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THE ACTORS' PERCEPTIONS AND EXPECTATIONS OF THEIR ROLES IN BIM-BASED COLLABORATION

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The inter-organisational collaboration with Building Information Modelling (BIM) is one of the hottest topics in construction sector nowadays. The implementation of BIM is a complex inter-organisational process, and the sharing of information among numerous actors from multi-disciplinary backgrounds may affect the actors' role perception and performance. This study offers insights into the BIM roles of various actors by analysing a BIM-based project carried out by an integrated partnership across many tiers. The analysis identified inconsistencies between the actors' perceptions and their partners' expectations of their BIM roles. Inconsistencies in BIM roles were more related to soft rather than hard (domain- or technical) skills. Mismatches were found in the architect's role, as it was deemed necessary to be more domain- and BIM-related, contrary to their perceptions. Likewise, the suppliers' role called for an enhanced BIM orientation. The paper concludes with set of suggestions for increasing the joint responsibility and supporting the multi-actor collaboration.

Keywords: Building Information Modelling, case study, collaboration, roles.

INTRODUCTION

Building Information Modelling (BIM) is a subject undergoing intense study in construction management research. BIM entails software applications, tools, activities and procedures for generating, managing and sharing building information among various multi-disciplinary actors. The use of BIM in construction projects has become increasingly popular, due to project benefits, e.g. time reduction, coordination improvement, lower costs and fewer returns for information (Azhar, 2011, Bryde *et al.*, 2013), and collaboration benefits (Barlish and Sullivan, 2012). Whereas BIM may improve collaboration among the various project actors, there is little research how the channelling of information flows in BIM affects the various actors' roles.

Sebastian (2011) provided evidence of changing roles of the clients, architects and contractors from BIM. BIM has penetrated into the professional routines of numerous multi-disciplinary actors. Not only architects and structural engineers but also clients, contractors, and suppliers gradually include BIM in their work routines. Thus, the business models of various construction professionals are transformed by BIM. When collaborating with BIM, actors develop BIM responsibilities at both technical and inter-personal levels (Gu and London, 2010). These transformations might further fragment the existing practices among actors, given that the construction industry is already described as scattered field with low employee satisfaction levels.

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The various national BIM reform agendas instigate a cultural shift towards increased collaboration and consistency of information sharing. This study focused on the changes of BIM roles within Supply Chain (SC) partnerships, which are consensus seeking and non-antagonistic (Gosling *et al.*, 2015). The term 'SC partnership' instead of 'partnership 'is used to denote a partnership extending across all tiers. The paper aims to gain a deeper understanding of how collaboration with BIM is affected by incongruences between one's own role perception and expectations of other actors.

First, related past work on BIM perception is presented. Then, the research questions follow. Next, the research methodology was reported. After presenting and analysing the data, the findings were discussed and compared to literature. The paper concluded with a summary and suggestions for construction practitioners to overcome the gap between incongruence in emerging perceptions and expectations in BIM-based teams.

BACKGROUND

The impact of BIM on the project lifecycle and actors

Benefits of BIM

BIM is a promising set of technologies for consistently sharing building information among various actors. BIM is as a 'multifunctional set of instrumentalities for specific purposes that will increasingly be integrated' (Miettinen and Paavola, 2014). BIM's 'ready packed' capabilities are likely to be accepted, due to their immediately shown benefits (Jacobsson and Linderoth, 2010). The built-in features of BIM applications have options for visualisations and quantity take-off (Eastman *et al.*, 2008). BIM can facilitate design with fluent visualisations, fast shop drawings, fast coding and precise interference detection (Azhar, 2011). Such benefits greatly alter the work of engineers, e.g. architects, structural engineers. The built-in cost estimating features of BIM tools facilitate the work of quantity surveyors and contractors (Azhar, 2011, Bryde *et al.*, 2013). Thus, most BIM benefits apply to operational and informational aspects.

The impact of BIM does not only pertain to *hard*, operational and informational, but also implicate relational aspects, e.g. commitment, trust. BIM also induces various *soft* gains related to shared information, such as coordination improvement, fewer returns for information (Azhar, 2011, Bryde *et al.*, 2013), and collaboration benefits (Barlish and Sullivan, 2012). Whereas BIM adoption rises in employees, firms, and countries, BIM implementation and collaboration are in flux. Succar and Kassem (2015, p.65) defined BIM implementation as a combination of readiness, capability and maturity that firms need to develop to have BIM successfully implemented. Thus, the involved project actors might vary in BIM readiness levels. Since collaboration involves to a multi-actor network, delving into the emerging BIM roles of various actors is needed.

Extant challenges and transformations from BIM

The use of compatible Information Systems (IS) has been deemed essential for the information exchange among various actors (from designers to suppliers) and could be used to integrate the design and construction phases (Dulaimi *et al.*, 2002). BIM is an IS, that allows the involved actors to use their preferred systems, meanwhile exchanging compatible information in Industry Foundation Classes (IFC) format, currently the main open data standard (Berlo *et al.*, 2015). BIM deeply affects collaborative processes by transforming the information exchange and inciting denser interactions. Thus, the roles of the clients, architects and contractors are likely to change due to the use of BIM (Sebastian, 2011). The changing roles from BIM pertain not only to domain-related and technical skills but also to relational managerial issues.

Dossick and Neff (2010) studying the interaction among Mechanical, Electrical, Plumbing (MEP) engineers, found BIM to enhance transparency by showing the connections among them. However, BIM did not foster closer collaboration across the firms. The changing nature of the (shared) deliverables and integration across professional roles carries implications for construction actors who might engage in roles beyond the disciplines in which they were originally trained in (Jaradat *et al.*, 2013). Davies *et al.* (2015) stressed that a 'combination of personality, experience, and training or education' is necessary to develop social competences for collaboration, communication, conflict management, negotiation and teamwork with BIM. An investment in social competences could, thus, support the emerging BIM-related roles. These social competences could be added to the traditional technical skills, including the technical skills that BIM use requires. In the context of this paper, the *soft* competences that could accompany BIM collaboration are defined as the skills do not require domain expertise or BIM-related technical nature, unlike the *hard* skills.

The impact of BIM from an inter-organisational perspective

Adopting and implementing BIM is thus a multi-faceted challenge. Its implementation induces various project-based, intra-organisational and inter-organisational changes. BIM not only affects the knowledge-based, technical nature of construction work but also affects the soft and intangible aspects of communication and collaboration, thus the team's relational management. According to Orlikowski and Gash (1994) the concept of 'technological frames' signifies that actors may have varying 'assumptions, expectations, and knowledge' (skills) about the use of IS, e.g. BIM. Thus, it might be useful to investigate the actors' perceptions and expectations in respect to the use of BIM. Yet, most BIM-related studies exclusively focus either at the designer (Son *et al.*, 2015, Ding *et al.*, 2015), or the facility owner (Giel and Issa, 2016, Korpela *et al.*, 2015), or the contractor (Ahn *et al.*, 2016) or the engineers (Dossick and Neff, 2010, Gu and London, 2010), neglecting the impact of BIM on the work of sub-contractors and suppliers. There is a lack of understanding about what BIM means to the actors in a multi-actor project network, and how BIM influences their role perception.

The construction industry could thus be considered a supply-demand network (Christopher, 2005) with multiple "action-reaction" relations among its actors. One more important characteristic of construction industry is the project-based focus, which due to its autonomy and discontinuity impedes learning and reduces possibilities to standardise (Jacobsson and Linderoth, 2010). Thus, an analysis of the meaning of BIM implementation within structured inter-organisational teams, and particularly in contractually bound SC partnerships with long-term relations could provide insights into the changing roles upon the introduction of BIM. Such insights are important, as BIM-based collaboration needs better-structured teams (Dossick and Neff, 2010). The study therefore addressed the following research questions:

- What are the perceived roles of actors in a BIM-based project?
- What are the expected roles of the various actors in a BIM-based project?
- What are the implications of the mismatches between the perceptions and expectations of roles in a BIM-based project for construction practitioners?

METHODOLOGY

Research background and rationale

The study explored the emerging BIM roles of actors who were contractually bound in SC partnerships. The Netherlands is an appropriate research setting for cultural reasons, for its ubiquitous consensus-seeking, *'poldermodel'* culture that fosters close collaboration among project actors. Winch (2002:25) describes the Dutch construction industry as a Corporatist type System where the "social partners", - like trade unions - are keen to negotiate instead of seeking confrontation to optimise benefits to the Dutch workforce and the society at large and to reduce the costs and risks.

The empirical context of the study was a set of actors organised in a SC partnership initiated by the contractor. The partnerships not only provided a structured setting for the study but also enabled the data collection process and the unobstructed access to information, given that all SC partners saw value in further researching their relations. Moreover, this non-antagonistic setting could serve as a ground-up approach for BIM implementation. After all, many national mandates, e.g. The Egan Report and the Publicly Available Specifications (PAS) 1192 in the United Kingdom (UK) have been envisaging the integration of the supply chain, triggered by close collaboration.

The study used case study methods to explore the research questions. The case was a real-world building project and involved various actors. The case study was selected over isolated interviews with construction firms, to avoid impression management and retrospective sense-making that often arises in interviews among isolated interviewees (Eisenhardt and Graebner, 2007). The study was interpretative and focused more on information richness, sense, and meaning (Yazan, 2015), than generalisation.

Case study protocol

Data collection and analysis

The roles of the various professionals were explored as to both BIM-related and inter-organisational aspects. The data were collected from in-depth interviews with nine multi-disciplinary actors of the BIM-based case. The interviews were semi-structured, lasted about one hour, and had consistent preparation and data handling. Before the interviews, all interviewees had the same information about the study goals. Question hand-outs were used in the interview. The interviewees conversed in Dutch and with their permission they were recorded to aid the transcription and translation, by research assistants. The transcripts were analysed with qualitative analysis software, using free codes. The interviewees agreed on using their input for research, but opposed to publishing their details. The authors are not affiliated with the firms.

Interviewees and the nature of the questions

The interviewees were asked to reflect on their newly emerging roles in a BIM-based project. Table 1 contains their domain, function and whether they used BIM. The interviewees were first asked to describe their position, the project, the motivation for using BIM, and their roles. Apart from reflecting on their roles, the interviewees were encouraged to reflect on the changing roles of their partners. No probing techniques were used to receive feedback about all expected roles. When no information about any actor was received, it was an indication of a not content-based relation between them. The roles were analysed as to domain expertise skills and emerging BIM roles.

Table 1: Interviewed firms and employees for the case.

Actor	Function/position in the firm	BIM
Contractor	Site Engineer/BIM Coordinator in training	x
Architect	Project Architect	x
Structural Engineer	Lead Engineer	x
Mechanical Electrical Plumbing (MEP) Engineer	Tender Manager	
MEP Engineer	Site Engineer	x
MEP Engineer	BIM Modeller	x

Sub-contractor	Project Leader	
Supplier	Director	
Supplier	BIM Modeller	x

CASE DESCRIPTION AND ANALYSIS

Case description

The case concerned the construction of a housing tower, with 83 housing units in South Holland. The tower was developed over a pre-existing shopping arcade, and there were high technical and logistical challenges. The contractor held long-term contracts with the architect, the structural engineer, the steel sub-contractor and some suppliers. BIM was used from initiation and "as-built" BIM would be delivered. About ten firms used BIM, which was requested by the contractor and not by the client, to increase project quality, via a clause in the framework agreements.

The partnership was formed by 'dyadic' relations initiated by the contractor. The architect had an exclusive relation with the contractor. The contractor also had an exclusive relation with the structural engineer, but not reciprocal, i.e. the structural engineer also worked with other contractors. The contractor had agreements with some other suppliers, his 'preferred partners'. The preferred partners were firms that were already culturally aligned with the contractor. The final selection of the preferred partners was made considering the availability of selected individual employees.

Case analysis

The narratives from the case actors were organised (1) according to their own perceptions of their emerging roles in the BIM-based project and (2) around their expectations of the other actors' roles. Given their existing long-term SC partnership, the narratives witnessed experiences stemming from previous collaborations. The next paragraphs present distinctive and thought-provoking quotations from selected actors.

Architect: Perceptions and expectations
The architect acknowledged the importance of their domain expertise-related input in the project: '*Funny enough those responsibilities did not change that much. You're still responsible, whether it is an architectural model or a drawing. That actually has not changed that much'*. She also added that they felt particularly '*responsible for a good architectural BIM model and to encourage the collaboration'* among the various parties. For this reason, they were proactively seeking input from their partners in various ways, e.g. through co-locations, emails, and phone calls. The partners deemed the architects' input highly important, because it defined *'the form and space in which partners had to operate'* (Contractor-Site Engineer). Most of the emphasis from the actors was given to the architect's domain expertise and technical-based skills. They did not address the architect's social competences.

Structural Engineer: Perceptions and expectations
To the structural engineers, coordination skills were considered as important as their domain expertise and technical-based skills. Whereas their primary role is the design of the structural BIM model, requiring good mastering of BIM skills, they additionally '*monitor all other suppliers, especially if it has a connection to the structure'*. At the same time, they adjusted their mode of communication to the BIM process: '*We now increasingly communicate only with BIM models instead of drawings and details'*. Other actors held the structural engineers responsible for retaining long-term interactions with the architect to share knowledge and were seen as complementary disciplines: '*they always have to sit together'* (Sub-contractor-Project Leader).

MEP Engineers: Perceptions and expectations
The MEP engineers considered their roles to require more domain-related skills than soft competences. They stressed that the BIM-related activities are a '*joint responsibility'* and a matter of everyone being '*respectful to each other'*. Other actors expected the MEP engineers to more frequently engage in proactive knowledge sharing and informal communication by email and co-locations, to avoid the contractor '*just playing the postman between'* (Sub-contractor-Project Leader).

Contractor: Perceptions and expectations
Aside from domain-related tasks, such as '*reducing the cost of failure'*, the contractor's project leader perceived his role as a set of soft skills to inspire '*a whole different way of working together (…) talking about partnering but not price-hunting' and 'to roll out the whole story about the BIM-culture in the chain, and to get everyone excited'*. He aimed to engage in a transparent way and from an early stage onwards with the other actors in the project. Moreover, he emphasised that he was responsible for taking on the role as the BIM coordinator: '*basically I need to be the communication link among them (…) to ensure that the errors are accordingly communicated'*. The suppliers had underscored the importance of a permanent BIM coordinator from the contractor's firm being on the construction site. This was probably the motivation for the contractor firm to train the Site Engineer as a BIM coordinator. The other actors expected the contractor to have '*planned the occasional moments where everyone sits around the table'* (MEP Engineers-Tender Manager) and prepare BIM agreements. '*For the contractor the role changed. And that really concerns both the process and planning. They much earlier think ahead, thinking about the accountability of other involved parties'* (Architect-Project Architect). The architects also expected that the contractor became '*all of a sudden responsible for the whole BIM model',* thus becoming responsible for the full coordination.

Sub-contractor: Perceptions and expectations
For the concrete sub-contractor, the main domain-related responsibilities, e.g. '*schedule (…), delivery on time and been attuned to all parties, has not really changed'*. However, because of the strategic decision to outsource the development of BIM to a BIM drafting firm, this major impacted their work, as the lack of an in-house BIM engineer at the sub-contractor was considered a draw-back by the other actors. The Architect-Project Architect stressed: '*that can also be a sign that their knowledge around the BIM model stops* as they *just hire a BIM drafting firm*'. In contrast, the sub-contractor emphasised relational or soft skills, such as being collaborative and flexible '*we sit together in the office and that is very handy. If we need to go together to the contractor's office building, I have each time to consult with the BIM drafting firm (…) but to me that is very flexible'*. The sub-contractor was also very keen to engage in informal communication: '*the communication is basically with all the parties*' and advocating a relational or soft-competences view about BIM: '*I still find a strong point in using BIM is making you think about the other disciplines*'.

Supplier: Perceptions and expectations
According to the steel supplier, the perception of their role responsibilities was acknowledging and respecting the BIM-related and contractual agreements, rather than the domain expertise. He used BIM to look up others' work: '*BIM has a big advantage, you can quickly see what everyone is doing'*. They also engaged in informal communication to support the BIM process: '*we always work with the same standards. We want to provide good quality, so they (contractor) created standards. We have to coordinate because each has its own way of working and especially in BIM'*. However, not all suppliers in the project used BIM and therefore, the architect mentioned that:

'*some suppliers are accustomed to the contractor checking everything in detail. And the control is now moved to them and that they find it inconvenient (…) they find it very scary.* (Architect-Project Architect).

Table 2: Occurrences of the perceptions and expectations of the various actors' BIM roles.

Actor	Perception of own role	Expectations from other actors
Architect	BIM technical skills, seeking consensus, and engaging in informal communications	Domain-related expertise and engaging in early discussions
Structural Engineer	BIM technical skills, coordination, domain-related expertise and engaging in informal communications	Ensuring long-term relations
MEP Engineers	Domain-related expertise and showing respect	Engaging in informal communications
Contractor	Engaging in early discussions, meeting the formal agreements, coordination, and BIM technical skills	Domain-related expertise and ensuring long-term relations
Sub-contractor	Domain-related expertise and engaging in informal communications	BIM technical skills and ensuring long-term relations
Supplier(s)	Meeting the formal agreements and engaging in informal communications	BIM technical skills, discipline-related expertise, and coordination
Client	N/A	Engaging in early discussions and informal communications
Multi-actors	N/A	Communication across all tiers, seeking consensus and displaying joint responsibility

Whereas the client did not participate in the interviews, they were expected to play a more dominant role during the early project phases. A collective expectation was that all parties assumed the client to show more responsibility, seeking for consensus and informally communicating with partners across all tiers. Table 2 summarizes the recurring concepts across all interviewees. The concepts are organised according to the actors' own perceptions of their BIM roles and their expectations of the other actors' BIM roles. Table 3 reports the frequencies of the perceptions and expectations of roles into soft and hard aspects and therefore shows the mismatches associated with the changing BIM-related actors' roles.

Table 3: Summary of the frequencies of soft and hard concepts related to BIM roles, throughout the perceptions and expectations of the various actors.

	Perception of own role		Expectations from other actors	
Actor	Soft competences	Hard skills	Soft competences	Hard skills
Architect	19	16	11	17
Structural engineer	25	27	6	2
MEP engineers	5	5	8	1
Contractor	26	9	36	13
Sub-contractor	16	7	9	6
Supplier	5	2	15	22
Client	N/A	N/A	6	4
Multi-actors	N/A	N/A	76	38
Totals	96	66	167	103

DISCUSSION AND IMPLICATIONS

The findings revealed various BIM-related roles among the multi-disciplinary actors as well as some mismatches in their perceptions. Overall, more *soft* than *hard* dimensions were identified during the discussions about BIM collaboration (Table 3, *Totals*). This finding corresponds to results of others showing that soft competences were mobilised within the context of BIM (Dossick and Neff, 2010, Gu and London, 2010, Davies et al., 2015). Mismatches were observed between one's own perceptions and expectations from actors for BIM roles, particularly between the architect and suppliers. This is consistent with Orlikowski and Gash (1994) that delving into shared perceptions about BIM is important in assessing its impact on construction firms.

The largest inter-organisational mismatches concerned the architect (Table 3). The architect considered their BIM roles to emphasise collaboration and soft skills and less domain expertise (see Table 2), whereas other actors' expectations stressed the importance of domain-based skills. This incongruence might be explained from the traditionally central role that the architect plays in construction projects, which with the rise of BIM, tends to become more instrumental rather than being responsible for the building product. The other partners' expectations are consistent with results from studies about the importance of the architectural model in developing the BIM process (Jaradat *et al.*, 2013). Similarly to past studies, the role of the client in fostering innovation, i.e. BIM, was deemed crucial (Jaradat *et al.*, 2013, Sebastian, 2011). The findings about the MEP engineers contrast with the results of Dossick and Neff, (2010). This difference may stem from the MEP firm in the present study offering integrated design and installation services, whilst in the former study MEP services were delivered by various firms. Finally, the findings offer suggestive evidence of a shift in the role of the suppliers. With BIM, they seem to acquire a larger responsibility, with an additional need for social skills.

Although the focus of the study was inter-organisational, some unexpected intra-organisational observations could shed more light on BIM implementation. A typical combination of complementary BIM functions in firms included a BIM modeller, a BIM-knowledgeable project manager, and a BIM-enthusiast project leader (see Table 1), depending on the firm size. Such contrasts with firms having BIM not included in their business plans. They hired BIM drafting firms (see the sub-contractor's analysis). The latter echoes long-standing strategic dilemmas in innovation change management, about outsourcing or training in-house staff to new technologies, as in the contractor's firm (see Table 1 and the contractor's analysis). The above discussions on varying functions and BIM-related business models carry implications for construction (management) professionals how to disseminate BIM.

A potential limitation is that the study concerned a SC partnership. Such partnerships across all tiers of the construction industry are quite popular in the Netherlands. They feature shared decision-making, consensus-seeking and self-organising project teams and may rely on cultural traits being typical to the Dutch culture. This might indicate that the collaborative culture is a promising way forward in enriching BIM implementation with soft aspects by circumventing hierarchies, seeking consensus and collaborating beyond contracts and prices. Indeed, the findings seem to provide supportive evidence that BIM-based projects need better-structured inter-organisational teams (Dossick and Neff, 2010), and provide suggestive evidence of integration across the supply chain, as aspired in the Egan Report in the UK.

CONCLUSIONS

This study investigated the emergence of changing roles due to BIM. The analyses were performed along the axis of inter-organisational relations and aimed to reveal discrepancies in actors' perceptions and expectations of BIM roles. Results showed that informal interactions, communication across all tiers and desire for long-term relations were soft competences supporting BIM. Interestingly, and unlike his perception, the architect's BIM role expectations emphasized domain expertise and BIM skills. Other actors expected suppliers to develop a stronger responsibility for their work and BIM deliverables, and take their share in BIM collaboration.

Acknowledging the differences in the perceptions and expectations of BIM roles could contribute to BIM dissemination. BIM influences the organisation of firms, by requiring complementary BIM roles at operational and strategic levels. It seems that whether a firm adopts BIM by training engineers or outsources the BIM functions affects them being perceived as equally capable partners. Successful BIM implementation requires domain expertise and BIM-related skills as well as soft collaborative skills and clear intra-organisational BIM objectives.

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