the product group. Other durability requirements include product quality and durability testing and parameters, mechanical resistance criteria and durability parameters.

Many of the EU Ecolabel product group include requirements for design for reparability and availability of spare parts. The product group criteria require design that allows a professional engineer or service personnel to change parts with tools that are normally available for them. In addition to the technology product groups, the EU Ecolabel product group on mattresses includes a requirement (nr. 13) whereby the “manufacturer shall demonstrate that the mattress can be dismantled for the following purposes: undertaking repairs and replacement of worn-out parts, upgrading older or obsolete parts”. The criteria on televisions and computers, as well as mattresses combine reparability and upgradability into one requirement. No other EU Ecolabel product groups have requirements on upgradability.

Nordic Ecolabelling is designed to ensure that products are of good quality (E.g. White Goods criteria: 4). Criteria for most non-disposable products include requirements for durability and quality, many with a specified obligatory warranty/guarantee period. As shown by table I, the Nordic Swan Ecolabel includes durability requirements in many product groups belonging to different product category type. Reparability is a requirement mainly in electronic devices and household goods. Upgradability is mentioned in only one product group – Computers vs 7.3. It includes in its definition that a Nordic Ecolabelled computer is “easy to upgrade, dismantle or recycle” (Nordic Ecolabelling of Computers: 4).

Product design that allows for easy dismantling, repair and upgrade through the availability of replacement parts is at the centre of service life time extension. Related requirements are reflected in several of the Nordic Swan Ecolabel criteria, in particular for electronic devices and household goods. In addition, product service time is reflected in several disposable products, making reference to the use or operating time of the product (e.g., candles, sanitary products and primary batteries). The rechargeable Batteries product group is interpreted as including a requirement on multi-functionality as it requires that the charger can be used for a minimum of two battery sizes.

Discussion

Ecolabels include many different types of criteria for products that can increase the product service times. This way ecolabels can be a suitable tool for influencing the current trend where product life spans are decreasing. To counter this trend, physical life spans of products need to increase. Product service time can be extended if the product is by ecolabel requirements assured to be durable, repairable or upgradable or has maximised use intensity through multi-functionality.

The ecolabelling schemes include criteria that promote durability of the product. These are characterised through quality requirements as well as requirements on

Aspect	Product Group Nordic Swan	Product Group EU Ecolabel
Durability	Furniture and Fitments, Windows and Doors, Durable/ Resistant Wood for Outdoor Use Floor Covering, Construction and Façade Panels, Closed Toilet Systems, Suppliers for Microfibre based cleaning, Toys, Outdoor Furniture, Boilers for Solid Biofuels, Stoves, Textiles, Hides, Skins and Leather, Rechargeable Batteries, White Goods, Compost Bins, Imaging Equipment, TVs and Projectors, Office and Hobby Supplies.	Flushing Toilets and Urinals; Sanitary Tapware; Water Based heaters, Imaging Equipment, Computers, Televisions, Furniture, Mattresses, Textiles and Footwear.
Reparability	White Goods, Furniture and Fittings, Compost Bins, Closed Toilet Systems, Boilers for Solid Biofuels, Imaging Equipment, TVs and Projectors and Computers.	Flushing Toilets and Urinals; Sanitary Tapware; Heat Pumps; Water-based heaters; Imaging equipment; Computers; Televisions; Furniture and Mattresses.
Upgradability	Computers	Computers; Televisions; Mattresses
Multi-functionality	Rechargeable Batteries	

Table 1 Extension of Product Service Time in Ecolabelling Requirements.

warranties and guarantees. To assure that the product is in use for as long as possible and value is kept in the system, requirements on upgradeability and reparability are important. Multi-functionality would reduce the idle time of a product. However, it is shown here that only in one product group studied there was a requirement indicating multi-functionality.

The concept of "longevity" includes the longer use of a product by a consumer, which is promoted by the currently prevalent ecolabel requirements. However, it builds in also the duration of a product's refurbished use (Franklin-Johnson et al. (2016:596). To date requirements for repair and upgrade are not prevalent in the body of criteria documents studied for this paper. Nevertheless, there are product groups, such as imaging equipment (Nordic Swan) that include obligations that enhance reparability. The Nordic Swan's product group on Remanufactured Toner Cartridges includes a system of take-back as a requirement. Extending these kinds of requirements to other product groups with a view to increase the resource use time within a product system, are a means to enhance product life times.

Ecolabelling schemes are designed in a way that they drive a market based change towards more sustainable consumption and production patterns. It is the role of ecolabelling to point out the best-performing products within a product category. An assurance that the product is durable, reparable and upgradable fits well in this role. These product features also play a role in influencing the volumes of consumption, especially in product groups where throughput cycles are relatively fast and where the disposal depends on the poor quality and short life time of a product. However, as ecolabelling is only suited for product groups for which differences in environmental performance can be distinguished there are products that are not suitable for ecolabelling (Thidell 2009: 42-43).

The underlying motivation in the transition to circular economy is to create more value from fewer resources. One approach to value creation is increasing the amount of time during which a resource provides value (Franklin-Johnson, 2016). In addition to increasing the requirements on longer life spans of products, various models of value creation in using more durable ecolabelled products in a circular economy should be researched. This could include, for example, creating ecolabel criteria for sharing economy services.

This research has presented the requirements that aim to extend product life times, found in the award criteria documents of two ecolabelling schemes. A future research that would strengthen this analysis would be to quantify the expected and actual use times and physical life times of ecolabelled products, in comparison to products without an ecolabel.

Conclusions

Product design that allows for easy dismantling, repair, upgrade and through the availability of replacement parts is at the centre of service life time extension. Related requirements are reflected in several of the Nordic Swan Ecolabel and EU Ecolabel product-specific criteria sets, in particular for electronic devices and household goods. In this article, it is suggested that ecolabels, through setting strict criteria for product design, contents and functioning, and for condensed consumer oriented information, are well placed to drive the uptake of products and services aligned with the objectives of Circular Economy. The examination of the product group specific criteria documents indicates that requirements on durability, upgradability and reparability can well be set, and are already included in ecolabel requirements. While durability is already present the criteria for a variety of different product groups, upgradability and reparability are currently required for fewer products, such as computers and televisions mentioned above. Future revisions of product-specific criteria sets present an opportunity to apply circular economy relevant requirements on upgradability and reparability in a broader suite of product groups.

Acknowledgments

This research was undertaken as part of the project "Nordic Swan, Circular Economy and Product Environmental Footprint" funded by the Nordic Council of Ministers.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-391

PLATE conference
Delft University of Technology
8-10 November 2017

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Product Lifetimes And The Environment

The role of product designers in the transition towards the circular economy: a reality check

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Keywords
Designer's role
Product design
Practice
Circular economy
Transition

Abstract
This paper examines the role of product designers in the transition towards the circular economy. Both scientific and grey literature show remarkable optimism when it comes to role strategic and coordinating role designers could play in this transition process. However, there has been little examination of the actual role and influence designers have in practice. In this paper we review the roles that designers play in the transition towards a circular economy according to literature. Through semi-structured interviews, we uncover the views of designers themselves, which we then use to make a comparison. Our main conclusion is that designers experience a lack of knowledge and/or work in predetermined solution spaces, which prevents them from taking on the role that is expected in literature.

Introduction

Within literature statements like "Designers have a significant responsibility to shape the current status on how products and services are built" (Moreno et al., 2016:1) are not uncommon. As one of the first to talk about sustainable design, Buckminster Fuller (1969) envisioned that designers should engage in ephemeralization, a term coined to explain that designers should start "doing more with less", i.e. resource efficiency expanded on this thought Papanek (1971) in his book Design for the Real World, where he took an extreme stance against the role of the designer stating that 'there are professions more harmful than industrial design, but only a few of them'. Andrews (2015) argues that designers helped enable the linear economy and she suggests that they have the potential to facilitate and even lead the development of a circular economy. Finally, in the What Design Can Do manifesto 2017 van Lier (2017) claims 'Designers are pioneers, driving forces, flag bearers for change, active at micro and macro levels', echoing the perception that they fulfil prominent roles. These statements sparked a further investigation into visions that exist about the role of the designer in the transition towards a more sustainable system. Here we focus on the transition to the circular economy. In addition to a literature review we carried out interviews with designers from practice, addressing (1) their current role (2) their vision on the role designers should fulfil in the transition towards the circular economy and (3) the barriers they experience or foresee. We choose this method as a means to be able to make an objective observation of nuances between the visions in literature and practice.

Method

Literature Review

Using the evidence-focused literature review technique proposed by (Hagen-Zanker & Mallett, 2013), a literature review has been carried out to uncover the different perspectives regarding the roles and activities of designers in the transition process towards a circular economy. Following the protocol of Hagen-Zanker & Mallett (2013), grey literature was included when deemed relevant and snowballing was done via the reference lists of the selected sources. For retrieval initially the following search terms were used: ("role of" AND "product designer*" OR "role of" AND "industrial designer*") AND ("in transition") AND ("circular economy" OR "sustainability") within the timeframe 1950-2017 during October 2016 to February 2017 in Google Scholar.

Even though there is a slight distinction between product designers and industrial designers both are part of the world of so-called 'object design'. Heskett (2002) describes them as "virtually interchangeable", because there is a focus on making an 'object' in both professions. Therefore, the final search terms include both types of designers.

Semi-structured interviews

Within the research domain of 'organizational role theory' (Biddle, 1986), roles in organizations are seen as "social systems that are pre-planned, task-oriented and hierarchical" (Biddle, 1986:73). As the purpose for doing interviews with designers from practice was to learn more about their current and prospective roles, they were queried about their job descriptions, their place in the work hierarchy, and the activities performed as part of their position. In February 2017, eight semi-structured interviews (Patton, 2002) were conducted. All participants were educated as product designers. Their wide range of positions (from product designer to sustainability manager or CEO of a design agency) ensured different perspectives were included and made it possible to widely reflect on the results from the literature

Results

Literature

The initial search yielded a total of 51 articles. Articles were excluded based on the absence of a vision on the role of designers. This left 12 articles after exclusion, which were used to 'snowball' to 41 articles. Looking at the literature review results, three categories were formulated:

1. The designer's role in general.

2. Developments in the role of the designer over time

3. Visions on designer's roles in the future

The designer's role in general

The role of designers has been described from varying perspectives. Across different fields, the major roles that could be identified were a (1) strategic role (2) coordinating role and (3) a functional role.

Strategic role

Designers operating in a 'strategic role' are, are involved in the development and execution of (company and/ or product) policy/strategy, and are responsible for formulating an overall, integrated vision for future solutions (Joore, 2010; Papanek, 1971). This also entails being involved in the product development process early on (Bakker, 1995; Behrisch, 2013), developing the framework within which functional products will be developed (Bakker, 1995), initiating projects and leading the design in the intended direction (Seidel, 2000; Perks et al., 2005).

Coordinating role

Designers in a 'coordinator role' are focused on balancing different interest and ideas among a group of stakeholder (Behrisch, 2013; Battiston, 2015; Manzini & Coad, 2015; Ortiz, 2012; Tan, 2012; Julier, 2007). They facilitated, support and enable the conversations between these actors (Tan, 2012) and form a bridge through which this knowledge transfers and is translated to the design discourse (Battiston, 2015; Verganti, 2008).

Functional role

Within the 'functional role', the "designer's task is to translate a product idea into a concrete product" (Bakker, 1995:43; Behrisch, 2013).

Designers carrying out this role are involved from product idea to an implementable solution (Bakker, 1995) and focus on the materialization of the product rather than the development of the higher level product policy.

Note however, that the roles are not mutually exclusive; one person can fulfill multiple roles.

Developments in the role of the designer over time

Valtonen (2005) is one of the few authors who gives an overview of how the role of the industrial designer has broadened since the emergence of the field in the 1950s. She describes how designers have evolved from creators of objects (functional role) to innovation leaders (strategic role) in the 2000s (Maciver, 2011; Valtonen, 2005). While Valtonen's (2005) research is limited to the Finnish designer, a similar widening in the role is being echoed in other fields (Joore & Brezet, 2015; Meroni, 2007; Thackara, 2006; Gaziulusoy, 2015; Bakker, 1995; Banerjee, 2008; Maciver, 2012; Roth, 1998). Jin (2015) in additional mentions a broader role as coordinator. The evolution to a wider role, seems to be connected to designers having to work on progressively complex problems (Gaziulusoy, 2015; Roth, 1999).

Visions on designer's roles in the future

In the table 1: Future visions of designer's roles we see parallels with the former categorization of roles. Although most authors do not explicitly place the envisioned roles in the context of a transition, the fact that the visions stem from authors within a field that differs from the status quo reflect which roles are assumed in the transition process towards more sustainability/circularity. While authors call on designers to adopt more social and moral responsibility in their work in general (Buckminster Fuller, 1969; Papanek, 1971; Tonkinwise, 2015) some assign specific roles. First of all, the role of coordinator (Thackara, 2006; Morelli, 2007; Jin, 2015; Daalhuizen, 2014). Manzini (2009) and Joore (2010) envision a strategic role in addition to this. In contrast, Emilson et al. (2011) conceptualize that designers should fulfill a functional role in addition. Lastly, there are also authors, who rather only foresee a single strategic role (Joore & Brezet, 2015; Jin, 2015; Bakker, 1995; Smulders & Subrahmanian, 2010).

In short, the overview reflects that there is an overlap in the visions across the three main roles and that these visions stem from a sense of responsibility.

Practice

Background Interviewed Designers

The categorization of owners (participant 1-4, all owning a small consultancy) versus non-owner (participant 5-8, all employed in a large organization) determined whether or not the designer was involved in strategic decision making (table 2: Background Interviewed Designers). Even though the non-owners in some cases mentioned that they were involved in more strategic roles (e.g. building and managing of teams, and leading projects), they are not in the position to determine the overall company strategy regarding sustainable design. Interviewee number 5 and 6 mentioned that depending on the project they alternated between a more strategic role and a functional role.

FUTURE VISIONS OF DESIGNER'S ROLE		
ROLE DESIGNER	QOUTE	CITATION
Facilitators	From thinking of ourselves as the authors of a finished work, **we had better evolve toward thinking of ourselves as facilitators whose job is to help people act more intelligently**, in a more design-minded way, in the systems we all live in. (Thackara, 2006:214)	(Thackara, 2006)
Social Visionaries	[…] Social Practice Theory **demands that designers acknowledge their responsibility for determining how our societies are made durable** (to paraphrase Bruno Latour). Tonkinwise (2015)	Tonkinwise (2015)
Intermediary, Solution provider, Coordinator	And agreed, the designer can play a significant intermediary role between a diversity of actors in and around the company. [….] Joore (2010:44;). […] the r**ole of the designer could be broadened to more of a coordinating role between or above the parties**. (Joore 2010: 199)	Joore (2010)
Social and environmental responsible	Victor Papanek (1971) **called for designers to integrate more social and environmental responsibility** in their work in his manifesto Design for the Real World: Human Ecology and Social Change. (Tan 2012: 113)	Tan (2012); Papanek (1971)
Social and moral responsible	Thirty years ago, Buckminster Fuller (1969) […] **called for designers to adopt more social and moral responsibility** in their work. (Tan 2012: 2)	Tan (2012); Buckminster Fuller (1969)
Connectors, Facilitator, Quality Producers, Visualisers, Visionaries, Future Buiders, Promotors of new business Models, Catalysers of Change	**Understanding the new designer role**: designers as connectors and facilitators, as quality producers, as visualisers and visionaries, as future builders (or co-producers). Designers as promoters of new businessmodels.Designers as catalysers of change. (Manzini 2009:11)	Manzini (2009)
Faciliator	Both companies and **designers will no longer be proponents of a set of products and service**s to passive users, but **rather the facilitators of a system of value co-production**. Therefore, they will loose the central role they had in the previous contextual condition, and become catalyses in a networked system. This requires [...] designers learn new methods and languages to operate in the new context. Morelli (2007:18)	Morelli (2007)
Questioner, Maker	(1) For some of the participants **its role should be 'the questioner',** which means that designers should support the stakeholders involved in a process by highlighting issues and key aspects. […] (2) **Other participants stated that the context analysis is not the core competence of design in social innovation, instead they were suggesting 'making': visualizing, prototyping** and showing as the ability of designers to bring to life participants' ideas and imagination and support them in prototyping processes for nding opportunities and possibilities. (Emilson et al, 2011: 26)	Emilson et al. (2011)
Strategic Role	"Change actors like **designers play a strategic role in innovation and transition** processes towards a sustainable society." Joore & Brezet (2015:92)	Joore and Brezet (2015)
(Knowledge) Brokers	Jin (2015: 44) refers to Daalhuizen (2014), who suggests designers **can act as brokers to bridge different stakeholders and democratize collaboration processes**.	Jin (2015); Daalhuizen 2014)
Teamwork leaders	Jin (2015: 44) cites Smulders and Subrahmanian (2010): As coordinators and managers, **designers can act as agents to lead teamwork and incite change in stakeholders** who aren't necessarily educated in design.	Jin (2015); Smulders and Subrahmanian (2010).
Strategic	Designers have the potential to create innovative solutions for less environmentally damaging products and product systems. [...] The more a designer is involved in strategic planning issues (i.e. determining what product the company will be developing), the more influence he or she will have on the potential environmental impact of the product. (Bakker, 1995: 8)	Bakker (1995)

Table 1. Future visions on designer's roles.

Four interviewees out of eight said that they see it as their responsibility to actively acquire knowledge regarding sustainability (or circularity), while one interviewee mentioned that acquiring and implementing knowledge on sustainability was part of an actual company assignment. This company strategy was employed to create more buy-in within the company the designers were working in. The interviewees, who mentioned that they acquired knowledge based on their intrinsic motivation, did this inter alia to be able to convince clients about their capabilities.

Barriers recognized by designers

The interviewees were also asked to describe an ideal sustainable project that was meant to stimulate the transition towards sustainability and the role that they would envision themselves in. They were then asked which barriers they would realistically foresee regarding this project, based on everyday experiences. This resulted in the overview in table 3: Barriers recognized by designers. Seven out of eight designers envisioned a strategic role for themselves rather than a functional or coordinating role. Within a strategic role, they especially recognized the ability to be a visionary and/or the need

BACKGROUND INTERVIEWED DESIGNERS	1	2	3	4	5	6	7	8
Company Type	Design Consultancy	Circular Business Developer	Design Consultancy	Strategy Consultancy	Design Consultancy	Design Company	OEM	OEM
Owner	Yes	Yes	Yes	Yes	No	No	No	No
Position	CEO/ Product Designer	CEO/ Innovation director/ Product Designer	CEO/ Product Designer	CEO/ Strategic Designer	Product Designer/ Project Leader	Senior Designer	Sustainability Manager	Design Lead
Company Size	< 10	< 10	< 10	< 10	> 500	> 500	> 500	> 500
Higher level project activities								
Acquisition of projects	x	x	x	x				
Leading (Design) Projects	x	x	x	x	x	x		x
(Actively) Managing Teams		x		x	x	x	x	x
Making links between projects		x						
Finding Partners	x	x	x					
Guiding clients and guarding design process	x	x	x	x	x	x		
Internal Activities								
Strategic Decision Making	x	x	x	x				
Building Team						x	x	
Transferring knowledge on sustainability and CE (external workshops)	x				x	x	x	
Design Activities								
Designing Products	x	x	x		x	x	x	x
Designing Strategies				x	x			x
External Activities								
Acquiring knowledge on sustainability and CE	x			x	x	x	x	

Table 2. Background Interviewed Designers.

to be a role model for other designers. However, two designers mentioned a fear of becoming a 'preacher' (e.g. someone who constantly talks to others inside and outside the company about the absolute and correct way to reach more sustainability/circular).

In terms of barriers, all eight designers foresee problems with the long-term commitment and ability of clients to deal with setbacks during the transition to a circular economy. Overall it is apparent that while the owners of the agencies (participants 1-4) already are fulfilling a role that could be qualified as more strategic, they also foresee more barriers for designers to make the transition to a circular economy.

Discussion

Our results indicate that theory and empirical data only partially overlap. Firstly, literature shows three major roles: strategic, coordinator and functional. While the interviewed designers agree with a vision in which they fulfill a strategic role in the transition, they also foresee barriers within this regard. Some of them being the lack of know-how to find or create the right business case, not knowing how to assess the sustainability/circularity of an idea and not knowing how to apply systems thinking to come to a solution. Additionally, five designers imagined that working in a pre-determined solution space as a result of the functional role (as recognized by Koo (2016)) that they were carrying out, would be a barrier in the transition to carry out the envisioned strategic role. With respect to this, one designer working in a predetermined solution space in a design consultancy mentioned company culture, client interest and lack of government policy as additional barriers (in literature also recognized by Behrisch (2013)).

Secondly, the group of designers from practice mentioned the coordinating role only once when talking about the envisioned role. Instead, in practice it seems that designers foresee themselves fulfilling a strategic role. However, they foresee quite some limitations and boundary conditions that limits their possibilities. This might be connected to the fact that four of the interviewed designers actually already work in the positions in which they fulfil activities that overlap with those fulfilled in a strategic role. Through this they might have already experienced successes in executing sustainable projects. This in turn could have led them to extrapolate the vision in which they fulfill a strategic role. However, they also seem to be the ones foreseeing more barriers. This can be attributed to the fact that they do indeed have more opportunities to experiment more freely, hence they get confronted with more barriers.

Lastly, the interviewed designers showcased an intrinsic motivation to diminish the negative impact of products they design on the environment and society. They added that designers, apart from the role they already play, should always be critical 'questioners'. Yet, they express concerns of becoming a 'preacher'. This means that the impact of their efforts might be smaller than they would like it to be as they adjust their communication. Instead they might propose incremental sustainable solutions. In comparison, we see that the visions from practice provide

BARRIERS RECOGNIZED BY DESIGNERS	1	2	3	4	5	6	7	8	
INTERNAL (COMPANY)									
Knowledge/Training - CE Related									
Not knowing how to assess circularity of an idea	x	x		x	x	x			5
Not having the know-how to find or create the right business case	x				x	x	x	x	5
Not knowing how to use systems thinking to come to a solution		x				x	x	x	4
Not having access to courses about CE			x		x				2
Not having access to the (right) methods fitting the CE rhetoric	x						x		2
Self Criticism									
Fear of becoming a preacher	x					x			2
Position									
Not being involved in decision making (as a designer)		x	x	x	x			x	5
Having to work in a predetermined solution space	x	x	x		x			x	5
Not getting the opportunity to acquire and knowledge					x			x	2
Not being involved in the development of company policy					x				1
Having to create your own space as a (CE) designer		x							1
Recruitment									
Finding the right people to work with	x	x	x		x				4
Strategy									
No strategy/scope for CE					x			x	2
Long Term									
Having the patience to deal with setbacks, when commiting to CE/sustainability	x	x			x			x	4
EXTERNAL (COMPANY)									
Knowledge/Training									
Not getting the opportunity to transfer knowledge to clients			x						1
Recruitment									
Not finding the right partners to work with			x					x	2
Projects/Clients									
Clients not being interested in (real) CE		x		x	x		x		4
Clients' priorities within sustainability projects		x	x	x					3
Lack of projects with a sustainable focus				x					1
Circular Buy-In									
Ability to bring together a network of partners to develop a CE solution		x	x	x	x	x		x	6
Long Term									
Not having the patience to deal with setbacks, when commiting to CE/sustainability	x	x	x	x	x	x	x	x	8
Not having enough financial resources	x	x			x				3
Clients not being ready to accept (big) change	x	x							2
Examples									
Lack of successful scalable examples to learn from				x					1
CUSTOMER									
Consumers not caring enough about sustainability				x		x		x	3
GOVERNMENT									
Policy									
No policy in place		x							1
Designers not being involved in policy development					x				1
No conditions/incentives created to invest/support CE					x				1
Excisting conditions									
Virgin/low-quality resources being cheaper				x	x				2

Table 3. Barriers recognized by designers.

more nuance towards the strategic role of designers and instead add insights regarding the foreseen barriers.

Further Research

The research described here shows that there are promising paths for further research into the role of the designer in the transition towards the circular economy. Future research should deal with the limitations of this investigation. First of all, the small sample size of only eight participants hampers generalization of the results. In addition, the interviewed group did not cover designers working in middle-sized companies, while this could have led to different observations. Further research should therefore focus on selecting a larger and more heterogeneous sample in terms of designers working in a specific position. Moreover, the external barriers mentioned need to be validated in further research.

Further exploring the designer's role will be particularly relevant for insight in the development of skills, competences and capabilities, required to enable designers to optimally fulfill the various roles that are requested when working in different positions. Lastly, the scope of this research was limited to visions within the design field when it comes to the role of the designer. Future research should show whether other fields also mention that designers should play a specific role.

Conclusion

This paper explored the current role of the designer, visions in literature about the desired role of designers in the transition towards the circular economy and the barriers perceived in practice. Within literature the main visions are that the designer should assume a strategic or a coordinating role. Designers/owners working in small sized agencies agree with the first role, which covers activities that they currently already perform. However, they experience and foresee barriers to be able to fulfill this role, such as having to work in a predetermined solution space and lack of knowledge about assessment.

There seems to be less agreement on the role as a coordinator, which is frequently mentioned in literature, but not by the interviewed designers working in practice.

This study paves the way to explore the type of skills, competences and capabilities designers need to develop in order to play the most effective role in the transition towards the circular economy.

Acknowledgments

This work has been conducted as part of the Resource Conservative Manufacturing (ResCoM) project that has received funding from the European Union's seventh Framework Program for research, technological development, and demonstration under grant agreement no. 603843. The authors also would like to thank the interviewed designers for their participation.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-397

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Challenges and support for scaling up upcycling businesses in the UK: insights from small-business entrepreneurs

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Keywords
Product longevity
Scaling up
Sustainable business
Sustainable production
Upcycling

Abstract
Upcycling is the creation or modification of a product from used materials, components and products which is of equal or higher quality or value than the compositional elements. Within the context of increased product longevity, it enables a reduction in the use of raw materials by extending the lifetime of used materials, components and products, thereby increasing material efficiency and reducing industrial energy consumption. If scaled up to a considerable level through appropriate interventions, upcycling could, in theory, contribute significantly to preventing environmental harm. In particular, upcycling-based businesses have been identified as one of sustainable alternatives to prevailing business models that are based on unrestrained access to virgin materials, in contrast with the circular economy. Previous research regarding upcycling has focused mostly on fashion and textiles and highlighted the potential of upcycling businesses, providing sector-specific suggestions for expansion beyond their currently niche status. There is a critical knowledge gap concerning ways of achieving the full potential of upcycling-based businesses across the whole economy. This paper therefore provides results from a study on the challenges that upcycling entrepreneurs face when attempting to scale up and how to overcome them, based on an exploratory workshop with 12 British upcycling entrepreneurs. It identifies the key challenges faced by upcycling businesses and presents a mapping of the systemic support required for overcoming them, with potential actors.

Introduction
Upcycling is defined as the creation or modification of a product from used materials, components and products which is of equal or higher quality or value than the compositional elements (Sung, Cooper, & Kettley, 2014; Sung, 2017). It is an umbrella concept which incorporates 'creative' repair (e.g. darning), reuse (e.g. redesigned and remade clothing), refurbishment (e.g. upholstery), upgrade (e.g. IKEA furniture hacks), recreation (e.g. fashion items from clothing) and more. Upcycling is both a form of alternative consumption in which people can engage (Albinsson & Yasanthi Perera, 2012), and a form of alternative production that environmentally-conscious entrepreneurs can utilise (e.g. Sung & Cooper, 2015). Within the context of increased product longevity (Cooper, 2010), it enables a reduction in the use of raw materials by extending the lifetime of used materials, components and products, thereby increasing material efficiency and reducing industrial energy consumption (Allwood, Ashby, Gutowski, & Worrell, 2011). The reduction in energy consumption contributes ultimately to lowering greenhouse gas emissions (Hamit-Haggar, 2012). It also reduces solid waste or, at least, delays the addition of waste to landfill (Bramston & Maycroft, 2013; Zhuo & Levendis, 2014). Thus, if scaled up to a considerable level through appropriate interventions (Van den Bosch, 2010), upcycling could, in theory, contribute significantly to preventing environmental harm.

Previous research regarding upcycling has focused mostly on fashion and textiles (e.g. Han, Tyler, & Apeagyei, 2015; Paras, Curteza, & Pal, 2016) and highlighted the potential of upcycling businesses, providing sector-specific suggestions for expansion beyond their currently niche status. There is a critical knowledge gap concerning ways of achieving the full potential of upcycling-based businesses across the whole economy. In other words, how could this niche practice of upcycling in different businesses be scaled up?

This paper therefore aims to provide some commercial insights for upscaling upcycling-based businesses across different product categories in the context of small enterprises in the UK.

Methods
This research used a workshop[1] as a method for data collection. A participatory workshop with British

[1] *A facilitated event, normally lasting one day, for a group of between about 12 and 24 attendees which involves some degree of active participant action and interaction (Rust, 1998).*

upcycling-based entrepreneurs was organised in March 2016 at the University of London.[2]

Sampling and respondents

A workshop invitation was sent to 21 UK-based upcycling enterprises (identified through a Google search and word of mouth), Remade in Britain (a UK-based online upcycling marketplace: http://www.remadeinbritain.com/) and all identifiable upcycling-based makers (n=76) involved in Folksy (a UK-based online craft marketplace: https://folksy.com/). Workshop advertisement was also posted on 29 Hackspace/Makerspace google groups/fora (selected on the basis of the accessibility and activeness).[3] Twenty-five people expressed their interest in participation, of which 12 eventually took part in the workshop.

The 12 participants comprised 10 females and 2 males. Nine people were between 30 and 49 years old and 3 were over 50 years old. Most businesses were sole traders (n=9), followed by private limited companies with less than 5 employees (n=2).[4] Eight were full-time, 3 part-time, and one considered their upcycling as a hobby. Annual gross sales for most businesses (n=10) were under £10,000, followed by between £10,000 and £20,000 (n=2). The product categories they had were fashion items (n=3), home accessories[5] (3), furniture (2), jewellery (2), cabins (1), musical instruments (1) and artwork (1).[6] The materials they used for upcycling were mostly used timber (n=4), fabrics (4) and packaging (3).[7]

Procedures and analysis

The half day workshop consisted of keynote speeches,[8] small group activities and a whole group discussion. For the small group activities, the participants were separated into two groups (6 per group) and each group was supported by an expert facilitator. The questions for the small group activities were open-ended questions on challenges faced by participants in their upcycling businesses and the support required for scaling up.[9] During the group activities, the participants were asked to write down their answers on post-it notes and stick them on the mapping board, indicating the size of each challenge and how common they are, and the importance of each type of support and the level of demand for it. After each small group activity, the results were presented to the whole group, who then discussed the actors responsible for introducing the changes.[10]

The presentations of the results of small group activities and the whole group discussion were audio-recorded and transcribed. The transcript and mapping results were combined and categorised for interpretation through manual coding.

Results

The results are presented below with three categories: challenges, support and responsible actors.

Challenges for scaling up

Five themes emerged in challenges for scaling up upcycling businesses: materials, the craft of upcycling, marketing, the working environment, and consumer attitudes (see Table 1 for a summary). Sourcing sufficient used/waste materials was regarded as a big challenge and storing materials as a small challenge by most participants. The craft of upcycling (including material collection) was commonly viewed as time-consuming and this was not reflected in the price. One participant stated, *"There's a massive amount of time involved in craft and hand-making processes. […] Some people say 'Well, it didn't cost you anything for the raw materials, so can I have a discount?' People don't appreciate the time it takes to source the materials."*

Varied product quality and inadequate quality assurance were seen as big challenges by many participants. One said, *"Maybe some customers have had poor experiences [with upcycled products] in the past, and don't want to go down that route? And there's no quality assurance, regulations, or insurance."* Working with damaged materials was a common, small challenge in upcycling craft. Most participants found marketing time-consuming, as put by one, *"If you are making individual pieces, which will often happen with upcycled products, you've got individual photos, individual descriptions, which take time."* The distinctive nature of upcycled products was considered to make it more difficult to position such products in the market. Identifying suitable marketplace (both online and offline) was a common, medium scale, challenge in marketing. Regarding the working environment, most sole trader participants indicated that they have a problem finding a suitable space in which to work. They either work from home, dealing with limitations and problems (e.g. limited space for materials and equipment, interrupting family, disturbing neighbours) or pay rent for the work space, which can be expensive.

Consumer attitudes were mentioned several times. Consumers' preference for mass-produced products was commonly perceived as a big challenge. One participant said, *"If your products are beautiful and consumers will*

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[2] *The event was organised by the 1st and 2nd named authors.*

[3] *Whether or not it has a Google group/forum, and whether or not it has relatively high recent posting and read numbers in the forum.*

[4] *The other participant engaged in upcycling as a hobby and thus lacked legal status.*

[5] *Home accessories include home fragrance & candles, cushions, wall art, rugs, vases & bowls, photo frames, ornaments, lighting, curtains & blinds, mirrors, artificial flowers, clocks and door stops (e.g. House of Fraser, 2017).*

[6] *Two entrepreneurs produce fashion items and home accessories.*

[7] *Other materials (n=1) included bicycle inner tubes, ceramics, electronics, glasses, jewellery, metal, musical instruments, paper, and interesting discarded objects and materials.*

[8] *Rebecca Earley, Professor of Sustainable Textile and Fashion Design at the University of the Arts London and director of the Textile Futures Research Centre, presented on her textile upcycling practices. Jamie Billing, Programme Leader for product design and innovation at the Plymouth College of Art and co-founder and technical director of Co-oproduct (an online platform for sustainable product design teaching and learning materials including upcycling), presented exemplary projects of upcycling in product design for sustainability.*

[9] *"What challenges have you encountered for growing your business?" and "What support do you need to grow your business?"*

[10] *"Who do you think should act on providing support?"*

come in and look at them, but then they will walk away and buy something mass-produced from Debenhams [...] because it's from a known brand. That's what they like." Consumers' perception of upcycling (either non-existent or negative), reluctance to accept alternative (or waste) materials, and fear of product failure were also identified as challenges to overcome. On these matters, participants' comments included: *"Upcycling is not mainstream yet and consumers don't know about it"*; *"Consumers have low confidence in longevity and material finish [of the upcycled product]"*; *"Different can be scary"*; and *"Consumers have preconceptions that you are trying to sell them rubbish."*

Support for scaling up

Five themes emerged in support for scaling up upcycling businesses: a) changing consumers' perceptions, b) financial and business management support, c) marketing support, d) materials, facilities and tools, and e) network (see Table 2 for the summary).

Changing consumers' perceptions turned out to be the most important support that upcycling entrepreneurs need. The participants emphasised the importance of education and communication to raise awareness and enlighten the general public about the value of upcycling, providing evidence of environmental sustainability of upcycling and using social media for public engagement. One participant stated, *"The key thing is, first of all, education and communication to more people that what we are doing is the right thing."* Another said, *"Teaching the right values to start appreciating creativity. [...] Too many people walk past, enjoy the upcycled products, and then go to the shopping centre to buy products."*

Financial and business management support was regarded very important. Many participants agreed that grants, loans, and low business rates for start-up costs and equipment would be extremely helpful. They stated that support with funding bids and some tips and know-how for managing businesses in creative industry would be very helpful. Effective marketing and promotion support was required for both online and offline activities. The participants did not seem to know how best to utilise social media in particular. One said, *"Can we do everything through Facebook or Twitter? You've got all these platforms, and is there anything to bring them all together so you don't spend all your life just tapping away at the computer?"* Another said, *"The downside of doing the same thing on all the platforms is that people will start to turn off."*

Connections with physical stores and pop-up shops for product exposure and actual selling was commonly required. Stable material suppliers, places to work (away from home), and equipment hiring service were identified as fairly important by some participants. Hiring industrial equipment was considered especially important for productivity, as put by one participant, *"If you do want to do that mass-produced in a sense, you always need to do repetitive bit of work to some products. How easy would it be to do that task if you could borrow industrial equipment?"* Networks amongst upcycling entrepreneurs were commonly perceived as a potentially extremely helpful support. They anticipated that they would learn from each other by, for example, holding regular events, and dealing with workload peaks by sharing work.

Scale of the challenge	Frequency of the challenge	
	Common	Uncommon
Big	-Sourcing sufficient materials -Time-consuming upcycling craft -Time-consuming marketing -No product category -Variable product quality and inadequate quality assurance -Place/space to work -Consumers' preference for the mass-produced	-Expensive rent (for work space) -Consumers' reluctance to accept alternative materials
Medium	-Identifying suitable marketplace (on/off line) -Consumers' perception of upcycling	-Disturbing working environment (at home)
Small	-Limits in working from home -Storing materials -Working with damaged materials -Consumers' fear of product failure	NA

Table 1. Challenges for upcycling businesses.

Importance of support	Demand for the support	
	High	Low
Extremely important	-Education and communication to raise awareness and enlighten the public about the value of upcycling -Grants, loans, low business rates -Community events and, networks for learning from each other	NA
Very important	-Use of social media for public engagement -Places to work (away from home) -Effective promotion and marketing -Creative industry business management support	-Help with funding bids -Stable material suppliers
Important	-Connections with physical stores and pop-up shops -Providing evidence of environmental sustainability	-Network of freelance associates to deal with workload peaks -Industrial equipment hiring service

Table 2. Support for scaling up upcycling businesses.

Actors responsible for change

Mainstream businesses, the government and local authorities were identified as key actors to act on scaling up upcycling businesses. Most participants believed that mainstream businesses should take more responsibility for their waste and encourage its reuse rather than pay to get it removed. One suggested role of mainstream businesses was to create a database collectively (at a regional or national level) to list their waste and donate or sell it to upcycling businesses.

Many participants felt that the government should amend policies and regulations on waste, health and safety to encourage more reuse, repair and upcycling. One participant argued, *"People shouldn't be allowed to throw perfectly serviceable furniture and other products away, because it's criminal."* Another complained, *"Where I worked, there were so many useable products. They didn't give them away because there is a rule that they have to destroy those for health and safety issues."* Another said, *"At my local recycling centre, as soon as something has gone in the recycling skips, it's council property. People throw away dining tables, chairs, etc. And you cannot just take them out or you will be charged with theft."*

Some participants felt that local authorities could play an active role to promote reuse, repair and upcycling to better deal with municipal solid waste. One said, *"Blackpool Council has a shop outside of their recycling centre and the stuff that gets taken in, it all gets sorted. If it's resalable, they will clean it and sell it on-site. They have knick-knacks, furniture, fabrics, and stuff. They mend electrical products. All councils should do that."*

Discussion

Many of the challenges to upcycling businesses are also common in hand-made or craft businesses or start-ups. The hand-made or craft process is time consuming, and such products require time-consuming marketing (e.g. Liebl & Roy, 2004; Rosner & Ryokai, 2009). Any such business needs sufficient space to store materials and suitable markets to sell products, and competes with mass-produced products (e.g. Dissanayake, Perera, & Wanniarachchi, 2017; Jaitly, 1989; Tung, 2012). Many start-ups are based in a garage or struggle to find affordable work space (e.g. Audia & Rider, 2005). Particular challenges for upcycling businesses are in: a) sourcing sufficient used or waste materials with consistent types and quality, b) working with damaged materials and assuring quality, and c) changing consumers' perceptions and beliefs about upcycling and upcycled products.

Many of the suggested forms of support would be beneficial to hand-made/craft businesses or start-ups. Connections with retailers and an industrial equipment hiring service could benefit any craft businesses (e.g. Jakob, 2013). Financial support or help with funding bids, networks with other entrepreneurs, use of social media, affordable workspace, support for effective promotion, marketing and business management could benefit any start-ups (e.g. Bruneel, Ratinho, Clarysse, & Groen, 2012; Carson, Cromie, McGowan, & Hill, 1995; Chandra & Medrano Silva, 2012; Jenssen & Koenig, 2002; Watson, Hogarth-Scott, & Wilson, 1998). Forms of support that are particularly significant for upcycling businesses are the provision of stable material suppliers, skills development for high quality upcycling, education and communication to improve consumers' perceptions and beliefs about upcycling and upcycled products, and policies and regulations to encourage more reuse, repair and upcycling.

Synthesising the results, Figure 1 maps the challenges and forms of support for scaling up upcycling businesses with potential actors. Local authorities, mainstream businesses and the Arts Council, Crafts Council, Design Council and Research Councils could potentially play a major role.

Local authorities could: a) run reuse and upcycling centres along with recycling centres, serving as a stable material supplier; b) provide affordable workspaces and, perhaps, an industrial equipment hiring service; c) create or support a local upcyclers' community; d) raise awareness by organising events and seminars; and e) offer financial and business management support. Mainstream businesses (especially manufacturers) could: a) create a database of their waste for materials provision; b) offer unused industrial equipment as a hiring service; and c) share their retailers and know-how of marketing and promotion. The Arts Council, Crafts Council, Design Council and Research Councils could: a) provide subsidies for workspaces; b) bring together upcycling entrepreneurs at a national level; c) transfer knowledge in effective marketing and promotion and in business management; d) disseminate upcycling knowledge; and e) support upcycling research and related initiatives (e.g. funding, collaboration).

Central government could introduce policies and regulations to encourage more reuse, repair and upcycling,

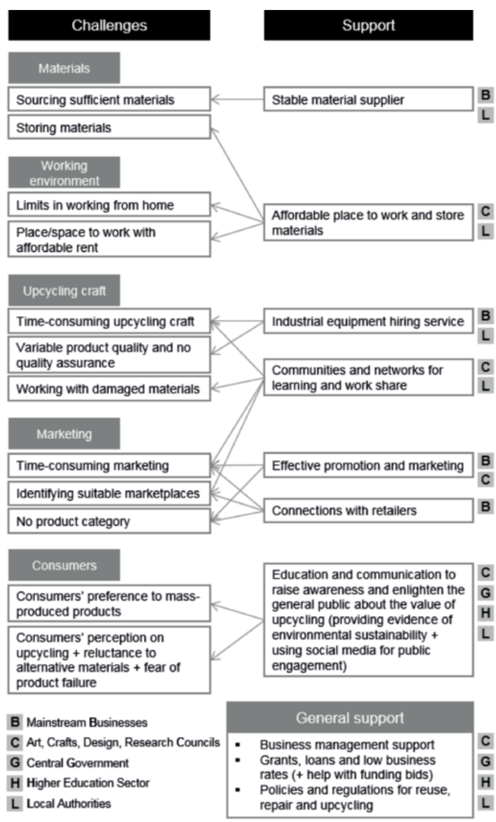

Figure 1. Mapping of challenges and support for scaling upcycling businesses with potential actors .

including use of the school curricula to instil the value of upcycling in children. The higher education sector could play a crucial role in providing evidence of the environmental benefits of upcycling and equipping young adults with a new mind-set more open to alternative forms of consumption (cf. purchasing mass-produced goods). Art and design departments and business schools, in particular, could seek funding to work with upcycling businesses.

Among all the potential forms of support suggested by participants, improved materials provision, communication and education for the general public (e.g. television programmes, media coverage, community events and curriculum enrichment), tax benefits and subsidies for upcycling businesses, and grants and subsidies for upcycling research and related initiatives have been identified as priority interventions (considering potential impact and feasibility) for scaling up upcycling (Sung, 2017).

Conclusions

This paper investigated challenges and support for scaling up upcycling businesses across product sectors in the UK through an exploratory workshop with 12 British upcycling-based entrepreneurs in small businesses. It described British upcycling entrepreneurs' perceived challenges, with an indication of their size and importance, and the support required for scaling up their businesses, with an indication of the importance of and demand for each form of support. It mapped the systemic support required to overcome challenges, with potential actors.[11]

Acknowledgments

The initial data collection and writing-up was funded by Nottingham Trent University with support from the RCUK Energy Programme's funding for the Centre for Industrial Energy, Materials and Products, grant reference EP/N022645/1. Further analysis and writing-up was funded by Nottingham Trent University's Materials Research Seed-Corn Fund. We would like to thank Sarah Kettley and Julian Robinson for facilitating group discussions.

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[11] *Building on this research, the ongoing inter-school collaboration project between the School of Architecture, Design and the Built Environment and Nottingham Business School at Nottingham Trent University investigates challenges and success factors for scaling up upcycling-based SMEs mainly utilising wood and textiles in the UK with systems thinking approach.*

Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-402

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Deconstructing cultural values of products: implications for sustainable design

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Keywords
Cultural values
Cultural meanings
Cultural products
Laddering technique
Sustainable design

Abstract
In a global era where products are reaching across international boundaries, designers are increasingly challenged to design for diverse cultural context. Designers are agents of cultural change and should be cognizant of the impact their products have on local markets. The key for developing culturally appropriate products lies in understanding how cultural objects acquire and communicate cultural meanings. The goal of this paper is to deconstruct and categorize cultural meanings associated with objects and highlight the key determinants that contribute to cultural values. Cultural product images and phrases were analysed using a four-layered model for classifying cultural meanings. Participants were then engaged in a laddering interview to understand the key determinants of cultural values. The analysis reveals eight key determinants of cultural values. The determinants are mapped across four key continuums: appearance–representation, self-identity–group affiliation, personalization–shared belongingness, and stories–memories. In addition, the determinants of cultural values are compared with the key determinants of product attachment. Findings of the study reveal a strong overlap between the determinants of cultural values and product attachment. The paper also outlines a framework for achieving culturally sustainable design. The outcomes of this study have several implications for designers and educators that aim to achieve culturally sustainable design. This study believes that products that reflect cultural values have a higher emotional attachment to consumers resulting in longer life-spans and culturally sustainable consumption.

Introduction

Multi-nationals expanding their business across international boundaries are agents of cultural change and should be cognizant of the impact their products have on local markets. Corporations developing products for the local market need to understand user-product interaction as a part of a cultural process where consumption of (or lack of) certain products or services is a reflection of deliberate cultural choices and, by extension, reflects the shared cultural values of the group. To achieve sustainable consumption, Dolan (2002) point out that people have to feel culturally aligned and connected to products. Engaging consumers in culturally appropriate consumption will ensure that those objects have higher emotional attachment, longer life-spans and end up in landfills much later than other comparable products. The key for developing culturally appropriate products lies in understanding how cultural objects acquire and communicate cultural meanings.

The goal of this paper is to understand how users describe and categorize cultural meanings associated with objects, and highlight the determinants that contribute to cultural values. In addition, this paper provides a brief overview of determinants of product attachment and compares it with the determinants of cultural values that emerged from data. The findings of the paper highlight significant overlap between determinants of cultural values and product attachment. The strong overlap between the determinants points at the importance of decoding cultural values of objects as a way of achieving higher product attachment. Furthermore, the determinants of cultural values are discussed as a potential framework intended for designers, researchers and corporations for achieving culturally sustainable design.

Literature Review

Cultural approach to Sustainability

The current approach to sustainability in design and product development mainly focuses on environmental issues, and to a certain extent on social and economic aspects. Unfortunately, practitioners and academicians have often ignored or are unsure of how to deal with the cultural dimensions of sustainability. Schaefer & Crane (2005, p. 85) have argued that viewing sustainability from a cultural lens is a challenging proposition but it also "opens up different, more diverse, and potentially richer ways of thinking about sustainability." This research presents a way to examine sustainability from a cultural lens.

The discourse on sustainable consumption and sustainability can be studied from two distinct approaches (Schaefer, & Crane, 2005; Dolan 2002): an individualized choice oriented perspective and a sociological and anthropological perspective. The individualized choice oriented perspective, consider consumers as free, sovereign, rational actors and focuses on understanding their psychological and cognitive processes. The disciplines of psychology, marketing, economics have supported this view of consumption and is central to the ecological discourse on sustainability. The implicit assumption in this objectivist approach centre around the needs and wants of the rational individual and "neglect the significance of consumption practices as embodying the relations between individuals" (Dolan, 2002, p. 170).

The sociological and anthropological approach focuses more on the social and cultural construction of consumption and questions the rationale behind consumption. In this approach, the emphasis is "less on how people perceive, evaluate, and select different consumption options and more on the function that consumption has in their lives, both individually and as members of social groups" (Schaefer, & Crane, 2005, p. 83). Consumption viewed from cultural lens includes consumption for pleasure, self-identity, establishing social relationships, and communicating symbolic and cultural meaning (Schaefer, & Crane, 2005). In short, the social and cultural conceptualization of consumption acknowledges the evolving nature of consumers from rational actors to communicators (Corrigan, 1997). This paper follows the anthropological approach (McCracken, 1988) to study the role of commodities that "mark social boundaries and hierarchies within any social system, and the potential of commodities to reflect cultural principles" (Dolan, 2002, p. 178). Material artefacts represent the materialization or visual manifestation of prevailing value and symbol systems of cultural groups (Dolan, 2002, p. 178; McCracken, 1986). Following this notion, this study aims to deconstruct cultural meanings of material artefacts and highlight the determinants of cultural values. This research analyses cultural objects beyond its utilitarian purpose and highlights the role of objects in creating self-identity, establishing social relationships and communicating symbolic and cultural meanings. Understanding the determinants of cultural values situates material objects as a part of a cultural process where consumption of certain products or services is a reflection of deliberate cultural choices and, by extension, reflection of shared values of cultural groups (Dhadphale, 2017). Schaefer & Crane (2005) have argued that our understanding of sustainability can be enriched by emphasizing the social and communicative role of material artefacts and identity construction (self and group) through consumption.

The following section discusses the notion of cultural principles (McCracken, 1986) or situated cultural differences (Appadurai, 1996) as a methodological tool to categorize cultural meanings. Furthermore, a four-layered model for classifying cultural meanings is discussed. The key assumption is that cultural values of the group are manifested in distinctive (culturally situated differences or cultural principles) materiality, practices, symbolic meanings and ideology that mobilize group identity.

Classification of Cultural Meanings

Appadurai (1996) argued that material artefacts can open themselves up to many forms of investigation in pursuit of an understanding of their cultural meanings. According to McCracken (1986, p. 71), culture constitutes the phenomenal world in two ways. Culture is both the 'lens' through which we see the world and the 'blueprint' of how individuals shape the world (McCracken, 1986, p. 72). Material artefacts significantly contribute to the culturally constituted world as they are "vital, tangible record of cultural meaning that is otherwise intangible" (McCracken, 1986, p. 73). Material artefacts (McCracken, 1986, p. 71) "carry and communicate cultural meanings" in the phenomenal world we operate in.

McCracken (1986) categories cultural meanings into two key aspects: cultural categories and cultural principles. Cultural categories determine "how this world will be segmented into discrete, intelligible parcels and how these parcels will be organized into a larger coherent system" (McCracken, 1986, p. 73). In simple terms, cultural categories represent the segmentation of the phenomenal world. Cultural principles are the organizing ideas by which the segmentation is performed (McCracken, 1986, p. 73). Similar to cultural principles (McCracken, 1986), Appadurai (1996) presents the notion of situated cultural differences as a way to categorize the phenomenal word. There are two key aspects to situated cultural differences. First, culturally situated differences are "differences in relation to something local, embodied, and significant" (Appadurai, 1996, p. 12). These are differences a cultural group would utilize as local and distinctive differences that are significant to the group. Second, situated differences are differences that "either express, or set the groundwork for, the mobilization of group identities" (Appadurai, 1996, p. 13). Situated differences could be local, embodied and significant material artefacts, practices, ideologies, rituals that mobilize group identities by highlighting the shared values of the cultural group. For example, Harley-Davidson enthusiasts are a distinctive group with shared values that are manifested in different aspects of everyday life.

This paper utilizes the notion of cultural principles (McCracken, 1986) and situated cultural differences (Appadurai, 1996) as a way to categorize cultural meanings. The key assumption is that cultural values of the group are manifested in distinctive materiality, practices, symbolic meanings and ideology (culturally situated differences or cultural principles)) that mobilize group identity. To deconstruct cultural values (that mobilize group identity), it was critical to develop an applicable coding scheme to categorize cultural meanings. Classification of cultural meanings into layers is guided by the work of prominent scholars like Trompenaars and

Hampden-Turner (1997), Hofstede (2001), Hall (1976), Spencer-Oatey (2000) and others. Trompenaars and Hampden-Turner (1997) outline three layers of culture; the outer layer that includes the material artefacts and products; the middle layer representing norms and values and the core that represents the fundamental assumption about human existence. Hofstede (2001) provides five layered classification of culture that includes practices; rituals; heroes; symbols and the core represented by cultural values. Spencer-Oatey (2000) also identified four layers of culture; the outer layer that includes artefacts, products, rituals and behaviours; the mid-layers that includes systems and institutions; beliefs, attitudes and conventions and the core representing basic assumptions and values.

Based on the approach suggested by Trompenaars and Hampden-Turner (1997), Hofstede (2001), Hall (1976), Spencer-Oatey (2000), a four-layered classification model (M-I-S-V) was developed (Figure 1). The four-layered model classifies cultural meanings into 1) materiality (M; materials, processes, product aesthetics and semantics), 2) interactions (I; rituals, practices, and interactions), 3) symbolic meanings of interactions and products (S; self-identity and social status, group identity, product personality and brand identity) and 4) cultural values (V). Similar to the other models described above, this model assumes that both the tangible (materiality and behavioural/interaction) and intangible (symbolic meanings; group and self-identity) aspects lead to shared cultural values.

Methodology

This paper address three key research questions: 1) How do users categorize cultural meanings associated with objects; 2) What are the key determinants that contribute to cultural values and 3) How do the determinants of cultural value compare to the determinants of product attachment?

To answer the following questions, empirical study was conducted in two phases. In the first phase, using a survey questionnaire, 27 participants were asked to provide 5 images of cultural products and 5 images of non-cultural products. For every product, participants were asked to

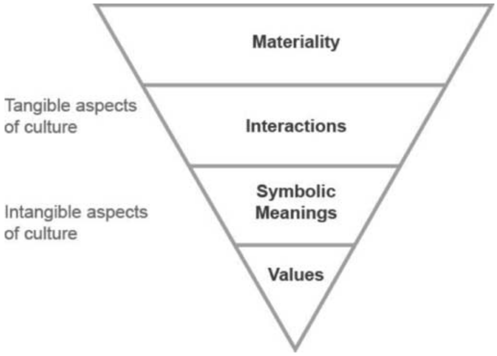

Figure 1. Layered classification of cultural meanings.

provide a short rationale (1-2 sentences) for selecting product images that were cultural and non-cultural. Content analysis was conducted to analyse and categories (RQ1) key words and phrases used to describe cultural objects. The content analysis was guided by typological analysis framework suggested by Hatch (2002). Typological analysis begins with the process of reducing and categorizing data based on existing typologies (Hatch, 2002). In this case, the four-layered classification model (M-I-S-V) was used to reduce and categorize data. The text provided with each image was coded and categorized into four layers (M-I-S-V): material, interactions, symbolic meanings and values. For example, participants mentioned 'samurai sword' as a cultural object primarily based on its form, texture and semantics. This object was then categorized into the material (M) layer. Products were categorized into multiple layers based on description provided by participants. For example, 'wedding rings' and 'wedding dresses' were considered cultural because of its materiality (the expensive diamond and wedding gown; (M)) and what the objects signify (symbolic meanings; (S)). Next, 15 images of cultural objects were selected based on the cultural specificity continuum outlined by Athavankar (2004). According to Athavankar (2004) objects can be categorized on a continuum from culturally shielded objects to culturally liberate objects. Culturally shielded objects were (also called traditional objects) objects such as wedding dresses, wedding rings, Chinese traditional clothing, Japanese samurai sword, traditional paintings, and others that have a history and special significance in respective cultures. Culturally liberate objects (although no object is culturally free) are modern mass-produced objects such as iPhone, Converse All-Star shoes, Solo party cups, McDonalds burgers, Chopsticks, NFL football, Hello Kitty, BMW cars and others. The selection of 15 cultural products and categorization of key phrases into the M-I-S-V model laid the foundation for the next phase of data collection.

In the second phase, 23 participants were interviewed using laddering interview technique to understand the determinants that lead to cultural values. Participants were asked to pick 10 images from a pool of 15 preselected cultural products. For each image, participants reflected on the connection between materiality (M), interactions (I), symbolic meanings of objects (self and group identities) and the resulting cultural values (V). Laddering interview technique based on means-end theory (Gutman, 1982, Woodruff, 1997) was used to understand cultural values. Means-end theory assumes that consumers logically link product attributes (A), consequences (C) that results in the abstract desired-end state (DES). Similarly, for this study, the laddering interview assumes that participants can logically connect different aspects of cultural meanings (M-I-S-V; materiality, interactions and symbolic meanings) and in the process, highlight the determinants that express cultural values. Interviews were analysed to identify key determinants. The structured approach of laddering technique was helpful to limit interview time and ensure positive engagement. The cultural values

(DES) uncovered during the interviews is not the main focus of this study. The determinants that lead to cultural values is the central piece of this study.

Findings

Determinants of Cultural Values

The analysis of interviews revealed 8 key determinants of cultural values. Each determinant was primarily discussed in relation to another complimentary determinant resulting in 4 pairs of determinants. The determinants were mapped across four continuums: 1) Appearance–representation, 2) self-identity–group affiliation, 3) personalization–shared belongingness, and 4) stories–memories. The following section briefly summarizes the determinants with examples. Due to the broad nature of data collected, each continuum of determinants is presented with limited examples. The continuums presented should not be considered discrete. Data analysis shows strong interrelationships between all determinants.

1. Appearance–Representation: Participants discussed materiality (appearance; form, colour, texture, graphic markings, and specific materials) as a key determinant of cultural values. Participants considered the ‘samurai sword’, ‘Chinese clothing’, ‘chopsticks’, and ‘wedding rings’ as cultural objects primarily based on the appearance of the product. For example, participant #2 highlighted, “the unique curved handle, the grip, the length of the sword, and the leather” all reflect the values of “disciplined, traditional and strength.” Symbolic meanings were discussed in relation to the appearance of products. For example, wedding rings were considered cultural objects (Participant #3) as they symbolize “commitment, wealth, power and status in the society.” All participants constantly interlinked the character of the product and the symbolic meaning associated with it.

2. Self-identity–Group affiliation: According to participants, products that supported formation of self-identity were considered cultural products. For example, Converse All-Star shoes were discussed as a product that helps form self-identity. According to one participant, “the classic, timelessness, simple, look of Converse, lets you create your own identity with it, but also makes you a part of this youthful, stylish, practical and trendy group.” Participants discussed the ability to personalize Converse shoes to communicate self-identity but at the same time also relate to the share values of the group.
   On the one hand, participants used Converse shoes to communicate self-identity, but on the other hand were proud to share group values and stabilize group identity. Similarly, more contemporary products like IPhone, luxury cars were considered suitable to expressing self-identity at the same time projecting group affiliation. The constant negotiation between self-identity and group affiliation was the key determinant of cultural values.

3. Personalization–Shared Belongingness:
   Personalization was discussed as a process for achieving self-identity and was considered a key determinant of cultural values. Individual values are partly a product of shared culture and partly a product of unique individual experiences (Schwartz, 1994). This reference from Schwartz, (1994) was seen in the interviews as participants discussed personalization (similar to the possession and grooming rituals discussed by McCracken (1986)) for cultural products. Participants discussed the ability to personalize (and in the process, create unique individual meanings) contemporary products like IPhone, Converse All-Star shoes, Hello Kitty, NFL, wedding rings and luxury car brands. According to one participant, “IPhones are mass produced but I know mine is different than others. The apps, the case, data, photos all make it my own.” The longer the process of personalization, participants felt that the product reflected their personal values and at the same time the shared group values. Associating oneself to a particular product reflected shared belongingness (the IPhone or Converse loyalist) and cultural values.

4. Stories–Memories: Participant strongly felt that cultural products facilitate the creation of unique stories. Participant #14 talked about how every young teenager has a unique story associated with their first pair of Converse All-Star shoes. As one participant shared, “having the same pair of Converse that my mom had 30 years ago creates this bond between us. She remembers her first pair and now I have the same.” Products were considered cultural if they facilitated creation of personal stories or memories. Participant #12 shared a memory related to burgers: “I remember my mom and dad flipping burgers for us when the weather was nice. Even today, eating McDonalds reminds me of my childhood and the time with my parents.” She considered McDonalds burger as a cultural icon because it reflects the ritual of barbequing on long weekends; a ritual shared by many families in the United States.

Comparing Determinants of Product Attachment and Cultural Values

How do the determinants of cultural value compare to the determinants of product attachment? This section briefly reviews literature on determinants of product attachment and then discusses the similarities and overlaps with the determinants of cultural value that emerged from the data. Schifferstein & Zwartkruis-Pelgrim (2008, p. 2) define product attachment as the “strength of the emotional bond a consumer experiences with a durable product.” Mugge, et. al (2008) outlined four key determinants of product attachment: pleasure (Jordan, 2002, Norman, 2004), self-expression, group affiliation and memories. Schifferstein & Zwartkruis-Pelgrim (2008) discuss the interrelationship between irreplaceability, indispensability, self-extension and product attachment. Schifferstein & Zwartkruis-Pelgrim (2008) outline seven key determinants of product attachment: enjoyment, individual autonomy, life vision, memories, utility, reliability and market value. Adding to the list of determinants, Chapman (2005) and Oulasvirta & Blom (2008) specifically discuss the role of product character and personalization as determinants of attachment. Although this paper does not directly address product attachment, the findings reveals an interesting overlap between determinants of cultural values and product attachment. Table 1 compares the determinants of product attachment and cultural value.

Product appearance evokes feelings of pleasure that result in stronger attachment with products. In comparison, uniqueness of appearance (specific materials or textures) and semantic associations were considered key elements for revealing cultural values. Pleasure, utility and reliability of products was not considered key for expressing cultural values. The most promising overlap between the determinants was the 'personalization ritual that expresses self-identity and in the process builds unique associations (stories and memories) with products. Shared belongingness and group identity is a way to establish shared cultural values that act as boundaries that distinguishes one group from another.

Conclusions

Implication for culturally sustainable design

The outcomes of this study have several implications for designers and educators that aim to achieve culturally sustainable design. This paper follows the anthropological approach to sustainability that emphasizing the social and communicative role of material artefacts in creating self-identity, establishing social relationships and communicating symbolic and cultural meanings. Products aligned with cultural values are not merely utilitarian objects but are social and cultural expressions that mark social boundaries, establish group identity and communicate symbolic and cultural meanings. The determinants of cultural values are discussed as a potential framework intended for designers, researchers and corporations for achieving culturally sustainable design.

How can we define cultural sustainability? And how can designer develop culturally sustainable products? Following the early definition of sustainability provided by 'The World Commission on Environment and Development' (1987) and the Oslo Symposium on Sustainable Consumption (1994), and the review of current literature in sustainability, consumption and culture (Dolan, 2002; McCracken, 1988; Appadurai, 1996; Giddens, 1990; Schaefer & Crane, 2005; Corrigan, 1997) culturally sustainability can be defined as: the acquisition and use of goods and services that involves the materialization and embodiment of cultural modes of thinking and behaviour at an individual and societal level sustaining and enriching a particular way of life (culture) while creating social and cultural identity for individuals and groups, accounting for cultural change, and minimizing environmental impact through cultural appropriateness, so as not to jeopardize the social, cultural, economic and environmental existence of future generations.

This definition of cultural sustainability embraces the social and communicative role of products for creating self-identity, establishing social relationships and communicating symbolic and cultural meanings. It is not only limited to only understanding the environmental needs of future generation but also includes social and cultural practices that are equally important for better life standards for future generations. The determinants of cultural values illustrated in this paper can be a starting point for designers to achieve culturally sustainable design. Designers can consider the following four dimensions (and determinants) when developing culturally specific products: sense of identity, sense of self, character of product and product associations. In order to achieve culturally sustainable design, designers need to combine and carefully balance the four dimensions. Certain determinants like sense of identity and product associations cannot be controlled by the designers and consequently are hard to implement. However, the four dimensions (and determinants) can provide a valuable framework (Figure 2) to guide culturally sustainable design.

Attachment Determinants (based on review of literature)	**Cultural Value Determinants** (themes emerged from data)
Appearance / Character	Appearance–Representation
Pleasure	Self-identity–Group affiliation
Personalization	Personalization–Shared belongingness
Utility	Stories–Memories
Memories	
Self-expression & extension	
Group affiliation	
Reliability/Longevity	

Table 1. Comparison of product attachment and cultural value determinants.

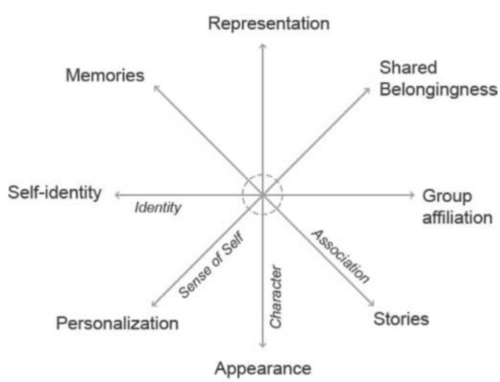

Figure 2. Framework for culturally sustainable design.

The first dimension (character of product) involves materialization and embodiment of implicit and symbolic cultural meanings through form, materials and manufacturing processes that are expressed in design attributes. One end of this continuum refers to utilizing local material finishes, aesthetics, styling, manufacturing processes, and other design attributes that contain implicit cultural meaning. On the other end represents the symbolic meaning associated with products. Culturally sustainable design should promote a *sense of self* and a *sense of identity*. On one hand, products should encourage personalization that expresses self-identity. On the other hand, products should facilitate and strengthen the connection with other individuals; shared belongingness and group affiliation. The fourth dimension deals with product association. Stories or memories associated with products express the individuals' past, present and future position in relation to other people and cultural context. Designers cannot directly influence formation of stories or memories. However, it is critical for designers to acknowledge the role personal narratives play in establishing self-identity and group associations. The framework presented in not exhaustive and should be considered as a starting point for designers to implement culturally sustainable design strategies. This paper believes that products aligned with cultural values are likely to demonstrate higher emotional attachment, longer life-spans and end up in landfills much later than other comparable products. The overlap between the determinants of cultural values and product attachment can lead to interesting future investigations.

Acknowledgments

I would like to thank the reviewers for their insightful comments on the previous version of this paper. The reviewers' comments were really helpful in improving the quality of paper.

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*Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)*

DOI: 10.3233/978-1-61499-820-4-408

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Product Lifetimes And The Environment

Do-Fix workshops: understanding users' product repair experience

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Keywords
Product repair
Product longevity
Repair experience

Abstract
The characteristics of the current production and consumption system such as high consumption rates, overuse of natural resources and growing waste have engendered various environmental, social and economic problems. Despite the rise of product-service systems and the importance of user experience in design, most consumer goods are nevertheless still considered as throwaway items. It is crucial to understand our behaviour to overcome these problems and offer promising solutions. This paper presents the results of a research that explores users' repair experience and the factors affecting their repair process aiming to encourage people to repair products more. Four repair workshops were conducted with 52 participants. Participants brought their damaged products to the workshops and chose a suitable method to repair their products. Consequently, their repair experience was explored and three phases including discovery, idea generation and implementation were identified. Additionally, the motivations and barriers around the product repair were discussed. The findings can be of value for designers and design researchers as they can facilitate future attempts to "design for repair".

Introduction

Repair plays a significant role in product longevity and accordingly has a huge potential for addressing environmental problems related to premature product obsolescence. We need to understand the repair experience in order to be able to act on this potential of repair. However, understanding experience is a complex task (Forlizzi & Battarbee 2004), and many approaches exist in this subject area (Alben, 1996; Forlizzi & Ford, 2000; Kerne, 1998; Desmet & Hekkert, 2007). The existing research about the user experience has mainly been studied by the human-computer interaction community (e.g. Desmet & Hekkert, 2007; Hassenzahl & Tractinsky, 2006; Forlizzi & Battarbee, 2004; Schifferstein & Hekkert, 2008).

Product experience refers to the awareness of psychological effects elicited through interaction with a product (Schifferstein & Hekkert, 2008). It is a subjective process because experiences differ according to individuals and situations, and may vary over time (Hassenzahl, 2003). A product cannot be merely seen as a thing with functions and benefits because it is a part of a complex system and network of relationships (Hassenzahl, 2003). According to Desmet and Hekkert, there are three different levels of product experience, including aesthetic experience, experience of meaning and emotional experience (2007). Additionally, Crilly, Moultrie and Clarkson (2004) explain the consumer response to the visual appearance of products in their article 'Seeing things: consumer response to the visual domain in product design.' They define cognitive response as 'the judgements that the user or consumer has about the product based on the information perceived by the senses.' (2004, p. 552). They define three cognitive response categories: aesthetic impression, semantic interpretation and symbolic association.

The literature review highlights the lack of research into understanding the repair experience. The majority of research that study repair is sustainable design practices (Cooper, 2013; Fletcher, 2012, Charter & Keiller, 2014; Middleton, 2012) and studies that aim to inform HCI scholarship (Rosner, Jackson, Hertz, Houston, & Rangaswamy, 2013; Jackson, 2014; Maestri & Wakkary, 2011; Crabtree & Rodden, 2004; Taylor & Swan, 2005). These studies did not explore repair as an experience or the factors that affect the repair decision. However, there are two papers that explore user barriers in relation to clothing repair. Gwilt (2014) investigates the community-based approaches aiming to revive the clothing mending practices. She examines online and offline activities to enable knowledge exchange and build communities. Rather than having one focus, this paper discusses many subjects related to clothing repair including the methods that would revive the community-based approaches to clothing repair, potential roles of online and offline activities, what people do with damaged clothes, repair barriers. Finally, the author claims that a larger study is needed to investigate the ways to encourage people to engage in repairing (Gwilt, 2014, p.5). Similarly, McLaren and McLauchlan (2015) focus on clothing repair and investigate the barriers to mending and suggest solutions. This paper presents a detailed and clear historical review of clothing repair. It provides a more detailed investigation in relation to clothing repair barriers compared to Gwilt's paper (2014). The barriers they identified are financial cost, lack of time and skills, negative stigma attached to repaired clothes and psychological barriers which refer to the psychological effects of the availability of endless cheap products on users (McLaren & McLauchlan, 2015). To conclude and make the gaps in knowledge more clear, these two studies do not focus on the repair experience and its phases. This research aims to explore users' repair experience and the factors that can escalate repair practices with the help of Do-Fix workshops.

Do-Fix Workshops

Four repair workshops were conducted with fifty-two participants. Fifty-four per cent of them were female and forty-six per cent were male. They were between the ages of eight and sixty-six and were from a range of different occupations, including university students, designers, and retired teachers (Figure 1). Table 1 shows the workshop participants in numbers with the products they repaired and the repair methods they used. The participants were selected from the group of people who were interested in repair, and want to repair products. I concluded that purposive sampling is the most suitable tool for the study. As I found out during the pilot studies, it was not possible to collect data from the people who do not want to repair products and who are not interested in repair. I put up posters and placed advertisements on various websites such as callforparticipants.com, twitter.com and facebook.com to recruit participants for workshops.

Before the workshops, various old and new repair methods and materials were tried and tested. Among these repair methods, particular ones were chosen including kintsugi, patching, darning, and 3D printing spare parts considering the research aim. Additionally, a tool bag was organised that includes materials and tools such as fabric, 3D printing pen, patches, sewing tools and Sugru (Figure 2).

Three Phases of the Repair Experience

The data about participants' experience was collected from the worksheets that participants filled and through my observations. The worksheet included qualitative

Figure 1. Nine participants attended the first session of Workshop 3.

Participant number	Gender	Repaired Product	Repair Method
WORKSHOP 1			
P1	M	Ceramic bowl	Kintsugi Sugru
P2	M	Clothes hanger	Repaired with metal wire
P3	F	Macbook charger	Sugru
P4	M	Silicone watch strap	Sugru
P5	F	Boots	Sugru and T- patches
P6	M	Grater	Repair ideas were generated - not repaired
P7	M	Ceramic plate	Kintsugi
P8	M	Leather bag	Textile patches
P9	M	Ceramic cup	Kintsugi
WORKSHOP 2			
P10	F	Trousers	Patching
P11	F	White long dress	Textile patches
P12	M	Wood necklace	Repaired with glue
P13	F	Mobile phone	Sugru
P14	F	Socks	Textile patches
P15	F	Knitted jumper	Darning
P16	F	Nike shoes	Sugru
P17	F	Sneakers	Textile patches, Sugru
P18	F	Striped orange jumper	Textile patches
P19	M	Sweatshirt	Repaired after the workshop with Plaster patches
P20	M	Backpack, broken clips	Sewing, velcro
P21	F	Jeans	Textile patches
P22	F	Green cardigan – Macbook charger	Darning - Sugru
P23	M	Laptop case	Textile patches
P24	F	White women's top	Not repaired
P25	F	Red backpack	Textile patches
P26	F	Socks	Textile patches
P27	M	Blue shirt	Patching
P28	M	Blue Dress	Sewing
WORKSHOP 3			
P29	F	Computer Mouse	3D printing pen
P30	M	White earphones	3D printed part
P31	M	Sunglasses	Not repaired
P32	M	Plastic lid	Sugru
P33	F	Ceramic cup	Sugru
P34	F	Leather Jacket	T- patches
P35	F	Slippers	T- patches
P36	F	Black Jumper	3D printed patches
P37	M	IPad Case	Sugru
P38	M	Teddy bear toy	Textile patches
P39	F	Ceramic egg holder	Kintsugi
P40	M	T-shirt	Plaster patches
P41	M	Pencil case	3D printed patches
P42	M	Socks	Plaster patches
WORKSHOP 4			
P43	F	Ceramic spoon holder	Kintsugi kit
P44	F	Teapot	3D printed part
P45	F	Plate	Kintsugi kit
P46	F	Tray	Repaired with glue
P47	F	Watch strap	3D printed patches
P48	M	White ramekin	Kintsugi kit
P49	M	Socks	Plaster patches
P50	F	Tights	Plaster patches
P51	M	Blue backpack	Textile patches
P52	F	Jumper	3D printed patches

Table 1. The workshop participants in numbers with the products they repaired and the repair methods they used.

Figure 2. Workshop tool-bag including materials and tools such as fabric, 3D printing pen, patches, Sugru and sewing tools.

questions such as 'What is your product? Can you explain your process and your work?' I identified a phenomenological method as the best means for this research because the preliminary focus is to gather data regarding the experiences and perspectives of people about product repair. I took notes on the conversations I had with the participants and my observations. These notes also enabled me to better understand participants' repair process. In phenomenological studies, validity is obtained by looking at the field notes multiple times. This helps the researcher to become free of preconceptions and merely report what s/he sees and experiences. After the workshops, I wrote each participant's answer on a sticky note and put all the notes on a paper on the wall to explicitate the data and see it as a whole. Meaningful clusters started to emerge from the participants' answers and three phases of repair experience namely: discovery, idea generation and implementation were developed after the analysis. The outcomes are presented below with examples from the repair processes and participants' quotes, to explain the contribution of this research.

Figure 3. Participant 4 repairing his watch strap.

Figure 4. Participant 28 was concerned about fixing his girlfriend's dress.

1. Discovery

The first phase of the repair is when people inspect and discover the features of their products.

When a product breaks, it is experienced in a different way (Heidegger, 1996). It turns into a problem and we start to think about it accordingly and notice its different features. Desmet and Hekkert's (2007) framework of product experience, together with Crilly et al.'s (2004) cognitive response categories, were instrumental for this research in exploring how people discover their broken products. Participants defined their products according to three aspects: the meaning of the product, its aesthetic features and emotional value. The meaning of the product refers to its symbolic value that a human gives to the product. For instance, Participant 4 explained that his watch was an 'impressive' watch from a well-known brand (Figure 3). Other participants focused on the aesthetic aspects of the products: Participant 1, for instance, explained that his product was an antique bowl with a gold rim. Lastly, some of the participants described their products by considering their emotional value. For instance, Participant 28 was concerned about fixing his girlfriend's dress, which had an emotional value for the couple (Figure 4). The emotional value was not only a factor that affected participants' repair processes, it was also a result of it. In other words, an object might become emotionally valuable after repairing it because of the unique memory users share with the product. Chapman (2009) explains

Figure 5. Participant 15 said her knitted jumper became personal, unique and valuable after the repair.

Figure 6. Participant 5 explained her colour choices, design ideas and possible material selections through ideation drawings.

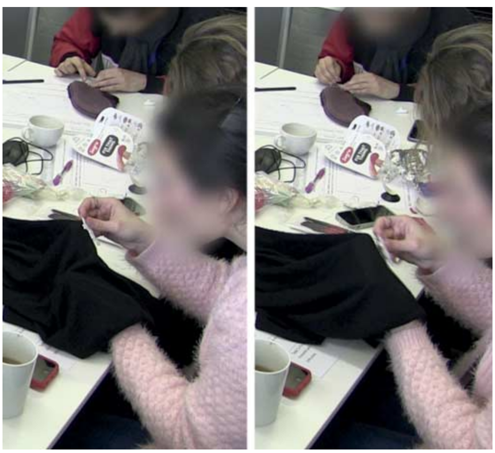

Figure 7. Participant 36 had difficulty in coming up with repair solutions.

Figure 8. Participant 19 was one of the participants who struggled during the implementation process.

that a product possesses a narrative when users share a unique personal history with it (p.33). Participant 15's knitted jumper was a good example of this: she said, 'It has become very personal, unique and valuable to me now' after repairing it (Figure 5).

2. Ideation

The second stage of repair experience is the ideation stage. It is when people start to think about repair solutions for their damaged products. They explore the colour choices, develop design ideas and choose materials (Figure 6). For example, Participant 5 brought her brown leather boots to the first workshop. One of the pairs was frayed on the front right-hand side and had a small tear on it. She considered repairing it with textile patches and Sugru. Finally, she made the frayed parts stronger with a textile patch glued inside the boot and also put a Sugru patch covering the torn part on the outside.

Some of the participants identified the ideation part as the most enjoyable part of the repair process (P5, P6, P11, P13, P14, P19, P24, P27, P34, P38, P49, P51). Participant 14 said that making design choices while fixing the object was entertaining. Similarly, Participant 27 stated that he enjoyed searching for new possibilities and trying design ideas during the idea generation stage.

Besides the enjoyable aspects, participants also stated that they had some difficulties in coming up with solutions and choosing the right techniques and materials during the ideation part (P2, P19, P20, P23, P25, P32, P36, P37). Participant 36 explained her struggle as 'Finding a solution about how I could fix this sweater was difficult. I think if the sweater were not expensive I would not fix it' (Figure 7).

3. Implementation

The implementation stage is the active part of the repair process. It is the stage of repair when the solutions are implemented. Although most of the participants stated that they enjoyed the implementation, it was one of the most challenging parts of the repair process. Participant 19 was one of the participants who struggled during this process. He had brought his sweatshirt which had some small holes in it (Figure 8). I observed that he was hesitating to start mending the sweatshirt. Then he stated that he could not sew. When I suggested to him that he could glue on small patches he replied that he was not good at glueing and would mess it up. He did not repair the sweatshirt at the end. This incident again showed that the real problem is not the damage, but is rather human behaviour and people's relationship with the products.

Figure 8. Participant 19 was one of the participants who struggled during the implementation process.

Another participant was worried about taking risks during the repair process. Participant 5 said, 'I am scared of doing something that I cannot go back on if I change my mind'. Consequently, these cases showed that if the repair process was reversible participants found it easier to engage in the activity. Some participants also stated that they were worried about the strength of the repaired part and how long the repair was going to last (P1, P3, P4, P10, P20). For example, Participant 3 said that she needed the product and was worried about whether the repair would last.

Conclusions

According to the results, participants tend to choose low skills level and low knowledge level repair activities. Currently, it is often easier and cheaper to buy a new product rather than repairing a broken product. As a result of this, methods, materials and tools should be easily accessible to encourage people to repair their products rather than buying a new one. Participants also preferred long-lasting repair solutions, as they might get frustrated in spending time on the same damage repeatedly. Functionality of the product and reversibility of the repair method are other significant factors affected participant's repair experience according to the data inferred from this research.

Repair connects people to products. People engage with products on a material level through repair. In other words, they observe and better realise the materials, form and structure of a product because they consciously think about the product as they need to understand the damage before developing a solution for it. Accordingly, we can say that repair enables a deeper engagement with objects and bring a new consciousness to the user in terms of their relationship with products. Design plays a central role in engaging people in repair and creating repairable products and tools. People willing to repair can be supported with tools, kits and instructions. This paper explained the three phases of users' product repair experience and discussed the factors that affect their process. Further studies can explore how new contexts for product design can be developed to enhance repair practices.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-413

Over the hill? Exploring the other side of the Rogers innovation diffusion model from a consumer and business model perspective

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Keywords
Innovation
Business models
Automotive
Product lifespans
Classic cars

Abstract
The Rogers model of innovation diffusion has long featured in accounts of the penetration of new product technologies into society (Rogers, 2003). The contention in this paper is that this model is in fact only half complete, for it deals exclusively with the uptake of new technologies rather than their retention or abandonment. Taking the Rogers model as a point of departure, this paper seeks to characterize consumers who retain technologies, then identify business models designed for those consumers.
Implicit in the Rogers model is that existing technologies become obsolete, and hence displaced by the emergent technologies. In reality, a new technology may be additional to the suite of products available to consumers, and therefore not necessarily associated with the direct displacement of an existing technology. However, much product innovation is concerned with generational improvements in technologies or with new technologies that, while having no direct equivalent in current use, do indeed displace existing solutions.
The paper therefore analyses the contribution of extended product lifetimes within circular economies. The relevance of this contribution is that product longevity is one means by which lifestyles characterised by material affluence are reconciled with resource scarcity. Product longevity has the potential to contribute to slowing down the 'velocity' of material flows within the circular economy, and hence defer the investment of further energy (and materials) into the next cycle of consumption. Bock et al. (2012) identify that there are several pathways by which business model innovation may contribute to more sustainable production and consumption.

Introduction

Bock et al. (2012) identify that there are several pathways by which business model innovation may contribute to more sustainable production and consumption. One of these pathways is to slow down the rate of consumption. In the circular economy concept there remains an environmental and economic cost to recycling products and their constituent materials, even though such recycling may reduce the net level of material consumption.

From an eco-efficiency standpoint, it is often argued that there will be a point at which the additional performance of a new product will outweigh the benefits of retaining an old product. Such debates are highly relevant in products with a rapid rate of technological improvement, and where there are incentives for users to dispose of older products. The presence of these twin characteristics is discernible in several technology categories including, for example, domestic heating systems, refrigerators, and air conditioning systems. The retain/discard debate is frequently found with respect to cars, for example, where attempts are made to quantify the 'breakeven' point of carbon emissions in new car manufacturing and disposal, against those of retaining an existing car in use, and where successive policies of 'scrappage incentives' have been justified at least in part on environmental grounds (van Wee et al., 2011). This paper therefore takes examples and evidence from the retention of cars in use.

We argue that the retention or disposal of products is not simply a reflection of a utility-maximizing rational economic individual coming to a logical decision based on monetary or indeed environmental factors. Rather, just as the Rogers model has certain 'behavioural' traits built in, so the decision to retain complex and enduring products such as cars has social, cultural and emotional dimensions that may transcend issues of efficiency or financial prudence (McCracken 1986). That is to say, there are clearly situations in which the owners or users of products actually cherish those products, those material possessions and, from a sustainability perspective, there is value in understanding why this might be so (McCracken, 1986, 1988, 2005).

Consumers and the diffusion of new technologies

The Rogers model is usually presented as shown in Figure1.

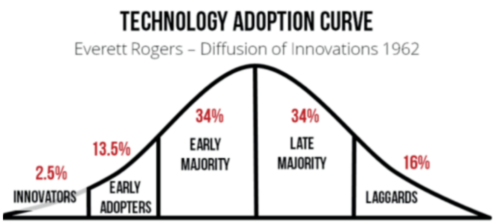

Figure 1. The Rogers Diffusion Curve.

Several criticisms can be levelled at this diagram:

- It assumes a 100% market penetration.
- It is highly ideological in the use of language with 'innovators' and 'early adopters' contrasted with those 'laggards' who presumably lack the wit and intelligence to adopt the technology in question.
- It lacks a spatial component in that innovations may be cluster adopted in a certain location, but not in others.
- It treats all consumers as equal when in many cases the innovators or early adopters are in the form of state agencies such as the military, who may also be co-creators of the technology (cf. Mazzucato, 2013).
- It fails to consider the differences in business model associated with the different phases of technology uptake.
- The question of change over time is not specified.

Notwithstanding these criticisms, we can, in rough terms, identify three phases of business model to accompany the Rogers model:

- In the early phase, the value proposition is centred on additional or unique performance benefits albeit at higher cost. The business model is dominated by close contact with the customer / user whether state, corporate, elite individual or crowd-funder.
- In the second phase, market expansion into the early majority is characterised by a transition to more stable product design, a focus on manufacturing economies of scale, reduced cost, and logistics and distribution systems to expand the volume and spatial extent of the market.
- In the third phase profitability starts to decline, and consolidation or rationalisation with cost reduction and cost competition become the predominant focus. This phase is typical of mature commodity industries.

To highlight these issues, we can present a redefined Rogers diagram in which the bell curve shape remains, but where the first half of the diagram is concerned with the adoption of a technology while the second half is concerned with a technology being abandoned (Table 1). This version of the model therefore gives a rather different focus on the cumulative way in which a product is eventually abandoned in the market – though, as we make clear, the reality is that in many cases the product does not entirely disappear but may take on rather different socio-cultural meaning and, with this, be serviced by rather different business models.

In passing, this means that the classic 'early adopter' diagram (the Rogers innovation and adoption diagram) is incomplete as it only deals with the uptake of new technologies, rather than the discarding of existing technologies.

Upswing		Downswing	
2.5%	Innovators	16.0%	Fickle disposers
13.5%	Early adopters	34.0%	Enthusiastic followers of fashion
34.0%	Early majority	34.0%	Cautious followers
34.0%	Late majority	13.5%	Reluctant disposers
16.0%	Laggards	2.5%	Determined retainers

Table 1. Extending the Diffusion Model.

In the Rogers diagram there is an assumed end-point of 100% adoption of the technology or innovation in question. But what is the curve for the rate at which a technology is abandoned? Is it a sort of mirror image in which some are 'early abandoners' and others are 'late retainers'? Is the whole curve stretched out over a longer time period than the uptake curve with a long 'tail' over which past practices and technologies remain in use? Nostalgia is a powerful cultural force in this regard, and many practices that have apparently been consigned to history can remain as echoes of an earlier era (McCracken, 1986). Is there even some form of rebound, wherein a technology and set of practices apparently in terminal decline become resurgent again, perhaps with a new generation of 'early re-adopters'? Think in this context of the renewed popularity of vinyl records and record players for listening to music and of riding and driving steam trains. Also note that sailing and horse-riding have far from disappeared despite the fact that for most practical uses these modes have been replaced by later technologies (Geels, 2002, 2005). Instead, the determined retainers or re-adopters do so within new, leisure-oriented, business models that often involve the incorporation of new technologies in their own right; modern sailing vessels are a far cry from their 19th century predecessors, for example.

The issue is therefore to identify consumer characteristics or desires that are fulfilled by product longevity and product retention. The emotional attachment to the product may arise out of an accumulation of experiences with that product, and the associations that such experiences give rise to, their 'displaced meaning' (McCracken 1986, 1988, 2005). Hence products may be cherished to an apparently irrational degree, primarily because of this set of associations. In addition, the ability to interact with the product (by 'tinkering' for example) may act to increase the sense of personal ownership and emotional investment that transcends a narrow economic calculation of utility (Franz, 2005; Nieuwenhuis 2014). The ability to share that emotional experience with others may act to reinforce the social value of product retention. There are some fundamental human characteristics here regarding the desire to hoard, and to catalogue, classify and itemise. Communities of interest therefore act as important mechanisms that legitimize and indeed celebrate types of product retention (Nieuwenhuis, 2008).

Such practices are a common feature of most societies, and are expressed in, for example, the existence of libraries, museums, relics, and the recurrent fascination with antiquity.

Product longevity and business models

The notion of 'built in obsolescence' reflects a view that certain products, including cars, were designed with a deliberate intention to have a shorter in-use phase than technically possible, in order to stimulate the market for replacement products; a trend resisted in the early days by Henry Ford, but very much promoted by General Motors under Sloan in the 1920s. Ford's position is set out clearly in My Life and Work (Ford 1924: 148-9). A far cry from planned obsolescence. Ford is challenging both his main competitors – notably General Motors – but also his own collaborators inside the company, who were pressing for replacement of the Model T which Ford himself had been planning to build essentially for ever. Sloan's contrasting approach at GM is summarized by Flink (1988: 234).

It could be argued that fashion in products acts in a similar manner, as a form of aesthetic obsolescence. In either case, the business model is predicated upon revenues derived from the sale of new products and related services (such as finance or insurance), and hence there is scant corporate interest in extending product longevity. This focus on new product revenue streams can result in design biases that result in prioritising ease of manufacture over repair, thereby further weakening the business incentive to support longevity (Chapman, 2005). Consumers are arguably 'educated' into this concept, with an acceptance that repair and re-use of many products is simply not financially worthwhile and is often technically impossible (Chapman 2005; Franz, 2005; Muis, 2006).

The mainstream literature on business models has something of a bias towards certain categories or types of business. That is to say, there is a predisposition to focusing on e.g. manufacturing business models rather than service; and those business models involving online or digital components. Research into business models and sustainability is more diffuse in character, with examples drawn from a range of sectors (e.g. clothing; food and beverage; transport) and a range of participations in the value chain (e.g. manufacturing; logistics; retail; service).

Business model innovation may contribute to enhanced sustainability in a circular economy setting in several ways. These can include:

- Supporting a new product in use by the provision of replacement parts and related services, including design for such provision.
- Increasing the 'capture' of products and materials to prevent them entering waste streams.
- Increasing the intensity with which a product is used, thereby amortising the resource investment more completely.
- Reducing the volume of new products required through sharing or multiple-use.

Examples from automobility and the automotive industry

Previous research has identified the fundamental characteristics of the automotive industry business model as it applies to contemporary mass production. This model has emerged, albeit unevenly, over time as other competing models have been marginalized or vanquished (Sabel and Zeitlin 1985, 1997). The predominant automotive industry business model has its foundations in the emergent mass production industry of North America in the early 1920s, and is defined by three main innovations: the moving assembly line along with standardized production pioneered by Ford; the all-steel body developed by Budd; and the multi division multi-brand structure along with credit finance for consumers as typified by the contributions by General Motors under Sloan (Nieuwenhuis and Wells, 2007, 2015). Ultimately, these innovations resulted in an industry business model centred on manufacturing economies of scale, centralized factories, long outbound logistics lines, independent franchised dealerships to sell the product, and revenues mostly generated by the sale of new product. The model was particularly suited to driving down the cost of production and thereby expanding the available market by reducing the price faced by consumers. In the early years of this mass industry the need for differentiation was low because consumer priorities were simply based on accessing motorized mobility.

Cars are interesting as an example of product longevity because they embody some important characteristics that speak to consumer attitudes and behaviours that were identified as significant in product retention. Over time, business models and practices have developed that seek to serve consumers seeking to retain their cars in use (Nieuwenhuis 2008, 2014). This industry – which includes the trade in classic cars, parts for these, events to enjoy them, etc. – has framed new business models around apparently obsolete products thereby belying their very obsolescence. The industry can also include vehicle manufacturers who offer parts and restoration services for older models, and for some low-volume or specialist vehicle manufacturers this long-term relationship with their customers is a key element of securing an enduring income stream from those vehicles originally manufactured. Interesting UK examples are Morgan and Bristol.

Conclusions

The aim of this contribution has been to show that Rogers' iconic diffusion model is too simplistic and partial to reflect reality and that there is, therefore, a strong case to be made for extending it to include not only the full process of the adoption of new technologies, but also the persistence in many cases of those very technologies they seek to replace. Not only do such technologies often persist, they become core to new business models and subject to new innovation development paths. These new insights can form the basis of a new way of thinking about the obsolescence of displaced products, which, in reality, may be nothing of the kind. This in turn can lead to developing and promoting more durable products, supported by new and novel business models in the quest for more sustainable consumption and production in the context of the move towards more circular economic models. The classic car phenomenon, whereby cars are retained in some form of use well beyond their planned lifespan, is used as an example where this development can already be observed today. Though in many respects obsolete, many such cars remain in regular use – sometimes daily use – and a significant support sector has grown up to enable this development. In the process, new business models have been developed that instead of supporting new products, support and incorporate such obsolete products, albeit in a manner different from the business models that supported these products when new.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-417

Classifying circular business models: a practice-based review

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Keywords
Circular economy
Business model
Business model innovation
Circular business models

Abstract
Business models have a crucial role to play in the transition to a circular economy. Circular business model innovation provides an arena for studying the creation of such circular business models and enables companies the possibility to identify new value creation opportunities, such as capitalizing on embedded value of products over multiple lifecycles. In comparison with the trajectory of traditional business model innovation literature, circular business model innovation is underdeveloped, and this paper aims to make a contribution to the ongoing theoretical discussion. Through review and categorization of 140 circular business model case examples, this paper makes a first attempt to verify previous literature and unify academic and industry understanding of circular business models. The findings are expected to be useful in advancing the field of circular business model innovation and assisting practitioners in the design and development of new circular business models. While the results suggest convergence around three circular business model types: 'Access/Performance Model', 'Extending Product Value', and 'Extending Resource Value', other previously identified circular business model types should not be discounted.

Introduction

Over the past few decades, resource constraints coupled with increasing consumption have spurred interest in shifting to a more 'circular' economic model. In moving to this circular economy (CE), the maintenance and reutilization of stock is emphasized (Stahel, 2013). Undertaking such activities in practice may, however, be a challenge due to the current linear system that does not emphasize reverse supply chains and other lifecycle management practices necessary to achieve a CE. In addressing this issue, authors have highlighted circular business models as key enablers of CE due to the fact they can help facilitate and enable product life extension and closure of resource loops (Bakker et al., 2014b).

The concept of circular business models is viewed as a key research area in the field of CE (Lieder & Rashid, 2016). However, when compared to traditional management literature, research on circular business model innovation is currently underdeveloped. Traditional business model innovation literature has evolved over the past few decades and with a strong practical focus (Wirtz et al., 2016). Much of the research has centered on utilizing cases from practice to aid in the identification of definitions, ontologies, building blocks, and configurations which help to clarify the business model concept and assist firms in undertaking business model innovation.

In comparison, the term 'circular' has been used to describe a variety of different business models (Lewandowski, 2016) and is widely used in industry as well as academia. While some authors in the field of circular economy have presented conceptual definitions and archetypes of circular business models (i.e. Bakker et al., 2014a; Bocken et al., 2016), literature comparing and contrasting these various viewpoints is limited. Furthermore, and to the best of this author's knowledge, no study has presented a practice-based review of circular business models, although such an approach has previously been useful to unify the different types of (sustainable) business innovation present in both practice and literature (Bocken et al., 2014).

This paper therefore aims to help converge current knowledge on circular business models and facilitate future research on circular business model innovation by exploring conceptualizations of circular business models. First, a brief overview of existing definitions and categorizations from academic literature are presented before a review of business case examples from practice is undertaken. After presenting the results from analyzing 140 circular business model case examples, the paper concludes with a brief discussion about current understandings about circular business models and circular business model classifications schemes. The findings are useful not only for advancing the field of circular business model innovation, but also in assisting practitioners in the design and development of new circular business models.

Circular Business Models Literature

Definitions

Business models are often defined as how organizations create, deliver, and capture value (Osterwalder et al., 2010). In order to provide some clarity to circular business models, the concept of a 'linear' business may be used as a contrast. Linder and Williander (2015) describe such linear business models as where:

> *"the conceptual logic for value creation is based on a material flow where (only) virgin material enters the value chain upstream and all product value except raw material value is added through manufacturing and user behaviour"*

Yet, while use of this conceptualization implies the opposite for circular business models - that value creation in circular business models is based upon 1) many types of material flows (not only virgin materials) and 2) many types of value added activities (not only manufacturing and user behavior) - academic literature on circular economy appears to approach the circular business model topic from multiple perspectives (Lewandowski, 2015).

Linder & Williander (2015), for example, inherently imply circular business models are circular only when products return to producers[1]. While such a definition appears appropriate for their case study investigation into why circular business models, especially remanufacturing and reuse, are not undertaken by original equipment manufacturers, this manufacturer-centered perspective is not present in Bocken et al. (2016)'s explanation of circular business models. Here a systems perspective is implied, describing circular business models as business models that contribute to the "slowing, closing, and narrowing resource loops" (Bocken et al. 2016).

Classification Schemes

In addition to explicit definitions, both academia and practitioners have worked to develop classification schemes for circular business models. While this approach is reflexive of the theoretical development trajectory for traditional business model literature (Osterwalder et al., 2005), the methodological approaches utilized to create such circular business model categorizations are not transparent within existing literature.

Drawing on Bakker et al. (2014a)'s classification scheme, Bocken et al. (2016) present six classifications, referred to as 'circular business strategies': (1) the access/performance model, in which value is created by providing customers the use or performance of products in lieu of ownership; (2) extending product value, in which value is created by exploiting the residual value of unused, broken, or discarded products; (3) the classic long-life model, in which value is created by delivering customers a durable product; (4) the encourage sufficiency model, in which value is created by reducing end-user consumption; (5) extending resource value, in which value is created by exploiting the residual value of resources; and (6) industrial symbiosis, a process-oriented solution in which value is created by using residual outputs of processes as input for new processes.

In comparison to Bakker et al.'s (2014a) five-type classification scheme, updates by Bocken et al. (2016) include: combining two previously separate models (the 'Access model' and the 'Performance model'); broadening the scope of the so called 'Gap exploiter' model beyond 3rd parties (now referred to as 'Extending resource value'; removing the 'Hybrid model' (where selling durable products is combined with fast-moving consumables to create value); and introducing 'Encourage sufficiency' and 'Industrial symbiosis'.

Circular Business Model Cases

To contribute to the ongoing conceptualization of circular business models and identify how current understandings align with previous classifications, a review of circular business model case examples was conducted. To do so, a

Publication Year	Publications Reviewed
2010	Park et al.
2012	Damen; Ellen MacArthur Foundation; Lee et al.
2013	Evans; Ellen MacArthur Foundation; Schulte; Kok et al.; Joustra et al.
2014	Bakker et al. (a); Bocken et al.; Ellen MacArthur Foundation; Genovese et al.; Lacy et al.; Mentink;
2015	Bocken et al.; De Jong et al.; Ellen MacArthur Foundation (a); Ellen MacArthur Foundation (b); Ellen MacArthur Foundation (c); Florin et al.; ING Economics Department; Kiørboe et al.; Linder & Williander; Murray et al.; Prendeville & Bocken; Roos & Agarwal; van Renswoude et al.; Whalen et al.
2016	Antikainen & Valkokari; Beulque & Aggeri; Bocken et al.; Ellen MacArthur Foundation; Guldmann; Lewandowski; Lieder & Rashid; Ovaska et al.; Scheepens et al.

Table 1. Overview of publications reviewed.

[1] *They write: "a business model in which the conceptual logic for value creation is based on utilizing economic value retained in products after use in the production of new offerings. Thus, a circular business model implies a return flow to the producer from users, though there can be intermediaries between the two parties" (Linder & Williander, 2015).*

Classification Category	No. of cases	Example Cases
Access and Performance Model	48	Amazon 'Textbooks as Service'; Vigga 'baby clothes by subscription'; Zipcar 'car sharing'; Bag, Borrow, or Steal 'handbag rental'
Extending Product Value	56	Brightstar corporation 'buy-back & tradein services for mobile phones'; Agito Medical 'refurbishment of medical equipment'; Godsinlösen 'repair of mobile phones'
Classic Long Life Model	4	Martela Oyj FI Furniture 'long life furniture'; Google data centers 'designed to last'; Techno gym 'design for extended life', Repack 'reusable packaging'
Encourage Sufficiency	1	Martela Oyj FI Furniture 'customers purchase according to needs'
Extending Resource Value	47	Aquafill 'chemical textile recycling'; Worn Again 'textile recycling'; Icelandic Recycling Fund 'recovery and recycling of fishing nets'; Grundfos 'take-back and recycling of pumps'
Industrial Symbiosis	7	Royal DSM 'selling cellulosic bioethanol created from feedstock'; GRO Holland & LaPLace 'coffee residues to grow mushrooms'; Kroger Grocery 'foodwaste into renewable energy'
No Classification	2	Splosh 'cleaning supplies'; Sharetribe 'platform for creating online marketplaces'

Table 2. Results from categorizing cases.

search for literature making use of the term 'circular business model' was performed within academic directories (i.e. Scopus and Science Direct) between August - November 2016. The resulting literature, as well as its references, was scanned for explicit mention of cases studies and examples of circular business models. Due to the limited results, the search was then opened to secondary sources (i.e. grey literature). In total, within 38 references (as shown in Table 1), 207 cases referred to as 'circular business models' were collected for review.

Of these cases, 140 cases examples were determined to be unique (i.e. not repeated in different sources) and described a business model (i.e. details about how the firm creates, delivers, and captures value were provided). As shown in Table 2, the cases were then classified according to the previously presented Bocken et al. (2016) framework. The total number of cases presented in the table exceeds 140 as some cases were classified under more than one category.

The majority of cases were classified into three types: 'Access/Performance', 'Extending Product Value', and 'Extending Resource Value'. The remainder of this section summarizes main findings from analysis of the cases in these three categories. Quantification is denoted by [n=number of cases].

Access/Performance Model

Most firms within this category fell under one of two categories: those who own assets [n=24] and those who do not [n=12]. The value creation and delivery methods for the former focus on distributing said assets multiple times. This lowers the total cost of ownership for customers and leaves the responsibility of maintenance and repair of assets on the firm. Over half of these cases came from the apparel and transportation industries, with dress and handbag hires such as Rent the Runaway and Bag, Borrow or Steal and car hires such as Car2Go and Co-wheels. Value capture methods appear dependent on the number of times and length for which assets are distributed. This, in turn, is dependent on product type and offer

In contrast, firms without their own assets were characterized as facilitators – connecting those who have something (i.e. unused space) with those who desire it. Such examples include Off2Off, a platform that helps firms match supply and demand of goods and resources across their organization, and Lyft, a platform that provides transportation services by targeting drivers with extra seats available. Multiple methods for capturing value were identified including transaction, or service fees, and monthly membership fees.

Extending Product Value

The majority of firms within this category [n=35] were identified as product resellers. These firms rely on creating and delivering value by retrieving used products and capturing value by selling them to other customers. The firms who did not focus on reselling appear to create and deliver value by providing services that extend product life such as repair (i.e. iRepair, a repair shop for electronics) or collecting products for input in new production (i.e. SAB Miller's returnable bottle program).

A variety of value propositions for the return/supply of used goods – ranging from buy back, discounts, and trade-in solutions - were identified in the cases. Walmart and GameStop, for example, both offer a trade-in program for used video games and then resell them.

Extending Resource Value

The majority of cases in this category [n=30] described firms undertaking material recycling activities. While the firm in the identified case was often the party carrying out the recycling, there were some instances where the firm did not perform the recycling, instead partnering with other firms in order to recover material value.

In addition to recycling, a few cases [n=9] highlighted business models focused on the sourcing of used materials as inputs for new products. Examples include Freitag and Deadwood who 'upcycle' material into apparel and Philips who uses recycled plastic in products to reduce cost. Finally, three cases did not describe business models that enable recycling or the use of previously used material. Instead, these firms capture value by playing a facilitating role in 'linking up' parties with waste to those who desire it.

Discussion & Conclusion

The results provide interesting insight into current understanding of circular business models. As multiple cases were identified to fit with more than one archetype, the review illustrates firms may not only apply one circular business strategy, but instead pursue multiple strategies. For many of the companies, circular business models were also often pursued alongside linear business models.

Considering the majority of cases were classified into three business model archetypes, the results suggest some type of convergence around the circular business models centering on access/performance and those that extend either product or resource value. However, the other three ('Encourage sufficiency', 'Industrial symbiosis', and 'Classic long life') should not be immediately disregarded. Some or all of these three concepts could be underrepresented because of a limited number of cases examples that exist to illustrate these types of models.

Furthermore, for most archetypes there was some challenge in classifying the cases. Potential 'Classic long life' cases were often questioned because it was difficult to discern the accuracy of the claims from marketing language. Interpreting 'long life' was also a challenge. For example, one case (Splosh) ultimately left unclassified - as it did not align with Bocken et al. (2016)'s examples of classic long life - could potentially be viewed as a classic long life model as Splosh's product is designed for reuse and replaces something that is normally discarded after one use[2]. Drawing the line between extending product and resource value was also a challenge in some cases. For example, H&M's garment collection, while classified by Bocken et al. (2016) as 'Extending product value', was classified in this paper as 'Extending resource value' as the majority (if not all) of the returned garments are recycled rather than reused.

Some of the existing archetypes appear to be more suited as subcategories. In classifying the cases, it became apparent that 'Industrial symbiosis' appears to be a subcategory of 'Extending resource value'. While industrial symbiosis may be a 'process oriented solution' it still focuses on the exploitation of otherwise wasted resources. It is therefore proposed 'Extending resource value' and 'Industrial symbiosis' are consolidated, with the latter as a sub-category of the former.

In line with the above recommendation, further in-depth review of the other business model archetypes should be undertaken to create an updated and consolidated typology. Within this adjusted typology, various characteristics - such as the types of collection methods used by firms to extend product value – may be elaborated on to help enable the design and development new circular business models.

Acknowledgments

This research is supported by the Mistra REES program, which is funded by Mistra (The Swedish Foundation for Strategic Environmental Research).

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[2] *Interestingly, while this case may not have completely aligned within any of the Bocken et al. (2016) categories, it did fit the 'Hybrid model' identified by Bakker et al. (2014a).*

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-422

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Risk & Race: creation of a finance-focused circular economy serious game

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Keywords
Circular economy
Business models
Financing
Serious game
Business game

Abstract
As the topic of circular economy gains increasing popularity, a growing number of serious games and tools have been developed to assist in educating about circular business models. A review of these existing games suggests a lack of emphasis on business operations and financial implications behind circular business model investment decisions. In contrast, recent academic literature suggests the economic implications of adopting circular business models should be stressed, given potential financial differences between circular business models and linear business models. This paper introduces Risk & Race, a serious game developed to assist in bridging this gap between literature and practice by illustrating the financial drivers and barriers to implementing circular business models in practice. Initial findings from testing with students suggest the game succeeds as a support tool for modeling business operations and explaining the financial side of circular business models.

Introduction

Governments, companies, and scholars have expressed concerns about the long-term viability of our current resource production and consumption rates. Many consider moving to a more circular model as a necessary and logical step for today's society. Analysis also suggests this makes sense from an economic standpoint, with estimates that moving to a circular economy could generate €1.8 trillion within Europe by 2030 (Ellen MacArthur Foundation, 2015).

Companies, perhaps intrigued by the promise of cost savings and new business opportunities, have expressed interest in applying this circular way of thinking in the development of new business models. Business models describe how a company creates, delivers, and captures value (Osterwalder et al., 2010) and are viewed as important enablers for circular economy (Bakker et al., 2014b). Circular business models imply that the useful life of products and components is prolonged and/or material flows are closed.

In practice, many types of circular business models are emerging, with Bakker et al. (2014a) distinguishing five types: Classic Long Life Model, Hybrid Model, Gap-Exploiter Model, Access Model, and Performance Model. However, in moving to adopt these models, companies often encounter barriers. Many models encourage retained ownership of physical assets, resulting in capital tie up and increased business risk (Linder & Williander, 2015). Furthermore, a change in business offer (i.e. moving from selling to renting) can disrupt the revenue stream and lengthen return on investment periods. As such, literature has highlighted the need for further understanding about financing circular business models, especially aspects related to investment decisions for physical capital assets (Korse et al., 2016).

To help increase understanding about circular economy and the development of circular business models, a number of serious games have been developed. This is likely due to both games' abilities to model complex systems and assist in reasoning and planning (Sitzmann, 2011; Ke, 2009). However, a review of these existing games reveals a focus on motivating the creation of circular businesses rather than specifically addressing economic aspects of business operations or detailing financial implications behind investment decisions.

Developed to address this gap, the business game *RISK & RACE* has been developed and this paper investigates how such a serious game can assist educators in modeling

Increased return on investment time & cash flow uncertainties
Difficulty and costs associated with arranging reverse logistics
Increased human resources costs
Upfront investment needed for innovation (i.e. adapting products for CBMs)
Changing market demands & assumptions

Table 1. Key Financial Barriers to CBMs.

drivers and barriers of circular business models. Following a brief background section about existing games and previous research, the scope and theory behind *Risk & Race* is presented. Finally, first insights into the applicability of the game in education are summarized from play testing sessions with high school and higher education students.

Background

Circular Business: Drivers & Barriers

Previous research has highlighted the significance of financial drivers and barriers in regards to adopting circular business models.

Proponents of circular business models stress potential gains from reduction of risk (i.e. greater security of resource supply, protection against price volatility) (Peck et al., 2015) and economic growth (i.e. new revenue opportunities, new market potential, and cost savings in manufacturing) (Ellen MacArthur Foundation, 2013). However, as the assumptions that business operations are based upon change over time and with different market demands (Linder & Williander, 2015), macro environment conditions do not always prove certain circular business decisions to be economically beneficial.

Furthermore, adopting circular strategies in reality poses financial threats to firms' existing business models and a number of barriers have been identified. Much of the knowledge about circular business is based on existing literature on product service systems as, in contrast to the current linear 'sell more, sell faster' business model, circular business models often move away from one time sale of products.

In addition to impacting company cash flow and lengthening return on investment periods (Mont, 2000), additional firm resources are often required. Products many need to be redesigned in order to make them more durable, repairable, and upgradable (Sauve et al., 2015; Berchicci and Bodewes, 2005), leading to greater upfront investment. Additional costs may also result from arranging take-back and reverse logistics (Kissling et al., 2013) or hiring additional employees to perform skilled tasks such as repair (Kowalkowski et al., 2015). As such, many firms do not implement circular business models. Table 1 summarizes these identified barriers.

CE Game-based Tools

Games for learning, or serious games, often represent reality and present players with a unique dynamic learning situation (Crawford, 1984). In the fields of sustainability and circular economy, such games have received attention as learning objects in both research and practice (DeWulf, 2010, Sadowski et al. 2013, Life cycle game, 2016). Recent games developed within the field of circular economy include *In the Loop* (Whalen & Peck, 2014), *Make it or Break it* (ResCoM, 2016), the *Game of Circularity* (Resource 2015 and the Game of Circularity, 2015), and *Circulab* (Circulab game, n.d.).

While these existing circular economy-focused games have specific and differing learning outcomes, most aim at giving a generalist introduction to various motivations for a circular economy and simplify the financial perspective. For example, although *In the Loop* utilizes a monetary system where players must make strategic investment decisions, purchase resources, and distribute products, players do not track financial records (i.e. fixed and variable cash flow) and human resources are notably absent. As such, players receive surface-level takeaways regarding the financial implications of circular business models.

Risk & Race: Overview & Theory

Risk & Race (Figure 1, Table 2) is a serious game developed to explore the financial side of circular business models. At the beginning of the game, each player 'inherits' a manufacturing company in debt. The aim is to increase company value throughout the game and be the company with the highest value at the end of the game. This company value is expressed by the player's total amount of cash, investments, labor force, and societal impact.

The game is played in ten to fifteen rounds. Each round signifies one year and the game follows a pre-set narrative with various scenarios (i.e. PESTEL forces) unveiled each round that change the game conditions. Using game mechanics similar to other 'worker placement' games[1], players need to carefully choose and plan their actions during each round. They can purchase resources, produce and sell products, train employees and make investments in an effort to increase company value. After each round, players must 'bookkeep' by recording their fixed and variable costs, investments, and revenue from product distribution.

The game environment of *Risk & Race* is a complex system with multiple feedback and feedforward loops which can be divided into two main parts: the external environment (i.e. the game narrative and other players' actions) and the internal environment (i.e. player's decisions and company resources). The game's changing narrative mimics many factors in the current external business environment that are seen as drivers for circular economy. Price volatility

Figure 1. Playing Risk & Race. © S. Manshoven

[1] *Also known as action drafting, this is a game mechanic where players choose action(s) to perform from a set of actions available to all players by placing workers on spaces associated with the desired action.*

Risk & Race	
Funding	EIT Raw Materials
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Keywords	Business game, board game, circular business game, Circular Economy
Published	May 2017, Belgium
Language	English
Time	2,5 hours
Players	4 individuals or teams
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Table 2. Risk & Race Information Summary.

and uncertain supply of resources is expressed throughout the game through player competition, limited quantities, and, following external events, changing resource prices or availability. Policy mandates and new technologies, such as the phasing out of certain resources due to health concerns or improved recycling abilities, also influence players towards adoption of circular business models.

At the same time, barriers to adopting circular business models are present. Table 3 summarizes how the key financial barriers to adopting circular business models are modeled in *Risk & Race*. Unlike other circular economy games, *human resources* are required to perform activities (i.e. purchasing materials, producing products) and, as such, players must balance employment costs with every action, thus illustrating the limited capacities of firms.

The external business environment also impacts each company as, following certain market trends, *market demand* changes each round with the game narrative. Also, resource costs can change due to price volatility on the market, or geopolitical tensions, changing the company's profit margin. Players can react to these evolutions by investing in new or more efficient product design and in new (circular) strategies to assure their resource supply.

Other financial implications of certain internal business decisions related to circular business models also become apparent as the game progresses. As players may choose to distribute products either through direct sales (ownership) or pay-per-use contracts, i*ncreased return on investment periods* are modeled. While the latter distribution method reduces the effect from certain external environmental influences (i.e. resource competition), the longer pay-back time is clearly modeled.

Finally, adoption of above-mentioned policies and new technologies require *significant upfront investments* and do not have clear rates of return. In some cases, players must first invest in multiple strategies before being able to see long-term financial benefits. As such, circular business decisions usually make more economic sense as play progresses rather than in the beginning of the game.

Initial Testing Insights

After an initial iterative design process, playtesting sessions were conducted in Finland, Germany, the Netherlands, and Belgium with a variety of potential target groups including business professionals, entrepreneurs, high school students, and university students. To provide some insight into the game's potential as a tool in education, this paper briefly reflects on only the latter two types of sessions, specifically three sessions with students that took place during the second half of 2016. One session was held with high school students in Germany [n= 12], while two sessions were held with master's students in the Netherlands [n=26] and Finland [n=66].

While all sessions emphasized the need for a moderator to guide each round, clarify concepts, and ensure the game runs smoothly, results indicate *Risk & Race* could provide valuable contributions to educational programs, especially for master's students. Most participants used a combination of distribution types and purchased strategies, enabling them to compare the effects that various circular (and linear) actions had on their company financials. Surprisingly, participants also did not find the bookkeeping aspect of the game tedious, as there was some concern from the designers that this part would be seen as distracting from gameplay.

After playing the game, master's students reported greater knowledge about resource management, business continuity, and company finances due to the game's emphasis on resource purchasing and cash flow. While a comparison of pre and post surveys taken by students in the Netherlands reported an emphasis on smart investment after playing, surveys from both master's

Key CBMs Financial Barriers from Literature	**Embodiment in *Risk & Race***
Increased return on investment time & cash flow uncertainties	Visible by comparing the two types of distribution: Direct sales (player gains revenue immediately); Product-Service (player receives slightly more revenue, distributed over three rounds)
Difficulty and costs associated with arranging reverse logistics	Economic costs and uncertainty of take-back volume associated with operating reverse logistics
Increased human resources costs	Human resources required to operate circular strategies; players must make trade-offs between hiring new workers or smartly allocating current employees.
Upfront investment needed for innovation (i.e. adapting products from CBMs)	Significant investment required for circular strategies; some are also conditional (i.e. you must invest in 'Circular Design' before you can remanufacture products).
Changing market demands & assumptions	Game is dynamic system with external influences: Market demand and resource prices fluctuate during the game; External events reveal new conditions; Players compete over the same resources.

Table 3. Embodiment of key financial implications of CBMs within Risk & Race.

student groups indicated increased familiarity with a variety of business-related and circular economy-related terms and concepts including variable cash flow, fixed cost, product service systems, remanufacturing, and reverse logistics.

In contrast, some additional modifications could be necessary if the game is to be used more widely with high school students. The high school students appeared to have more difficulty than the master's students in understanding and playing the game. Furthermore, some language issues were also encountered. While the master's students were familiar with working in English, the German high school students were not.

Conclusions

This paper introduced *Risk & Race,* a game developed to increase understanding of circular business models. While financial differences between linear business models and circular business models are often stated to exist, when educating about circular economy concepts through the use of game-based learning, such differences are not often explicitly illustrated. This paper provides a first overview of how main financial drivers and barriers to adoption of circular business models from literature have been translated and embodied in a serious game.

Risk & Race appears to make a valuable contribution to the growing field of circular economy serious games as the game provides insight into company finance and illustrates resource management, company cash flow, and the influence of external factors (PESTEL). However, elaboration on current findings and additional playtesting must be carried out. Reflection of the game development process and specific mechanics could also be interesting from a serious game design perspective.

Acknowledgments

The author thanks the *Risk & Race* development team as well as the playtesting participants for their valuable support and feedback. *Risk & Race* was developed in partnership with VITO, TU Delft, In the Loop Games, VTT, and Wuppertal Institute and funded by EIT Raw Materials. This paper is also supported by the Mistra REES program, which is funded by Mistra (The Swedish Foundation for Strategic Environmental Research).

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-426

Ever-faster, ever-shorter? Replacement cycles of durable goods in historical perspective

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Keywords
Replacement cycles
Acceleration
Product lifespans
Historical
Empirical evidence

Abstract
Predicted by popular theories of acceleration, such as the theory of planned obsolescence and the rise of a throwaway society, the ever-faster replacement of durable goods is widely assumed in the literature. This paper confronts this assumption with long-term empirical evidence from three distinct cases – wheat seeds, automobiles, and mobile phones. The cases show that there is no dominant logic or force underlying historical changes in product durability, lifespans, and replacement cycles. Neither are such changes entirely unpredictable: There are clear patterns where these phenomena go up or down for sustained periods of time. The observed patterns in replacement cycles call for an empirically grounded theory that can explain both periods of acceleration and deceleration and connect durable goods replacement decision-making with developments at the aggregate level.

Introduction

The starting point of this paper is the observation of a profound disconnect between empirical research and the abstract theories informing the debate on product lifetimes and replacement cycles. In fact, the past two decades have seen a remarkable increase of research on product lifetimes and obsolescence. Researchers of various disciplinary backgrounds have explored the multifaceted nature of this phenomenon from a wide range of different perspectives (see the reviews of Cooper et al. 2015; Rivera and Lallmahomed 2015). Despite the substantial amount of studies that accumulated over the years, however, there is a striking dearth of research on historical changes in replacement cycles.

In part, this lack of research may be due to limited access to reliable, longitudinal data on replacement cycles. This would not explain, however, why this situation extends to durable goods for which historical changes in replacement cycles were already estimated and published. More plausibly, it may be argued that historical changes are understudied because the acceleration of consumption, in the sense of ever-shorter cycles of replacement, is widely taken for granted. The sense that consumer goods are replaced at an unprecedented rate is tightly connected with common assertions that 'we' live in a 'throwaway society' or 'take-make-dispose economy'. After all, such an acceleration of consumption is predicted by all major narratives and theories informing the debate on product lifetimes and replacement cycles.

This paper confronts the assumption of ever-faster replacements with existing empirical evidence on the historical evolution of replacement cycles. Such evidence is extremely scarce, but nonetheless provides sufficient ground to call the accuracy of theories of acceleration into question. The evidence presented in this paper stems from extant research on wheat seeds and automobiles and an ongoing study of replacement cycles in the British mobile phone market. The observations from these cases call for the need of a middle-range theory that connects replacement decision-making with patterns at the aggregate level and is able to explain both periods of acceleration and deceleration.

The paper proceeds with a brief overview of existing theories and research on changes in replacement cycles over time. This is followed by a description of the British mobile phone market and some key observations I made in studying the replacement cycles of mobile phones. Finally, I discuss the implications of the empirical evidence presented here for future research.

Theories of acceleration

Theories of the escalation of demand abound in the literature (see Sanne 2002; Shove and Warde 2002). Due to space limits, the following paragraphs present only the sources of change that are cited most frequently in the debate on product lifetimes and replacement cycles.

The idea of 'planned obsolescence' is perhaps the most influential theory in this literature and enjoys much attention in the public and political debate (see Wieser 2016). The theory was particularly popular in the heydays of critical theory (e.g. Baudrillard 1998; Galbraith 1958; Marcuse 1964; Packard 1961), but is still present in contemporary thinking (e.g. Gorz 1999; Lodziak 2002; Maycroft 2009; Pope 2017; Slade 2007). The roots of this theory can be found in Marx's analysis of the driving forces of capitalism, in particular the observed necessity to speed up the circulation of capital. The basic argument is that the commodification of time creates pressure on individual capitalists to produce durable goods faster and faster, a development that needs to be accompanied by a parallel speeding up of consumption processes. Planned obsolescence, which can be regarded as a summary term for all practices of producers to accelerate the devaluation of consumer goods, is considered a key strategy to reduce the barriers to faster turnover times of capital (Harvey 1989). The replacement cycle of durable goods is thus essentially determined by manufacturers and predicted to shorten over time.

Another set of influential theories posit that the past decades have brought about a fundamental shift in the way things are appropriated. It is argued that the consumers relationship to things changed from one based on the principles of frugality, care, and stewardship, to one based on impatience, ephemerality, and low attachment to one's possessions. Modern hyperconsumerism of rapid product replacements is thus variably characterised by a throwaway culture (Toffler 1970), a culture of immediacy (Tomlinson 2007), an aesthetics of ephemerality (Appadurai 1996), or a desire for the new (Campbell 1992, 2015). A fundamental driver of this rise of a throwaway society is seen in advances in technology, which allowed for continuous reductions of the average cost of products (e.g. Campbell 2015; McCollough 2012; Schor 2013). Also, post-modern theories which interpret consumption as a means for the continuous renewal of the self are relevant here (e.g. Bauman 2005; Featherstone 1991; Giddens 1991). The aestheticisation of everyday life and import of fashion logics into markets which have traditionally been based on different values, are regularly quoted in these literatures as key drivers of this shift to fast consumerism.

Few commentators would nowadays agree on the statement that the fast pace of product replacements is driven by a single dominant factor. A more common argument is that the consumers' desire for the new and the capitalists' pursuit of profits perfectly complement each other and mutually reinforce processes of acceleration (e.g. Jackson 2009; Rosa 2015). The argument advanced in this paper is neither to deny that many spheres of life are accelerating, nor that the theories quoted in this section have anything interesting to say. Rather, I suggest that theories of acceleration provide an impartial picture of changes in replacement cycles and the widespread reliance on them has narrowed the gaze of empirical researchers. In particular, the assumption of ever-shorter replacement cycles of durable goods is rarely questioned by theorists of acceleration.

Historical patterns in replacement cycles

As stated in the introduction, there is very little evidence on changes of replacement cycles over time. The bulk of research that aims to explain the length of replacement cycles is on the consumers' replacement decision-making processes (see Guiltinan 2010), emotional attachment and product longevity (see Page 2014), or on corporate practices and marketing (e.g. Bayus 1988; Spinney et al. 2012). The disconnect between this research and the theories presented in the previous section is evident in the little commonalities between those theories and the ones applied in studies of replacement cycles, the latter being by far and large rooted in economics and social psychology.

More recently, a few studies estimated historical changes in replacement cycles for various consumer goods (Bakker et al. 2014; Huisman et al. 2012; Prakash et al. 2016). They consistently show that replacement cycles have become shorter over time, but were able to estimate the development for short periods of time (5-10 years) only. Given the susceptibility to the selection of the period when studying such short periods, I limit the following discussion to research which studied the development of replacement cycles or comparable measures over a substantial period. There is no objective criterion for what counts as a long-time period, but it is meaningful to consider the length in relation to the overall industry life cycle. Plant seeds and automobiles are two interesting goods for which comparable data was estimated and analysed for such a long period.

Plant breeding

Plant breeding is largely overlooked, yet one of the most intriguing cases of obsolescence. The case is unusual as it goes beyond the predominant attention to fast-moving consumer goods in the high-technology sector. The seeds' natural life cycles were already manipulated in the 19th century to adapt them to commercial cycles (Moskowitz 2009). In a rare and insightful study, Rangnekar (2002) investigated the historical evolution of the durability of wheat seeds in the period from 1960 to 1995. In the case of seeds, durability is measured in terms of their resistance to diseases. The durability of a product is not the same as its replacement cycle, but the two are intricately connected.

According to Rangnekar's estimations, the seeds' durability significantly shortened until 1973, followed by a long period of relative stability (see figure 1). Rangnekar shows that the compromises in durability were paralleled by a proliferation in the number of varieties, revealing the double-strategy of breeding companies to shorten turnover times. Although the author prefers to call this a form of planned obsolescence, it is important to note that such compromises in durability were not made without improvements in other dimensions. The lower durability is at least in part a consequence of the higher efficiency of the new seeds as the author remarks.

Tellingly, the second half of the studied period did not receive much attention from the author. Why did the durability of wheat seeds stabilise? In his conclusions, Rangnekar suggests that there might be a 'lower bound to strategies of planned obsolescence'. Too frequent

Figure 1. Average age of wheat seed varieties (1960-1995); source: Rangnekar (2002).

introductions of new varieties with higher efficiency might discourage customers to buy the new variety, making it more attractive to wait until its price falls. Annual introductions of new varieties do not appear to drive replacements in this market, however, considering that varieties were replaced only every six years on average. As Rangnekar notes, reduced durability is a stronger motivation for customers to replace a variety. Although the reasons for the stabilisation of the seeds' durability remain eventually unexplored, the study is interesting for finding evidence in support of the theory of planned obsolescence, but also against it – showing that the durability of a good can be held constant for a sustained period of time.

Automobiles

The automotive industry, specifically the conflict between Ford and General Motors, is regarded as the birthplace of planned obsolescence (Slade 2007). The rise of 'Sloanism', the strategy of accelerating obsolescence by means of annual introductions of new styles, has been studied in great detail (Cader 2012; Flink 1988; Frank 1997; Gartman 1994). The fast pace of new model introductions had its counterpart in rapid replacements. According to the estimations of Hundy (1976), the average lifespan of a car was 8 years before the Second World War and fell down again to 11 years after it had increased during the war period. What is rarely acknowledged, however, is that the average lifespan of cars has not reached such a low level since the 1960s. Hamilton and Macauley (1998) found that the average age of cars increased by 30% until 1991 (see also Steffens 2001) and more recent data show that this upward trend continued in many countries in the 2000s (Oguchi and Fuse 2015).

The ever-longer lifespan of cars is intriguing in light of their cultural importance, but also considering the significant efforts that governments around the world put into removing old, emission-intensive cars from the roads. Car scrappage schemes are designed to deliberately accelerate obsolescence, either to reduce overall emissions or stimulate new car sales (see Van Wee et al. 2011). The market of automobiles is further interesting because it is characterised by declining product release cycles since the 1970s. In the UK, new products with major facelifts were introduced every 5 years in the 1990s, compared to every 7 years in the early 1970s (interestingly, release cycles were under 4 years in the mid-60s) (Holweg and Greenwood 2001). The past decades thus defy some key predictions of theories of acceleration.

In search of explanations for the deceleration trend, Steffens (2001) found that in the Australian market, increasing real prices for new cars explain much of the variation. A study of the UK market, however, found that prices for new vehicles were actually falling and can thus not explain their increasing age (Hamilton and Macauley 1998). The study looked at two additional variables beyond the price for new vehicles: their durability and the costs of repair and maintenance. They conclude that the longevity of cars had indeed increased during this period, but this is rooted in falling costs for repair and maintenance services induced by increased competition, rather than in improvements in car durability. Their results suggest that car lifespans are essentially determined by the total costs per mileage. The different findings of these two studies show that it is important to pay attention to variations across countries or regions. Furthermore, results need to be interpreted with caution, as both studies investigated only a very small set of variables.

Mobile Phones

The data on the historical development of replacement cycles of mobile phones stems from my ongoing research of the British mobile phone market. The case study design on which this study is based, allows for a more comprehensive appreciation of the contextual conditions within which replacement cycles develop, informed by expert interviews and a detailed review of market research reports, trade journals, and business newspapers.

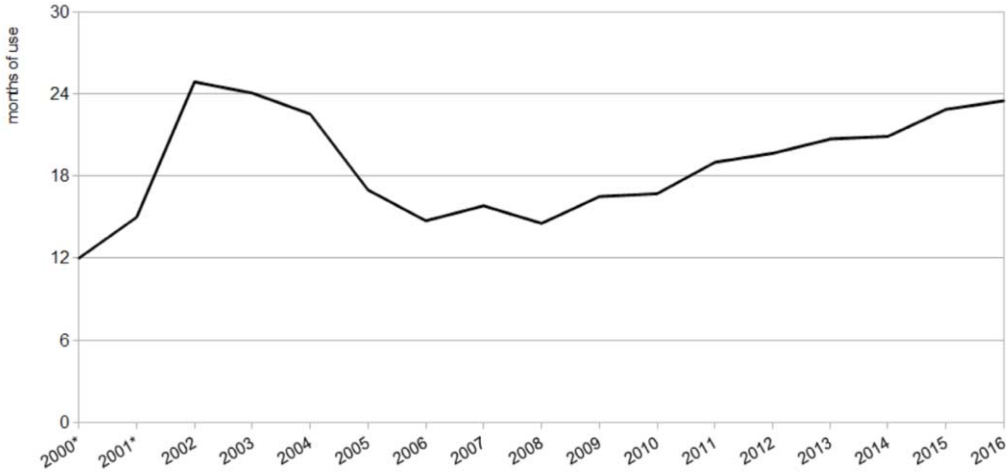

*Figure 2. Mobile phone replacement cycle in the UK (2000-2016); own calculations; *based on estimates of industry sources.*

The relatively short history of mobile phones makes it possible to estimate the development of replacement cycles for the whole saturation period. In the UK, more than 50% of the adult population possessed at least one phone in 2000. Figure 2 depicts the development of the replacement cycle since then, revealing a slight upward trend until 2002, a period of acceleration between 2003 and 2006, a short period of stabilisation (2007-2008), and a final period of steadily lengthening cycles until 2016.

This up and down of replacement cycles cannot be explained by any theory of acceleration, but needs to be understood in light of the competing interests and strategies of various actors on the one hand, and variations in the perceived pace of innovation and obsolescence on the other. Whereas the leading manufacturers and retailers constantly tried to shorten replacement cycles, mobile operators fairly successfully worked in the opposite direction for most of the study period, continuously lengthening service contracts to bind existing customers to their network. Only since 2012/3, due to innovations in service contracts, have their interests converged. However, even the orchestrated efforts of leading manufacturers, retailers, and operators at accelerating the replacement of mobile phones had limited success so far, as replacement cycles continued to increase in most recent years.

The consumers' perceived pace of innovation and obsolescence is key for understanding this development. Since the release of the first iPhone, which brought about a dominant design in mobile phone technology (cf. Giachetti and Marchi 2010), many consumers do not see much difference between each new model launched on the market and thus prefer to keep their phones longer (Milanesi and Guenveur 2016), despite falling prices and fast product introduction cycles. Contrary to the idea of consumers having a throwaway mentality and insatiable desire for the new, consumers evaluate phones in different ways and replace their phones only when they consider a replacement to be worth it (cf. Wieser and Tröger submitted). The phone's durability is a dimension that has become more important, reflected in the recent trend towards increasingly waterproof and shock-resistant phones. The period of fastest replacements (2003-2008), by contrast, saw the diffusion of highly popular features like inbuilt cameras and music players. A downside of this trend, however, was an extremely low battery life, limiting the potential longevity of phones. What the case shows, in sum, is that there may be competing interests related to replacement cycles and that no single stakeholder group can determine their length on its own.

Conclusions

The three cases presented in this paper – wheat seeds, automobiles, and mobile phones, show that there is no dominant logic or force underlying historical changes in product durability, lifespans, and replacement cycles. Neither are such changes entirely unpredictable: There are clear patterns where these phenomena go up or down for sustained periods of time. As for the larger literature on acceleration and the sociology of time, however, clearly more empirical work is needed to create a counterbalance to the dominance of abstract theory (see Wajcman 2008). Such research, when conducted in various contexts, could significantly enhance our understanding of replacement cycles.

The observed patterns in replacement cycles further call for an empirically grounded theory that can explain both periods of acceleration and deceleration and connect durable goods replacement decision-making with developments at the aggregate level. Possible candidates are middle-range theories such as social practice theory (as proposed by Jaeger-Erben et al. 2016), actor-network theory, or institutional theories. A case in point is Shove et al.s' (2007) use of a range of theories to understand the dynamics of kitchen renewals. Theories like these further highlight the contributions of various actors beyond consumers and manufacturers, including various intermediaries, but also non-human devices which participate in the performation of temporal order. Moreover, a theory of replacement cycles or product lifetimes would need to take seriously the multiplicity of interests and valuations in a given context, conflicts which are at the roots of variations in replacement cycles.

From the perspective of environmental sustainability, the evidence presented here provides some ground for optimism. Not only does it show that there is no necessary drive towards acceleration, but also that businesses can survive and make profits during sustained periods of shortening replacement cycles. Hence, long replacement cycles and economic imperatives may not be mutually exclusive.

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*Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)*

DOI: 10.3233/978-1-61499-820-4-432

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Interdisciplinary circular economy design education through local and regional partnerships

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Keywords
Circular Economy
Interdisciplinary
Applied Design
Education
Collaboration

Abstract
A review of Educational Sustainable Development (ESD) strategies has found that participatory and collaborative partnerships are the most effective for engaging students with sustainability. To enable students from Higher Education to experience and understand the relevance of the Circular Economy, as opposed to the linear economy, a series of 'real-life' collaborative projects have been created for Design students from Product Design, Fashion Design, Commercial Interior Design and Landscape Architecture, bridging the schools of IT Computing and Business with Art and Design. These 'real life' projects have been created in collaboration with local and regional charities, local Government and companies. The focus of these 'real-life' projects is based upon facets of the Circular Economy, such as 'Design for Longevity', 'Reuse', 'Repair' and 'Recycling', with the intention of engaging staff and students with the Circular Economy within each unit of assessment. This work is evaluated using an educational framework based upon the ESD principles, which is embedded throughout the Applied Design degree programmes, with the aim of creating engaging partnerships to improve the quality and impact of the student learning experience. This paper will describe some of the 'real-life' case studies, focusing upon first year Design degree students, the outcome of these projects will be discussed and reflections made. Fundamentally it is found these collaborative partnerships have the ability to empower students to become active partners in the Circular Economy and the Sustainability agenda.

Introduction

The Circular Economy is recognised in Higher Education (HE) as the alternative to the linear design process. In contrast to the linear economy, the Circular Economy (2017) requires applied design disciplines to think systemically, according to Lovins (2013), and to engage with regional and local communities and businesses. Design students need to consider product longevity, repair, reuse, remanufacture and recovery of waste streams, while considering the impact upon the environment, society and economy. In an international review of national and regional Education for Sustainable Development (ESD) strategies, Tilbury (2011) concluded that participatory and active learning approaches are perceived as being the most appropriate to learning for sustainable development.

The University of Gloucestershire (2017) applied design disciplines, i.e. Product Design, Fashion Design, Commercial Interior Design and Landscape Architecture, have thus created partnerships with local and regional organisations to create 'Live' participatory site-based projects to create an educational framework, shown in Figure 1. This engages undergraduate students with the Circular Economy and ESD principles throughout the whole of their undergraduate programme, (Ryan and Tilbury 2013), (Tilbury and Cooke, 2005) as described by Williams and Ryan (2016). Students exchange discipline specific design skills to respond collaboratively with these organisations to solve real-world sustainable challenges. This longitudinal study initiated in 2015, has evaluated the quality and impact of the student experience through a framework of five components of assessment, reflected in the IUCN publication prepared by Tilbury (2011). These components are: Futures Thinking, Critical and Creative

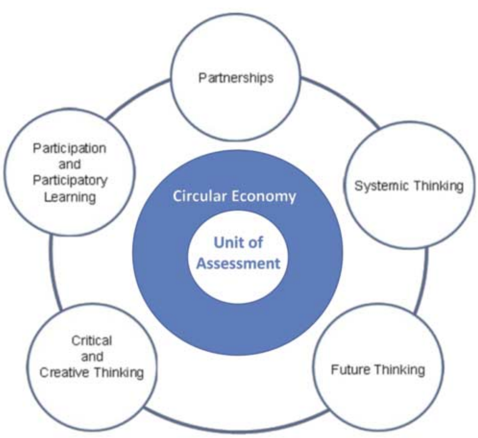

Figure 1. Educational framework.

Thinking, Systemic Thinking with particular focus upon Participation and Participatory learning and Partnerships as described by Williams and Ryan (2016).

Partnerships

The focus of each collaborative project is based upon learning outcomes of the unit of assessment, for each individual design discipline (as shown in Figure 1). Simultaneously each project focuses upon the loops of the Circular Economy through partnerships with local and regional organisations (RCE7 2017). The Circular Economy and it's relationship to the 'live' project is introduced at the beginning of each project, to all design students involved in the collaboration. This paper will focus upon the projects undertaken within the first year of the degree programme only.

Product Longevity

The concept of product longevity, as described by Chapman (2005) and Bakker (2014) was initially introduced during the first collaboration, with Product and Fashion Design students and the clothing company SuperDry (2017), in 2015. The aim of this project was to design a Spring/Summer collection of clothes, bags and shoes, to raise awareness of the waste streams created by 'fast fashion' and to design good quality products for SuperDry.

Design students were assigned to mixed groups and provided with an exchange of discipline specific skills. The unit of assessment for each design discipline was Human Factors and Sustainable and Ethical Design for Product and Fashion students, respectively. The intention was to extend the product life by improving the suitability and usability of clothes, shoes and bags, through an exchange of human factors lectures to all design students. Product Design lecturers taught Human Factors' user centered design tools: personas, scenarios, The Four Pleasures (Jordan, 2002), Maslow's hierarchy of needs and the concept of Emotional attachment by Chapman (2005), and the notion of the 'Classic Long Life model' by Bakker (2014).

Conversely, a range lectures on textile choice, shoe and bag design and manufacturing processes were taught to Product and Fashion Design students by Fashion lecturers, technicians; and designers from SuperDry. This included the durability and emotional attachment to denuim by SuperDry designers. The aim was to employ durable 'fit for purpose' materials, suitable for the intended user groups and their everyday needs.

Initially, observations of SuperDry consumers in two retail outlets, in depth interviews with the retail managers in their flagship store in London and SuperDry designers, were carried out to create personas and scenarios to understand the needs of the users. One group of students identified that SuperDry's main target consumers were 'festival goer's'. Through the development of the scenarios, they chose to design a 'two-in-one' robustly designed bag to comfortably carry heavy clothes and personal goods, to a festival camping place. The smaller bag could be detached to carry expensive personal belongings, to prevent stolen possessions and later used as a personal bag for outdoor or travelling activities. Through the support of a Fashion Technician the Product Design students were able to design and make well-made bags, employing durable fabrics suitable for the function intended. The students also carried out user testing techniques (taught in the Human Factors module) and tested the bag for functionality and suitability.

The advantages of interdisciplinary knowledge exchange and participatory learning through partnerships was evident with this project. Product and Fashion Design students gained in-depth knowledge of SuperDry's consumers, designing, purchasing and manufacturing choices. Product and Fashion students also experienced opposing design processes. Fashion students, for the first time, were required to question who were the users and understand their emotional and physical needs before attempting to design. They unexpectedly found that the purchasers were the parents and grandparents of the users and needed to use more robust textiles to carry the weight of the items identified. Product Design students were able to learn how to make robust working prototypes using textiles, that they tested and refined for durability.

The suitability of the products created for the functionality and usability identified, resulted in solutions that were designed for the customer's needs, rather than solely focusing upon a style or season, resulting in fast fashion.

Reuse and redistribute

The notion of reuse with regard to the Circular Economy, was introduced to first year Product Design students through a '3D Modelling and Computing' unit of assessment in 2015, in collaboration with the British charity 'IT Schools Africa' (2017). IT Schools Africa follow the 'Gap Exploiter Model' described by Bakker (2014). They 'exploit' the 'leftover value and lifespan' of an existing product (Bakker, 2014) by exporting used computers, donated from schools and companies throughout the United Kingdom, and set up IT classrooms throughout Africa. The aim of this project was to raise awareness of the circular, added value, of reusing a product. Product Design students were required to design an IT classroom in Malawi, using local materials, to enable the school children to reuse used donated computers. The classroom design solutions were required to accommodate older larger sized computers through the use of 'Solidworks' (a 3D parametric computational software) that they were being taught for this unit of assessment.

Interviews were undertaken of the secondary school children, teachers and Head of School from three schools in Malawi, a local school in Cheltenham, and the employees of IT Schools Africa. This was to establish the environmental and spatial requirements of the larger secondhand computers and their users

Product Design students benefited from engagement with 'IT Schools Africa', who participated in fortnightly meetings with the Product Design students, providing them with pragmatic feedback upon their computational concept development. Reuse, as not a difficult concept for students to understand with the advent of 'Ebay' (2017). Through visits to IT Schools Africa, the students learnt about the social and economic benefits of being a 'gap exploiter' (Bakker, 2014), as well as learning about the processes required to reuse second hand computers. They simultaneously learnt how to design ergonomic classroom furniture and layout for different cultural expectations using newly acquired 3D computational skills. The students were able to meet out of work volunteers who benefited from gaining work experience with the charity. They were also able to question how the computers were transported throughout Africa and learn about the benefit of the secondary school students being taught IT skills to support them in gaining professional employment. The Design students also learnt that African schools were required to make a donation for the computers to recognise their worth and thus be treated with the care.

This research is now concerned with bridging the gap between repair and Hackerspaces (2017), as discussed by Charter and Keiller (2014). To create solutions for the end-of-life electronics, for the flow of materials and components to become circular.

Repair and maintain

The notion of repair was introduced through a monthly 'Regeneration' Repair Café based in the local community, launched in May 2016, as described by Repair Café (2017) and Parker et al (2016). This collaboration of Product Design students with the Local Council Waste Team (2017), and a local sustainable charity Vision 21 (2017), is described by Williams and Ryan (2016). This was based upon the unit of assessment 'Materials and Manufacturing' for first year Product Design students and 'Design for Sustainability' for second year Product Design students. During the launch of this project students carried out qualitative primary research of the community's attitudes and behaviours towards repair, and learnt how to deconstruct, repair and re-assemble goods with the community's products, alongside qualified volunteer engineers and electricians, (Rosner, 2012), (Salvia, 2015), (Scott and Weaver, 2014). Final year Graphics students created the Regeneration branding, as shown in Figure 2, and an upcycling exhibition of denim jeans was created by first year Fashion Design students for their Ethical and Sustainable Design unit of assessment.

Figure 2 Branding created by final year graphics students

Product Design students benefited from gaining knowledge of a vast array of products spanning approximately 50 years of design, which were brought into to the Repair Café. They gained first-hand experience of the emotional attachment of people to their products (shown on BBC Hugh's War on Waste 2016), together with the typical faults of components and materials. They were also required, as part of their 'Materials and Manufacture' unit of assessment, to choose one product from the Repair Café, record and evaluate the ease of disassembly/assembly, the materials and manufacturing methods, establish the fault and redesign to overcome the fault.

The Product Design students over the past two academic years, through anecdotal feedback, have commented that they did not initially believe that repair would be interesting, until they participated in the Repair Café. The Fashion students felt empowered to 'make a difference' through the experience of being involved with the local community. The Product Design student involvement in the Repair Café is now annually employed as part of the 'Materials and Manufacturing' unit of assessment and is an evolving project based in partnership with the Gloucestershire County Council Waste Team, Vision 21 and the community.

Recycling

Waste streams from the textile industry have recently been addressed to support the 'I love my Clothes' WRAP campaign (2017). This recent partnership included the local Gloucestershire County Council Waste Team, Bristol Textile Recyclers (2017) and first year Fashion, Product and Interior Design students. The project has focused upon the notion of creating future scenarios for clothes, luminaires and furniture, using reclaimed textiles from the regional Bristol Textile Recycling Centre (2017). The Interior and Product Design students focused upon the design of 'a space within a space', luminaire and seating for the local Cheltenham Minster (2017) and the Wilson International Art Gallery (2017), as part of a product design Human Factors unit of assessment. Whereas, the Fashion Design students responded as part of their Ethical and Sustainable Design module. The expectation for each discipline's assignment was to creatively include the use of textile waste streams within their design solutions. The best designs of the three disciplines were given the opportunity to exhibit these designs as part of the launch of a newly established sustainable forum for textiles 'Thread Counts' on the 22nd April 2017: A fashion and textiles forum for sustainable and creative futures. Aiming to increase awareness of slow ethical textiles and sustainable fashion, while promoting it to a wider public audience regionally and contribute to developing a pedagogic framework for e-learning, research as practice and impact specifically around ESD (supported by LIFT, 2017). A new 'Makerspace' (2017) was also introduced to the community during this week-long exhibition, to teach how to repurpose textiles.

The textile 'recycling' project did not involve the 'making' support from the fashion department to teach the Product Design students the skills required to make their products, due to time constraints, even though textile machinery was available. The Product Design students, majority being incidentally male, did not have the experience to make well finished textile products, but alternatively engaged through hand sewing. Some male students also experienced difficulty in creating solutions using textiles without the support of Fashion Design. However, the outcome for the Thread Counts exhibition was extremely creative, with luminaires that were made from various sized jumpers named 'a hug from above' and a modular chair design that was aptly threaded together.

Renewable energy

Renewable energy has been introduced through the collaboration of Commercial Interior, Product Design and Landscape Architecture students, University gallery curator and the Estates department. Through the exchange of discipline specific knowledge of solar gain, energy efficiency, as well as bio philia and rainwater harvesting to create designs for the University art gallery and surroundings.

Results

This longitudinal study has evaluated the quality and impact of each student's experience at the beginning and the end of each academic year, through the five units of ESD assessment, as described by Tilbury (2011). Feedback from the students reported positive feelings of empowerment due to the tools and 'real life' experiences they gained, feeling that they are 'making a positive change for the future'. Sustainability has become a natural part of their approach to design problems.

Some students experienced difficulties in group working due to a minority of students not participating equally, which is generally common in group projects. However, this is outweighed by the first-hand experience the students have gained of the Circular Economy. The confidence and knowledge gained through these collaborations has enabled students in subsequent years of study to independently engage with external local organisations e.g. 'When in Rome' (2017) (a local wine import company) and the Director of Hewlett-Packard (2017) to carryout Life Cycle Analysis and further learn about the Circular Economy, in the second year of their degree.

The Product Design students that collaborated in the SuperDry project in 2015, have further successfully employed the interdisciplinary knowledge and skills learnt, in subsequent projects using textiles.

Conclusions

The launch of the now established monthly Regeneration' Repair Café (2017) has become a successful strategy for teaching Design students about the restoration of products and more recently Film media students to regularly engage with the local community and learn about repair and reuse.

The comparison of the projects over the last two years has shown that lecturers and technicians must support the teaching of interdisciplinary skills and knowledge exchange. This is required to enable the students to experience the advantage of these collaborative projects.

The timely organisation and agreement of the aims and objectives of the project are paramount to prevent student dissatisfaction. Timetabling differences, bridging two different schools of IT Computing & Business and Art & Design has been challenging. This has been overcome with collaborative making-workshops and exchange of lecture time.

These interdisciplinary industry-relevant experiences have contributed to the students' professional portfolio and skills which have been recognised as a UNU Flagship Project, Finalist in 2016 Green Gown Awards (2017) and 'Highly Commended' in the Furniture Reuse Award, UK.

The prime aim of this framework has shown that design disciplines can collaboratively explore sustainable practices, with particular reference to the Circular Economy, through the engagement of embedded pedagogical principles of Education for Sustainable Development, in regard to individual unit of assessments. Where students are active partners in the sustainable agenda.

Acknowledgments

We would like to acknowledge the support and encouragement of the Director Sustainability, Dr Alex Ryan, David Entwistle from Vision 21 and Kate Cole of Gloucestershire County Council. Also the first PLATE conference for the inspiration to launch the Regeneration Café to inspire young people and women, in particular, to Repair and engage with sustainable agenda. Finally, to all the University of Gloucestershire Product Design, Fashion Design, Commercial Interior Design and Landscape Architecture staff and students for their great enthusiasm and support.

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*Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)*

DOI: 10.3233/978-1-61499-820-4-437

Impact on resource intensity from consumer disposition: Relationship with product lifetime and disposal

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Keywords
Product lifetime
Consumer disposition
Survival analysis
Resource intensity

Sustainable resource use is a key challenge for our global society, and consumers are certainly responsible for making our resource use more efficient, e.g. by longer use of products and handing their End-of-Life products (EoLs) in to appropriate recyclers. Product lifetime can be one essential sustainable consumption intensity indicator to measure how much value the consumer extracts from a product. We have investigated the relationship between lifetime of electrical and electronic equipment (EEE) as well as EoLs destinations and consumer dispositions through a quantitative survey questionnaire amongst consumers in Japan. We identified three dispositions; well-organized, trend-conscious and community participation. All of these dispositions had non-negligible influences on both lifetime and EoLs destinations. The consumer groups with bigger potentials to improve resource intensity in terms of lifetime and of EoLs destinations were different. Policy makers can set two different policies to two different groups, and both policies will have positive impacts independently.

Introduction

Global resource demand has experienced a sharp increase triggered by emerging economies. This makes our concerns more serious; starting from the availabilities to the associated environmental impacts. Sustainable resource use has now become one of the greatest challenges in the world (OECD, 2016; G7, 2015). National and regional governments have implemented various policies to make their resource use more sustainable. (EC, 2015, MoE, 2017). Academic communities have huge potential to contribute in various contexts. One potential area of contribution is quantifying the material flows and stocks of our whole society, including the entire life cycle, not only production but also the use and disposal. Considering the whole life cycle is important when we discuss sustainable consumption and production. Material Flow/Stock Analysis (MFA/MSA) can help us to understand the current state of the flows and stocks and also pave a way for a more sustainable, resource-decoupled system. Here, product lifetime plays a crucial role for being the key parameter of the estimation of flows and in-use stocks of End-of-Life products (EoLs) (Glöser et al., 2013). Using a product longer means extracting more value from the same product. In this context, product lifetime can also be a sustainable consumption indicator to know the resource intensity on the consumer side by measuring how much value is obtained (Murakami et al., 2010). It is also important to note that consumers can reduce the resource intensity by handing their EoLs to the appropriate stakeholders, who can recycle the EoLs most efficiently. Therefore, the length of product use, product lifetime, and disposal behaviour, especially the EoLs destination, are two main issues we discuss in this paper.

Many researchers have recently worked on product lifetime estimation and extension. There is a large body of work trying to improve the estimation of probabilistic lifetime distribution in detail with quantitative methods (Oguchi et al., 2006, Murakami et al., 2017). There are also some studies on lifetime extension; detecting the factors that influence the lifetime, not only the products' characteristics such as durability, but also the users' properties (need, attachment), in order to suggest possible measures for lifetime extension (Cooper, 2005, Cox et al., 2013). But the latter studies are mostly qualitative and the influence on lifetime through the user's intrinsic dispositions have not been quantitatively investigated, which is a common approach in case of waste disposal behaviour (Bortoleto et al., 2012).

The goal of our research is to identify the group of consumers who have more potential to reduce resource intensity through longer product use and/or the choice of EoLs destinations. Therefore, our purpose is to develop a method and show the potential use of it. More concretely, we quantify the influence of consumer intrinsic dispositions on product lifetime and EoLs destinations based on quantitative analysis through a survey questionnaire. Then, we identify the critical dispositions of consumers to make suggestions for further policies and researches on sustainable resource use.

Method

Definition of product lifetime varies depending on the purpose of its use, as categorized in Murakami et al., (2010). Domestic service lifespan or possession span should be used in case of estimating the outflows in the form of EoLs, whereas duration of use is more suitable for estimating the in-use stock, not including hibernations.

Our research is comprised of four steps. The first step is a survey questionnaire to acquire information on the product lifetimes and the consumers' dispositions. Next, we conducted factor analysis to identify specific dispositions. Then, the influences of dispositions as well as demographics on product lifetimes were investigated with survival analysis. We also explored the dispositions' effects on EoLs destinations by taking a chi-square test. Finally, we classified consumers using the dispositions and demographics with k-means clustering to identify potential consumer groups for sustainable resource use.

Questionnaire survey

An online survey questionnaire was conducted in Japan with the sample size of 2,303 following Japanese census (gender, age and geographic region). The questionnaire consists of two sections. The first section asks possession span and EoLs destinations. We chose seven electrical and electronic equipment (EEE) groups (Table 1). The respondents were asked about the possession spans and EoLs destinations of their currently and previously owned items (maximum three items per product group per respondent) purchased from 2001 to 2012. Our main focus was on disposal behaviour and possession. Then, in this research, we chose possession span instead of the duration of use as the product lifetime indicator.

The second section attempts to reveal consumer dispositions. De Young (1986) identified that the four satisfaction scales; Self-Sufficiency, Participation, Luxuries and Frugality, have a significant influence on the satisfaction gained through recycling/reusing behaviours. We chose Participation, Luxuries and Frugality from De Young's work and added Well-organized as the satisfaction scales which influence the product lifetime. We prepared 14 behaviours (shown in Table 2) totally independent from use or disposal behaviours and asked the degree of satisfaction through those behaviours in a seven-point scale. Through applying factor analysis to the result, we obtained the satisfactory scales that each should reflect the consumers' dispositions.

Product (The words in "" are used as abbreviations for those product groups)
Cellphone (including smartphone) and tablet "Cellphone"
Digital camera and DVD player "Digital camera"
Printer and deferment type game console "Printer"
Telephone, FAX, portable music player and portable game console "Portable music player"
PC
TV
Air conditioner

Table 1. Product groups in focus

Factor analysis

The number of factors was determined through parallel analysis, and the Cronbach alpha was used to ensure the confidence of each factor. The solution was obtained with maximum likelihood and oblimin rotation. Here we are able to acquire factor scores which indicate the degree of disposition for each respondent with negative value representing weak disposition and positive value representing strong disposition. All procedures were conducted using statistical application R and its package "psych" (Brostrom, 2016).

Survival analysis

Proportional hazard model and Weibull baseline hazard function were utilized as (Fernandez, (2001). The hazard function can be denoted as Equation (1), where t represents lifetime, x represents the explanatory variables (numeric variables are standardized), λ represents the shape parameter and η represents the scale parameter. The

$$h(t,x,\lambda,\eta) = \frac{\lambda t^{\lambda-1}}{exp(\lambda\eta)} exp\left(\sum \beta x\right) \qquad (1)$$

solution was obtained with by maximizing partial log-likelihood and coefficients β was tested by Wald method with 5% significance level. And Tthe final regression model for estimation was obtained by subtracting insignificant variables from the initial regression model with containing all variables until all remaining variables shows were significance. All procedures were conducted using R and its package "eha" (Revelle, 2016).

k-means clustering

Respondents were classified into three groups (showing high, moderate, or low degree of disposition respectively) for each factor score. All procedures were conducted using R and its package "cluster" (Maechler et al., 2016).

Chi-square test

The differences in proportion to the EoLs destinations between the groups obtained with k-means clustering were examined with chi-square independence test with 5% significance level, using R.

Result

Consumer dispositions

According to parallel analysis, we adopted three factors shown in Table 2. *Well-organized* represents how much satisfaction the consumer can gain by behaving in a well-organized way. *Trend-conscious* represents the degree of satisfaction obtained by following the trends. And *community participation* represents how much satisfaction community participation can give to the consumer. Compared with the satisfaction scales, Luxuries completely corresponds to *trend-conscious* and Participation to *community participation*, which were identified as expected. Originally, we expected dispositions of Well-organized and Frugality to be independent, but our analysis suggested that the two should be integrated into one under the name *well-organized.*

Product lifetime and consumer dispositions

Estimated coefficients for explanatory variables in equation (1) are shown in Table 3. Positive value of coefficient means a negative impact on lifetime, that is, the lifetime of the product will be shorter as the degree of variable increases. As shown in the table, except for digital camera, printer and air conditioner, lifetimes have meaningful relations with at least one of the dispositions. To discuss this in more detail, *well-organized* generally has a positive effect on lifetime whereas *trend-conscious* has a negative effect. When we look at *community participation*, its effect varies among different product groups. For example, it has a positive effect in case of cell phones but turns out to have a negative effect in case of PCs. This difference in impact is consistent with the result of Cox et al. (2013), which indicated that products with different categories have different reasons and process for being obsolete and therefore implies some differences in the impact of consumer dispositions. Looking at the demographics, age has positive impact on lifetime for all products except printers. Other demographics such as gender or marriage also have impacts on the lifetimes of some products, especially cell phones. Comparing the value of the coefficients which have sufficient significance level, we may reasonably conclude that the effect of dispositions on the lifetimes are non-negligible.

Behaviors	Factor 1	Factor 2	Factor 3
Factor 1: *Well-organized*			
Make plans for a trip	0,71	-0,08	0,16
Arrive early for a meeting	0,67	0,01	0,01
Clean the desk	0,67	-0,04	-0,03
Use products as long as possible	0,61	0,11	-0,02
Save water and electricity	0,49	0,29	-0,05
Avoid trains/buses to save money	0,43	0,08	0,11
Keep a household account	0,32	0,09	0,26
Factor 2: *Trend-conscious*			
Go to a first restaurant in Japan	-0,06	0,73	0,14
Put on the latest clothes	-0,06	0,72	0,07
Buy a popular new product	0,08	0,71	-0,06
Go to a new neighborhood restaurant	0,27	0,57	-0,04
Factor 3: *Community Participation*			
Join in a cleaning activity	0,05	-0,07	0,86
Participate in regional	-0,06	0,14	0,77
Chat with your neighbors	0,14	0,09	0,6
Variance explained (%)	0,172	0,145	0,13
Cronbach alpha	0,83	0,805	0,809
			RMSEA=0.067

Table 2. Factor loadings for dispositions.

Figure 1 shows the estimated lifetime distribution of cell phones from the regression model; *trend-conscious, community participation*, gender, age, household income (high income) and personal income (high income) are considered as explanatory variables. The black curves in the graphs show the fitted curves for lifetime distribution of cell phones from the regression model for each group without any explanatory variables, whereas the red curves show the ones with representative values of each group for all variables. We can clearly see that the regression model shows a good fit to the black stepwise lines which is obtained with Kaplan-Meier method of survival analysis, indicating that the regression model is good enough to predict the actual lifetime.

EoLs destinations and consumer dispositions

The EoLs destinations also showed significant relationship with every disposition for at least one product group (Table 4), which corresponds to the result of De Young (1986). In detail, those who have more satisfaction in well-organized and also those who gets more satisfaction from community participation have a smaller proportion of hibernating products (products that are still in possession but no longer used, i.e. disuse). Those who are more trend-conscious tend to have less hibernating products but sell more products as second hand.

Consumers with bigger potential to improve their resource intensity

Here we chose cell phones for our in-depth case study, because of its rapid penetration around the world as well as its high content of valuable resources. Respondents were divided into several groups by their degree of *trend-consciousness*, gender, and age so that we can identify consumer groups with bigger potential to improve resource intensity; more frequent replacement and more hibernating EoLs. Values in Table 5 are the inverse of average lifetime for each group, which indicates the frequency of product replacement as an indicator of efficient resource use. The higher value of replacement means less efficient resource use. Table 6 shows the proportion of hibernating (i.e. disused) cell phones for each group. Males in their 20s and 30s as well as females in their 20s all have higher degrees of trend-conscious and tend to have shorter lifetime and thus less efficiency.

Regressor		Cellphone	Digital camera	Printer	Portable music player	PC	TV	Air conditioner
Well-Organized		0,1	-0,283	-0,12	-0.503**	-0,116	-0.254*	-0,079
Trend-conscious		0.336**	0,089	-0,064	0.402*	-0,154	0,225	0,088
Community participation		-0.293**	0,274	0,215	0.396*	0.378**	0,199	0,097
Gender	Male	0.331**	0.9**	0,118	0,32	-0,183	0,168	0,058
Age		-0.261**	-0.434**	0,053	-0.362*	-0.376**	-0.587**	-0.564**
Marriage	Not married	-0.292*	-0,484	-0,133	-0,208	0	-0,04	-0,054
Children	No child	0.322*	0,06	0,056	0,017	0,172	-0,253	-0,022
Household	Low (<4Myen/y)	-0,22	-0,055	-0,441	-0,487	0,038	-0,144	0,017
income	High (>10Myen/y)	0.354*	-0,207	0.899**	-0,31	0,301	0,088	0,383
Personal	Low (<4Myen/y)	0,032	0,028	0,26	-0,458	-0,185	-0,184	0,081
income	High (>10Myen/y)	-1.033**	-29,7	-0,441	-1,117	-1.157*	-1,595	-0,842
log(scale)		2.959**	4.064**	3.08**	3.596**	3.074**	3.029**	4.178**
log(shape)		0.257**	0.307**	0.495**	0.219*	0.474**	0.722**	0.191*

** Statistically significant for 1% level, * Statistically significant for 5% level

Table 3. Coefficients of variables in proportional hazard model.

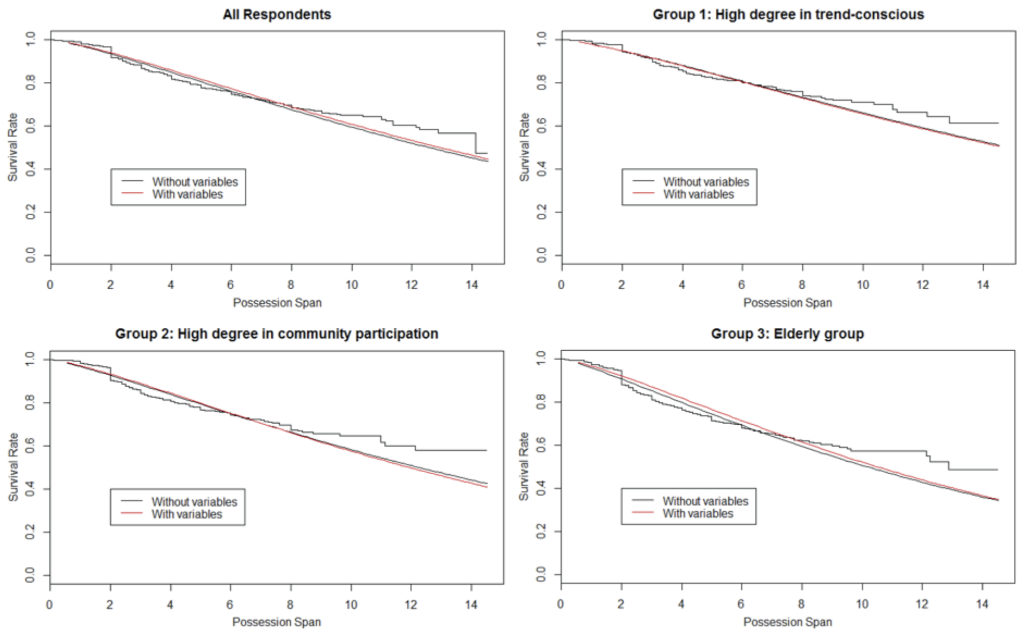

Figure 1. Lifetime distribution of cell phones with different consumer groups.

Product groups	Destinations	Well-organized High	Moderate	Low	Trend-conscious High	Moderate	Low	Community participation High	Moderate	Low
Cellphone	Combustible	1,9%	1,9%	0,8% **	1,3%	1,0%	1,4% **	1,8%	2,2%	0,8% **
	Other MSW, SWEEE	8,4%	10,2%	7,1%	7,8%	7,5%	8,5%	9,5%	6,0%	8,2%
	Hibernation	63,4%	65,2%	68,4%	64,6%	65,2%	67,7%	63,1%	67,7%	67,4%
	Retailer	17,2%	15,5%	16,6%	15,9%	19,4%	16,0%	17,0%	17,2%	16,1%
	Secondhand	9,1%	7,2%	7,1%	10,4%	6,9%	6,4%	8,6%	6,9%	7,4%
Digital camera	Combustible	0,9%	2,4%	1,5%	1,1%	1,1%	1,8%	0,6%	1,4%	2,0%
	Other MSW, SWEEE	18,0%	19,6%	21,1%	20,3%	17,1%	20,5%	22,0%	17,2%	19,7%
	Hibernation	61,1%	55,8%	58,1%	60,2%	59,3%	57,0%	57,6%	59,9%	58,2%
	Retailer	12,2%	14,4%	13,2%	11,4%	13,7%	14,1%	13,0%	14,0%	13,1%
	Secondhand	7,8%	7,8%	6,2%	7,0%	8,7%	6,5%	6,8%	7,5%	7,0%
Printer	Combustible	0,6%	1,4%	1,7% *	1,5%	2,2%	1,0%	1,1%	1,3%	1,5% **
	Other MSW, SWEEE	33,7%	27,9%	33,8%	33,9%	34,6%	30,9%	37,4%	28,3%	31,1%
	Hibernation	38,2%	45,8%	35,8%	36,2%	37,4%	40,4%	33,0%	46,0%	39,3%
	Retailer	20,9%	17,9%	22,5%	20,8%	20,9%	21,3%	21,6%	17,1%	22,1%
	Secondhand	6,7%	6,9%	6,1%	7,5%	4,9%	6,3%	6,8%	7,2%	6,0%
Portable music player	Combustible	2,5%	3,0%	2,4% *	3,1%	2,1%	2,4%	2,5%	2,7%	2,5% **
	Other MSW, SWEEE	39,4%	33,9%	40,1%	38,6%	38,2%	38,6%	43,1%	38,4%	36,2%
	Hibernation	35,7%	43,1%	36,7%	34,1%	40,3%	39,3%	29,8%	44,0%	40,4%
	Retailer	17,0%	17,5%	17,8%	19,1%	16,2%	17,0%	19,9%	9,3%	18,6%
	Secondhand	5,4%	2,4%	3,1%	5,2%	3,1%	2,8%	4,8%	5,6%	2,3%

MSW: Municipal Solid Waste, SWEEE: Small Waste Electrical and Electronic Equipment
** Statistically significant for 1% level, * Statistically significant for 5% level

Table 4. Difference in destinations between different consumer groups

Females in their 20s with a moderate degree of trend-consciousness and those in their 30s with low degree of trend-consciousness, tend to have more hibernating (i.e. disused) phones. These Consumer groups have large potential in the context of frequency of replacement and of hibernation, both of which can be important targets for policy-makers.

Discussion

We investigated the relationship between product lifetimes and consumer dispositions. High degree in the factor *'well-organized'* will increase lifetime and decrease hibernation 9i.e. disuse). Those who prefer to be more well-organized use their product more carefully and longer, and they also find it less bothersome to take EoLs to their designated places therefore they do not leave them at home. On the other hand, consumers who are more *trend-conscious* have shorter lifetime for their belongings, less hibernating (i.e. disused) products but more sales to secondhand. This may be because those who are more trend-conscious are willing to get the more up-to-date products, which leads to faster obsolescence of their products before mechanical failure without much reduction in values. Age also has positive impact on lifetime. One possible explanation

		Trend-conscious		
		High	Moderate	Low
20s	Female	0,122	0,093	0,074
	Male	0,147	0,115	0,087
30s	Female	0,108	0,085	0,074
	Male	0,132	0,1	0,081
40s	Female	0,102	0,076	0,061
	Male	0,12	0,094	0,072
50s	Female	0,108	0,071	0,052
	Male	0,101	0,08	0,064
Over60	Female	0,07	0,055	0,043
	Male	0,083	0,067	0,048

Table 5. Frequency of replacement.

		Trend-conscious		
		High	Moderate	Low
20s	Female	65,2%	86,5%	67,4%
	Male	55,6%	61,0%	63,0%
30s	Female	65,0%	61,3%	88,2%
	Male	60,7%	60,8%	63,8%
40s	Female	69,1%	63,9%	70,5%
	Male	58,7%	72,7%	68,3%
50s	Female	67,0%	68,0%	55,2%
	Male	54,9%	72,9%	65,1%
Over60	Female	65,0%	71,6%	60,0%
	Male	71,7%	63,1%	60,5%

Table 6. Proportion of hibernation.

can be the size of the housing. That is, elderly people live in a larger house, which allows them to keep their EoLs hibernating (i.e. in disuse) for a longer period of time.

One important finding from our research is that consumer dispositions have distinct relationships with lifetimes but also at the same time have a difference in influence between different products. We need to conduct more case studies for different products to compile more information.

We found out that consumer dispositions which were already revealed to have relationship with EoLs destinations also have relationship with product lifetime. Understanding dispositions is now more meaningful to make our resource use more sustainable from consumer-side.

Since quantitative results can provide more support when setting the policies and estimate their quantitative effects, our approach is really useful, both to identify the possible and effective targets of certain policies and to measure how well the policies have impacts on the society. For example, females in their 20s tends to replace their cell phones more frequently and have more hibernating (i.e. disused) phones. However, our analysis with disposition revealed that highly trend-conscious females in their 20s replace more but do not necessarily have more hibernating (i.e. disused) phones. In fact, moderately trend-conscious females in their 20s tends to have significantly higher rates of hibernating (i.e. disused) cell phones. This means that making trend-conscious females in their 20s aware that hibernation is not a sustainable consumption patterns is less meaningful than targeting other females in their 20s. Increasing consumers' awareness level is always important to motivate them to behave more sustainable. And in increasing awareness level, identifying the target is important. For this example, we need to make all females in their 20s aware that frequent replacement is not sustainable, but less need to raise awareness on hibernation for a part of them.

Conclusions

Sustainable resource use is a key challenge for our global society. It is necessary to realize that not only producers and policy makers but the consumers bear responsibility. They have even greater roles in the challenge since the change in consumption pattern can have strong impact throughout the whole value chains and therefore the entire material cycles. Product lifetime can be one critical indicator to assess the extent to which a consumer is advancing toward sustainable consumption pattern. We clarified that consumers with different dispositions behave differently; product lifetime and/or the EoLs destination is different. The proposed approach enables us to cluster consumer groups and show appropriate approaches to make each group's resource use better.

Acknowledgments

This research was partially supported by the Environment Research and Technology Development Fund (3K153009) of the Ministry of the Environment, Japan.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-442

Taking good care: investigating consumer attitudes to product maintenance

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Keywords
Maintenance
Care practices
Product
Consumer

Abstract
Building on the work undertaken in the 'Caring Project' (Gwilt, Leaver, Fisher, Young. 2015), this secondary inquiry seeks to ascertain specific aspects of maintenance practices that are employed by users and to understand the drivers behind some of the key decisions taken when maintaining products. Through an empirical study that involved gathering data using methods including a survey, observations and cultural probes, the findings reveal some of the motivations behind the choices of those who self-maintain and those who choose to have that work carried out by a service provider. Moreover some insight into the prompts that trigger why users instigate product maintenance, and the equipment selected and used in the maintenance of common objects are also discussed. These initial insights support the potential for a larger study with the ultimate aim of influencing designers and manufacturers in the development of longer lasting products.

Introduction

It is widely accepted that extending the lifespan of consumer products is desirable and can make a significant contribution towards slower consumption, therefore reducing the impact of consumerism on the environment (Cooper, 2005). Amongst many strategies and approaches that can be used to extend the life of products, there is recognition that many types of product require regular maintenance to keep them functioning at their optimum performance and to prolong their useful life. In some cases, this maintenance is intended to prevent catastrophic failure, such as in aircraft or motor vehicles, and strict maintenance schedules exist with regulations to ensure that these are adhered to. In other cases regular maintenance can extend the time by which a product is seen as desirable. There are also many examples of products that would benefit from regular maintenance to maintain optimum performance characteristics and to extend the product lifespan, but where the imperative associated with potential catastrophic failure does not exist.

The European Union has taken steps towards providing a regulatory framework in the Ecodesign Directive that currently requires manufacturers to supply information for consumers on how to maintain a product in order to maximise its lifespan and to minimise its impact on the environment. It also requires that manufacturers consider maintenance and the availability of spare parts at the design stage (European Parliament. 2009). Providing consumers with guidance and considering maintenance during the design stage of a product can go someway towards sharing the responsibility of optimal product lifespan as it is accepted that the lifespan of a product is affected by the day-to-day treatment that it receives (Cox, Griffith, Giorgi, & King, 2013). For this to be effective in extending product lifespan it is important to understand users attitudes towards maintenance; the drivers and barriers that may exist; as this could aid the design of products, systems and information that encourage correct maintenance practice.

The 'Taking good care' project

Insights gained from a previous study (Gwilt, Leaver, Fisher & Young, 2015) indicate that there is much to understand about the drivers and barriers that influence consumers' motivation to carry out maintenance on the products that they own or use. It was also clear that there are a diverse range of products that benefit from regular maintenance to ensure optimal performance and durability. In light of the gap in knowledge concerning the maintenance practices of users the 'Taking Good Care of Things' project was developed to reveal insights that can support designers, manufacturers and consumers to engage in practices that promote extended product lifespan. This work in progress contributes to a growing body of work and is intended to inform further studies.

Methods

For this preliminary study, qualitative and quantitative methods were employed with the aim of revealing insights into the maintenance practices of users, the motivations to conduct maintenance and the tools or services employed to that end.

In order to understand the breadth of opportunity for study that this area represents, in this first phase of the work cultural probes (Gaver, Dunne & Pacenti. 1999), in the form of a 'field kit', were distributed to a small group of users who were identified through established networks and were known to own one of a diverse range of products that may benefit some form of maintenance. The cultural probe field kits contained a single use camera, blank postcards, graph paper to produce a map and a notebook to act as a journal or diary. On each item in the kit was a short written prompt asking the recipient to record specific aspects of their maintenance activity. Five kits were distributed to users who, between them, owned a vintage sewing machine (participant 1), a mountain bicycle (participant 2), a banjo (participant 3), a collection of road bicycles (participant 4) and horse riding equipment (participant 5). The information returned in the completed kits contained materials that point to a rich source of opportunities for further research and in this case informed the next phase of this study.

In the second phase the information gathered from the cultural probes were analysed and a set of questions emerged to form the basis of a survey. This consisted of a self-completion, online survey that posed a series of initial questions, which led respondents on to further appropriate related questions. 42 male and female respondents who represented a range of adult age groups completed the survey. The survey was designed to discover the reasons why some users undertake maintenance themselves and some choose to have all or some of this undertaken by others. Furthermore, it set out to discover if there was a difference in the prompts that trigger the maintenance activity between these two groups. Finally, the survey asked questions about the tools and other equipment use during the maintenance procedures.

Findings

Cultural Probe

Participants returned the cultural probe field kits after a week of use. Whilst the probes are not intended to be formally analysed and are to be considered as a means of providing initial insight and direction for this study (Gaver, et al. 1999) there are some key themes that emerged from the material gathered during this exercise.

Maintenance as an extension of the activity associated with the product was a common theme linking all of the participants as regular maintenance directly preceded or followed use in all cases. Participant 2, The mountain biker, is a good example of this; he thoroughly cleaned and lubricated his bike after every off-road ride. Equally, the horse rider cleaned and oiled the riding equipment after every outing. Alongside this regular maintenance that is directly linked to the use of the product, most participants reported additional occasions when longer, more thorough maintenance sessions took place that were not linked to immediate use. Participant 1's vintage sewing machine was maintained 2 or 3 times a week when in use, then was thoroughly cleaned twice a month.

All participants reported and produced maps that described specific dedicated locations where the care and maintenance was carried out and identified that tools and equipment necessary for the task were stored nearby. In most cases a combination of specialist tools and equipment were used alongside general tools and appropriated household materials. In some cases users had manufactured their own specialist tools or equipment to suit their own circumstances.

All participants reported that they used a variety of sources to inform their maintenance practice. These included instructions that were supplied with the product; maintenance and repair manuals bought separately, websites, online video content and knowledge handed down from friends or relatives.

Survey

In analysing the data gathered through the online survey respondents had to declare and describe the maintenance practices regularly employed when caring for a product in regular use. The majority of respondents identified an item on which the remainder of the questions were then based. Initially 2 respondents felt that there was nothing that they could reflect on, which required regular maintenance, but when informed that maintenance could include making adjustments, cleaning and caring for materials, they identified a product that they owned or used.

Who maintains and why?

Of the 42 respondents, 48% stated that they completed all of the maintenance themselves, 40% employ a combination approach where they personally undertake some maintenance work but selected tasks are deployed to others, and 12% have all of the maintenance carried out by someone else. The different motivations underlying the choices of how to have maintenance undertaken were then explored.

When asked 'Why do you choose to do all or some of the maintenance yourself', respondents were prompted to choose multiple answers from a number of options. Of those who stated that they undertake all of the maintenance, 70% agreed that the reason for this was that they enjoyed the activity, 60% agreed that it was to ensure that the work was completed to their 'high standards', and 50% agreed that they did this to save money. By contrast, the respondents who stated that they undertake some of the maintenance, but have some carried out by others identified with a different set of key motivations. 53% agreed that they chose to do some of the work themselves as it needed doing often and 41% agreed they did it to save money.

Those who initially identified that they choose to have all or some of the maintenance carried out by someone else (22 of the 42 respondents) were given a number of options to choose from to describe why this was the case. 82% agreed with the statement: 'The work requires specialist knowledge that I don't have." and 45% with "The work requires specialist facilities that I don't have."

Prompts and triggers

After beginning to identify the reasons for conducting maintenance it follows that there is merit in understanding the triggers that prompt users to initiate maintenance procedures. The two groups: those who do all and those who do some or none, were asked, "What prompts you to carry out the maintenance?". Of those who indicated that they undertook all of the maintenance, 60% agreed that this formed part of a regular routine, 40% agreed that there was an indication from the product and 30% that they followed guidelines that were supplied with the product. The group who identified that they have all or some of the maintenance carried out for them chose the same top three statements, but assigned a different value to them. 77% of this group agreed that it was an indication from the product, 32% agreed that they were following guidelines and only 18% agreed that this was part of a regular routine.

Motivations for maintenance

In order to explore the motivations experienced by users to ensure that the products owned and used are well maintained, all respondents were asked to rate a series of five statements in terms of how relevant they were to them. Users could select a rating from 0 to 10, with 10 being identified as most relevant and 0 as not relevant at all. The average score for each statement was then calculated to give an indication of the perceived relevance of the statements.

Of these statements, three achieved average scores above 8, the highest scoring statements were:

"I carry out the maintenance to make my product last a long time", (average score 8.74) with 50% of all respondents rating this as 10, most relevant.

"I carry out the maintenance to ensure safe operation", (average score 8.67) with 52% of respondents rating this as 10, most relevant.

"I carry out the maintenance to keep my product performing at its best", (average score 8.4) with 38% respondents rating this as 10, most relevant.

The further two statements:

"I carry out the maintenance to keep my product looking good" and *"I carry out the maintenance to ensure my product keeps its value*", scored 6.17 and 6.38 respectively.

Knowledge and equipment

The cultural probes that formed the initial exploratory stage of this investigation indicated that a variety of sources were used to learn how to maintain products. They also indicated that users kept a range of specialist and more general tools and products with which to carry out the tasks.

All respondents were asked, "How did you learn to do this maintenance?" and they could choose as many of the possible answers as were relevant. Results were relatively evenly spread across this category, with the most popular response being a manual supplied with the product as their main source of information, 40% chose this option, followed by being taught by a relative where 36% chose this option.

When asked to indicate which type of item was used for maintenance, 69% of respondents identified both general tools and specialist tools. Lubricants were also commonly used with 63% selecting this option. Of these items, 80% of respondents identified that they bought the tools or equipment specifically for this purpose and 54% stated that they already had this equipment at home.

Conclusions

Maintenance is accepted as a key topic for product design in a circular economy model (van den Berg & Bakker, 2015) and the roles of manufacturers, service providers and the consumer in making products last longer have been considered for some time (Hinte, 2004). Changing the relationship between the manufacturer and consumer from that of a short transaction based model to a longer lasting sale and service relationship is seen as a positive model to encourage product life extension (Chapman, 2005). In uncovering attitudes to maintenance, the drivers and barriers that exist can provide product designers with a better understanding of how to develop products that encourage maintenance and care, thus extending the lifespan of the product and maintaining optimum performance over a longer period of time.

Material gathered through the cultural probes provided a basis for this enquiry whilst also generating insights that can help to understand this complex issue. The probes indicate that regular maintenance of products linked to a specific activity is often carried out as an extension of that activity. In this case the products examined were linked to a leisure activity and it may be the case that the user considers the maintenance as an integral part of that activity. This is supported with evidence from the survey that indicates that the strongest motivation for those who choose to carry out maintenance by themselves was enjoyment of the task itself. This group also indicated that the maintenance they chose to undertake formed part of a regular routine. By contrast, the strongest motivations identified by the group who only do some of the maintenance themselves were more strongly associated with a regular need and cost saving. It follows that there is a case for promoting user maintenance by embedding this action within the routine use-cycle of the product.

The need for specialist knowledge and equipment were considered the strongest barriers to user maintenance, however there is evidence that users are prepared to purchase equipment and use a variety of information sources specifically to support this activity. Removing the need or the perception that there is need for specialist knowledge and equipment may encourage the reluctance to engage in care practices that support extended product lifespan.

As maintenance is generally most effective when applied at the correct interval, understanding the triggers that engage users to initiate maintenance is important. All users identified that an indication from the product was a significant factor, but this must be considered further as it is not clear if this is as a result of a specific service indicator, or a more subtle form derived from the users intimate understanding of the characteristics exhibited by the product during use.

Whilst it is encouraging to observe that the motivation to keep products well maintained is most strongly associated with longer product lifespan and optimal product performance, it is acknowledged that this is a preliminary study and this subject warrants further investigation.

Acknowledgments
This project was funded by the Art and Design Research Centre (ADRC), Sheffield Hallam University.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-446

Planned obsolescence in the circular economy

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Keywords
FMCG
Circular Economy
Planned Obsolescence
Product-Service Systems
Customer Journey Mapping

Abstract
Objective: Ordinary Fast-Moving Consumer Goods (FMCGs) often thrive on implementing the planned obsolescence business strategy, i.e. controlling product lifetime through material selection. This wasteful and resource-depleting linear approach to production has resulted in goods that offer convenience along the lifetime of the consumable components, and are re-purchased after disposal. Contemporary FMCGs have similar characteristics but different product-service systems (PSSs). The circular economy (CE) proposes PSSs as an opportunity to increase the circularity of resources. This paper investigates these PSSs implemented in contemporary FMCGs and reviews opportunities for the planned obsolescence strategy in the CE.
Method: Customer Journey Maps (CJMs) were developed for three contemporary FMCGs (Fuji disposable camera, HP ink cartridge, Kartent) and compared to the map for a standardised ordinary FMCG.
Result: In contemporary FMCGs the inventory and maintenance phases are eliminated by introducing services operating in the purchase, use and disposal phases. Services in the disposal phase are critical to enable the circularity of contemporary FMCGs.
Conclusions: Consumers do not need inventory if the services in the purchase and use phases are aligned and available at the right time and place. This increases convenience, but does not make the use of the products more compatible with a CE. The real opportunity for FMCGs is in the elimination of the maintenance phase and the integration of end-of-life services. If planned obsolescence is communicated clearly to customers through lifetime indicators that allow involvement in end-of-life services, it could shift FMCGs towards a circular performance-based approach to production.

Introduction

The business strategy behind Fast-Moving Consumer Goods (FMCGs) emerged early in the 1900s when an international cartel agreed on a lifetime of 1500 hours for lightbulbs (Andrews, 2015). Meanwhile, DuPont started using Nylon for stockings in a format prone to laddering (Agrawal, Kavadias, & Toktay, 2016). Earlier designs of these goods were longer-lasting. However, producers soon realised that repetitive sales of consumable goods would be more profitable than one-off sales of durable goods. As a result, product developers started to strategically pre-define a consumer-satisfying functional use time for these goods and subsequently to select ephemeral materials to embody them. The goal became to *control product lifetime through material selection*. Material-based design decisions impact durability and reliability of components (Maycroft, 2009). Goods designed with this approach have a built-in obsolescence (Papanek, 1985) that supports a linear take, make and dispose model.

Disposal of short-lived goods has been causing significant accumulation of waste and is a cause for future resource shortage, threatening the environment. Planned obsolescence is a powerful tool for business as it makes consumer goods rapidly become obsolete and replaced (Andrews, 2015). The business strategy of FMCGs thrives on high sales volumes, against low margins. This has, over time, transformed many luxury goods into basic necessities (Maycroft, 2009) which have been designed for convenience at the expense of durability. FMCGs can be characterised by their *consumability, convenience* and re-*purchasing*:

- The functional value of FMCGs is determined by the *consumable* component. (De los Rios & Charnley, 2016). After the consumable component has been used-up (e.g. food is eaten, the ink in a pen is finished) or has lost its functionality (e.g. broken lightbulb, blunt razor blades), the facilitating non-consumable components (e.g. food packaging, razor handle) become redundant, and are disposed of by consumers. For most FMCGs, various types of indicators communicate obsolescence through perception and experience (e.g. faded razor lubricant strip or worn out toothbrush bristles (Maycroft, 2009) and laddered stockings (Andrews, 2015).

- One of the strongest forces for consumption of FMCGs is *convenience* (Bakker, Hollander, Hinte, & Zijlstra, 2014). Convenient goods are 'suitable for your purposes and needs, causing the least difficulty' (Cambridge Dictionary). FMCGs are manufactured in high volume to offer low-priced goods. Fulfilling needs on a global level, by designing universal goods which provide consistent results under the worst possible circumstances, allows for production of significant volumes (Braungart & McDonough, 2008).
- After disposal of FMCGs consumers *re-purchase* them to achieve the same result and fulfil their continuous need.

Ordinary FMCGs (Figure 1) fit into product categories such as 'food and beverages' and 'personal care'; 'baby care' and 'pets'; and even in 'apparel' and 'electronics'. Goods outside these categories are also transitioning into convenient, consumable and re-purchased necessities, e.g. camera. In this paper, these goods are referred to as 'contemporary FMCGs' in this paper. Contemporary FMCGs are not used as frequently as ordinary FMCGs, but they are similar in that they are single-used for a consistent result and the product lifetime is controlled through material selection, see Table 1. Contemporary FMCGs have adopted services, e.g. to allow new subscription-based sales models or to allow the use of valuable materials (Grant & Banomyong, 2010).

Up to 75% of all industrial energy is linked to the extraction or production of basic materials (Stahel, 2013). In the FMCG sector only 20% of the total material value (estimated at 3.2 trillion USD) is currently recovered. There are opportunities in the manufacture, distribution, consumption and post-use processing of FMCGs that have the potential to increase material recovery to up to 50% (Ellen MacArthur Foundation, 2013b). The economic and environmental opportunity for improved resource management is huge. However, marketing universal products designed for a worst-case scenario imply that nature is the enemy (Braungart & McDonough, 2008) and this leaves little opportunity for recycling them.

Access and experience strategies have been proposed to help shift to a Circular Economy (CE), together with

Ordinary FMCG	Contemporary FMCG
Consumable	
Convenience	
Re-purchase	
Everyday use (everyday)	Occasional use (occasional)
Frequent use	Infrequent use
Consistent use	Intensive use
Simple product	More complex product
Available in any nearby supermarket	Available through customised sales channels

Table 1. Differences and similarities between characteristics of ordinary and contemporary FMCGs.

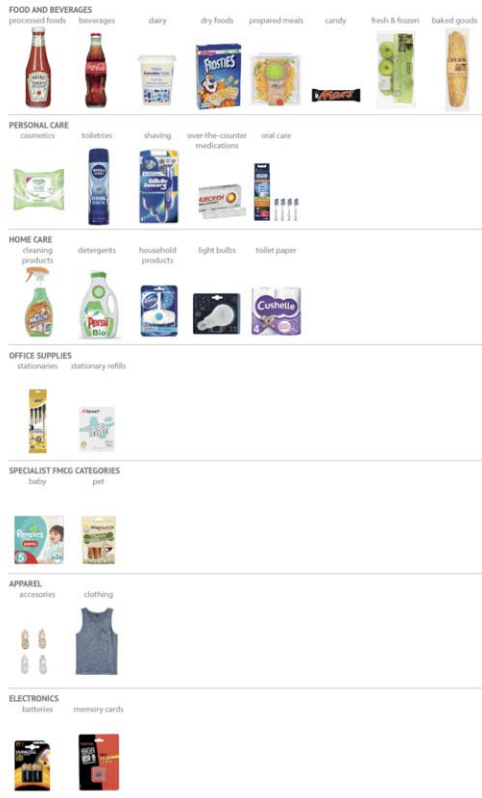

Figure 1. Examples of ordinary FMCGs.

economic incentives for slowing resource loops (Bocken et al., 2016). In nature, consumption is not related to waste (McDonough, 2013), nor is it in a CE where the reuse of material is the foundation for economic growth (Ellen MacArthur Foundation, 2013a) and resource loops are extended and/or closed (Bocken, de Pauw, Bakker, & van der Grinten, 2016). Product-service systems (PSSs) could help shift towards an economy that is more focused on offering the right experience through the use of products rather than their one-way consumption (Bocken et al., 2016; Ellen MacArthur Foundation, 2013a; Manzini, 2009; Pine II & Gilmore, 2013). If services are to contribute to circularity, the way goods are made, used and disposed of is significant (Scheepens, Vogtländer, & Brezet, 2016). Hence, a simple re-design of existing typical goods is not likely to be sufficient (Manzini, 1994) to move towards circular business models.

The aim of this paper is to investigate the PSSs adopted in contemporary FMCGs and to review opportunities of the planned obsolescence in the CE.

Method

The PSSs of contemporary FMCGs were identified using the Customer Journey Map (CJM) method. The CJMs are presented in Figure 2. The product data used to develop these maps is presented in Table 2.

Based on the characteristics in Table 1, several contemporary FMCGs can be identified based e.g. as single-use BBQs, cheap bicycle lights and disposable helmets. Three goods were selected for further investigation. The goods selected had to satisfy the following criteria: deviate greatly from ordinary FMCGs, because of their established and functioning PSSs; and represent a variety of customised PSSs in use.

1. **Fuji disposable camera.** This disposable camera consists of many mechanical and electrical components. Fuji has designed each component to be optimally reused and its materials recycled after the camera housing is returned (Grant & Banomyong, 2010). The facilitating components are collected by the stores offering photo development services.

2. **HP Ink printer cartridge.** HP cartridges are compatible with multiple printer models. They can be purchased online, as well as at some retailers and home care stores. Individual units are packed with a stamped envelope, which can be used to send the empty cartridges back to HP. Cartridges can also be refilled at other dedicated stores (Maycroft, 2009).

3. **Kartent.** This cardboard tent is sold through organisers of multiple-day festivals (Kartent, n.d.). It offers a convenient alternative to carrying and setting-up a tent, with the aim to reduce single-use of cheap durable tents. Kartent also offers the festival organisers a service to collect the cardboard for recycling after the festival (a small percentage is also reused).

	Standardised ordinary FMCG	Disposable camera	Ink Cartridge	Kartent
BASIC PRODUCT INFORMATION				
Product specification	multiple of consumable components packed together	photo camera to take 27 pictures	black ink printer cartridge for numerous HP printers	cardboard tent, available and prepared at festivals
Point of purchase	e.g. retailer, drug store, home care store, stationary shop	home care store, retailer, specialist store	online	online (event's website)
Product category	any of those presented in Figure 1	photography	printer supplies	camping
CONSUMER NEED				
Satisfying result	consistent, reliable and familiar results experienced	sturdy object for picture taking during events (e.g. holidays) and to have hardcopy pictures afterwards	print black ink on paper at home	a place to sleep during a festival, at the least efforts
Frequency of use	daily	occasionally	daily-weekly	occasionally
CONSUMABLE COMPONENT				
Component	one component typically is consumed	camera film	ink	cardboard structure
Lifetime	days-weeks	days-weeks 27 pictures	weeks 190 pages	days 4 in heavy weather
End of life	e.g. recycling, landfill, digested or other household waste stream	camera film kept by consumer after development	recycled (with paper)	recycled
FACILITATING COMPONENT				
Component	e.g. packaging material, handles and other facilitating components	camera housing	cartridge (empty)	N/A
End of life	e.g. recycling, landfill, digested or other household waste stream	disassembled for reuse of components and recycling of resources	return to HP in stamped envelop	N/A
PERSONAL ATTACHMENT				
Intensity of attachment during use	low	medium	low	high
Ownership	short-term ownership by the consumer until disposal	Fuji keeps ownership of the facilitating components	HP aims to regain ownership of the facilitating components	Kartent offers festivals a services to recycle the consumable components

Table 2. Product data used for the Customer Journey Maps.

Customer Journey Mapping

Product experience can be defined by the user-product interaction including aesthetics and emotional response and meaning attribution (Desmet & Hekkert, 2007). In the analysis of a customer experience, indirect points of contact (e.g. services, brands) are also taken into account (Meyer & Schwager, 2007). CJM originated as a marketing tool and is often used to construct visual representations of customer experiences (Crosier & Handford, 2012; Shih, Chen, & Chen, 2006). CJM can be used to identify what customers are trying to achieve at every step (Bettencourt & Ulwick, 2008). Customer experience is the subjective response that customers have to any direct or indirect contact with a company (Meyer & Schwager, 2007), and customers will always have an experience when purchasing services or goods (Johnston & Kong, 2011). Customer experience is shaped by:

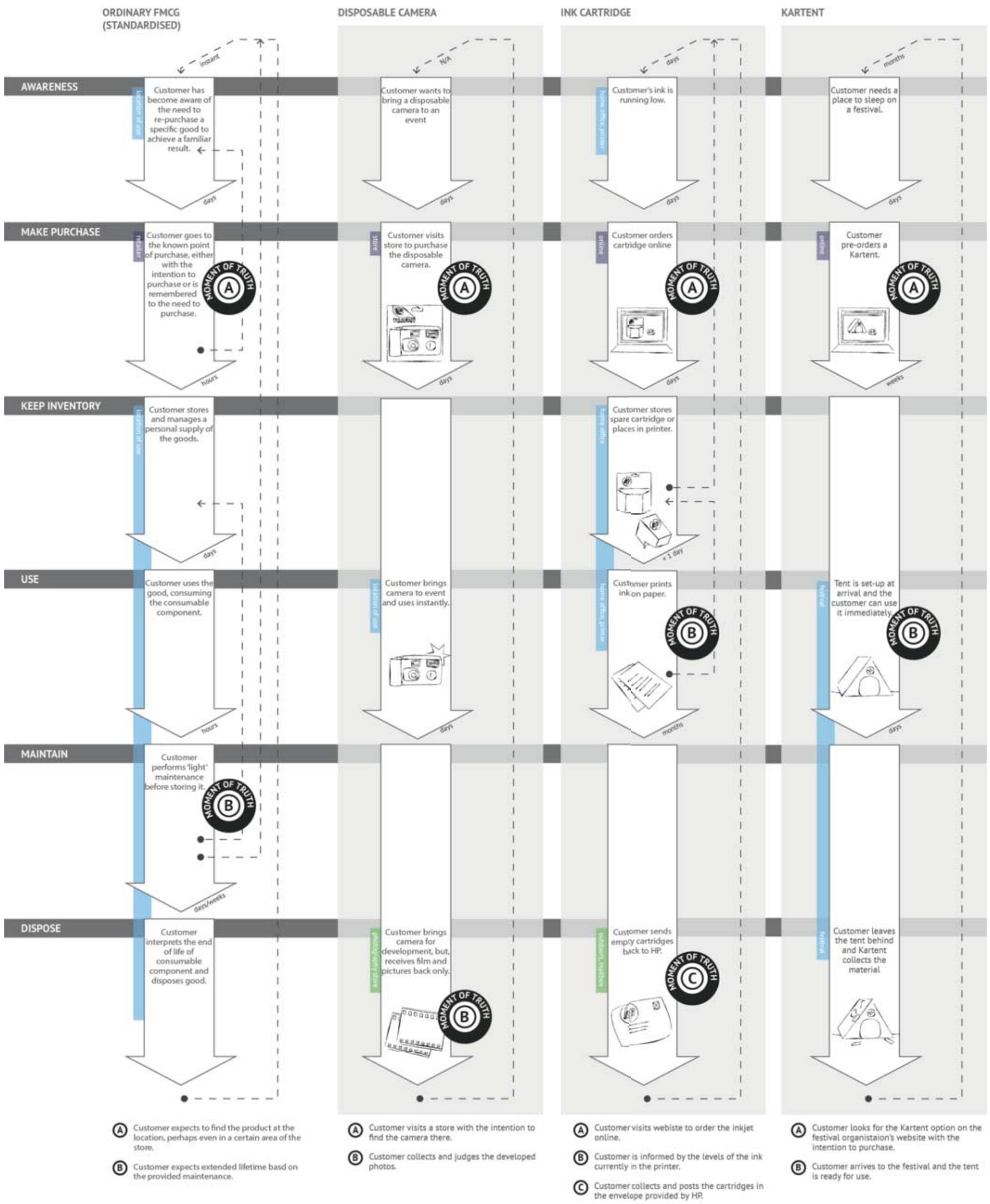

Figure 2. Customer journey map of any standardised ordinary FMCG and the selected contemporary FMCGs.

- *Touch Points* (TP). These are instances of direct and indirect contact with a product or service, or those representing either of them (Meyer & Schwager, 2007). Possible points of contact are typically visualised in CJM (Shih et al., 2006). In this research, specific states of a product are considered touch points; atmospheric (location) and process (time) elements have also been included (Stein & Ramaseshan, 2016).
- *Moments of Truth* (MOT). These describe key moments of interaction with the customer at which the company can make an impression (Carlzon & Peters, 1987). The term has been widely used in (customer) service design, but is also used by multinationals in product development [1].

Phases of CJM

Most CJMs focus on first encounters and propose phases such as 'search', 'evaluation', 'purchase' and 'post-purchase' (Stein & Ramaseshan, 2016). The focus of the customer journey analysed in this research is the path of re-purchase. The consumer (i.e. customer) knows what to get and expects equal experience and results, as well as to find the product in a familiar location. An analysis of a selection of ordinary FMCGs has provided 6 significant phases for this customer journey, which are shown in Table 3.

A standardised customer journey map for ordinary FMCGs was developed as a benchmark and compared to those for contemporary FMCGs to identify new design opportunities. The map is considered valid for any ordinary FMCG.

Findings

The aim of this research is to investigate the PSSs implemented in contemporary FMCGs. The Kartent, Fuji disposable camera and HP ink cartridge were selected as case studies. Awareness, make purchase, keep inventory, maintenance, use and disposal were identified as key phases of the customer journey for any re-purchased ordinary FMCG. In the following sections each of the phases is analysed, contrasting the way in which the phase is implemented in contemporary FMCGs compared to ordinary FMCGs.

Purchase phase

The need for purchasing and re-purchasing ordinary FMCGs occurs when personal inventory is low, or immediately after disposal. Consumers expect to find ordinary FMCGs at the nearest retailer, which provides a service of availability. Not finding these goods at the expected location can be disappointing. The purchase and re-purchase of contemporary FMCGs is less predictable and typically happens when the need occurs. Some are accessed through customised services, e.g. online retailers. Assuming consumers are always connected to the internet, online sales models of contemporary FMCGs provide increasingly convenient availability. Consumers are willing to pay for an experience of increased convenience if they satisfy needs at the right time and location, rather than through materialised objects (Tukker, 2004). To achieve this, purchases need to be made in advance of the use phase.

	Ordinary FMCG	Selected contemporary FMCG
Awareness	Customer has become aware of the need to purchase or re-purchase a specific good to achieve a familiar result.	Customer has a need to achieve a satisfying result, but the need is not continuous.
Make purchase	Customer goes to the known point of purchase, either with the intention to purchase or is remembered to the need to purchase.	Customer either finds the product online to purchase it or visits a dedicated store to make the purchase.
	SERVICE FEATURE: Availability	SERVICE FEATURE: Extended availability
Keep inventory	Customer stores and manages a personal supply of the goods.	Customer can or cannot keep inventory and purchase in advance what is needed.
Use	Customer uses the good, consuming the consumable component.	Customer uses the good, consuming the consumable component.
		SERVICE FEATURE: Right time, right place
Maintenance	Customer performs 'light' maintenance before storing it.	Customer cannot perform maintenance.
		SERVICE FEATURE: Life time indicators
Disposal	Customer interprets the end of life of consumable component and disposes remaining.	Customer reaches or perceives the end of life of consumable component and disposes through service.
		SERVICE FEATURE: Active customer involvement
		SERVICE FEATURE: Passive customer involvement
		SERVICE FEATURE: Invisible customer involvement

Table 3. Customer journey phases for ordinary and contemporary FMCGs and service opportunities.

[1] In 2002, A.G. Lafley (ex-P&G, CEO) wrote in a shareholder letter about the First Moment of Thruth (FMOT) as "when consumers stand in front of store shelf and decide whether to buy a P&G brand, or a competing product"; Lafly also identified the Second key moment (SMOT) and described it as "when consumers use a product and it delivers a delightful and memorable experience - or not and then decides whether to buy it again"; P. Blackshaw (ex-P&G, brand manager) later introduced a Third (TMOT) "where the product experience catalyses an emotion, curiosity, passion, or even anger to talk about the brand"(Aichner, 2012; Ewart, 2015). Google has recently introduced the Zero Moment of Truth (ZMOT), which is "when consumers research a product or are made aware of the product" (Aichner, 2012).

Inventory phase

Consumers are likely to keep a small supply of any ordinary FMCG. However, this trend is not always matched by contemporary FMCGs. If consumers, for example, are likely to keep a spare ink cartridge, disposable cameras are unlikely to be kept in stock. Instead they are purchased in advance of an event. Similarly, customers purchase the Kartent ahead and benefit from a convenient ready-for-use service in the use phase, rather than keeping stock. Customised purchasing-services are opportunities to increase the convenience.

Use phase

Ordinary FMCGs require planning to be available at the right time and place. Providing consumables at the time and place needed, minimises effort and decreases the difficulties that a customer could encounter, e.g. camping without carrying a tent, printing at home rather than at a copy-shop, capturing meaningful moments without owning a camera. Among the contemporary FMCGs studied, the Kartent is of particular interest because it even prepares the good for usage at the exact place of use.

Maintenance phase

Ordinary FMCGs have one component which is used-up after a (short) amount of time. These goods would typically come with an end-of-life indicator. Ignoring end-of-life indicators can sometimes increase product longevity (Maycroft, 2009). In addition, the life of the consumable components can be marginally extended by minimal maintenance of the goods (e.g. rinsing razor blades). In contemporary FMCGs maintenance is typically not allowed and consumers are provided with well-defined end-of-life indicators. The disposable camera, for example, can take 27 pictures. After this predetermined number of pictures is taken, camera becomes useless. HP proposes a lifetime of 190 printed pages, while its software informs the customer if low ink levels are reached. The latter can be considered the real indicator for the cartridge and cannot be ignored as the result is affected. Neither maintenance of the product is permitted to refill the ink level. Kartent guarantees 4 nights in heavy weather, which is aligned with the common duration of festivals. The end-of-life indicators proposed for the three contemporary FMCGs are absolute, simplified or wost-case. It is unlikely or even impossible for the product lifetime to be extended beyond what is proposed by the manufacturer. Hence in contemporary FMCGs, the maintenance phase is eliminated and product obsolescence is carefully planned. It is noteworthy that the lack of a maintenance phase limits user-object interactions affecting the potential to create customer attachments (e.g. configuration, repair) (Baxter, Aurisicchio, & Childs, 2015). In essence, consumers are charged for the time they spend with the good, which is key in the experience business (Pine II & Gilmore, 2013). Selling performance is the most profitable and most material-efficient business model of the circular economy (Stahel, 2013).

Conclusion

The materials of ordinary FMCGs are typically disposed of through local waste management systems without further company engagement. Supporting services were identified for the disposal of all the selected contemporary FMCGs. The disposable camera, for example, is returned to a store with the consumer's objective to have the film developed, while the remaining components are returned to Fuji (i.e. *the customer takes a passive role in recycling*). HP provides stamped envelopes with new products for the consumer to collect and return empty cartridges (i.e. *the customer takes an active role in recycling*). Finally, Kartent reuses and recycles remaining materials, but there is no touch point and the consumer is not involved in this process (i.e. *the customer's role in recycling is invisible*). If what happens after disposal is clarified early on (Papanek, 1985), material choices and the design of facilitating and consumable components could be informed by the selected end-of-life option (Ellen MacArthur Foundation, 2013b; Grant & Banomyong, 2010).

Discussion

This paper presented a preliminary study of contemporary FMCGs with the aim to identify new opportunities for the planned obsolescence business in the CE.

The contemporary FMCGs analysed in this research originated as durable goods. However planned obsolescence has been built in these goods and integrated within their services.

Services provided in the purchase and use phases have allowed eliminating personal inventory while increasing convenience, a product characteristic that consumers are often willing to pay for.

- Purchases through customised (online) models allow availability anytime, anywhere.
- Usage at the right time and the right place, increases convenience.

Selling increased convenience alone however, is not contributing to the CE.

The elimination of the maintenance phase risks to compromise consumer attachment. In an experience economy, clear lifetime indicators are important to achieve resource-efficiency. At the end-of-life disposal services need to be provided at the right time and place. The lifetime of goods must be controlled and adequately communicated if consumers are to be involved in a system that recovers the facilitating resources.

The CJMs presented in this paper have been constructed based on published data. Future work could include direct research with consumers in order to gather more accurate and objective insights to generate the maps. Nevertheless, in this research the identification of the phases and touch points was more important.

Conclusion

Planned obsolescence has been used as a powerful tool to control the product lifetime of ordinary FMCGs. This research investigated durable goods that have been transformed into short-lived fast-moving goods with the aim to learn if planned obsolescence can be used within the frame of the CE. For its successful implementation in a CE, services in the disposal phase of the FMCGs are crucial for the recovery of resources. The role of the consumer in this system needs to be carefully designed for. This research proposes to use planned obsolescence in favour of the CE, which is a rare positive approach to planned obsolescence. It contributes to research on FMCGs and the CE with new opportunities for short-lived products.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-453

Preserving objects, preserving memories: repair professionals and object owners on the relation between memories and traces on personal possessions

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Keywords
Repair
Possessions
Traces
Ageing
Memories

Abstract
Traces of ageing and use on the material of products, and memories associated with products, have been found to contribute to product attachment and can stimulate product longevity. We present findings of a qualitative study that focused on the relation between traces of ageing and use on personal possessions and memories and the effects of repair on objects. With this research, we intended to increase our understanding of the role of traces on personal possessions and memories. We interviewed five professionals at their workplace who worked as a restorer or did repairs of personal possessions, and five owners of a repaired or restored possession. The motivations for bringing an object for repair were not only related to the deteriorating condition of the object but were also triggered by situational events or circumstances, such as passing on ownership or knowing someone who could repair the object. We found five different categories of traces among the possessions of the interviewed object owners: Traces of use, traces of ageing, traces of repair, traces of accidents and alterations. We found that objects gained meaning after the repair. When object owners or repair professionals decided not to repair traces, it was often for aesthetical and reminding reasons, but also because it may be how the owner remembered the object. Traces can cue associations to their use in the past, and also to the (imagined) history of the objects. These findings indicate that repair can enhance the cueing of memories and that preservation of meaningful traces may contribute to attachment.

Introduction
Personal possessions can go through many material changes over time. For example, due to ageing, breakage, or usage and maintenance. Often possessions collect marks and traces or have undergone modifications during their lifetime. These references to time past are known to contribute to increased attachment to the object (Belk, Wallendorf, & Sherry, 1989; Kopytoff, 1986).

Not every trace of ageing and use is valued. The materials of objects play an important role in how ageing manifests itself on objects. Rognoli and Karana (2013) make a distinction between degrading and maturing of materials. Natural materials such as wood and leather may even improve their qualities over time and are often perceived as 'maturing'. Besides the appearance, also utility, enjoyment and memories are suggested to play a role in attachment (Mugge, Schifferstein, & Schoormans, 2010; Mugge, Schifferstein, & Schoormans, 2008; Schifferstein & Zwartkruis-Pelgrim, 2008; Wallendorf & Arnould, 1988).

Several studies indicated that especially for products that have been owned for a long time, memories are a major reason for attachment (Niinimäki & Armstrong, 2013; Page, 2014; Schifferstein & Zwartkruis-Pelgrim, 2008). In contrast, for more recently owned products these studies indicated that enjoyment and pleasure are the most prominent factors.

Schifferstein and Zwartkruis-Pelgrim (2008, p.8) recommend that designers "facilitate the formation of associations between products and people, places or events (memories)". They proposed that designers could use materials that allow graceful ageing, or otherwise physical signs of past events, to facilitate the connections of memories to objects. This may increase the value of the product and its quality to cue memories. Also, Page (2014) found that "[p]roducts that had aged with dignity, showing the general wear and tear of use were often connected with fond stories and experiences" (Page, 2014, p. 279). These findings indicate that traces and ageing of the material contribute to cuing memories.

In this paper, we present a selection of the findings of a study that focused on the relation between traces of ageing and use on personal possessions and memories. Memories are one of the reasons why people develop an attachment to personal items. By investigating traces of ageing and use on objects, we intend to increase our understanding of cuing memories and the role of traces in this, which may feed into the design of objects and technology to facilitate remembering (Van den Hoven & Eggen, 2014).

Method

For this study, we approached repair professionals, as we assumed they are experts on the topic of traces of use and ageing. We also interviewed object owners of repaired objects with traces of ageing and use. The research commenced after acquiring ethics approval from the university, and conducting a pilot study with a repair professional (furniture maker). We interviewed five professionals who worked as a restorer, renovator, conservator, or did otherwise repairs of personal possessions, and five owners of a repaired or repurposed possession. These owners were not necessarily customers of the interviewed professionals; in fact, only one object owner was recruited via one of the participating repair professionals. The professions that were included in this study were: a furniture maker, a clock maker, a doll and bear repairer, a silver, gold, and metalware restorer, and a ceramics restorer (see table 1).

The interview method we used for interviewing repair professionals is known as 'contextual inquiry', where participants are interviewed and observed in their own work environment (Wixon, Holtzblatt, & Knox, 1990). The method combines elements of ethnographic field research and participatory design (Holtzblatt & Jones, 1993; Raven & Flanders, 1996). Interviewing the repair professionals in their workplace allowed the interviewees to illustrate their answers with material and objects they work with.

Participants and data collection

The five repair professionals we interviewed worked in Sydney and surroundings (Australia) and had a long-standing experience in their profession of at least 25 years. Their age ranged from 43 to 69, four were male, and one was female. The interviews took approximately one hour on average, varying between 22 minutes to 98 minutes and were recorded with a digital voice recorder. Photos were taken during the interview of objects that were pointed at or shown as examples when answering questions.

The interview questions covered topics such as the objects and the reparations or restorations they carried out, the meaning of the objects including memories, and the role of traces of ageing and use. Table 1 presents the objects the professionals covered and the types of traces these objects expose.

The object owners also lived in Sydney, were aged between 41 and 62, and three were female and two were male. Two object owners discussed two objects each, which led to seven objects in total. The object owners were interviewed either at the professional's workplace (1x), at the university (3x), or over the phone (1x). The interviews took approximately 37 minutes, varying between 32 and 46 minutes, and were recorded with a digital voice recorder. The objects discussed included a chest of drawers, an antique desk, a cabinet, a baby cot and changing table, a porcelain bowl, a porcelain doll, and a necklace (see table 2).

The questions asked to object owners covered topics about the history of the object, the meaningful properties to the owners, the traces of ageing and use on the object and the repair, and the meaning and memories the object evoked. The object owners were asked to send or bring a photo of the object to the interview if possible.

Analysis

The interviews were transcribed and the data was qualitatively analysed using open coding, following the bottom-up coding approach from thematic analysis (Braun & Clarke, 2006, 2012). The interviews from repair professionals and object owners were coded separately to allow for different perspectives to emerge. Coding first took place by hand, after which three topics (meaning of the objects and the reasons for repair, properties contributing to meaning, and role of traces of ageing and use) were selected to code in more depth with data analysis software NVivo (QSR International Pty Ltd, 2015). The initial codes were clustered or merged under themes. During the coding process, a few topics specific to either repair professionals or object owners were added when they seemed to be relevant for the research. The

#	Profession	Objects	Examples of traces
p1	Clockmaker	Clocks, watches, and music boxes (all from until the 1960's)	Damage of the surface (lacquer, paint), and wear of the mechanics
p2	Furniture restorer	Wooden furniture, sometimes statues	Broken parts, stained or damaged surfaces, moving parts do not function well (e.g. hinges of drawers or doors, parts that can open and close)
p4	Doll and bear repairer	Dolls, (teddy) bears, prams, wheel toys, and other toys	Paint, breakage, missing pieces (e.g. eyes, hair, or body parts), missing filling and fabric
p7	Metal-ware renovator	Silver and goldware, copper and brass, cutlery, candlesticks, trophies, ornaments, religious objects	Patina, fatigue of the metal, breakage, cracking and splitting, wear and tear of the surface, damage from over-cleaning, tarnish
p9	Ceramic restorer	Ceramic or porcelain objects such as ornaments, statues, china, lamps, vases, figurines, plates, cups, religious objects	Breakage, cracks, chips, missing pieces, stains (e.g. from food or rust), earlier repairs (glue, staples)

Table 1. Professions of the participating repair professionals and the objects they work with.

#	Object	Reason for repair	Current traces on the object
p3	Chest of drawers	Deteriorated, looked old and worn	Mark on the top where grandmother used to put the vase with flowers, shiny handles that do not belong to it, but were put on because grandmother liked it shiny (originally it was wood)
p5	Porcelain bowl	Broken when cat jumped on it	Crack from breakage, crazing of the porcelain
p5	Antique desk	Joints became wobbly and it eventually fell apart	Ink stains, scratches, wear of the wood
p6	Cabinet	Surface was scratched and looked worn	Veneer repair where colour does not match, parts of the brand label sanded away during repair, wear inside the drawers
p8	Necklace	String with beads broke (does not remember what happened)	Stiff compared to before repair, some scratches and perhaps a dent, little piece of string sticking out, it catches
p8	Porcelain doll	Maintenance, preserve it and display it at home	Missing foot of doll, discolouration of the dress (yellowing), tiny holes in the fabric of the shawl
p10	Baby cot and changing table made from parents' chair	Disassembled after clearance of parental house and repurposed pieces of wood when first grandchild was born	Chips off the wood

Table 2. Repaired objects from the participating object owners.

photos that were taken were not coded but used by the researcher to understand the transcripts.

Findings

We present a selection of our findings on the effects of repair and traces and the memories the objects and traces evoked, based on our interviews with repair professionals and object owners.

Motivation for repair

An important motivation to repair the object mentioned by both the repair professionals and object owners was the state of the object, such as breakage or objects that are not functioning. For example, a clock that has stopped working. A reason also was that the object had aesthetically deteriorated, for example if the object's surface was damaged, or *"because the lustre of it is gone" [p2]*, and sometimes the object still looks good but is brought in for maintenance.

Repair professionals also mentioned that intentions to 'pass on ownership' prompted the owner to bring the object for repair. This could be to a person whom the owner has a close acquaintance with, such as when a grown-up child moves out of the house. It was also mentioned that owners restore their objects when they want to sell them, and thus 'pass on' to dispose of the object, or motivated by monetary reasons.

Figure 1. Owner learnt that the compartments in the antique desk were used to store money.

Knowing somebody in their personal circle who could do the repair was a particular motivation for object owners to repair the object. Talking to the person reminded them of having an object themselves that needed repair or restoration. For example, one of the participants met a repair professional through a date, another had a friend who was a repair professional.

Also, some item owners had objects that were stored away, and needed repurposing or conservation before it could be used or displayed again.

Effects of repair

We asked object owners if the meaning of the objects had changed after repair. Interestingly, all but one object gained additional or stronger positive meaning after the repair. The aesthetical improvements made by the professional gave stronger associations to its style, or a higher appreciation of the object. For example, an antique desk (see figure 1), gained historical meaning because the participant learnt about the history of the item. *"I didn't realise quite what the desk would have been used for. And now I see it, you know, as a money desk, […] it has given me a little window into history that I didn't have." [p5]*

In a few cases, the repair also caused the loss of some qualities it had before. For example, the repair of a necklace caused a stiffness it did not have before breakage. Besides the personal meaning, participants also mentioned the item regained its functionality, including preserving it for the future and by being able to use the object again.

Types of traces

The object owners reported a variety of traces that were present on their items after repair (see table 3). The majority of traces were traces of use and traces of ageing. An interesting category of traces we observed were traces caused by the repair itself. For example, in the case of a repaired cabinet, where the new veneer not always matched the rest of the wood, and where the original label of the cabinet had been partly sanded away:

Traces of use (6x)	Traces of ageing (4x)	Traces of repair (3x)	Traces of accidents (2x)	Alteration (1x)
- Mark on surface where grandmother used to put the vase with flowers - Wear inside the drawers - scratches/dents - chips off the wood - Ink stains - Scratches	- Crazing of the porcelain - Discolouration/ yellowing of the dress - Tiny holes in the fabric of the shawl - Wear of the wood	- Veneer repair where colour does not match - Parts of the brand label sanded away during repair - Stiff compared to before repair	- Crack from breakage - Missing foot of doll (unclear where it is now)	- Shiny handles that do not belong on the chest of drawers, but were put on because grandmother liked it shiny (originally it was made of wood)

Table 3. Types of traces after repair of the seven objects in this study.

"You can actually see, he, in most cases he added the new veneer really really well. There is one whole section where actually the colour of the wood doesn't really match. […] he said he was really sorry that he did […], he accidentally sanded a little bit of the label. You can see kind of where he tried to sand around it, and slightly missed it." [p6]

Other instances of traces caused by the repair were when the repair or restoration did not come out as desired, for example, a doll's dress that stayed more yellow compared to the previous time, when the owner washed the doll's dress herself. Less frequent traces were traces of accidents and traces of alterations.

Not repairing traces

There was overlap in the reasons that repair professionals and object owners mentioned for deciding not to repair traces of ageing and use. Both groups mentioned that one reason was that improvements of repair did not outweigh costs or effort. Additionally, both groups mentioned that the traces of ageing and use were aesthetically appreciated, most owners do not want it to look like new. Besides the appreciation for the ageing, professionals also said that traces were kept because they reminded the owner of their past.

An interesting reason for not repairing the traces mentioned by a few participants is that the damage or traces had always been there, it was how they remembered the item. Regarding the missing foot of a porcelain doll (see figure 2) the owner said, among other reasons for not repairing it, *"it has never had it like that" [p8]*. The porcelain doll once had a second leg that is now missing, but it is not how the current owner remembers the object. Another

Figure 2. Porcelain doll with a missing foot.

participant explained that his grandfather had removed the original handles on a chest of drawers, because his grandmother liked shiny things. *"My grandfather put them on. I just remember I was polishing them. […] I wouldn't change it for the world." [p3]* Although not originally part of the object, they are kept and refer to the owner's childhood memories.

Traces and memories

Professionals mentioned many examples where traces acted as a reminder of the past, which was also a reason for keeping the traces, and the traces often referred to events or activities that caused the traces, including the person involved in this activity. For instance, a grandmother who caused a burning mark in the table with a hot iron, a layer of scale in a kettle due to the use of clay water from the area where the family lived, or children's Beatrix Potter bowls where the rubbing of the surface reminds them of the use when the children were little.

Also for some object owners, the still visible traces (after repair) played a role in remembering how they or their family members had used the object. For example, the mark on the surface where grandmother put the vase with flowers, and the scratches on the wood where the participant and his siblings, contrary to the wishes of their parents, would sit with their buckled sandals when they were little. Traces also referred to the past of the object without the owner being involved. The traces evoked awareness of the long life of the object, that it had been part of other people's lives (and being cared for), and its purpose of use in the past. Only in one instance the traces referred to a negative connotation, scratches and changes on a necklace that were simply 'annoying'.

Conclusions

We presented a selection of the findings of a qualitative study that focused on the relation between traces of ageing and use on personal possessions and memories. The study involved interviews with repair professionals and owners of a repaired object. With these findings, we gained insights on the effects of repair and traces on objects.

There were five categories of traces that were found on the objects of the participating owners in this study. Most were traces of use and traces of ageing, but also repair left traces on the object. Almost all participants mentioned that their objects gained meaning after the repair of the object.

Damage or traces were not always corrected by the repair professional, as people appreciate the traces aesthetically, or it serves as a reminder of the past, or simply because the improvements do not outweigh the costs. Also, how an object is remembered by the current owner plays a role, as some participants prefer to restore it to the state they remember it, even if that is not how the object originally looked like. Traces seemed to refer to activities or events that caused the traces, and also evoked a general awareness of the object's past.

These findings suggest that repair can enhance associations to the past, and that preservation of meaningful traces may facilitate the cuing of memories.

Acknowledgments

This research was supported by UTS PhD scholarships, and STW VIDI grant number 016.128.303 of the Netherlands Organization for Scientific Research (NWO), awarded to Elise van den Hoven. We would like to thank the participants who took part in this study.

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2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-459

Working with two theoretical perspectives from consumer studies to research product service system consumption

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Keywords
Consumer Culture Theory; Pluralism; Practice Theory; Product Service Systems

Introduction

Considerable research has focused on circular business models (cf. Boons and Lüdeke-Freund) such as Product Service Systems (PSS), systems of products, services, supporting networks and infrastructure designed to be resources efficient (Mont, 2002). Despite potential benefits, PSS implementation rates are poor (Vezzoli et al., 2015), especially in consumer markets (Rexfelt and Hiort af Ornäs, 2009). Surprisingly, there is paucity of research on the relationship of consumers with PSS (Catulli, 2012), from consumer studies perspectives in particular (Mylan, 2015; Catulli et al., 2017).

To address this gap in knowledge, Catulli et al. (2017) and Catulli et al. (Unpublished) explored consumers' relationship with PSS using respectively Consumer Culture Theory (CCT) and Practice Theory (PT). The two sets of findings generated by these approaches offer useful insights. For example, the CCT study revealed that PSS has limited ability to create the symbolic value consumers require and the PT study revealed that links of current consumption practices with every day social practices creates inertia to change and thus inhibits PSS diffusion. In conclusion, both studies suggest that further research is required drawing on consumer studies to help address problems with PSS consumption.

In our study, CCT and PT were used to analyse a single case of Use Orientated PSS consumption. The case was a rental scheme of infant equipment such as pushchairs aimed at parents. CCT and PT were used in pluralistic fashion to analyse the case as they problematize PSS diffusion differently; CCT as the role of PSS in consumer identity construction and PT as PSS as a support to performing practices which are fundamental to society. Yet, comparison between the two sets of findings from PT and CCT informed methods could reveal further rich insights on PSS consumption. If dialogue between perspectives can be promoted, this could, perhaps, yield better understanding of this phenomenon, provided the potential incommensurability of the two perspectives is respected. Thus there is a need to explore how a dialogue between the two perspectives of PT and CCT might be possible and initiated and to identify the possible benefits and pitfalls of such endeavours.

Relationships between different perspectives

In order to explore the relationship between the PT and CCT perspectives, the authors draw on literature concerned with interdisciplinarity. Interdisciplinarity is defined as "communication and collaboration between academic disciplines" (Jacobs and Frickel, 2009:44). For simplicity in this section we adopt the term "dialogue" to signify this communication and collaboration.

Some studies concerned with strategies to achieve sustainability suggest that these are hampered by the fragmentation of analytical approaches (Turnheim et al., 2015; Barry et al., 2008). Seen in this way, each analytical approach can be thought of as a lens that generates partial understandings of pathways to sustainability (Turnheim et al., 2015; Geels et al., 2016). However, Shove (2011) warns that differences in how different research approaches frame problems (e.g. sustainability) prevent integration of different theoretical perspectives (cf. Blaikie, 1991; Stirling, 2011; Hammersley, 2008; Turnheim et al., 2015). Barriers include incompatible styles of thought, research traditions, techniques and languages (Jacobs and Frickel, 2009). Seen in this way, integration of perspectives is not possible because of differing epistemological positions (Shove, 2011; Blaikie, 1991) as they focus on different units of analysis. Indeed, attempting unification and integration of perspectives and reducing diversity may lead to reductionism (Stirling, 2011). Although Practice Theory (PT) and Consumer Culture Theory (CCT) are closely related consumer studies perspectives, they still might have to be used in parallel. Whilst PT frames diffusion of PSS consumption as one of establishment of new social practices perhaps leading to multiplication and diversification of products used, CCT focuses on how consumers may construct their identities by adopting PSS. Moreover, they have different units of analysis, as one focuses on the individual consumers and the other on practices. With these differences, dialogue may be the only possible way to compare findings, this is called "dialogical strategy" (Hammersley, 2008:9). The next section explores how insights from the interdisciplinarity literature can suggest how these two supposedly incommensurable perspectives may be used.

Types of interdisciplinary studies

Literature suggests that there are different levels of "dialogue" between perspectives and disciplines, ranging from "light" dialogue with "one off" iterations to full integration based on iterative interaction and collaborative linkages (Turnheim et al., 2015). There are different types of interdisciplinarity ranging from (Jacobs and Frickel, 2009):

- *Cross-disciplinarity*, or *multi-disciplinarity*, i.e. a contribution from two or more fields to a research problem
- *Interdisciplinarity* or *pluri-disciplinarity*, integration of knowledge originating in two or more fields
- *Trans-disciplinarity*, where knowledge is produced jointly by disciplinary experts and social practitioners

In cross or multi-disciplinary research, team members from different disciplines work in isolated self-contained manner, in parallel or sequentially (Wall and Shankar, 2008).

Reasons to call on diverse perspectives

There has to be a rationale to employ different *methods* (even in parallel) (Fielding, 2012). This rationale may be linked with the objectives of the dialogue between approaches. These objectives should be criteria for the measurement of success and failure of that dialogue (Graff, 2016). The objectives of the dialogue may include:

1. *Corroboration* (Hammersley, 2008) *or Convergent validation* (Fielding, 2012), convergence to confirm the findings of a method with the other, or validation (cf. Rossman and Wilson, 1994). This is the most controversial objective as it is akin to triangulation, which Blaikie (1991) and Rossman and Wilson (1994) question, as findings from different perspectives are said to be incompatible (Blaikie, 1991).
2. *Elaboration (Rossman and Wilson, 1994) or* indefinite triangulation, comparing different narratives of the same event and search for complementary information or enrichment (Hammersley, 2008), or illustration and analytic density or "richness" (Fielding, 2012).
3. *Development* (Rossman and Wilson, 1994), to shape a perspective's method from the findings of another) and
4. *Initiation (Rossman and Wilson, 1994)*, when results from one method foster new lines of thinking.

If, following Blaikie (1991), the combination of perspectives and the methods they underpin was not legitimate, the only possible mediation between such perspectives would be epistemological dialogue or juxtaposition, which aims at enriching knowledge (cf. Fielding, 2012) *without* combining perspectives and methods (Hammersley, 2008). By this route, researchers can enhance and deepen their understanding by adopting different perspectives in a pluralistic fashion, then comparing notes with other researchers and seeing different approaches to a problem (Stirling, 2011).

The authors suggest that the usefulness of a dialogical strategy to approach different sets of findings generated by methods informed by the PT and CCT perspectives should be explored, and the next section outlines possible approaches to this.

Conclusions and directions for discussion

A discussion between academics is recommended to suggest possible directions to develop bridging strategies for PT and CCT. How could these two perspectives be used to enrich the understanding of the relationship of consumers with PSS, and possibly other business models?

Three possible positions might be explored:

1. To use the two perspectives (and other perspectives) in a pluralistic fashion, i.e. without any attempt at integration
2. To integrate the two perspectives, which call for an approach to operationalize this integration
3. A middle position, where some sort of connection is made between the two perspectives

This might be positioned as a proposal to address the problem of fragmentation of research approaches raised by Turnheim et al. (2015) which is said to affect research on sustainability.

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-461

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Options for lifetime labeling: design, scope and consumer interfaces

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Keywords
Lifetime
Durability
Ecodesign
Labeling
Energy labeling

Abstract
In the context of the Circular Economy, there is a lot of discussion on how policies at European Union and member state levels could provide incentives for the design of more durable products. One potential policy approach is to mandate manufacturers to provide lifetime information to consumers at the time of purchase. This could be done through a specific labeling scheme, or by including such information in the mandatory energy labeling scheme. However, the concept of lifetime is far from straightforward, and it is crucial to analyze the type of product and user patterns if such labeling is to be adopted. In this paper we outline some of the policy options and the issues that must be taken into consideration.

Introduction

In the last couple of years, there has been a lot of interest in Europe for promoting longer product lifetimes; and encouraging design for durability is one of the product policy issues stressed in the European Commission's Circular Economy Action Plan, which states (European Commission, 2015, p.4):

"The Commission will promote the reparability, upgradability, durability, and recyclability of products by developing product requirements relevant to the circular economy in its future work under the Ecodesign Directive"

Often, 'product lifetime' is used interchangeably with 'product durability', but in reality there may be differences between the concepts. For instance, a product may be durable but still discarded before it is worn down because the consumer looks for novelty or better functionality, or because the product – while still working – may have a worse performance over time (e.g. a lamp with lumen depreciation). While there is no legal definition of durability, the following definition has been proposed (Boulos et al., 2015, p.4):

"Durability is the ability of a product to perform its function at the anticipated performance level over a given period (number of cycles/uses/hours in use), under the expected conditions of use and under foreseeable actions. Performing the recommended regular servicing, maintenance, and replacement activities as specified by the manufacturer will help to ensure that a product achieves its intended lifetime"

This definition does not include repair, but the potential to repair products can be very beneficial from an environmental perspective and can also save money for consumers. 'Design for reparability', however, is a difficult concept to measure (Boulos et al., 2015) and reparability depends on other factors not related to product design, such as the availability of spare parts at reasonable cost.

The main policies for regulating the life cycle environmental impacts at the European Union (EU) and member state (MS) levels can be seen in table 1 below. There is a large potential to set mandatory standards for durability under the Ecodesign Directive and this has already been done for vacuum cleaners and lighting products. There is however great variance among different product categories regarding the suitability of setting durability eco-design requirements (Boulos et al., 2015; VHK, 2014).

As we can see in the table, policies to promote durability, lifetime and increased durability are found both at the EU and MS levels. EU has the main competence to set product design regulations, so MSs have mainly promoted durability in an 'indirect' way through strengthening consumer protection rules. France has also implemented a scheme for incentivizing the availability of repair parts, which is a way to support repairs. France has also criminalized planned obsolescence, which sends a signal to the market, though it is difficult to enforce this rule in practice.

Generally, the increasing number of initiatives indicates a lack of belief that markets alone will deliver more durable products without governmental interventions.

Potential for policies that provide consumer information on lifetime

While rules on consumer guarantees and burden of

Type of environmental aspect	European Union law and policy	Examples of member state (MS) policies
Chemical content	• Horizontal legislation (e.g. REACH) • Sector oriented laws (e.g. Packaging, electronics)	• Green public procurement criteria • Eco-labels
Collection and recycling of waste products	• General rules and guidelines (e.g. Waste Framework Directive) • Sector oriented laws (e.g. WEEE Directive; Waste and packaging waste Directive)	• Waste related taxes • Mandatory re-use obligations for white goods (Spain)
Energy efficiency	• Mandatory energy performance standards (MEPS) (set under the Ecodesign Directive) • Mandatory energy labeling (set under the Energy Labeling Directive) • Voluntary labeling (Energy Star)	• Eco-labels • Green public procurement criteria
Durability, lifetime, remanufacturing and reparability	*Direct incentives:* • Mandatory lifetime requirements set under the Ecodesign Directive for vacuum cleaners, lighting products *Indirect incentives:* • Minimum rules on consumer guarantees • Green Public Procurement poised to add availability of spare parts, reparability, minimum warrantees, and standard fittings to revised criteria	*Direct incentives:* • Banning planned obsolescence (France) *Indirect incentives:* • Incentivizing provision of spare parts (France) • National rules on long consumer guarantees and/or changed rules for burden of proof is transferred from seller to consumer (several MS) • Public procurement of remanufactured furniture and computers (Sweden) • Support to 2nd hand market (several MS)

Table 1. Environmental product policy instruments at the EU and member state levels (Source: Faure and Dalhammar, forthcoming).

proof for product failures may provide some incentives for 'design for durability' among manufacturers, another policy has been proposed recently: the provision of information to the consumer of the expected lifetime of a product at the time of purchase (ENDS Europe 2016; REEUSE, 2015). One potential way forward is to include durability information in the mandatory EU energy labelling scheme. In the EU Action Plan for a Circular Economy, the Commission also states that it will *'specifically consider . . . durability information in future Energy Labelling measures'* (European Commission 2015, p.8).

However, key questions relate to the scope of such a scheme for consumer information (i.e. which product groups should be included), how it should interact with other policies, whether it should be standalone information or provided through existing labeling schemes, and how the information may best be conveyed to consumers. There are indications that consumers have problems understanding some of the information provided in existing energy labeling schemes(ECOFYS, 2014; Waechter et al., 2015), and it is paramount that experiences from different labeling initiatives are considered when a lifetime labeling scheme is designed.

Another complication is that the concept of 'lifetime' is not straightforward. For example, when it comes to LEDs it is lumen depreciation over time, in addition to failure in operation, that is crucial; and for some lighting consumers colour depreciation over time may be important (Richter et al., 2017). Lifetimes for products like electronics, which can also be expressed in years, are also dependent on the intensity of use assumed. User patterns and the extent of B2B vs. B2C transactions will also vary between products groups, which means that the labeling must be product group specific.

Additional complications include what kind of information that should be provided in relation to durability. Apart from straightforward information about projected lifetime, labeling could touch upon other issues including:

- Availability of spare parts
- Extended warranties or free repairs for a set period
- Whether the product is compatible with other products
- Whether the product design is modular in order to allow the user to replace parts
- Reparability or ease of disassembly
- Whether the product is upgradeable
- Whether software updates influences the product performance, and how
- The weight of durability compared to environmental impacts from other product characteristics (e.g. energy efficiency).

For some product groups, it is common that manufacturers voluntarily indicate expected lifetime on the packaging, for instance light bulbs. However, it is not necessarily evident for the consumer exactly what the lifetime claims imply. A further problem is that a manufacturer can claim that a product has a long lifetime in relation to other products in its specific product category, but not necessarily in comparison with other competing product category. One example concerns claims from manufacturers of halogen light bulbs that the product is 'long life'. This may indeed be true when compared to other halogens, but not when compared to LED light bulbs which typically have a much longer lifetime than halogens. This implies that consumers may be misled in some cases.

Thus, providing lifetime information to consumers can be an important driver for designing durable products, but the complexities involved means that more research is needed to move forward and adopt relevant policies.

Acknowledgments

This research was funded by the Swedish energy Agency (Grant 36936-1).

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*Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)*

DOI: 10.3233/978-1-61499-820-4-464

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Consumer expectations of product lifetimes around the world: a review of global research findings and methods

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Keywords
Circular economy
Consumer goods
Consumer survey
Product lifetimes

Abstract
This paper presents the findings of research to identify and evaluate current studies into consumer expectations of product lifetimes across durable goods. Following a literature review, studies were classified using a product categorisation scheme formulated at Nottingham Trent University and a product lifetime expectations typology adapted from Oguchi et al. (2016a) was developed. The results would appear to suggest that consumer expectations of product lifetimes are in decline, and that those in the United Kingdom appear to be lower than those in other parts of the world. However, identifying differences in consumer expectations of product lifetimes is hindered by the different methods employed in studies, as face-to-face interviews, and online, telephone and postal studies all have the potential to produce different results. Three key challenges to furthering research into consumer expectations of product lifetimes were identified: Product coverage, definitions of consumer expectations and sampling strategies. Only if these challenges can be addressed will researchers be able to draw meaningful conclusions on both personal and cultural trends in expected product lifetimes and make a positive contribution to addressing both material and social aspects of the circular economy.

Introduction

The extension of product lifetimes has been identified as a fundamental strategy to work towards a circular economy (Bakker, Wang, Huisman, & den Hollander, 2014; Moreno, Braithwaite, & Cooper, 2014). However, research has suggested that current product lifetimes for electrical and electronic equipment (EEE) may not always meet consumers' expectations (Oguchi et al., 2016a), potentially indicating a demand for longer lasting products. Furthermore, the methods used to assess consumer expectations are often inconsistent (Oguchi et al., 2016b). This makes comparison of studies across space and time difficult, preventing researchers from coming to robust conclusions on whether product lifetime expectations are declining. This understanding is critical because if consumer demand for longer-lasting products is decreasing, then this makes it harder to make the business case without recourse to statutory instruments (Ervine, 2010), public policy (Cooper, 2010a) and environmental arguments (Cooper, 2010b). In addition, divergent methodological approaches (Oguchi et al., 2016a) and inconsistent product coverage (ERM, 2011) hinder researchers' ability to conduct cross-cultural studies (Oguchi & Fuse, 2015). This makes it difficult to understand differences in product lifetime expectations which may be embedded in the cultural context in which the acquisition, use and disposal of consumer goods are situated.

This paper collates and compares previous research into consumer expectations of product lifetimes. It then outlines and evaluates their findings and methods to elucidate trends in consumer expectations and identify how this field of research, which is crucial to the attainment of a circular economy (Montalvo, Peck, & Rietveld, 2016), can be taken forward at a global level.

Methods

A critical review of the literature (Grant & Booth, 2009) was undertaken by identifying key recent publications (2000 onwards) in the field of expected product lifetimes and examining their reference lists. This was corroborated with keyword searches (e.g. expected product lifetimes) in Google Scholar (Google, 2017) and Scopus (Elsevier, 2017). The review undertaken at Nottingham Trent University (NTU) was compared to parallel work carried out at the National Institute for Environmental Studies in Japan to ascertain if there were any gaps in the NTU study. Ten publications from across the globe which explicitly surveyed consumer expectations of product lifetimes were identified. The methods employed by these studies and the products they cover are detailed above (Table 1).

Product coverage was determined using a product categorisation scheme developed at NTU (see Table 6 in the appendix). The classification scheme groups products into eighteen product categories and is informed

Study	Methods	Products studied	Number of products studied	Number of product categories covered
Oguchi et al. (2016a)	Online survey	Electrical and electronic equipment	4	2
Echegaray (2016)	Telephone interviews	Electrical and electronic equipment	10	3
Wieser et al. (2015)	Online survey	General	21	7
Consumer Technology Association (2014)	Telephone interviews	Electrical and electronic equipment	10	1
Langley et al. (2013a)	Online survey	Clothing	24	1
Knight et al. (2013)	Telephone survey	Electrical and electronic equipment	3	2
Cox et al. (2013)	Focus groups	General	30	10
Wilhelm et al. (2011)	Online survey	Electrical and electronic equipment	1	1
Tasaki et al. (2004)	Postal survey	Electrical and electronic equipment	6	3
Cooper (2004)	Household interviews	Electrical and electronic equipment	15	5

Table 1. Study methods and product coverage.

Expected product lifetime	Description	Examples
Intended	How long does the participant plan to use the product	Langley et al. (2013a); Tasaki et al. (2004)
Ideal	How long does the participant want the product to last	Oguchi et al. (2016a)
Predicted	How long does the participant anticipate that the product will last	Cooper (2004); Cox et al. (2013)

Table 2. Typology of expected product lifetimes (adapted from Oguchi et al., 2016a).

by previous research in both actual (e.g. Gutierrez, Adenso-Diaz, Lozano, & Gonzalez-Torre, 2011) and expected product lifetimes (Table 1), Mintel Academic market research reports (e.g. Carroll, 2017) and the classes of durable goods outlined in United Nations Statistics Division's (1999) Classification of Individual Consumption According to Purpose (COICOP). Durable goods are defined as products "that may be used repeatedly or continuously over a period of more than a year" (UN, EC, OECD, IMF & World Bank, 2009).

A typology for expected product lifetimes was adapted from a recent study of consumer expectations of product lifetimes for electronic goods (Oguchi et al., 2016a). Oguchi et al. (2016a) examined three different types of consumer expectations: Intended, ideal and predicted lifetimes. The adapted expected product lifetimes are defined above (Table 2). These definitions serve to distinguish between a participant's intentions for a product's use-time and their understanding of how long it should last (lifetime).

Study	Intended lifetime	Ideal lifetime	Predicted lifetime
Oguchi et al. (2016a)	X	X	X
Echegaray (2016)			X
Wieser et al. (2015)			X
Consumer Technology Association (2014)			X
Langley et al. (2013a)	X		
Knight et al. (2013)			X
Cox et al. (2013)			X
Wilhelm et al. (2011)		X	X
Tasaki et al. (2004)	X		
Cooper (2004)			X

Table 3. Expected product lifetimes surveyed by each study

Questions concerning intended lifetime seeks to ascertain how long a participant plans to use a product for. However, questions concerning ideal or predicted lifetimes strive to ascertain how long a participant wants or anticipates a product to last respectively. This typology was applied to eleven studies to facilitate comparison of consumer expectations between studies (Table 3). The findings of this exercise are described in the following section.

Results

An initial evaluation of expected lifetimes across 73 products would appear to indicate lower consumer expectations in the United Kingdom (UK) than Europe, as well as a decline in the lifetime expectations of UK consumers over time. Geographic comparisons were possible for 23 of the products, representing six product categories. Twenty-two of the products had shorter predicted lifetimes in the UK in comparison to Europe. Temporal comparisons were possible for 13 of the products, representing four product categories. The results indicate that 12 products had shorter predicted lifetimes in more recent studies. Table 4 provides an example of predicted lifetimes for washing machines.

However, drawing firm comparisons between these studies is hindered by the following factors: Limited product coverage, inconsistencies in the questions posed by the studies of consumer expectations and the employment of differing sampling strategies. These are described below.

Product coverage

Seven of the ten studies addressed expected product lifetimes for EEE (Cooper, 2004; CTA, 2014; Echegaray, 2016; Knight, King, Herren, & Cox, 2013; Oguchi et al., 2016a; Tasaki, Terazono, & Moriguchi, 2004; Wilhelm, Yankov, & Magee, 2011), two studies addressed a range of durable goods across the product categories (Cox, Griffith,

Study	Echegaray (2016)	Wieser et al. (2015)	Knight et al. (2013)	Cox et al. (2013)	Cooper (2004)
Location	Brazil	Austria	England and Wales	United Kingdom	United Kingdom
Method	Telephone interviews	Online survey	Telephone interviews	Focus groups	Household interviews
Predicted lifetime in years	10.00	12.58	7.14	5-6	12.00

Table 4. Geographic and temporal differences in predicted product lifetimes for washing machine.

Study	Question
Echegaray (2016)	"Thinking about the way you use these devices, what do you consider as the minimum reasonable time they should last? How much time should (DEVICE) last?" (Echegaray, 2016, 201)
Wieser et al. (2015)	"How long do you expect the following products to last or flawlessly function under normal intensity of use (in years and months)?" (Wieser et al., 2015, 390).
Consumer Technology Association (2014)	"About how many YEARS would you expect the following electronics products to last before the technology is outdated or stops working?" (CTA, 2014, p.8)
Cooper (2004)	"What would be a reasonable life-span for these products?" (Mayers and Cooper, 2001, p.108)

Table 5. Examples of questions posed by selected studies on predicted lifetimes.

Giorgi, & King, 2013; Wieser, Tröger, & Hübner, 2015) and one study examined clothing (Langley, Durkacz, & Tanase, 2013a, 2013b) (Table 2). Seventy-three products were surveyed in the ten studies, representing twelve of the eighteen product categories defined by NTU. Six product categories were not evaluated by current research, these were: Bicycles, jewellery, clocks and watches, kitchenware, musical instruments, small tools and fittings and sports equipment.

Whilst recent research has examined the product lifetimes of a number of products it is not exhaustive, there are still areas which need to be further investigated to understand consumer expectations of product lifetimes across all categories of durable goods.

Consumer expectations

The results show that the ten studies evaluated were amenable to classification using the typology for expected product lifetimes (Table 4). Nine of the studies explicitly address predicted lifetimes, while only three address ideal lifetimes and two address intended lifetimes. The limited information on the questions posed to consumers by some of these studies and inconsistences in the questions (Table 5), make direct comparison difficult as the extent to which they conform to the typology of expectations outlined in this paper (Table 2) is unclear.

Sampling strategy

Nine studies employed survey methods with varying sample sizes and strategies (Table 1). Cox et al. (2013) was the only study in which focus groups were used for data collection, during which participants deliberated to reach a consensus on expected product lifetimes. The other nine studies employed face-to-face, postal, telephone or online survey methods, and participants individually responded as either individuals or heads of household. Additionally, all the studies were conducted at varying scales, from a focus on urban areas to nations as a whole, in six countries across the world. When coupled with the inconsistences in the questions posed by the studies discussed above, the diverse sampling strategies make it difficult to compare expected lifetimes across studies.

Discussion

The inconsistent product coverage, differences between the consumer expectations under investigation and divergent methods and sampling strategies employed pose barriers to understanding consumer expectations of product lifetimes. These challenges are discussed below and suggestions are offered to address them.

Product coverage

Current research into consumer expectations of product lifetimes has primarily focused on EEE, whilst limited research has been conducted on clothing and consumer durables in general. This has resulted in patchy coverage with everyday products such as kitchenware, small tools and fittings, and space heating and cooling products being poorly understood in terms of product lifetime expectations (ERM, 2011). Academic enquiry to address the challenge of product coverage in the future could focus on studying under-researched products and evaluating the uniformity of consumer expectations across products within particular product categories (e.g. mobile phones and laptops within electronic goods).

Consumer expectations

The variability in the focus of questions posed by previous research in consumer expectations hinders the comparability of past research findings. Whilst a number of studies could be considered to have evaluated predicted lifetimes (as defined by Oguchi et al., 2016a), relatively few have examined ideal lifetimes and intended use times. Without knowledge of the consumers' ideal lifetimes and intended use, it is difficult to ascertain whether current product lifetimes wholly meet the expectations of the consumer.

Further investigation should seek to estimate and evaluate differences between different types of product lifetime expectations, and identify how these expectations might change over time. This is crucial if the potential for lifetime extension and "slowing resource loops" (Bakker et al., 2014, 309) is to be fully realised.

Furthermore, future research should clearly stipulate what type of consumer expectations are being investigated and increased focus should be placed on understanding ideal and intended lifetimes. Research into intended lifetimes could follow the active use approach developed by NTU and WRAP (Waste & Resources Action Programme) in their study of clothing longevity (Langley et al., 2013a, 2013b; McLaren, Oxborrow, Cooper, Hill, & Goworek, 2015) whereby participants were asked how much time has elapsed since they acquired the product and how long they intend to continue to use it for.

Sampling strategy

The variety of methods and sampling strategies employed in the research make direct comparisons between studies difficult. The majority of studies in consumer expectations of product lifetime employ opt-in sampling strategies whereby participants elect to take part in market research. In the fields of opinion polling and market research, questions remain around the representativeness of using non-probability (opt-in) sampling techniques such as consumer panels (Baker et al., 2010). However, cost remains a crucial factor limiting the application of random samples in this context.

Further enquiry should first seek to establish consensus among researchers in the field in order to develop robust and replicable survey methods and sampling strategies that can collect comparable data. The process of back-translation (e.g. Brislin, 1970) would ensure that meaningful data can be collected to facilitate cross-cultural studies. Comparative studies would enable the identification of both general and cultural/geographic-specific best-practice and barriers to extending product lifetimes (Oguchi & Fuse, 2015), supporting their role in attaining a circular economy (Montalvo et al., 2016).

Conclusions

This paper has identified and evaluated ten studies from across the globe which explicitly survey consumer expectations of product lifetimes. The findings would appear to indicate that consumer expectations are declining for many products. However, the variety of methods and sampling strategies employed by the studies makes direct comparisons problematic. This paper identified that if issues of product coverage, varying definitions of consumer expectations and sampling strategy can be addressed, then research in expected product lifetimes area will be able to make an invaluable, timely contribution to this emerging field of enquiry.

Acknowledgment

This project was financially supported by the UK's Engineering and Physical Sciences Research Council's Centre for Industrial Energy, Materials and Products (grant reference EP/N022645/1). The authors would like to thank Jayne Cox (Brook Lyndhurst, UK), Laura Hennies (University of Bonn, Germany), Keith James (WRAP, UK), Katherine Rutkowski (Consumer Technology Association, United States), Rainer Stamminger (University of Bonn, Germany) and Harald Wieser (Sustainable Consumption Institute and Manchester Institute of Innovation Research, UK) for information and advice on their recent studies. The authors would also like to thank Dr Angela Roberts for providing detailed comments on drafts of this paper.

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Appendix

Product categories	Description
Bicycles	Bicycles include all types of bicycles and tricycles except toy bicycles and toy tricycles.
Cars	Cars include all motor cars, passenger carriers and utility vans.
Clothing	Clothing includes coats, jeans, trousers and shirts.
Electronic goods	Electronic goods include mobile phones, computers, games consoles, cameras, printers, laptops, tablets, sound systems, radios and other electronic equipment.
Floor coverings	Floor coverings include carpets, rugs, vinyl flooring and floor tiles.
Footwear	Footwear includes shoes and boots.
Furniture	Furniture includes sofas, chairs, tables, dining chairs, bookshelves, beds, freestanding wardrobes and cabinets.
Household textiles and soft furnishings	Household textiles and soft furnishings include curtains, fabric blinds, bedding, cushions, tablecloths and towels.
Jewellery, clocks and watches	Jewellery, clocks and watches include jewellery, cuff links, tiepins, clocks, watches, alarm clocks and stopwatches.
Kitchenware	Kitchenware includes cookware, tableware, glassware, cooking utensils and storage containers.
Large kitchen appliances	Kitchen appliances include washing machines, fridges, freezers, dishwashers and ovens.
Musical instruments	Musical instruments include keyboards, wind instruments, string instruments and percussion.
Power tools for the home and garden	Power tools for the home and garden include electric drills and saws, hedge trimmers and lawnmowers.
Small household appliances	Small household appliances include irons, vacuum cleaners, kettles, toasters, other small kitchen appliances, and personal care appliances such as razors and hairdryers.
Small tools and fittings	Small tools and fittings include hand tools, garden tools, ladders, door handles and locks, power sockets, bulbs, batteries and wires.
Space heating and cooling products	Space heating and cooling products include boilers, radiators, water heaters, water storage tanks, storage heaters and air conditioning units.
Sports equipment	Sports equipment includes sport-specific footwear such as running shoes and football boots, and equipment such as bats, balls, weights and nets.
Toys and games	Toys and games include board games, puzzles, soft toys and electronic toys excluding games consoles.

Table 6. Nottingham Trent University in-house product categories.

Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-470

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Exploring a space of material scarcity through fiction and speculative design

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Keywords
Resources; Scarcity; Materials; Design; Functionality

Though speculative (Dunne & Raby, 2014), critical and fictional design are relatively established practices in the field of product design, they have had limited application to fashion products. The workshop: 'Generation Starships: Exploring a Space of Material Scarcity Through Fiction and Speculative Design' will help to further explore how they can be utilised as a change-making force to ideate circular economy solutions for the fashion industry. By transposing heightened contemporary issues in the fashion and textile industry into problems to solve in an extreme fictional scenario, the opportunity is presented to create radically innovative solutions.

Contemporary Context

The design industry functions as a complex, interrelated network of supply chains, stakeholders, information and material flows and cyclical timelines representing a vibrant and profitable multi-level industry. Design and production cycles are highly iterative and at times non-linear; however points of similarity exist between processes that can be summarised. A design brief outlines a task or problem; market research and creative inspiration inform decisions, while the design and synthesis phase proposes solutions. Sample making precedes promotion, marketing and wholesale orders, before production, distribution and consumption. Feedback loops within the cycle of materials supply, consumer demand, trend information and sales reports keep the critical path of the fashion system flowing constantly in this manner, without cessation. Framed in the context of the garment industry, the hyper-consumption of mainstream fashion emphasises contrasts with sustainable approaches, distinguishing between two main types of production and supply chain management. The triple bottom line aspects of social, environmental and economic impacts intuitively define the concept of sustainability (Elkington, 2004; Gunder, 2006; Markusen, 2003).

Environmental sustainability in design directly connects to production, use-phase and disposal practices, such as utilising less harmful raw materials, reusing and recycling discarded materials (Chen & Burns, 2006). Key metrics such as water use, carbon emissions, and waste and pollution levels indicate the scale of human transgression past the safe planetary boundaries from which a reversal of damage may have been possible. In the UK alone, 90 million tonnes water used by the clothing and textile industry, and 70 million tonnes of waste water were produced. The UK clothing and textile industry also produced 3.1 million tonnes of CO2e emissions in 2011 from 989,000 of fossil fuel. Globally the Carbon Trust (2011) estimate that the purchase and use-phase of clothing equates to over 850 tonnes of CO2 per year globally. In 2009 the safe planetary boundary of 350ppmv had already been exceeded and stood at 387ppmv (Rockström, 2009). 80% of the carbon impacts of clothing result from use-phase practices such as frequent high temperature washes, tumble drying and ironing (Draper, Murray, & Weissbrod, 2007).

A more balanced approach to resource efficiency requires the re-engineering of how products, components and materials are valued. The Circular Economy introduces sustainable patterns of consumption through responsible production and sustainable re-industrialisation that builds resilient infrastructure (United Nations, 2016). End-of-life materials are reused, recycled, recovered or restored as secondary raw materials in a cyclical systems of inputs and outputs (Ellen MacArthur Foundation, 2013). Renewable energy and the sustainable management of natural resources are emphasised (European Commission, 2011). The need for on-going innovation to transition the sector into a continuous positive development cycle underpins the establishment of circular economy fashion strategies.

Initiatives from the United Nations and European Commission have been limited in their legally binding capacity to achieve sustainability by alleviating global poverty. International agreements have been largely voluntary and have emphasised development through economic growth, often funded by global creditors. For the resulting financial obligations to be remunerated natural resources are exploited and environmental degradation follows. (Drexhage & Murphy, 2010; World Commission on Environment and Development, 1987). Decoupling prosperity and development from growth creates commitment to fairness and flourishing in a finite world (Oliver-Solà, 2010). Framing development in the context of whole systems thinking emphasises sustainability as the desired outcome, and provides guiding principles, processes and methods to enhance thinking on a systems based scale to utilise more circular methods of problem solving (Blizzard & Klotz, 2012). To formulate effective strategies in a circular economy, whole systems thinking necessitates the consideration of each stage in a cycle, from design and production to development and prosperity. Each stakeholder's role and viewpoint must be considered to ensure harmony and efficiency.

For effective circular economy design strategies it is necessary to consider each stage the cyclical process of design and production; including consumer viewpoints, use-phase and acquisition behaviours, resulting divestment, donation or disposal and the collection of these end-of-life materials. A significant proportion of landfill volume consists of material waste which contributes to toxic pollution, greenhouse gas emissions and the rapidly diminishing space for further landfill waste (DEFRA, 2009; Fletcher, 2008). Much of the materials into landfill through residual household waste could have been reused, recycled or recovered, creating both financial and environmental savings (Bartlett, McGill, & Willis, 2013; Woolridge, Ward, Phillips, Collins, & Gandy, 2006).

A hierarchy of end markets exists for re-circulated materials, in which the highest quality items are sold and reused locally, less good items are exported and the lowest grade items recycled, incinerated or put into landfill (Farrant, Olsen, & Wangel, 2010). For textiles, around 75% of these export sales are for reuse, and 18% are sold as recycling grades (Bartlett et al., 2013). A minimal percentage of collected textiles are upcycled into well-designed higher value items, which retail for prices comparable to those made from virgin fibres. A number of small, niche upcycling enterprises have emerged in the UK and Europe, setting a precedent for successfully creating stylistically relevant and commercially successful fashion styles utilising waste textile materials. Limited consumer understanding of the features and benefits of sustainable fashion combined with a lack of mainstream fashion coverage have restricted sales and growth in this area.

Fiction and Speculative Design

In this context it is clear that sustainability messaging has failed to demonstrate the importance of change in the practices of both the fashion designer and the consumer. New methods are required which will challenge people to think differently, allowing them a space to explore alternatives which is less beholden to prior expectations created by contemporary behaviours, visual and material cultures. This aspect is central to the speculative design work of Dunne and Raby (2014) and highlights the ability of design to transgress traditional boundaries, create ideas and stage questions, to invite re-consideration and ask 'what if'? This is a radical departure for the fashion industry, which is surprisingly unwilling to engage with change (as distinct from design novelty).

Science Fiction also asks 'what if'? It presents us with a fictional 'novum' (meaning new thing in Latin). A point of difference from our current reality, creating conditions which the Science Fiction Critic Darko Suvin describes as 'cognition and estrangement' (Suvin, 1979). Arguably this is the way our society has come to understand and engage with future scenarios as we seek elements of the familiar to enable us to suspend our disbelief at the nova, or elements of change. If the reality of our material usage and waste is not helping us to create design and making solutions for more sustainable fashion products, then can the novum (Suvin, 1979) of an extreme fictional scenario remove us sufficiently from the constraints of our current thinking? We propose the resource usage challenge of a generation starship. A closed environment, with no prospect of additional resource input on a journey to an earth-like planet which may take hundreds, or even thousands of years. This fictional scenario sets the design parameters from which speculative solutions can be developed. In this way we will test whether fiction and speculative design allow us to ideate innovative solutions to resource scarcity?

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Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-473

PLATE conference
Delft University of Technology
8-10 November 2017

PLATE
Product Lifetimes And The Environment

Electronic textiles and product lifetimes: exploring design strategies for product longevity

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Keywords
Wearables
Electronic-textiles
Clothing longevity
Product design
Sustainability

Abstract
Electronic textiles typically refer to textiles with integrated electronics (e-textiles) that can add additional functionality to a fabric or garment. Rapid growth in this area is on-going, with substantial benefits seen in sport, medicine and healthcare. Unfortunately, e-textiles can create environmental problems at the end of the product lifetimes due to the difficulties in separating electronics from textiles. The rapidly growing market for electronic textiles makes it increasingly important to find ways in which environmental impact can be minimized. Cross-disciplinary knowledge and understanding are essential to ensure environmental considerations are taken into account during the continuing development of e-textiles. This paper introduces the context of a workshop to prompt discussion on product lifetimes of electronic textiles, and strategies for improving the sustainability of this market. The workshop will include insights from a teardown of a piece of clothing with electronic functionality, giving the opportunity to find out what is inside an electronic textile and to discuss products that are being developed. The discrepancies in lifetimes of textiles, electronics and other components will be explored, along with discussion of methods of extending product lifetimes, reuse, recycling and disposing of products.

Introduction

This paper provides a context on sustainability of electronic textiles (e-textiles) in preparation for a workshop at the 2017 PLATE conference. The workshop brings together experts from electronics, product design and textiles to discuss lifetimes of an emerging product area that has yet to be explored fully. The workshop is organised by members of three research groups at Nottingham Trent University (NTU): the Advanced Textiles (ATRG), Clothing Sustainability (CSRG) and Sustainable Consumption Research Groups (SCRG). The aim is to bring together key expertise to explore discrepancies in the lifetimes of textiles, electronics and other components. Existing guidelines and further sustainability strategies will also be discussed. The priority of the workshop will be to set forth international collaboration on future research to bridge the gap in knowledge in this emerging field and to help develop new strategies for incorporating electronics into textiles in a sustainable way, specifically in relation to product lifetimes.

Context

The market for smart electronic textiles (e-textiles) and garments is growing rapidly, predicted to exceed 4.7 Billion US dollars by 2020 (Smart Textiles Market, 2017) with global technology and clothing heavyweights including, Google, Levi's, Nike, and Apple investing significantly (Balmat, 2017; The emerging e-textiles industry, 2016). E-textiles contain embedded electronics that provide enhanced 'smart' capabilities, whereby materials can sense, react to and/ or adapt themselves in response to external stimuli (Kettley, 2016; Black, 2007). These are used in the application of 'wearable technology' which exploit e-textiles as a soft surface within which connected systems can be incorporated into garments, giving potential to communicate with external devices such as smart phones or accessories (Kettley, 2016; Black, 2007; Braddock, Clarke & O'Mahony, 2005).

There are many health and wellbeing benefits of e-textiles in medical, healthcare, sports, and wellbeing contexts, where they can, for example, facilitate health monitoring (Lugoda, et al., 2015) or manage stress and anxiety (Tillotson et al, 2013). Commercial developments are often grounded in specific social contexts, such as interactive, networked 'hug shirts' that enable haptic communication between long distance partners (Cute Circuit, 2017); digital gloves that translate sign language into speech, for better communication and understanding between Deaf people and their hearing peers (Enable Talk, 2012); and temperature sensing socks that can warn of ulcer formation (Lugoda, et al., 2015).

These demonstrate that wearable e-textile garments and accessories can enhance quality of life, where the focus is on gaining societal – as well as economic – value out of technological innovation. However, literature shows that there are significant environmental issues surrounding both clothing (WRAP, 2012) and e-textile waste (Velden, et al., 2015; Kohler, 2013; Kohler, et al., 2014; Ossevoort, 2013; Wilson and Teverovsky, 2012). There is a significant risk that combining these two product areas, especially as they both represent short-life mass consumer goods, may lead to increased toxic waste (Kohler, et al., 2014). To be sustainable, technological developments must address social and economic concerns in harmony with nature, as agreed in the United Nations 2030 Agenda for Sustainable Development (United Nations, 2015). It is therefore important that design strategies to minimise the environmental impact of e-textiles products are developed, taking into consideration all stages of the product's lifecycle (Köhler, 2013). Challenges for the eco-design of emerging e-textiles have been discussed in relation to design for recycling, disassembly, and disposal (ibid.), but product lifetimes remains an underexplored area of investigation.

Product and material longevity is a key sustainability strategy: longer usable lives and circular material cycles can reduce the amount of raw materials required and reduce waste (Earley & Goldsworthy, 2015; Cooper, 2010). There are discrepancies between the lifetimes of textiles, electronics and other components in e-textiles, and complex challenges in making appropriate design choices for different garment lifetimes (Earley & Goldsworthy, 2015) that must be considered in designing for these converging technologies.

Clothing Lifetimes

It is estimated that 350,000 tonnes of clothing waste ends up in landfill in the UK every year (WRAP, 2012), and while the production, distribution and disposal phases all create environmental impacts, life cycle assessment (LCA) has found that the most effective intervention to reduce the environmental impact of the clothing industry is to extend the usable lifetime of garments through design, maintenance and re-use (WRAP, 2012). NTU research has extensively explored how to improve design and testing for clothing longevity (Cooper et al, 2016, 2014, 2013 & 2012).

A toolkit of industry-led strategies has been developed from the findings to support multi-disciplinary systems thinking across design, merchandising, business, production, marketing, and sustainability managers (Cooper et al, 2016). This included holistically promoting the importance of physical durability and testing, ensuring transparency and communication in complex global supply chains, supporting consumers through product labelling and communications, provision of lifetime guarantees, laundry, care and maintenance guidance, and enabling repair and adaptability through design. Adding emotional value to enhance user-product attachment and alternative business models to encourage greater active use of garments through leasing are also encouraged (ibid.).

Elsewhere, extending material lifetimes by keeping products in perpetual use through circular economy systems is also being explored (Earley & Goldsworthy, 2015). This explores the interplay between fast and slow fashion, recognising that different 'speeds' of products require different design approaches. As such, fashion and textile designers operate within complex problem spaces when developing and/ or selecting materials and approaches that have the most positive sustainability implications in relation to intended product use, lifetime and commercial restraints (Kane and Philpott, 2013). These considerations are particularly pertinent when aiming for enhanced 'positive' functionality offered by e-textiles and must be weighed up in relation to the social implications (ibid.). Knowledge and understanding of the whole lifecycle of materials from both a scientific, design and user perspective is essential.

E-Textile Lifetimes

In the development of sustainable garments that utilise e-textiles, the considerations mentioned above must also be considered, with added complexity of embedded electronic components. Increasingly sophisticated methods are being developed to add electronics into textiles, from early attachment to clothing surfaces or pockets (Cork 2013) to incorporating electronic functionality into the textile structure, such as incorporating electrically conductive yarns. More recent developments have seen electronic components integrated at a yarn-level (Dias, 2016) with the possibility of integrating a range of sensors (such as thermistors) or output devices (such as light-emitting diodes). Conductive inks, fibres, and power sources, may also feature.

This variety of electronic components contains non-renewable materials and minerals: plastics, metals, silicon, and 'critical' or 'conflict' minerals subject to high supply insecurity (scarcity) or geopolitical conflict (Köhler et al, 2013). Understanding of the issues surrounding these, ensuring supply chain transparency, design to enable recycling at end-of-life, use of alternative materials and promotion of sustainable products are therefore essential. Issues of physical durability specific to e-textiles include washability, durability of interconnects and inks, and lifetimes of components. Depending on the nature of a device the fibres may wear-out well before the electronics. Conversely, the rapid development of microelectronics might mean electronics may become out-dated before the material aspect of a garment. The lifetime of an e-textile is dictated by the shortest lifetime of any individual component, unless repair or replacement is possible.

Stakeholders in smart textile development, use and disposal cover a wide range including consumers, legislators, designers, engineers, garment producers, and consumers. Each group has differing priorities including functionality, cost, appearance, fashion, recyclability, and disposal. Ensuring knowledge and understanding of sustainability across design and production will be imperative, alongside supporting sustainable consumer behaviour during use, care and end of life. Lifecycle and systems thinking approaches are therefore required alongside technological research and development to enable design for sustainability of these converging technologies (Köhler, 2013), in order to consider their design, manufacture, use and end-of-life for extended product lifetime or maximised circular material lifetimes.

There are a variety of questions that need to be asked regarding this topic. Key to the focus of this workshop is what is the expected lifetime for an e-textile? Consumer perspectives on smart wearables in relation to clothing lifetimes, care, use and disposal also need to be explored. It is also important to deliberate the ethics of materials used and how they affect the waste stream, particularly identifying components that should never be integrated into textiles from either a safety or sustainability viewpoint. Currently it is unclear whether e-textiles are covered by textile legislation, or electronics legislation, and current recycling schemes for e-waste (Waste Electrical and Electronic Equipment Directive, 2005 [WEEE]) are not technically suited to deal with them (Köhler et al, 2014) so clarification and action is required. Reviewing these aspects together this will help to inform industry-led design strategies that ensure sustainable development within this emerging industry.

The Workshop

The aim of this workshop is to explore aspects of sustainability and product lifetimes relating to e-textile garments.

The introduction will include insights from the teardown of a smart garment, giving the opportunity to find out what is inside an e-textile and discuss products being developed in this fast growing market. The discrepancies in lifetimes of textiles, electronics and other components will be explored with an expert panel representing different perspectives relating to the research, development, manufacturing, and use of wearable e-textiles products. This will be followed by group discussions to explore each perspective further and discuss sustainable strategies.

Objectives include:

- To identify the current provision of sustainable strategies / toolkits for the development of smart wearable e-textiles;
- Discuss and explore a wide range of perspectives on the sustainability and lifetimes of wearable e-textile products;
- Extract data to identify challenges and opportunities to developing and implementing sustainable smart e-textiles design strategies;
- Identify research interests and map out future research proposals for potential cross-institutional international collaborative research proposals.

Proposed outcomes of the workshop will include:

- A new set of directions for the field, available open access to all participants after the event;
- Identification of collaborators for making funding applications at national, European and international scales to further the research agenda and/ or collaborate in an international research network.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-477

Interdisciplinary educational approaches to clothing longevity

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Keywords
Clothing longevity
Sustainable fashion
Sustainable education
Interdisciplinary

Abstract
How do we encourage and enable interdisciplinary systems thinking approaches to sustainable fashion design and business education? In preparation for a workshop at the 2017 PLATE conference, this paper introduces the context of a toolkit – The Clothing Durability Dozen (Cooper at al, 2016b) – aimed at enabling students to collaborate and learn about clothing longevity across disciplines and creating a better understanding of the roles that different departments can play in placing sustainable design strategies at the heart of the clothing industry. In line with education for sustainable development (ESD) principles, objectives include stimulating learning and promote core competencies, such as critical and systemic thinking, collaborative decision-making, and taking responsibility for present and future generations. In the workshop, participants will trial and contribute to the development of the toolkit and any necessary supporting material, the final version of which will be available for use as an educational tool.

Introduction

The Defra funded project 'Strategies to improve design and testing for clothing longevity' at NTU (2014-16) explored the technical, behavioural and strategic obstacles to implementing innovative and sustainable product development processes for extended clothing lifetimes and reduction of clothing waste (Cooper et al. 2016a). This followed WRAP's Valuing Our Clothes report, which estimated that 350,000 tonnes of clothing goes to landfill each year in the UK and identified life extension of clothes as the most effective strategy for reducing waste and the overall impact of clothing across garment lifetimes, from production to end-of-life (WRAP, 2012, Cooper et al, 2013).

Identification of the knowledge, skills, processes and infrastructure that could support design for longevity informed the development of a toolkit – The Clothing Durability Dozen – to enable clothing companies to collaborate across different departments, as it was found that the knowledge and skills often exist within the industry, but a more joined up, strategic approach is required, recognising that design for longevity should be an essential element of the entire fashion system (Goworek et al. 2013).

It has also been recognised that interdisciplinary systems thinking approaches to sustainable fashion education are necessary to teach new skills and aptitudes required in the global fashion industry (see for example: Williams, 2016; Earley et al, 2016). A movement supported by the United Nations, education for sustainable development (ESD), has advocated the holistic integration of sustainability in all higher education disciplines (UNESCO 2003, 2005 quoted in Armstrong & LeHew, 2014), with objectives to stimulate learning and promote core competencies, such as critical and systemic thinking, collaborative decision-making, and taking responsibility for present and future generations (UNESCO, 2017). It is also evident that a gap exists between design education and professional practice: departmental silos in education tend to work in isolation, preventing students from learning about working and communicating across disciplines, which is an essential part of industry working practice (Claxton & Kent, 2017; Earley et al., 2016).

An educational version of the Clothing Durability Dozen toolkit (Cooper et al., 2016b) has consequently been developed with the aim of enabling students to learn about clothing longevity as a sustainable fashion strategy, whilst considering the roles played by different interrelated departments in a fashion company, e.g. fashion designers, textiles designers, technologists, buyers, design managers, marketers, business strategists, and supply chain management. It takes an active, participatory approach to problem-based learning, involving students from a variety of educational departments playing different industry roles, underpinned by education for sustainable development (ESD) principles.

In preparation for a workshop at the 2017 PLATE conference, this paper introduces the context and background to the educational tool kit's development, which workshop participants will trial and contribute to. The final version will be available as an open access educational tool.

Education for Sustainable Development & Clothing Longevity

ESD aims to create interactive, learner-centred teaching and learning settings that support interdisciplinary collaboration and the development of the key competencies needed for promoting sustainable development (UNESCO, 2017). In the context of sustainable clothing and fashion education, this has been explored through diverse methods such as role-play (Williams, 2016), tool kits, (Earley et al, 2016), board games (Dobrosmyslova & Tångne, 2013), co-design workshops and digital platforms (Ballie, 2012; Hur et al, 2013), alongside conventional approaches such as lectures, workshops and student presentations (see for example Re:Dress, 2016). All advocate active learning through collaborative working and creative practice to better understand the context and background e.g. issues of sustainability in the fashion and textile industry and approaches to make things better. This is supported by design education theorists, advocating sense-making through making and doing. Gauntlett (2011) for example, argues that a hands-on approach to learning, and a spirit of enquiry and questioning, is required to make students thoughts, feelings or experiences manifest and tangible. The need for designers to develop empathy, curiosity, deep industry and sustainability understanding have been found to be key collaborative skills required to work across disciplines, essential for systems level change in the fashion and textiles industry (Earley et al, 2016).

Educational resources to support this include the TED 10 tool kit of sustainable fashion and textile design strategies, which are a very effective way of introducing key sustainability terms and approaches (TED, n.d.) and the Eco Chic Design Award Educators' Pack (ReDress, 2016), which include topics such as garment lifecycles, zero waste approaches, upcycling and reconstruction with supporting workshop activities and slideshow to introduce issues and case studies. These can facilitate active learning through making and encourage systems thinking, but are aimed exclusively at fashion and textile design students, working within predefined departmental silos. These educational silos and a general lack of set tools, staff knowledge, understanding and confidence to deliver have been identified as challenges in incorporating sustainability into textiles and apparel education (Armstrong & LeHew, 2014).

Industry guides have been developed recently to support industry practitioners, highlighting both the benefits of clothing longevity as a sustainability strategy and the challenges of integrating this into current industry practice. WRAP's Sustainable Clothing Guide (2017), for example, has been developed for industry, specifically focusing on life extension approaches to sustainability. Key approaches to achieving and enhancing clothing durability are outlined with a range of engaging tips, case studies and recommended action points for companies, including the importance of getting together with colleagues to plan and implement change across departments. Similarly the forthcoming Design for Longevity online platform, developed by the Danish Fashion Institute, aims to support sustainable fashion by helping designers and product development teams to adapt design practices towards longevity and circularity (DFI, 2017). Its authors recognise that designers do not often have the agency to enable change directly though, usually working in departmental silos on restrictive briefs without the authority to make change, but state that the platform aims to equip them with the knowledge and understanding to challenge existing ways of working (DFI, personal email communication, May 10, 2017). While both could be used as teaching aids or engaging and informative reading material for students, they are passive guides and neither include practical tools for facilitating collaboration between departments.

The educational version of the Clothing Durability Dozen tool kit aims to work towards addressing these gaps in HEIs by supporting the continuing professional development of academic staff whilst also allowing students to develop knowledge, understanding and key ESD competencies required for enabling sustainable change when in future industry roles.

The Clothing Durability Dozen

The Defra clothing longevity project built on previous research (Cooper et al., 2013; WRAP, 2013; Cooper et al., 2014) by drawing on technical innovations combined with knowledge of consumer perspectives, new product development (NPD) practices and commercial objectives (Cooper et al, 2016). Findings from a series of research activities resulted in the development of a tool kit for the industry, the Clothing Durability Dozen, intended to be a collaborative training resource and point of reference for industry practitioners and students.

The tool kit has been designed to enable clothing companies to collaborate across different departments, as it was found that largely the knowledge and skills exist in industry, but a more joined up, strategic approach is required to pool resources and make change happen. Containing clear concise materials, examples, and links to related or existing materials, such as WRAP's aforementioned Sustainable Clothing Guide (2017), the twelve topics cover areas specific to life extension in a wide and holistic way:

1. Designing for Durability
2. Understanding Consumers
3. Testing for Durability
4. Transparent Supply Chains
5. Product Labelling
6. Lifetime Guarantees
7. Cleanliness, Laundry & Care
8. Ease of Maintenance & Adaptability
9. Enabling Repair
10. Creating Emotional Value
11. Alternative Business Models
12. Communicating & Promoting

(Cooper et al., 2016b)

Figure 1. Front cover of Clothing Durability Dozen toolkit (Cooper et al., 2016b)

It will allow brands to recognise, map out and celebrate what they are already doing in these areas, and plan how they can go further. In an educational context, it is intended for use by groups of students from different departments such as fashion, textile and knitwear design, fashion management, marketing, and business courses. By role-playing industry positions, it will allow students to actively learn about and understand clothing longevity as an industry sustainability strategy together. By doing this, it offers a new approach to bridging the gap between education and industry practice.

The workshop

The aim of the workshop is to develop the educational version of the Clothing Durability Dozen toolkit by gathering feedback on the content, format and delivery from a variety of stakeholders.

The workshop will take the form of a facilitated role-play workshop to trial the toolkit across educational disciplines, e.g. fashion design, textile design, fashion technology, fashion management, fashion marketing and communication, business management, supply chain management etc., followed by the opportunity to provide feedback on the toolkit content, format and delivery.

Objectives include:

- Demonstrate and encourage interdisciplinary systems thinking approaches to sustainable fashion design, specifically clothing longevity;

- Gather feedback on the toolkit design, content and delivery with educators, researchers, students and industry representatives;

- Build participants' knowledge and understanding of clothing longevity as a sustainable fashion strategy

Outcomes

Outcomes of the workshop will be data gathered by observing participants, gathering feedback and design suggestions to inform final version of the educational toolkit. The final version of the toolkit and supporting educational material will be shared with participants for use as a teaching aid.

Acknowledgments

The tool kit presented in this paper resulted from a Defra funded research project EV0553 'Strategies to improve design and testing for clothing longevity'.

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Product Lifetimes And The Environment
2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-480

Practicing cherish-ability as a designer 2017

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Introduction

This paper provides a reflective review of the authors commercial textile design label 'SK Mclauchlan' founded in 1980 and practicing sustainable design since 1999. SK Mclauchlan's design philosophy involves designing 'pieces' that act as modern family heirlooms that can be passed from one generation to another using only materials that have already had a first life. This collaborative design process is undertaken in consultation with the end user and the design specifications are tailored to their own identity and personal preferences. This involvement added: individuality and content for the design pieces, which ranged from cushions / Christmas stockings, wall hangings to bed spreads. The pieces were either designed for the actual client or designed for another person to be gifted by the client.

This paper will provide an overview of SK Mclauchlan's design process and explore emotional durability within a textile design context. Furthermore, research will be undertaken to revisit a sample selection of pieces from the client's own archive to identify if they are indeed as emotionally durable, as intended. Finally, closing discussion will make recommendations for future research and share personal insight for fellow designers.

Practice Led Research

This case study references pieces made specifically for a particular client who contributed to an inclusive design process and together they developed a piece that incorporated emotional durability and explored cherish-ability (Chapman, 2006). This longitudinal study evolved over an extended period of time (1999-2017) and took place through physical and digital consultations and visual exchanges until the content and composition was agreed upon. The commissioned piece was then further designed and hand stitched by SK Mclauchlan adding decorative stitch via hand embroidery which was further embedded into the cloth.

Research

This research will apply an ethnographic approach to reflect back upon the designed artifacts to examine if the bespoke items are still in circulation, have they been kept and treasure? Have they been passed onto another generation as intended or have they been discarded? The findings from this enquiry will form the basis of the paper and proposed work shop.

This research will be a comparative analysis between a ' cherishablity' model and a traditional commercial model.

Rationale

According to Chapman, 'emotional durability' can be achieved through consideration of the following five elements. Each of the values below has been adhered to during the design process and the principles imbedded into the philosophy of SK Mclauchlan as a practicing textile designer.

Narrative: How users share a unique personal history with the product.
Consciousness: How the product is perceived as autonomous and in possession of its own free will.
Attachment: Can a user be made to feel a strong emotional connection to a product?
Fiction: The product inspires interactions and connections beyond just the physical relationship.
Surface: How the product ages and develops character through time and use.
Methodology: Adhering to the above principles research was collected digitally and orally using a questionnaire. The questionnaire was a method that would directly enable SK Mclauchlan to find out if the intended longevity of the pieces had been met.

Reasons for commissions

The original pieces were commissioned and gifted to clients from Scotland, London, Los Angeles, Canada and Australia. Age of pieces range from 1993-2017(1year to 24years). A range of reasons were given for design requests: Celebration /remembering an important event (18th birthday/ Wedding anniversary/ recognition of tradition / marking of a significant time or event/ a personal message of love. All requests were unique and personal to the client or commissioned by the client to gift to another.

Surprising Finding

An unexpected finding which further demonstrates the theory behind the practice: A client from Denmark had a problem: Her new puppy had quite severely damaged her commissioned wedding blanket. The choice was to replace the blanket with a new one or commission a repair. She chose to commission a repair and add this repair to their family story the repair was not perfect but the story it held was more important.

Some of the original reasons for ordering the pieces had changed but the pieces were still 'cherished'. (E.g. Blanket designed for a young boy whose teenage style now does not connect now with the younger content but the piece is still kept for the future it's the hope that blanket will be given to the next generation.)
Some of the younger clients who the pieces were designed for interpreted the work in a different way in which it was intended-noted that they enjoyed owning a piece that had a history to it. Clients have enjoyed the hand stitched quality of the work more than ever envisaged.

Clients responses

- Visually transport to a happy time (child now grown up)
- The piece 'tells' a story which adds to the families own history.
- Child slept with it acted like a security blanket.
- Pleasure that you have given and own something that will last a very long time.

- Personal enjoyment that someone has gone to the effort to design something especially for you.
- Several clients stated pleasure of owning something. Unique to them.
- Recognition of hand skill added value to the piece.
- Creating our own family tradition.
- Pleasure each time it is 'brought out' for Christmas. The family are making their own traditions.
- 'Most prized possession" hope that it will be handed down each generation and the memory of them will continue after their life and ceased.
- Celebration of the child's personality.
- Visual marking of time.

Comments on material longevity

Condition of the piece had lasted extremely well many saying "it was as good as new" even though several years old (oldest piece 24years old).
Tactile quality enhanced due to the nurturing feel of wool. The material is generally considered a high value material and as such increased its purpose and life span.
As a strategic approach, "emotionally durable design provides a useful language to describe the contemporary relevance of designing responsible, well made, tactile products which the user can get to know and assign value to in the long-term. Professor Jonathan Chapman.

"Cradle-to-cradle also challenges us to think about the real problem why we invented a product in the first place, and then think about ownership. In this way new business models can be designed."

The client felt involved in the process which further added to their emotional investment in the piece and added further value to the gift. The selection of the materials further added to the longevity of the piece. In terms of care and maintenance restricting the materials to either 100%wool or 100% cotton further encouraged product longevity. Tactile quality and material longevity further extended life time and appeal.
Additional benefit in selecting (1) material will enable the piece to be disassembled more successfully". Create products that are easy to disassembly: easy to repair/ modify " Fiona Balgooi
Materials for the proposed workshop have been collected via 'drop' off bags placed in the Textile studio at ECA. The bags have a suggested colour label attached to the them to encourage design students to value all resources. It acts as a visual display and a constant reminder of the surplus resources generated by textiles. Finding a 'use for this surplus is circular and recent involvement in https://remantleandmake.wordpress.com/about/ highlight the quality of some of the surplus resources founding manufactures in Scotland.

Traditional Commercial Model

The traditional role of commercial textile designers encourages them to design products directed by current trends. Material and content selection is driven by trend forecasts. This model encourages the designer to create many possibilities for the client. Choice encourages excess as many interpretations of a trend are demonstrated and presented to the client (the selection process generates waste)
The practice encourages choice with many pieces designed in order to determine the maximum option for the client. This model inevitably generates excess. It is estimated that the ratio of successful sales is 40% then a further 10% lost at production. As a designer, the wasted resources needed to fulfill this role was compared to SK Mclauchlan's Cherishability model which generates no waste.

Conclusion

In terms of designing a product that is designed to last we must also take care to enjoy the product. The product can become sacred with little or no inter action. Tactile purpose redundant and emotional connection lessened.
The over all opinion which was constantly commented on was the pleasure gained for a product that was not throw away was immeasurable. It sought to add balance in our modern 'throw away 'society. Ownership was long lasting and grounded by passing the product onto another generation.
The more purpose and individual the product was in relation to the client the longer it appears to be cherished and if it is cherished it will be cared for and considered important enough to become a modern family heirloom which will enhance it's product longevity.

To date all design pieces since 1999 are in circulation with the intention that they will be passed onto the next generation.

Product Lifetimes And The Environment 2017 - Conference Proceedings
C. Bakker and R. Mugge (Eds.)

DOI: 10.3233/978-1-61499-820-4-482

PLATE conference
Delft University of Technology
8-10 November 2017

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Product Lifetimes And The Environment

Consumer intervention mapping: a tool for the imagining of re-distributed manufacturing futures with consumers in the loop

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Introduction

This short paper describes work carried out as part of the 'Business as Unusual – Designing Products with Consumers in the Loop' feasibility study, which forms part of the EPSRC-ESRC (UK) funded Network in Consumer Goods, Big Data and Re-Distributed Manufacturing (RECODE)[1]. A multidisciplinary team from Cranfield University, Open University, Imperial College London and Loughborough University, and practicing industry leaders in the fields of sustainability, manufacture, big data, circular economy and consumer goods, were involved in the delivery of this feasibility study.

Consumer Intervention Mapping

Within Customer Relationship Management (CRM), Consumer Touchpoints (Dahan, Soukhoroukova, & Spann, 2010) are a well-established tool for understanding the interactions between a brand and its customers (Baxendale, Macdonald, & Wilson, 2015; Hogan, Almquist, & Glynn, 2005; Martin, Rankin, & Bolinger, 2011). The purpose of a consumer touchpoint diagram is to show all potential opportunities customers to "experience" the brand – for example advertising, packaging, after-sales service, etc. Touchpoint diagrams have been used in both academia and industry, to understand customer-brand relationships in sectors as diverse as energy supply, charities and consumer electronics. However, CRM typically focuses on interactions which the brand can control, ignoring those which brands are unable to influence. Consumer interventions such as post-purchase modification, repair and re-sale have therefore received little attention.

Within service design (Voss & Zomerdijk, 2010), Customer Journey Maps (CJM's) (Government, 2007) are employed as a method for documenting ways in which customers experience product-service systems. CJM's utilise touchpoints to understand how consumers perceive and relate to brands over a relevant timescale or throughout a relevant process. However in order to manage the chaotic feedback resulting from every customer having their own journey, brands typically employ personas to 'summarise' a subset of consumers (Dhebar, 2013). This inevitably focuses attention on a brand's core customers while excluding its outliers; as a result opinions of customers engaging with a brand in new or unexpected ways can be overlooked. In addition, in conventional manufacturing paradigms, customers appear at the end of the value chain (Gereffi & Frederick, 2010), i.e. the value chain is taken to end when a product is sold. In a re-Distributed Manufacturing (RdM) paradigm (EPSRC, 2013), customers can be engaged earlier (Sinclair & Campbell, 2014), and the value chain extended further. CRM literature has not previously given attention to CJM's within NPD, and has therefore neglected instances where customers engage with the design and production of products and services, rather than just their consumption.

We have introduced the concept of Consumer Intervention Mapping to visualise opportunities for consumers to intervene in intended or expected product lifecycles. In line with CJM methodology it takes a user-centric perspective, but untypically gives attention to outliers as well as core customers. Crucially, it allows journeys to be mapped throughout the entire product lifecycle, from design and manufacture, through sale and use, to repair, re-sale and disposal. A Consumer Intervention Map (CIM) can therefore explore new models of production and consumption which fall into re-distributed and circular economy paradigms (Moreno & Charnley, 2016).

In common with existing CJM models, the CIM depicts the customer journey space at increasing levels of detail. The widest level comprises three phases (Davis & Dunn, 2002): Purchase, Pre-Purchase and Post-Purchase. At the intermediary level, six phases (Chan & Mauborgne, 2000; Stein & Ramaseshan, 2016; Yohn, 2013) model the NPD process through to Usage. Finally at the narrowest level of detail, 18 discrete phases are represented (Chan & Mauborgne, 2000; Moreno & Charnley, 2016; Stein & Ramaseshan, 2016; Yohn, 2013). Following a systematic review of the literature, the map has been populated with relevant touchpoints, i.e. those where consumers directly and intentionally intervene to alter the brand's intended, or expected, customer journey (https://doi.org/10.17028/rd.lboro.4772275.v1). Passive touchpoints (for example

[1] The full report from this study will be available at http://www.recode-network.com/ in Q2 2017

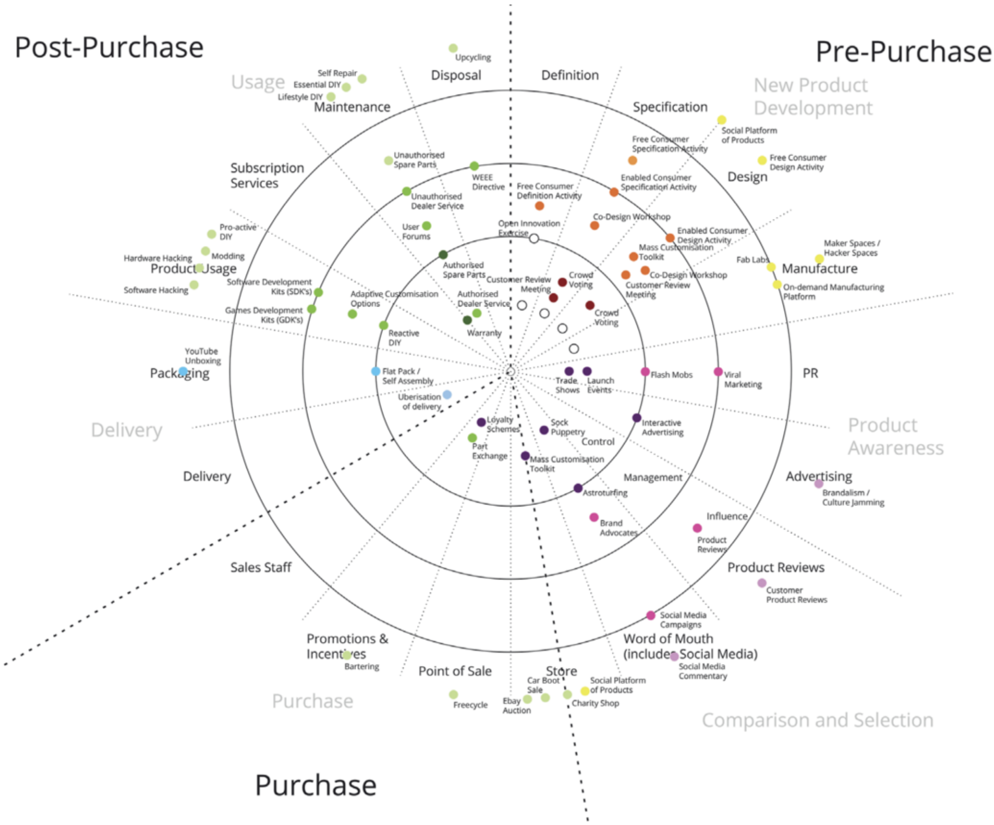

Figure 1. Consumer Intervention Map fully populated with intervention touchpoints.

magazine advertising or sales staff interactions) that do not involve consumer intervention are excluded. Finally, the identified touchpoints are mapped to their appropriate phases in the product lifecycle (Figure 1). Colour coding is used to identify touchpoints as occurring at different stages in the product lifecycle – manufacturing (orange), communication (pink), supply (blue) and usage (green); these are coloured darker or lighter according to the degree of intentionality a brand or manufacturer has in allowing consumers to intervene at this touchpoint.

Future Scenarios of Consumers in the Loop

Scenario planning is a methodology widely used by industry as a strategic planning tool which "aims to rediscover the original entrepreneurial power of foresight in contexts of change, complexity, and uncertainty. It is precisely in these contexts – not in stable times – that the real opportunities lie to gain competitive advantage through strategy" (Wack, 1985). Envisioning future scenarios enables companies to understand how the future might look based on the critical uncertainties facing them. The most common approach is the 'two axes method', allowing four contrasting scenarios to be generated (Government Office for Science, 2009). These visions can then be used for targeting shifts in business mind-set, strategy and activity.

In line with the aims of the RECODE network, this study's vision of RdM is based on three key assertions – that manufacturing is localised, people are involved in the design of their products, and overall resource use is low. Based on these three founding concepts, two critical uncertainties (or in this case, opportunities) are identified:

- *Product Longevity:* The length of the lifecycle of different types of products can vary greatly, from durables to disposables. Short life cycle products can include items such as food, personal care, and fashion; long life cycle products can include items such as electronic goods, furniture and homewares.
- *Consumer Design Drivers:* The type of consumer engagement in the process can vary greatly, depending on the types of user data and mechanisms of interaction available. Consumer inspired design occurs when large amounts of anonymised trend data is available to help direct design; consumer-led design occurs when individual users are able to be more hands on in driving design.

These uncertainties are used to create two axes and identify four quadrants for scenario planning. Each scenario describes a future of RdM based on four core factors: Design (is it carried out by consumers, or by experts?); Technology: (are important developments needed to support the supply chains, production, or consumer engagement?); Data: (is the most available and appropriate data used for consumer engagement big or small?); and Companies: (are they large multinationals or smaller local companies?).

Four scenarios based on these core factors have been developed (Figure 2) as follows:

1. CIRCULAR CONSUMABLES: Circular products with short life cycles are designed by gathering crowd sourced data to understand the needs of many, then produced, consumed, and recycled in a localised system.

2. DEMOCRATIC DESIRABLES: Connected products with extended life cycles are designed by monitoring life cycle data collected from embedded sensors, then produced, maintained and exchanged in a localised system.

3. TAILORED TEMPORARIES: Circular products with short life cycles are designed by individual consumers who tailor their products through dedicated online portals, then personalised, used, and recycled in a localised system.

4. ENGAGING ENDURABLES: Durable products with very long life cycles are designed by individual customers who work with makers to customise their purchases, then crafted and exchanged in localised systems.

Imagining re-Distributed Manufacturing with Consumers in the Loop

Based on the theoretical foundation described, two workshop activities have previously been devised and validated (materials for both workshop activities are available at: https://doi.org/10.6084/m9.figshare.4749727.v2).

The first of these involves the use of a toolkit to build future RdM scenarios. Working in the context of the four core factors previously described, participants are required to

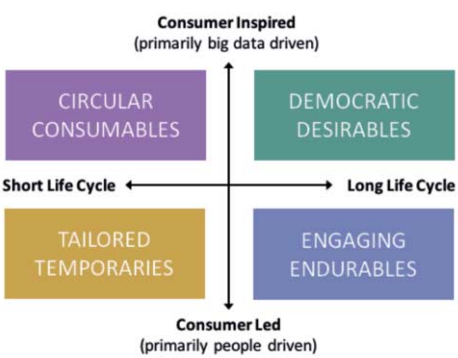

Figure 2. RdM scenarios.

Figure 3. Example RdM lifecycle scenario.

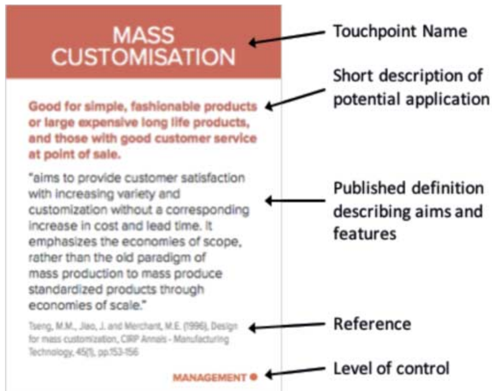

Figure 4. Layout of example customer interaction card.

consider the product lifecycle of a chosen product with regard to its design, purchase, usage and disposal. From previous exercises, a number of compelling stories have been created (Figure 3), identifying novel business models that may emerge as a result of local manufacturing with a low throughput of resources.

The second workshop activity involves participants creating a customer journey map through the new touchpoints, interactions and services needed to support new business models such as those generated in workshop activity 1. To help participants generate visions of their customer journeys, a set of Customer Interaction Cards has been developed (Figure 4). Method cards such as these are used widely in design practice as tools for enabling collaborative ideas exchange, and allowing participants to visualise and converge on concepts together (Wölfel & Merritt, 2013).

These cards, when used in conjunction with the CIM, enable participants to plot detailed and specific customer journeys (Figure 5). More generally, outputs from workshops conducted to date have typically revealed opportunities for re-Distributed business models in three main areas:

- *Collaboration:* By giving more control customers during the development of products, better communication can be facilitated. This could lead to stronger relationships between companies and people that last the full duration of the product lifecycle.

- *Responsiveness:* Closer relationships can also build trust and feedback loops between companies and customers. This enables more flexibility, and an ability to respond and adapt to user needs and other uncertainties.

- *Business Models:* More responsive modes of operation could unlock new business opportunities in RdM, enabled by new manufacturing technologies and customer engagement.

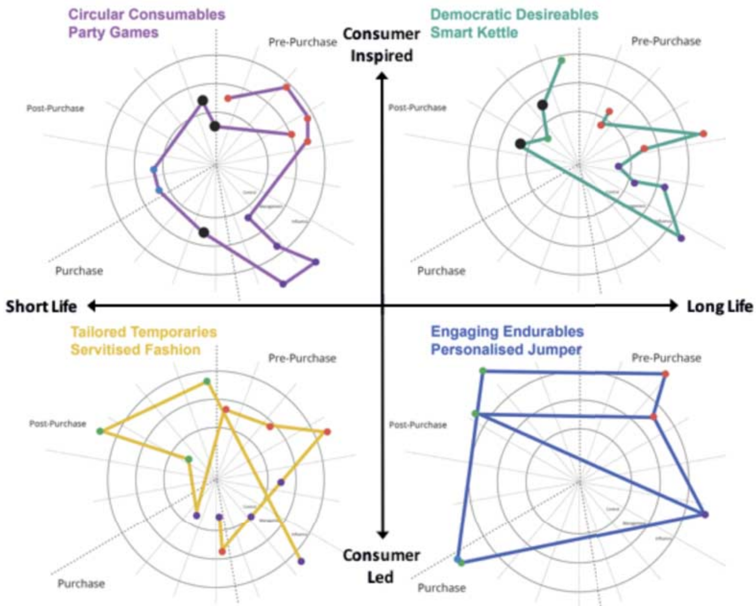

Figure 5. Workshop generated customer journey.

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