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BIM coordinators: A review

Structured abstract

Purpose (mandatory)

The purpose of the article is to explore the role, practices, and responsibilities of BIM coordinators (BCs).

Design/methodology/approach (mandatory)

The aim is achieved through a review of existing publications ($N=183$) in which the term “BIM coordinators” has been described and discussed ($N=78$), complemented by interviews with four Norwegian BIM experts.

Findings (mandatory)

The findings from the review indicate that the core responsibilities of BCs involve clash detection, managing information flows and communication flows, monitoring and coordinating design changes, supporting new working procedures and technical development, and acting as a boundary spanner. The complementary interview study extends these findings with two additional practices and a reflection on the experienced challenges, obstacles, and potential future development of the role. In essence, we propose that the role of BCs can be defined as being responsible for external/internal alignment and coordination of actor needs, and engaged in product-, process-, and system-oriented practices of BIM.

Research limitations/implications (if applicable)

Given that this study is primarily an integrative literature review of BCs, it has the limitations common with such an approach. Therefore, future studies should preferably extend presented findings through either a survey, further in-depth interviews with BCs, or reviews of closely related BIM specialist roles such as BIM managers or BIM technicians.

Practical implications (if applicable)

With BCs seemingly being central to information management and knowledge domain integration within the AEC industry, an understanding of their importance and role should be of interest to anyone seeking to tap into the potential of BIM. This article outlines specific implications for construction manager, educators, and BCs.

Originality/value (mandatory)

The value of this study lies primarily in the fact that it is the first thorough investigation of the role, practices, and responsibilities of BIM coordinators.

Key words: Integrated Practice, Building Information Modeling, Project Management, Information systems, BIM coordinators, AEC industry

BIM coordinators: A review

1. Introduction

Building information modeling (BIM) has emerged in recent years as a potential game-changer within the architecture, engineering, and construction (AEC) industry (Azhar, 2011). With BIM simultaneously constituting a product (*in terms of a structured datasets*), a process (*in terms of the act of creating and using a building information model*), and a system (*in terms of the establishment of a business and communication network*), it has clear potential to change existing industry practices as well as the collaborative climate among involved actors, enabling increased quality (Eastman *et al.*, 2011), sustainability (Wong and Zhou, 2015), safety (Zhang *et al.*, 2013), and efficiency (Eastman *et al.*, 2011), among other things. Still, it is well known that, without the enactment of practitioners, products, processes, and systems are little more than artifacts and mental models (Boudreau and Robey, 2005; Weick, 1988), which means that they are only put in motion, existence, and use through the everyday practice.

Looking at existing research on BIM, the primary focus to date has been on the former three dimensions (that is, product, process, and system), leaving the practitioner and their everyday enactment of BIM (that is, the practice) relatively uninvestigated (Succar *et al.*, 2013). Nonetheless, several authors have pointed to the importance of well-educated and competent practitioners in order to utilize the ‘full potential’ of BIM as an integrated practice (Ahn *et al.*, 2015; Succar *et al.*, 2013; Wang and Leite, 2014; Merschbrock and Munkvold, 2015; Singh and Holmström, 2015; Rogers *et al.*, 2015). It has also been observed recently that the increased adoption of BIM has led to the development of a number of new specialist BIM-related roles, such as BIM technicians, BIM operators, BIM coordinators, and BIM managers (see, e.g., Barison and Santos, 2010; Bavafa, 2015; Deutsch, 2011; Gathercole and Thurairajah, 2014; Mathews, 2015; Sebastian, 2011). It has even been stated that “*the emergence of formal BIM-specialist roles was one of the earliest and more obvious changes to industry practice resulting from the introduction of BIM*” (Davies *et al.*, 2014, p. 33). In their article on BIM competencies and capabilities, Succar *et al.* (2013) emphasized the need for further investigation of these roles and their specialized competencies, while Davies *et al.* (2014, p. 33) stated that the “*scope of tasks and responsibilities within such roles remain poorly defined*”. In the present article, we acknowledge these observations and engage in the daily BIM practices with a specific focus on what is claimed to be one of the most central new roles to have emerged; namely, the BIM coordinator (BC) (see, e.g., Gathercole and Thurairajah, 2014; Kassem *et al.*, 2014; Wu and Issa, 2013). The purpose is straightforward: to explore the role, practices, and responsibilities of BCs. This is achieved through an integrative review of existing discussions of BCs, complemented by interviews with four Norwegian BIM experts to ensure the credibility and transferability of the findings. It should be noted that there are reviews focused on various aspects of BIM (e.g., Cerovsek (2011), Volk *et al.* (2014), and more recently Gerrish *et al.* (2017) and Zhou *et al.* (2017)), as well as studies focusing on various project roles (e.g., Gaddis, 1959; Jha and Iyer, 2006; Jacobsson, 2011; Burström and Jacobsson, 2013). However, none of these studies have paid specific interest to the BIM specialist roles that have emerged.

The findings from this literature review suggest that the core responsibilities of BCs include (a) clash detection, which involves integration, identification, and proposing solutions; (b) managing information flows and communication flows; (c) monitoring and coordinating design changes throughout the construction process; (d) supporting new working procedures and technical development; and (e) acting as a boundary spanner. Still, as the literature review shows, and as the interviews confirm, the role and responsibilities are somewhat blurry and differ depending on, for example, the BIM maturity of the organizations, project size, other existing BIM roles, and background of the BC. The interviews show that BCs take on the practices of external and internal alignment and coordination of actor needs. Thus, the expert interviews both complement and extend the review with the understanding of what is done in practice, and provide a reflection on the experienced challenges, obstacles, and potential future development of the role.

The rest of the article is structured as follow. We start with a background and contextualization of BIM, where the four initially mentioned perspectives are outlined and discussed briefly (that is, BIM as a product, process, system, or practice). This is followed by a description of the methods used, and a presentation of the results from the integrative review and the interviews. We then discuss the similarities and differences between review results and interviews, followed by the conclusions.

2. BIM: Context and perspectives

Recent decades have seen a movement from non-digital drawings, via computer-aided design (CAD), to building information modeling (BIM) within the AEC industry. According to Azhar (2011, p. 242), this development should be understood as “*a new paradigm within AEC*” that has created novel benefits for various practitioners (Azhar, 2011; Manning and Messner, 2008; Davies *et al.*, 2017), but has also resulted in new challenges related to, for example, integration and uncertainty, as well as technical and legal issues (Azhar, 2011; Volk *et al.*, 2014). Still, even if the adoption rate of BIM has not been as rapid as advocates originally expected (Fox, 2014; Linderoth, 2010), and different countries have adopted BIM at various paces (Jensen and Jóhannesson, 2013), BIM is now one of the most common ways to approach the design and construction of large buildings (Bryde *et al.*, 2013), where many organizations operate BIM as a hybrid practice (Davies *et al.*, 2017). It is clear that the mentioned movement entails more than a mere technological shift, as it, for example, triggers changes in the roles of clients, architects, engineers, and contractors (Sebastian, 2011; Bråthen and Moum, 2016) and also necessitates integration of other involved stakeholders (Azhar, 2011).

So, with BIM allegedly constituting a “*new paradigm*” (Azhar, 2011), one might ask what changes (benefits and challenges) such a ‘paradigm shift’ might entail more specifically on both an organizational and individual level. However, the answer to such a question depends on which perspective of BIM is taken. As mentioned in the introduction, BIM can be understood from a number of different perspectives (product, process, system, or practice). Most commonly – and perhaps most closely related to the general layman’s understanding –

BIM can be seen as a **product**, if the focus is placed on software and the structured dataset. Relying on international standards, Volk *et al.* (2014, p. 111), for example, defined BIM as the “*digital representation of physical and functional characteristics of any built object*”. This puts the focus on the software programs and production of digital models, where the key benefits are the precise geometrical representation of the parts of a building in an integrated data environment. In addition to the software dimension, structured dataset, and digital representation, BIM could also be considered a **process** that encompasses all activities involved in the creation and utilization of the model as such (Azhar, 2011; Carmona and Irwin, 2007). One could describe the process perspective as *the act of producing and using a digital representation*; or, as Carmona and Irwin (2007) put it, “*the building team using BIM as the project delivery method*”. From this perspective, BIM is an integrated part of the project development, management, and delivery process (Bryde *et al.*, 2013), where it provides the possibility for rapid and accurate updating of changes (Manning and Messner, 2008) as well as support for cost reduction and control (Bryde *et al.*, 2013). The **systems** perspective of BIM has been less explored within the BIM literature than the first two perspectives. The core focus from this perspective is on the business- and communication network that is inevitably (and necessarily) created and sustained as a part of the utilization of the product and engagement in the process. In addition, it concerns the always-present contextual (or industry) conditions that impact the process and shape the adoption and use of BIM. With the AEC industry often being described as an fragmented environment (see, e.g., Jacobsson and Linderoth, 2010; Dainty *et al.*, 2006), a general benefit of BIM is its potential to enable “*increased communication across the total project development team (users, designers, capital allocation decision makers, contracting entities, and contractors)*” (Manning and Messner, 2008, p. 456). Still, these benefits will not emerge by themselves. Information systems-inspired studies that have focused on the adoption and use of BIM (see, e.g., Gu and London, 2010; Linderoth, 2010) clearly illustrate the institutional challenges involved. Linderoth (2010, p. 66), for example, described these challenges by stating, “... *the multilayered context, in which the ICT’s adoption and use is situated, is shaped by for example norms, actors’ frames of references, industry characteristics, rules and regulation, and company culture.*” The author further shows how these dimensions, including the actors, need to be taken in consideration as they impact BIM adoption and can create inertia (Linderoth, 2010).

Beyond the product, process, and systems perspective, BIM can also be seen as a **practice** in terms of how BIM (as a product, process, and system) is enacted by involved practitioners. Even if the concept of ‘practice’ holds a dual denotation in terms of both the doings of people and the principles that guide these doings (Schatzki *et al.*, 2001), there is a distinct conceptual difference between the guiding principles (*practices*) and the everyday actions (*praxis, or practice*). Practices connote the norms, traditions, and rules that (implicitly or explicitly) stipulate “*how the practitioner should act in a certain situation*” (Blomquist *et al.*, 2010, p. 9). In the case of BIM, for example, this is represented by the AEC industry practices, traditions, and norms in combination with BIM manuals and handbooks (see, e.g., Eastman *et al.*, 2011; Kristiansson, 2014). Praxis refers to the actions of ‘what people actually do’ (Whittington, 2006) which might (or might not) mirror the principles that guide the doings (that is,

expectations of ‘what should be done’). In the context of this paper, this means that the everyday actions that BCs (and other practitioners) take when working with BIM are of central interest. Also, the potential discrepancies between practices (prescriptions) and praxis (doings) are relevant to acknowledge as they might explain, for example, why various problems arise and why certain obstacles are hard to overcome. In the method section, when discussing study design, we will return to the importance of these potential discrepancies.

Looking at the existing BIM research, relatively few studies have taken on a practice perspective (see, e.g., Bosch-Sijtsema, 2013; Davies *et al.*, 2014; Gathercole and Thurairajah, 2014; Ku and Taiebat, 2011; Bråthen and Moum, 2016; Merschbrock and Munkvold, 2015 for exceptions). One recent and notable exception is Bråthen and Moum (2016), who studied the practitioners’ user of “BIM-kiosks”. Another notable exception, specifically related to BCs, is Bosch-Sijtsema (2013), who showed interest in how BIM (primarily as a product) influences both work routines and roles in inter-organizational construction projects. For example, Bosch-Sijtsema observed how BCs “*played an important and active role during the design discussions*” (Bosch-Sijtsema, 2013, p. 6). Another noteworthy contribution is Gathercole and Thurairajah (2014), who took stock of how BIM (as a product and process) influences and interaction on traditional construction project roles.

3. Method

Due to the limited focus on both practice and BIM-related specialist roles in existing literature, the methods applied in this article have been adaptive in nature and based on a combination of sources (see recommendations in Succar *et al.*, 2013). In terms of design, we opted for a two-step approach in order to cover existing studies in which BCs have been discussed, and also to complement these insights with an in-depth understanding of the everyday BIM practice. Consequently, the design is based on a combination of an integrative literature review (Torraco, 2005; Grant and Booth, 2009) and interview study (Rowley, 2012), which reflect the need to understand both prescriptions (practices) and doings (praxis). It should be noted that even if the literature review is structured in its approach, it is not conducted as ‘a systematic review’ in a strict sense (cf. Tranfield *et al.*, 2003), but rather as a classical literature review with a narrative synthesis (Grant and Booth, 2009).

With the “BIM coordinator” not being a clearly defined role in the existing literature, the literature review took its basis in the term ‘BIM coordinator’ rather than any empirically measurable characteristics or tentative definition of the role. In terms of classification, one could say it is ‘typological’ rather than ‘taxonomical’, meaning that the review is based on the notion of an ideal role from which a definition can be developed.

3.1. Review

The review part of the article was undertaken using Google Scholar, EndNoteX7, and NVivo for Mac as means of searching, structuring, coding, and analyzing information. When deciding on a suitable procedure, the rationale – based on the lack of previous review studies – was to maximize the number of entries related to BCs. As comparative studies have shown that Google Scholar has very broad coverage (Amara and Landry, 2012), but is just as

accurate as traditional search engines when conducting literature reviews (Jean-François *et al.*, 2013), it was considered the most suitable option. The literature review was undertaken in three steps following the recommendation of Torraco (2005).

Step 1: Initial search and retrieval of material. A total of 183 entries were found when conducting full-text searches for “*BIM coordinators*”, “*BIM-coordinators*”, “*BIM coordinator*”, and “*BIM-coordinator*” using Google Scholar. The initial searches were performed on the 24th of February 2016 and available entries were downloaded between the 29th of February and the 22th of March. Based on the findings, a complete list of references including keywords, abstracts, and available full-length material was downloaded to EndNoteX7. Unfortunately, because the entries varied among, for example, articles, theses, conference proceedings, books, and book chapters, not all entries were accessible in their full-length, even when we utilized available databases to complement the initial search. Nevertheless, all abstracts (and accessible full-length material) were downloaded and used in the second step.

Step 2: Screening and structuring material. When all available material had been downloaded, it was screened based on a number of exclusion criteria (a-c). Our initial intention was to only assess the title and abstract of each entry; however, due to the sometimes limited information provided in abstracts, full texts was instead used whenever available. Entries were excluded based on (a) being duplicates (*excluded, N=2*), (b) language, not comprehensible by authors^I (*excluded, N=7*), (c) having a focus that was clearly outside the scope of this article (*excluded, N=83*), or (d) not being of academic nature^{II} (*excluded, N=17*). A total of 105 entries were excluded in this step, leaving 78 for the following step. Given the nature of the exclusion criteria, a few entries were excluded for overlapping reasons; for example, entries that were both non-academic in nature and outside the scope of the article.

Step 3: Coding and analyzing material. With the screening process completed, the material was imported into NVivo for Mac and coded inductively. Out of the 78 entries included, seven were not accessible in digital form and therefore could not be imported. Imported material was first complemented with source classifications when missing (for example, if the material was a book, journal article, or conference paper), and thereafter a ‘text query’ and ‘word tree’ were utilized to provide an overview of the material. These methods enabled us to obtain a quick overview of both how the concept of BCs had been used in the material, as well as whether it was to be considered a key concept or more peripheral concept in each entry. Based on the purpose of this article, all entries were coded thematically on a semantic level by one of the researchers (Braun and Clarke, 2006). The primary focus and basis for the thematic coding was descriptions of the BC’s role, responsibilities, and practices. In order to ensure that each paper was coded in the same way, one of the authors coded all the material.

^I Non-English and non-Scandinavian material was excluded.

^{II} After careful consideration, a broad definition of “academic nature” was used. This means that, in addition to peer-review articles and books by academics, well-developed thesis work (PhD and masters level) and conference papers were also included.

In essence, each paper was read by one of the authors and all text related to BCs was coded sentence-by-sentence based on the information given. When available, the history and development of the role was also coded to a separate node. When all material had been coded, the tentative results were discussed and jointly revised by the two involved researchers. In this process, parental nodes/themes were discussed and jointly created/reworked. The aggregated results of the review are presented in the review (results) section under the following themes that cover the role and responsibilities:

- Clash detection: integration, identification and proposing solutions
- Managing information flows and communication flows
- Monitoring and coordinating design changes throughout the construction process
- Supporting new working procedures and technical development
- Acting as a boundary spanner

In addition to the five themes, a short overview of the evolution/history of the role was generated when coding the material. Material that was not accessible in digital form and was therefore not part of the NVivo coding process (seven entries) was manually assessed as a complement to the generated themes. Findings from this assessment were added to the themes. For a summary of the literature selection process, see *Figure 1*.

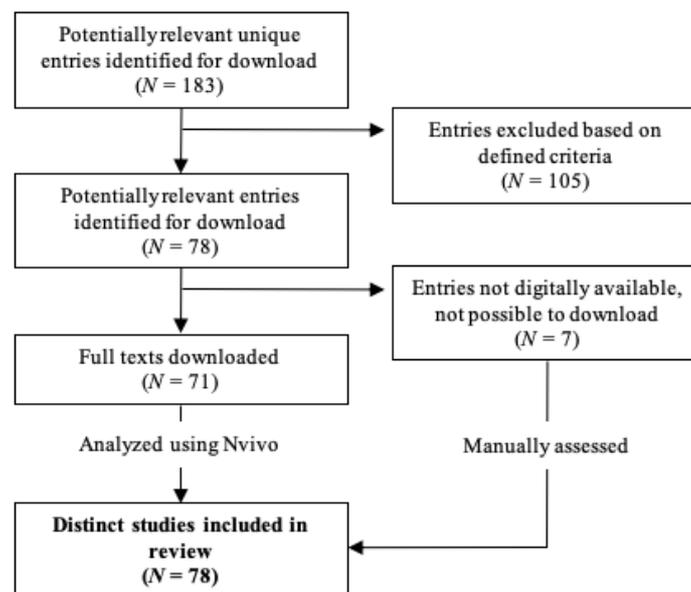


Figure 1: Flowchart of literature selection process

3.2. Interviews

With the review completed and themes summarized (that is, narratively written up), four Norwegian BIM experts were identified using existing contacts within the AEC industry. The main rationale for the interviews was to ensure trustworthiness in the results by triangulation. Thus, selection criteria were primarily based on industry experience and/or in-depth understanding of the BC role. All of the experts that we approached accepted the invitation to

be part of the study. An overview of the respondents, their experience, role, and the type of organization they are active within is presented as *Table 1*.

	Expert # 1	Expert # 2	Expert # 3	Expert # 4
Current role	BIM manager	BIM coordinator and architectural designer	BIM strategist and senior engineer	BIM coordinator and digital collaboration manager
Industry experience	19 years	1 years	35 years	13 years
Type of organization	Architecture firm specialized in construction architecture, planning, landscaping, and interiors.	Multidisciplinary consultancy firm specialized in community and urban planning, design, and project management.	International consulting group specialized in engineering, environmental science, and project management.	Engineering consultancy specializing in planning and development of energy, and infrastructure.
Geographical scope	Scandinavian	Multinational	Multinational	Nordic

Table 1: Overview of respondents

As mentioned, the interviews were undertaken in order to triangulate the review results in order to obtain an understanding of what is done in practice, as well as reflections on the experienced challenges, obstacles, and potential future development of the role. Before each interview started, the respondents were informed about the research project and the overall aim of the research. Informed consent was received. Conducted interviews were semi-structured, interview questions were open-ended, and divided into three parts.

- The first part involved a discussion of the practice, activities, and collaborations (covering what BCs do, what is expected from them, and who they work with and are dependent on). Basically, this ensured transferability of the review results without revealing what had already been identified.
- In the second part, a discussion focused on experienced challenges and obstacles (covering what the BCs find challenging in their everyday roles, and whether there are structural/organizational obstacles that hinders them from doing their job).
- The third part was a discussion of the future potential and (desired) development (covering what the respondents saw as the existing trends, future of the role, etc.).

The interviews were conducted using Skype in October–November 2016, recorded, and transcribed verbatim. Each interview lasted an average of one hour. Transcribed interviews were sent to the respondents for confirmation and thereafter treated in a similar fashion as the review material, in terms of using NVivo for Mac as a means of coding and analyzing. It should be noted that the interviews are ‘merely’ a complement to the literature review (which is important for the sake of trustworthiness and transferability of results, similar to an expert panel or focus group interview) and were therefore utilized to juxtapose the results in the discussion, comparing expectations with doings, and providing reflections of what the future might hold.

4. Literature review: BCs in contemporary research

Almost a decade ago, Howard and Björk (2008) focused on experts' views on BIM deployment within the AEC industry and reported on the experienced need for a specialized BIM role that engaged in tasks such as modeling, technology, applying standards, and spatial coordination. Similarly, Penttilä and Elger (2008) observed growing demands for a new coordinating role due to increased use of BIM. The following year, Dossick and Neff (2009) briefly reported on their observations of BCs in an article on the use of BIM technologies for MEP (mechanical, electrical, plumbing) coordination. Soon thereafter, several other authors mentioned the role and function of BCs, and their importance to both the deployment and use of BIM within the AEC industry (see, e.g., Deutsch, 2011; Barison and Santos, 2010; Lahdou and Zetterman, 2011; Morton and Thompson, 2011).

Following these initial observations, various researchers, and some BIM handbooks, soon started to report on the BC role and described its often open-ended set of responsibilities (see, e.g., Gathercole and Thurairajah, 2014; Davies *et al.*, 2014; Bosch-Sijtsema, 2013; Eastman *et al.*, 2011). For example, Barison and Santos (2010, p. 144) stated that “*a BIM implementation plan should include the definition of coordinator(s) and, after the initial goal is set, the BIM coordinator [...] can develop and carry out the detailed implementation of BIM*”. In the Australian NATSPEC (2011, p. 24), a BC was similarly defined as “*a person who performs an intermediary role between the BIM Manager and the modelling team. He/she implements the BIM Manager’s modelling standards and protocols and deals with the day-to-day coordination of team members to achieve project goals.*”

In 2012, Björk Löf and Kojadinovic (2012) reported that BCs were a relatively new role within Skanska Sweden, and described how the rationale for the establishment of this role was based on identified needs to support BIM in the design phase. Others have described the rationale for the new role as being based on the need to perform modeling and coordination tasks following BIM implementation (Poirier *et al.*, 2015); to complement the traditional role of project coordinators (Poirier *et al.*, 2015) or support project managers with specific BIM competence (Lahdou and Zetterman, 2011); or to work alongside and support the design project managers (Bosch-Sijtsema, 2013). However, Bosch-Sijtsema (2013) explained how, in her study the role had developed over the years from having a more technical focus towards having a more integrated coordination focus. This observation seems to be in line with other observation of BCs as traditionally having primary technical competences (Wu and Issa, 2013) and later observation of the needs of BCs to possess skills in “*leadership, communication, documentation writing, review and quality assurance procedures*” (Davies *et al.*, 2014, p. 36).

Based on the analysis of 300 job adverts, it was recently observed how the BCs were put forward as “*the most highly competent (BIM knowledge) member of the project team*” (Gathercole and Thurairajah, 2014, p. 12). However, when the authors examined the subsequent list of prescribed (and desired) responsibilities, they compared it to a “handyman’s” because it was both extensive and very varied (Gathercole and Thurairajah, 2014). Nevertheless, the role does appear to have a few distinctive areas of responsibility. The

areas of responsibility identified through the literature review are: (a) clash detection, which involves integration, identification, and proposing solutions; (b) managing information flows and communication flows; (c) monitoring and coordinating design changes throughout the construction process; (d) supporting new working procedures and technical development; and (e) acting as a boundary spanner. These areas will be further outlined in the following sections.

4.1. Clash detection: Integration, identification and proposing solutions

The first identified area of responsibility for the BCs relates to the practice of clash detection through the creation of a federated BIM model (Lahdou and Zetterman, 2011; Bosch-Sijtsema, 2013; Gathercole and Thurairajah, 2014; Wang and Leite, 2014). The clash detection practice can be divided into four stages: (1) model integration/verification, (2) clash identification, (3) solution generation, and (4) model revision, with a core focus for the BCs on detecting conflicts among various components (Lee and Kim, 2014). According to Bosch-Sijtsema (2013), however, BCs are often responsible for all stages but with the involvement of all design team partners. While the integration is primarily a practical/technical issue, the verification is actually a matter of quality assurance and control (Davies et al., 2014). Identified clashes can be divided based on their nature into ‘hard clashes’, ‘soft clashes’, and ‘time clashes’ (Tommelein and Gholami, 2012). Hard clashes refer to objects that occupy the same physical space and hence cause an incompatibility problem; for example, a clash between a vent pipe and a beam. Soft clashes refer to two objects that occupy or are in need of the same clearance space, such as a pillar occupying the clearance space of a door or a staircase. Time clashes relate to dependencies and the order (or process) in which objects need to be installed or built. The nature of the clashes triggers the need for different responses, solutions, and coordinating actions by the BCs (Karathodoros and Brynjolfsson, 2013). Even if automated clash identification is possible and commonly used, it has been argued that this frequently yields numerous “false positives” that require further assessment (Wang and Leite, 2014). Thus, an important task for a BC using automated clash detection is to distinguish between “real clashes” and the “false positives” that involve components that penetrate each other correctly and therefore do not require changes in design or construction (Gijezen et al., 2010; Wang and Leite, 2014). When identified clashes are assessed, they are to be summarized in a clash report that suggests possible solutions. Such reports are developed in collaboration with other design team partners in order to generate constructive change alternatives (Bosch-Sijtsema and Henriksson, 2014; Davies et al., 2014; Lee and Kim, 2014; Seo et al., 2012; Gathercole and Thurairajah, 2014; Wang and Leite, 2014).

4.2. Managing information flows and communication flows

In addition to the clash detection practice, the BC role also supposedly covers a responsibility to manage information flows and communication flows. As previously mentioned, it is clear that the BCs not only have a technical role but also, in several ways, a more integrative and operational function that complements that of the design project managers (Bosch-Sijtsema, 2013; Simey, 2013). For example, BCs are often described as the “only” role that has access to relevant information, and/or ability to work with and make changes in the federated model, whereas other personnel are limited to just the viewing versions (Simey, 2013). Prinsze (2015) specifically highlighted that each design change needs to go through the BC. He wrote,

“only the BIM coordinator had access to the central file [...] he merged everything together [...] and the merged model was accessible to all disciplines [...] this model was in fact the tool that made collaboration possible” (Prinsze, 2015, p. 33). Also, Aðalsteinsson (2014) described how it is the BC’s responsibility to oversee how information is entered into the model, and ensuring that information is available for all relevant disciplines. One often-presented way to concurrently enable integration and diffusion of information is through meetings; design meetings, coordination meetings, or BIM workshops (Bosch-Sijtsema, 2013; Wang and Leite, 2014). Bosch-Sijtsema (2013) observed that the BIM coordinator played an active and significant role during the design meetings and, according to Kassem *et al.* (2014), BCs sometimes also lead the client BIM workshop to provide the client with an overview of the work. The importance of participating in and/or hosting such meetings and establishing effective communication with other design team partners has also been highlighted by other researchers (see, e.g., Bloomberg *et al.*, 2012; Karathodoros and Brynjolfsson, 2013; McGough *et al.*, 2013; Kassem *et al.*, 2014).

4.3. Monitoring and coordinating design changes

Partly integrated with the responsibility to manage the information flow and communications flow is the task of monitoring and coordinating design changes. With the BC having dedicated (and sometimes sole) access to the federated model, it almost goes without saying that the monitoring and coordinating design changes throughout the construction process becomes a central activity (Prinsze, 2015). As previously mentioned, it is also up to the BCs to oversee how information is entered into the model and securing the availability of information to other actors (Aðalsteinsson, 2014). Several sources specifically indicate that it is the BCs role to coordinate among BIM modelers, design consultants, and cost consultant, as well as function as a coordinator between contractor and subcontractors (Davies *et al.*, 2014; NATSPEC, 2011). The BIM guidelines provided by the NYC Department of Design explain how individuals taking on the BC role require trade-specific experience and competence regarding monitoring and coordination (Bloomberg *et al.*, 2012). The observations by Aðalsteinsson (2014) and Bushnell *et al.* (2013) also strengthen the above-mentioned prescribed expectations to monitor and coordinate. For example, Aðalsteinsson (2014, p. 56) observed how it was specifically the BC’s responsibility to secure “*that the BIM model is up to date during the building process*”. This is further supported by McGough *et al.* (2013), who explained that it is the specific responsibility of the BC to ensure that the BIM content and coordination is developed and maintained.

4.4. Supporting new working procedures and technical development

Several authors have observed that the role and responsibilities of BCs have changed over time, from a more technical focus towards a more integrated coordination focus (see, e.g., Bosch-Sijtsema, 2013; Wu and Issa, 2013; Davies *et al.*, 2014). However, attending to technical development and to interrelated work procedures still seems to be a central responsibility. For example, in their study of Skanska, Björk Löf and Kojadinovic (2012, p. 43) claimed that “*the primary responsibility of the BC is to handle and support the change processes and new working procedures related to BIM adoption.*” The extent to which this is a core task could, according to other authors, depend on the BIM maturity of the organization and how much ‘new working procedures’ there is. Karathodoros and Brynjolfsson (2013, p.

20), who explicitly discussed the tasks and responsibilities of BCs, seem to have suggested that a technical focus and ‘supporting new working procedures’ is a core part of the role. Those authors stated that BCs, in addition to the management of design changes and information flows, shall “*coordinate all technical discipline-specific BIM activities (tools, content, standards, and requirements).*” Also, Lahdou and Zetterman (2011) and Gathercole and Thurairajah (2014) argued that BCs are responsible for technical development of BIM, while the Australian National BIM guide (NATSPEC) prescribes that BCs are to coordinate technical discipline BIM development, standards, and data requirements (NATSPEC, 2011).

4.5. Acting as a boundary spanner

The final area of responsibility that has been identified through the literature review is the role of “boundary spanner”. This term can be broadly defined as individuals within a system who have (either by taking on or being given) the role of linking their own organizations internal networks with external organizations (Aldrich and Herker, 1977). This means that they act as intermediators, build relationships, and manage interdependencies with other actors in order to solve complex problems. In the Australian National BIM guide, a BC is defined as “*a person who performs an intermediary role [...] and deals with the day-to-day coordination*” in relation to other actors (NATSPEC, 2011, p. 24). This indicates that BCs are expected to act as intermediators and, when successful, consequently become a boundary spanner. Thus, BCs are expected to act as the integrative link between different disciplines in order to bring about agreements or reconciliation when information conflicts arise. In order to achieve this, the above-mentioned increased attention to social aspects, leadership, and communication are essential (Björk Löf and Kojadinovic, 2012; Davies *et al.*, 2014). Recently, Mathews (2015) acknowledged that boundary spanning was an important skillset for BCs; also, in her study on inter-organizational collaboration in construction design, Bosch-Sijtsema (2014) empirically observed BCs functioning as boundary spanners. She wrote: “*from the observations it became clear that members who are knowledgeable and experienced in working with BIM became boundary spanners in practice during the meetings. The [...] BIM coordinator became a boundary spanner and [...] took the active role of facilitation and spanning boundaries in terms of asking questions, interpreting and requiring information and visualizing this with the model, and supporting joint decision-making with help of the 3D-model*” (Bosch-Sijtsema, 2014, p.11). It should be noted that a BC does not become a boundary spanner merely by being given the formal role of BC, but rather through his/her actions, knowledge, and the position as a successful intermediary in the organizational network. As noted in the same study, when the BC failed to enact the role as intermediary, “*this was reflected in confusion, lack of understanding, and discussion concerning the 3D design and how to work with the design*” (Bosch-Sijtsema, 2014, p.11). In essence, one might claim that the role of boundary spanner comes with being a “cutting-edge” BC, and is therefore an integral part of the previously listed responsibilities.

5. Interviews: BCs in practice

In the expert interviews, the review results presented above were verified but also problematized. Even if the results were not discussed with the interviewees, the content of the outlined responsibilities was addressed by the respondents when discussing the “practice,

activities and collaboration”. In addition to the roles and responsibilities deduced from existing literature, two additional practices were identified, both of which have allegedly grown out of the everyday challenges that BCs face.

5.1. External and internal alignment

A seemingly important practice for BCs is external and internal alignment, which involves keeping up to date and keeping the organization and its members aligned with contemporary BIM developments and existing practices. As explained by one of the respondents:

“An important part of the work is to follow technological development in the area and keep updated on the options we have. Preferably I need to be knowledgeable of national and international developments. I also need to be able to look into the future; I need to know where the market is going; I need to understand BIM and how information is integrated in the business processes; I need to be up-to-date when it comes to standardization and be able to deliver according to the market expectations, regulations, and the standard. The key is to be proactive and have a strong professional network.”

While some of the other respondents also touched on the need to be proactive, all respondents acknowledged that this is not always an easy task. As one of the respondents explained, the fact that the BC role is often a part-time duty means that there is not always time to be proactive. Following the same line of argumentation, another respondent said that, as a BC, it is important to *“make sure that all of our project managers know what we offer and not, when we work on a BIM-project”*. A third respondent said: *“one of the main roles of a BIM coordinator is to make sure that everyone is aligned, and to make sure that the system is up to date. Moreover, for every new project you need to make sure that the info sheet for the project you are working on is up to date. This entails the info on coordinate systems and info about what is expected. [...] This is just to make sure that everyone follows the same processes.”* A fourth respondent explained: *“It is, for example, important to make sure that everybody follows the same folder structure; in essence, follows the same way of working.”*

The practice of working with “external and internal alignment” could be said to be a prerequisite for being able to support “new working procedures and technical development”. As summarized by one of the respondents: *“In essence, my job as a BIM coordinator is to make sure that everybody talks with each other and that there is a collaboration between the different disciplines.”*

5.2. Coordination of actor needs

In addition to “external and internal alignment”, another practice addressed in the interviews, is the work to coordinate actors’ needs. In essence, this entails making sure that the client get what they should have and need, but not more than that. One of the respondents explained:

“We need to have a standardised approach as a ‘tool’ for our project managers to deal with clients wanting significantly more than what is included in our standard deliveries. It is not a matter of ‘BIM or not’. All information has a potential value

and associated cost. If the client want it to add value to their project, they should also be willing to pay for it. All new information needs to be quality-assured and coordinated in the project. That requires time-consuming processes with an actual price-tag for us. [...] My job is to work with tenders for our BIM services.”

Another respondent complemented this explanation by saying, *“different traditions and the engineering disciplines have different information needs; my work involves coordinating and aligning these needs.”* Similar how the practice of “external and internal alignment” is a prerequisite for the responsibility of “new working procedures and technical development”, the practice of “coordination of actor needs” can be said to extend the previously identified responsibility of “managing information flows and communication flows”. Still, there is an important difference. Because the “management of information flows and communication flows” is integrative in nature, it relates directly to the federated model, and the information relating to the model. The practice of “coordination actor needs”, on the other hand, is related to the expectations of different actors and the business aspect of how that information is used (or not used). Taken together, one can argue that this practice also contributes to the above-mentioned boundary spanner work as it potentially facilitates the building (and maintenance) of relationships among actors.

5.3. A role, not (yet) a profession

During the discussions regarding the every-day practice of BCs, it became clear that the BC role is often a part-time one; it can therefore be described as a role rather than a profession, even though two respondents argued that this is currently changing. One said, *“being a BC is a peripheral part of my daily life”*; another said that being a BC *“is today always a part-time role”*. The same respondent also said that most BCs in his organization are project architects who take on the position of BC in specific projects. Yet another respondent explained: *“I have this job in one of my projects, but I of course have other projects on which I work [...] the BC role consumes about 20 percent of my time in each project.”*

All respondents also confirmed that the BC role involves a wide set of responsibilities (*cf.* Gathercole and Thurairajah, 2014). Given that it is often a part-time duty, the scope of responsibilities seems to depend on the size of the project, the actors involved, and the background of the BC. One respondent said, *“disciplinary BIM coordinators are definitely dependent on scale”*. The same respondent continued: *“It is not that common to have disciplinary BCs. Most of our projects are not of the scale that this is needed. Most of our projects are a little bit smaller and then you only have a project-wise BIM coordinator.”* He went on to say: *“In bigger projects we have three different BIM roles that are involved. First we have a corporate strategic BIM person (we call them BIM strategists), then we have a project-level BIM coordinator building IFC models, and we have a coordinator role in each group (a disciplinary coordinator).”* Another respondent said: *“In the smaller projects the BIM coordinator is often a consulting engineers, but sometimes also an architect [...] When it is an engineer, the focus is on engineering stuff and when an architect, they mainly focus on the architecture stuff.”* That respondent ended by explaining that, independent of background, the BC is supported by the IT department when it comes to more technical issues.

6. Discussion: challenges, obstacles and future

It can be concluded from both the review and the expert interviews that BIM coordinators bear responsibility for a number of important tasks, covering aspects such as clash detection (integration, identification and proposing solutions); managing information flows and communication flows; monitoring and coordinating design changes throughout the construction process; supporting new working procedures and technical development; and boundary spanning. The interviews not only verified these areas, but also complemented them with practices such as external and internal alignment and coordination of actor needs.

In addition to discussing the everyday practice of BCs, the interviews also addressed the experienced challenges and obstacles, as well as the potential future of the role. All of the interviewees confirmed that the role has developed from being primarily technical to having a more relational focus. However, based on the listed responsibilities and practices, it is clear that the role mainly covers the design and production phases and that the individuals taking on this role need to have a good understand of both the technology and the process. In line with what Poirier et al. (2016, p. 784) recently stressed, it seems that BC role aims *“to fill a void, bridging the current gap that appears between traditional practice and innovative practice by levelling disciplinary and collaboration expertise to support efficient project delivery.”*

6.1. Challenges and obstacles

In filling this void, however, BCs experience certain challenges and obstacles. The prime challenges seem to be related to the fact that BIM is a disruptive technology that necessitates a new way of working. One respondent said: *“It is not just a tool. It is a new way of thinking business and way of working. It takes time to change the mind-set of the individual designers, project managers the leadership to make them understand.”* In the words of another respondent, *“BIM is a new field that challenges all parts of a firm.”* A third respondent said: *“The main issue is the people. The technology works. [...] The problem is old habits, old attitudes.”* He continued:

“They appreciate it, but some of them are not willing to switch, let’s say to the latest technology, and change the way they do things. Nobody is viewing things precisely like I view them, and we are not identical people. But, my point is that some of them have one way to do things, and they will keep this way for ever.”

The fourth respondent highlighted almost exactly the same challenge, saying: *“I meet a lot of people in the different areas that do not share that enthusiasm. They still want to work in the same old way. They have been working in the industry for many years, they have a lot of knowledge, but that piece of knowledge about BIM is missing.”* In essence, a lack of understanding among other actors seems to constitute a challenge for the BCs.

With the challenge of BIM also bringing a new way of working that not all involved actors understand, or are willing to accept, another interrelated challenge is addressed: the lack of innovative space due to a strong project focus. One respondent explained: *“Sure, you can*

solve the problems faster, and we can solve more complex algorithms faster than we could before, but there is not enough focus on business advantage. As with all project work, the focus is on time, cost, and quality... all the time. [...] innovation costs money. To utilize the full potential, innovation is needed.” He continued: *“I do not think that we are afraid to test out new stuff, I think we are afraid to spend money without guaranteed return.”* Complementing this, another respondent claimed that *“the contracts in the projects are focused at single deliveries rather than viewing the project in its totality.”*

Even if not directly related to the BC responsibilities, all respondents brought up the role of contracts as a challenge. One respondent said, *“The contracts constitute a problem; contracts are not designed to focus collaboration”*. She continued: *“Contracts and project models mainly focus and award deliveries from the single discipline rather than viewing the project in its totality.”* Another respondent said, *“Contracts are one of the major problems because the contracts we use now have not been updated and they do not support model-based work.”* He continued:

“Sometimes companies also to ‘hide behind the contracts’, so if BIM is not written in the contract then we cannot do it since we will not get paid for it. If the contracts would actually be made for making BIM models then firms would have to deliver different objects in the model and then you have it in a contract. If you look into traditional contracts then I think you would be surprised that it is still a very ‘old-school’ thinking and in our contracts, they have to deliver paper drawings.”

Overall, the respondents seem to be in agreement that the main challenges influencing the BC role relate to actors’ perception of BIM, old habits, lack of space for innovation, and contractual issues.

6.2. Future potential and development

Looking towards the future, the respondents pointed in two distinct directions: a changed view of BIM, and BIM as a fully integrated work practice. Regarding the former, one of the respondents argued that there is a huge “misunderstanding” of BIM, reducing it to being about the federated model (that is, a product focus). She explained:

“We need to get away from the model and focus on the process and collaboration. A focus on how the use of the model and all its integrated information can be used to support and improve the project process. [...] In the future, there will no longer be a need to focus on technological issues; the entire focus will be on the information chain and the process.”

Taking this a step further, another respondent argued:

“... the BIM coordinator role, as it is today, is a pure coordination role, both within the different disciplines and the inter-disciplinary coordination. [...]. It is a

bit about that everybody knows the correct way of doing stuff and that everyone follows the instructions ... In my view, in the future, everybody will simultaneously be working on a collaboration model. We will all work together with the other consultants, the construction company and the clients. This will be the future.”

Another respondent summarized by saying: “*In the future, when BIM is fully integrated, the BIM coordinator will just be a person who is sitting on site and observes and maybe fixes some errors. Or maybe he will just be part of the startup and then will go away from the projects when they run smoothly.*” In essence, if the respondents are correct, the BC role will be less of a problem solver and more like a collaboration facilitator. At least that is the direction in which the interviewed expects would like it to develop.

7. Conclusions

Taking its starting point as the limited focus on new BIM-related specialist roles and the lack of focus on everyday practice (see, e.g., Davies *et al.*, 2014; Succar *et al.*, 2013), the present article has sought to explore the role, practices, and responsibilities of BIM coordinators. Based on an integrative literature review of existing publications that have described and discussed BCs ($N=78$), five areas of responsibility were identified. To ensure credibility and transferability of the findings, the review was followed by interviews with four BIM experts, through which two additional practices were found.

The findings from the literature review indicate that core responsibilities of BCs are: (a) clash detection, which involves integration, identification, and proposing solutions; (b) managing information flows and communication flows; (c) monitoring and coordinating design changes throughout the construction process; (d) supporting new working procedures and technical development; and (e) acting as a boundary spanner. Through the interviews, these findings were verified and complemented with the practices of ‘external and internal alignment’ and ‘coordination of actor needs’. These two practices are shown to be complementary to the identified areas of responsibility – external and internal alignment being a prerequisite to support new working procedures and technical development, and the coordination of actor needs being an extension of the responsibility to managing information flows and communication flows. Based on these results, the role of a BIM coordinator (BCs) can tentatively be defined as *a role responsible for external/internal alignment and coordination of actor needs, engaged in product, process, and systems oriented practices of BIM*. More specifically, the role involves working with clash detection, managing of information flows and communication flows, monitoring and coordinating design changes, and supporting new working procedures, thereby acting as a boundary spanner.

From the interviews, however, it can be concluded that the role and responsibilities of BCs vary depending on factors such as the BIM maturity of the organization, the individual enacting the role, and the size of the project. It should also be noted that some of the responsibilities outlined in the literature review seem to be based on prescriptions – that is, ‘what should be done’ according to, for example, BIM manuals and handbooks (see, e.g., Eastman *et al.*, 2011; Kristiansson, 2014) – rather than purely empirical observations, and

might therefore not always be reflected in the emergent practice of ‘what is done’. This might also explain the identified variation. The described variety of tasks and difference between the ‘prescribed’ responsibilities and emerged practice still supports previous observations and extends the existing practice-oriented studies of BIM (see, e.g., Bosch-Sijtsema, 2013; Davies *et al.*, 2014; Gathercole and Thurairajah, 2014; Ku and Taiebat, 2011; Merschbrock and Munkvold, 2015), with important knowledge of the role and responsibilities of BCs.

Returning to the three (or four, if ‘practice’ is included) perspectives of BIM presented at the start of this paper, and juxtaposing those with the identified responsibilities, it can be concluded that the identified practice, to varying degrees, supports various notions of BIM. Two examples are the practice of ‘clash detection’ and ‘supporting new working procedures and technical development’, which is clearly related to the product aspect of BIM, and the ‘boundary spanner’ and coordination of actor needs, which relate more to a systems perspective and systems/process perspective of BIM. This is in itself not a revolutionary conclusion, but rather confirmation that the BIM coordinator role is important, and supports the process, processes, and system dimensions of BIM. The relationship among the identified practices and the presented perspectives is presented schematically in *Figure 2*.

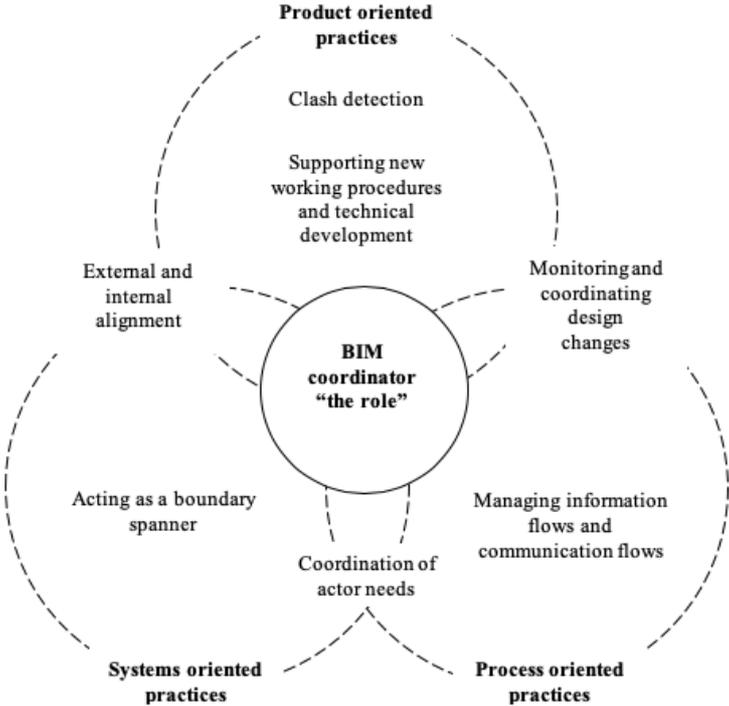


Figure 2: The role and responsibilities of BIM coordinators

Reflecting the current level of BIM maturity within the AEC industry, it can also be concluded that a BC is today more of a role than a profession and that the main challenges influencing the BC role relate to actors’ perception of BIM, old habits, lack of space for innovation, and contractual issues. These challenges support observations by, for example, Davies *et al.* (2014), who argued that BCs “often struggle to find sufficient time to work on

higher-level planning and management activities.” Still, with successful BIM use building on premises of mutual information sharing to establish a collaborative environment in projects, the BC role is of central importance. Also, with BIM generally intended to serve as a design space where multiple actors engage in collaborative dialogue, the role of BCs as boundary spanners seems to be becoming increasingly important. Paradoxically, the primary objective for BCs – that is, to enable all involved actors and disciplines to share useful information – also seem to be their biggest challenge. However, Davies *et al.* (2014) proposed that “*as the market for BIM projects increases this is likely to improve, with greater awareness of the skills and responsibilities of the BIM specialist developing along with increased uptake of the technology and processes.*” Only time will tell whether this will actually be the case.

8. Practical implications and suggestions for future research

Based on the above outlined findings, there are clear practical implications for construction managers, educators, and BIM coordinators.

First, bridging the gulf between the traditional construction business functions and the emerging role of BIM coordinators requires management to develop a new set of expertise. Based on the conclusion, construction managers would need skills such as IT planning, IT budgeting, and IT resourcing to provide BIM coordinators with the means to do their jobs. Moreover, management would need to be able formulate IT strategies that firmly anchor the new BIM coordination roles in their organizations. BIM coordinators are champions for a substantial IT-driven organizational change and they need managerial support to prevail.

Second, it would seem that the implications for educators are to provide learning that span a variety of topic areas in BIM systems, products, and processes. Learning outcomes would need to be hands-on skills for modeling and clash detection, information systems management, inter-organizational coordination, as well as basic computer science. In our view, the very breath of skills required calls for the development of new specialization areas in tertiary civil engineering education.

Third, the implications for BIM coordinators would suggest that their role extends far beyond the hands-on assembly and coordination of digital models. Their role would seem to involve fostering an (inter-) organizational culture, handling human and social aspects to create an open environment in which professionals readily share information. Awareness of these challenges is an important first step.

Finally, all of the above-mentioned implications potentially open the way for future research. Examples could include studying the perception of emerging BIM roles from a project managers’ perspective, or conducting an in-depth study into the inter-organizational challenges that BIM coordinators potentially face. The fact that this study is primarily an integrative literature review of BCs, it has the limitations common with such an approach. Therefore, future studies could preferably extend presented findings through a survey, further in-depth interviews with BIM coordinators, or a review of closely related BIM specialist roles such as BIM managers or BIM technicians.

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