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Radical transformation or restricted agenda?

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Industry 4.0 in Construction: Radical transformation or restricted agendas?

Abstract: The fourth industrial revolution (Industry 4.0) is poised to transform the architecture, engineering and construction (AEC) sector from a project-based industry to a market-based industrialised process. Yet, its (s)low uptake can be attributed to current emphasis on technological adoption. In this briefing note, it is argued that ignoring non-technical aspects such as the social will to change and ethical choices can result in Industry 4.0 failing to deliver its transformative power in the AEC sector. Rather than to focus on technology, questions are raised around systemic change by considering people and process issues. Furthermore, instead of focussing on the calculative value of Industry 4.0, there is also a need to consider (ethical) values when making decisions in the data-driven world of Industry 4.0.

Keywords: business, ethical values, information technology, Industry 4.0, management, social change.

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Introduction

In the recent McKinsey report *The Next Normal in Construction*, Ribeirinho *et al.* (2020) outlined future trends, which call for transforming construction from a fragmented project-based industry to a market-based industrialised process that integrates design and fabrication. This perennial call for integration has resurfaced again in the discourse of the fourth industrial revolution (or Industry 4.0), a rhetoric that has garnered growing support in policy, practice and academia.

Industry 4.0 describes the fourth wave of industrial transformation driven by data, digital technologies and automation, and distinguishable from earlier waves of mechanisation (first revolution), electrification (second revolution) and computerisation (third revolution) (see e.g. World Economic Forum, 2018, and; Dallasega *et al.*, 2018). The fourth revolution lies not in the creation of new technologies *per se*, but in the combination of different technologies, many of which have already been developed decades ago. This technological bricolage that increasingly blurs the line between the digital (or virtual) and the physical world allows for the automation of decision-making and for turning data into value-creating opportunities. In finding new ways to generate value, especially following recent crises such as the Global Financial Crisis and now Covid-19, Industry 4.0 has manufactured the (re-)imagination of a brave new mass-personalised and self-configured world deemed to be(come) more efficient and flexible.

Despite the optimistic outlook of Industry 4.0 technologies, the problem of scaling up Industry 4.0 technologies continues to persist. Numerous surveys have shown how the AEC sector lags behind other sectors in implementing Industry 4.0 technologies (e.g. Manyika *et al.*, 2017, and; Hawksworth *et al.*, 2018). Often, the gap between the aspirations and actualities of Industry 4.0 in the AEC sector is explained through the problem of resistance to technological change (see e.g. Hall *et al.*, 2020). An argument is put forward in this briefing note that the narrow focus on technology has thus far limited the potential for Industry 4.0 to deliver radical transformation. Simply emphasising technological adoption ignores the social and ethical aspects needed to realise the transformative power of Industry 4.0. The purpose of this critique is therefore to shine the spotlight on the social aspects and ethical choices, in order to generate further interesting and important questions on Industry 4.0 in the AEC sector.

Just because we *can* does not mean we *will*…

To promote Industry 4.0 technologies in the AEC sector, there has been an emphasis on the benefits of efficiency in reducing the cost and time for building. These tended to showcase what the technology *can* do. Technologically-deterministic accounts abound to highlight ever-expanding digital capabilities in the AEC sector. New modelling capabilities, for instance, can build on the power of new data representations leading to novel, more optimised building geometries that in turn affords better user comfort and satisfaction. New sensing capabilities embedded across the supply chains can help produce more efficient logistical flows that in turn reduces the carbon and energy footprint of the AEC sector. New machine learning capabilities can help automate decision-making for better integration between design, construction and maintenance of the built environment.

Notwithstanding the technological capabilities of Industry 4.0, the problem of (s)low adoption in the AEC sector is due to non-technical reasons. In a poll of 23 senior executives, for example, the World Economic Forum (2018) found that the key impediments to adopting Industry 4.0 technologies at scale lie with challenges of recruiting and upskilling the workforce (i.e. people) and collaboration across the value chain (i.e. process). Manyika *et al.* (2017) also argued that even if there was the business case for technological deployment, there are social reasons that explain why the sector will not scale up these developments, since "the world's economy will actually need every erg of human labor working, in addition to the robots, to overcome demographic aging trends in both developed and developing economies" (p. 2). Furthermore, as Hawksworth *et al.* (2018) stressed, just because something can be done using the latest technology does not mean that there is the will to change; often regulatory and organisational constraints can get in the way.

The AEC sector is a mature industry with a well-embedded structure of professional and craft-based roles organised to deliver projects. Breaking this institutionalised mould to embrace systemic innovation is therefore challenging. Incumbent organisations tend to resist the entry of disruptive newcomers who do not conform to existing structure and practices of the industry (Hall *et al.*, 2020). This also explains why reviews of Industry 4.0 in the AEC sector have thus far highlighted its limited application, with scholars mainly focussing on building information modelling rather than the broader ecosystem of Industry 4.0 technologies (see e.g. Oesterreich and Teuteberg, 2016). Given the complex and risk-averse nature of the AEC sector, new technologies are often cautiously introduced typically by adding incrementally new technical functions to existing technological regimes (Chan, 2020), and where it is common to see a hybrid of new practices combining with old habits and logics (Boland et al., 2008; Harty and Whyte, 2010).

Embracing technological change required in Industry 4.0 is therefore not just a matter of adopting new technologies. Systemic change is needed. Robinson *et al.* (2016), for instance, studied how Laing O'Rourke developed the modular plant room with a view to drive more predictive performance from mechanical and electrical (M&E) services. Although sensing played an important part to provide intelligence for predictive maintenance, generating new value was not only about embedding more or better sensors, but also an overhaul of the activity system. Combining years of developing expertise on design for manufacture and assembly (DfMA) and offsite production, Robinson *et al.* (2016) traced how introducing new sensing capabilities to existing M&E services can disrupt existing value chain (contractual) relationships, communities of practice, division of labour and performance outcomes. As Hall *et al.* (2020) found, making systemic change towards a more industrialised process in the AEC sector requires strategic change in managing established and emerging players across the value chain and getting partners to step outside of their knowledge comfort zones.

… and if we *will*, it does not mean we *should*.

Following the spread of the Covid-19 pandemic, lockdowns have severely affected supply chains and on-site activities all around the world. Consequently, two immediate responses can be observed. On the one hand, there are those who call for greater capital investment. These technological optimists take the view that

investing in technologies can substitute human labour thereby making the industry more resilient to future lockdowns and pandemics. So, for instance, robotics, artificial intelligence and prefabrication offsite can ensure continuity in production, while drones can help monitor the condition and progress on site. On the other hand, employers have also been anxious to reopen construction sites swiftly by making the case that construction workers are also essential workers[1] vital to keeping the infrastructure running. Although seemingly distinct, what these responses have in common is the making of (ethical) choices of machines over humans, productivity over health, both of which point to the relative lack of valuing human labour.

In moving towards an industrialised process, Industry 4.0 privileges the standardised and standardisable, the calculative and the calculable. In the data-driven world projected in visions like those found in McKinsey's *Next Normal in Construction*, algorithms overtake (human) managers in bundling resources together so that market efficiencies can finally address and eradicate the problem of waste in project-based working. With the machine dominating, humans become the expendable force. In modelling the future of employment, Frey and Osborne (2017) unexpectedly found that jobs in the construction industry are extremely susceptible to computerisation. Nevertheless, this should not come as a surprise. For all the exhortations of the market value of technology giants like Google, the employment figures of these firms pale in comparison to those of traditional production firms. In Hall's *et al.* (2020) analysis of Project Frog, for instance, they found that to maintain strategic advantage, their workforce needed to shrink by more than half within a three-year period. At a time when recovery from the Covid-19 crisis means that jobs must be created and sustained, this again raises the question of ethical choice. And such choice is not just about the number of jobs, but also about the quality of jobs. In a critical essay, Fleming (2019) asked why so many poor-quality, low-paid jobs persist in an age when robots promise so much of a better, much easier future.

The drive towards Industry 4.0 also brings with it a spatial concern. Notwithstanding the developments in offsite production, the AEC sector remains distinct from its manufacturing counterpart in the site-based nature of its production. It is the unpredictability of assembly on site that led respondents to Manyika's *et al.* (2017) survey to think there is a less than one-in-two chance of fully automating construction. Furthermore, its localised production also means that construction activity invariably connects, physically and culturally, with its situated environment. As Cho (2018) remarked, "elements are shuffled within the unrehearsed nature of their surroundings, tilting and shearing between their organic boundaries, just as the building itself snuggles into the hillside". For Marina Tabassum, an architect who won design awards for the Bait Ur Rouf Mosque in Dhaka, buildings are not just technical artefacts but also "living beings" that breathe and have a soul (cf. Cary, 2017: 203). Thus, the imperfections of (handi-)craft work in construction also invokes a sense of engagement with local materials, local labour, and local communities.

By exploiting the economies of scale and scope in Industry 4.0, the AEC sector is being transformed into a globalised sector, where the locus of production can be anywhere and nowhere. Yet, this drive to standardise and industrialise does not necessarily translate to better built environment outcomes for the communities it

[1] Similar to workers in healthcare and emergency services

serves. As one of Hall's *et al.* (2020) case study demonstrate, turning construction from a localised site of production to one that bundles together resource requirements from multiple projects in the market, attention is shifted towards feeding the factory such that "a steady line of production" can be maintained – in the words of one of the interviewees, "The factory is a "hungry beast" burning cash and "needs to be fed" (Hall *et al.*, 2020: 331).

In a dystopian account of the machine taking over, Lindebaum *et al.* (2020) argued that in the data-driven world of today, algorithms are "supercarriers of formal rationality". This means that the calculative and calculable overwrite the sense and sensibilities of human judgement in seeking efficiencies of standardisation. Yet, human life is not just about the rational, but also the emotional. As Pfeiffer (2018: 212) remarked, "Humans are not completely brain-driven, we also have bodies. Our bodies "know" and feel". Sennett (2018) distinguished between the prescriptive smart city and the coordinative smart city; the former "does mental harm; it dumbs down its citizens" while the latter "stimulates people mentally by engaging them in complex problems and human differences" (p. 144). He added that in the coordinative smart city, "people have to get engaged in the data, interpreting it (the hermeneutic) and acting on it, for better or worse – a coordinative smart city can make mistakes" (p. 166).

In its current form, Industry 4.0 can lead to restrictive agendas. In the bestseller *The Age of Surveillance Capitalism*, Shoshana Zuboff (2019) discussed the art of reality business. Tracing the rise of Sidewalk Labs[2], she explained how Google entered the field of urban mobility by creating the internet infrastructure to collect data about people's movements in cities like Detroit. However, in order to rationalise data about citizen movements, public money was spent to integrate players like Uber, which in turn reduced citizen choice and removing more affordable options. Later on, Sidewalk Labs was to embark on creating the masterplan for Toronto's Quayside smart city, a project that was rejected in 2019 in part because of fear of what Google would do with citizen data. The promises of more open and democratic forms of innovation with end-user engagement is delivered with prescriptive solutions by a few mega-corporations like Google; the rhetoric of data democracy translates to the reality of data dictatorship (Ploeger and van Loenen, 2018).

For all the claims of Industry 4.0 offering mass personalisation and choice, and in the era of Big Data, having more information is not necessarily better since having more information does not mean that conflicting interests and ethical values can be resolved. As Eubanks (2017: 125) cautiously warn, information systems "can help manage big, complex social problems. But it doesn't build houses, and it may not prove sufficient to overcome deep-seated prejudice against the poor".

Concluding provocations

In conclusion, conversations about the power of Industry 4.0 in transforming the AEC sector is likely to continue and intensify in years to come. In this critical briefing, it has been argued that developments have to date been about the technologies of Industry 4.0, thereby downplaying the social inputs and impacts that Industry 4.0 can

[2] Part of Google's Alphabet Inc.

bring in such transformation. A number of questions remain that could provoke future lines of inquiry, including:

- How do we move beyond current conversations about production efficiency to examine how Industry 4.0 can bring about social effectiveness? In sketching out the core principles, Lasi *et al.* (2014) acknowledged that Industry 4.0 is not just about smart factories and building ever more efficient cyber-physical systems, but also about better adaptation to human needs and engendering social responsibility. How do we examine and ensure that the promises of the disruptive technologies also deliver for the common good, and what kinds of regulatory regimes need to be put in place (see van Dijck *et al.*, 2018)?
- How can we use Industry 4.0 as a means to make new and more equitable forms of collective debate, understanding and insight (Finn, 2018) such that the aspirations of end-user engagement in designing the built environment can be met? How can we open up algorithmic organising to scrutiny such that questions of "Who knows? Who decides? Who decides who decides?" (Zuboff, 2019: 230) can be made transparent?
- In what ways can Industry 4.0 technologies change work in the AEC sector for the better? How can we repurpose the discussion so that we temper the pursuit of formal rationality with human learning of values? What evidence is there to show the promises of Industry 4.0 for improving and increasing the number of 'good' jobs in the production of the built environment (cf. Fleming, 2019)?

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