Embedded Contexts of Innovation: BIM Adoption and Implementation for a Specialty Contracting SME

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<th>Journal:</th>
<th>Construction Innovation: Information, Process, Management</th>
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<td>Manuscript ID:</td>
<td>CI-01-2014-0013.R1</td>
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<td>Manuscript Type:</td>
<td>Research Article</td>
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<tr>
<td>Keywords:</td>
<td>Building Information Modeling (BIM), Small or Medium Enterprise (SME), Specialty Contractor, Case Study Research, Innovation, Context</td>
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Abstract

Purpose - The radical innovation process behind the adoption and implementation of building information modeling (BIM) for a specialty contracting small or medium enterprise (SME) was studied. This article offers two distinct perspectives on BIM adoption and implementation, which are underrepresented in the current literature: the SME perspective and the specialty contractor perspective. It also attempts to bridge the gap between the growing literature on BIM adoption and implementation and the established literature on innovation by developing the notion of embedded contexts in the innovation process.

Design/methodology/approach - A mixed-method, longitudinal case study approach was employed in this research project to study the evolution of the innovation process and its impact on the Organisation over time. The objectives of this research were to investigate and document the different factors mediating the BIM adoption and implementation process for the Organisation across various contexts, the mechanisms put in place to facilitate this process, and the perceived impact within the Organisation.

Findings - The initial transition to BIM represented a radical innovation for the Organisation. Subsequently, a series of incremental innovations took place to further advance the Organisation’s BIM capabilities. This innovation process is influenced by different layers of embedded contextual factors, which can be mitigated by, among others, a clear strategic approach towards the innovation process approach. Specialty contractors can leverage BIM within their own supply chain and reap significant benefits.

Originality/value - This article offers an in-depth study of radical innovation within a specialty contracting SME. This study discusses the influence of four embedded contexts on innovation for a specialty contracting SME: (a) the industry context; (b) the institutional context; (c) the organisational context; and (d) the project context. It also offers insight into the factors, mechanisms and their impact on the innovation process.

Keywords:
Innovation process, Building Information Modeling (BIM), Small or Medium Enterprise (SME), Construction industry, Specialty Contractor, Case Study Research, Adoption, Implementation, Context

Paper Type:
Research Paper
Introduction

Building information modeling (BIM) has been recognised by the Architecture, Engineering and Construction (AEC) industry as having significant potential to positively impact project delivery and outcome. However, both researchers and practitioners alike agree that the adoption and implementation of BIM is a challenging endeavor. Among others, the BIM adoption and implementation process is highly contextual and discipline specific. The importance of this perspective lies in the divergence of ‘social worlds’ (Taylor, 2007) within the AEC supply chain. While past research on organisational innovation has documented the importance of context and environment in the innovation process, this dimension has largely been ignored in the BIM adoption and implementation literature.

This study investigates the contextual nature of innovation through the study of BIM adoption and implementation for a specific industry segment: a specialty contracting SME working in the mechanical contracting field. The motivation behind this study lies in the scarcity of research in this area, particularly within small or medium enterprises (SME). This particular area is important due to the considerable amount of SMEs that form the AEC industry’s supply chain. For example, 99.0% of the Canadian construction industry is made up of small (between 5 and 99 employees – 38.5%) and micro (less than 5 employees – 60.5%) businesses (Industry Canada, 2014). Furthermore, the majority of these SMEs are found to not be implementing innovations within their organisations and invest little in research & development (Statistics Canada, 2011). The need to focus particular attention on SMEs and their capacity to innovate, in this case to adopt and implement BIM, is thus significant. In parallel, the specialty contractor’s perspective is of interest due to the potential for significant productivity gains from the use and deployment of BIM in the field, although its adoption and implementation has not yet been fully realised (Boktor et al., 2013, Isaac and Navon, 2013, McGraw-Hill, 2009, McGraw-Hill, 2012).

The findings of this study reveal key factors, mechanisms and impacts, developed across four distinct yet embedded contexts: (a) the industry context; (b) the institutional context; (c) the organisational context; and (d) the project context. The findings stem from the longitudinal case study of a mechanical contracting SME adopting and implementing BIM. The objectives of the research were to investigate and document the various factors mediating the Organisation’s BIM adoption and implementation process, the mechanisms put in place to facilitate this
Two key findings emerged: First, the transition to BIM was a radical innovation for the mechanical contracting SME under study. Once the infrastructure for BIM was in place, a series of incremental innovations took place to further develop the Organisation’s BIM capabilities. Second is the very limited influence specialty contractors have on the deployment of BIM throughout a project’s lifecycle. While Owners, General Contractors and Architects are in a position to drive BIM at the project level, specialty contractors are dependent on upstream efforts to maximise their work, which limits the opportunities for productivity gains in the field, for the generation of knowledge and for the leveraging of project experience to develop internal BIM capabilities. In contrast, a clear organisational vision and strategy, combined with a structured approach to the BIM adoption and implementation process was shown to result in positive gains for the Organisation, regardless of its external contexts.

Background: On Innovation and BIM adoption

Innovation in the AEC industry

The context of innovation, its process and its outcome has been the subject of much research over the past three decades in the AEC industry. The innovation process has been defined as ‘the development and implementation of new ideas by people who over time engage in transactions with others within an institutional context.’ (Van de Ven, 1986, p 591). For innovation to occur, the confluence of three elements is required: the generation of an idea (stemming from a need), the opportunity and its diffusion/adoption (Gambatse and Hallowell, 2011, Rogers, 1962, Winch, 1998). Typically innovation types fall into one of the following categories: Technological innovation, encompassing both product and process innovation - new product offerings or product improvements and the creation or improvement of methods of production, service or administrative operations; services innovation - the development of core competencies and products; and organisational innovation - the development of management initiatives (Oke et al., 2007). Innovation stems from, among others, an organisation’s desire to gain competitive advantage, reduce costs, enhance quality, technological opportunity, or institutional requirements. (Mitropoulos and Tatum, 2000, Pries and Janszen, 1995, Rankin and Luther, 2006).
Various models of innovation have been developed for the AEC industry. Slaughter (1998) presents a seminal model of innovation, relating degrees of innovation - incremental to radical innovation, its adoption and its impact. Winch (1998) presents a model of construction innovation, which relates four processes (adoption, implementation, learning and problem solving) across three different environments (external, firm and project). Furthermore, viewing construction as a complex systems industry, the author adapts Miller et al. (1995) structural context of innovation management for the construction industry. The innovation superstructure (clients, regulators and professional institutions), the systems integrators (architects, engineers and general contractors) and the innovation infrastructure (trade contractors, specialist consultants and component suppliers) are distinguished. An interesting feature of this model is the apparently secondary or supporting role that trade contractors have in the overall innovation process. This model is further investigated by Rutten et al. (2009), in particular the role of systems integrators in coordinating inter-organizational innovation. This view however is limited to success factors supporting various types of innovation and very little mention of environmental or contextual factors are made.

The body of work of Sexton and Barrett (2003a, 2003b, 2006) has contributed multiple perspectives on the innovation process for SMEs in the construction industry. They propose three models of innovation: a generic model, a ‘modes of innovation’ model and an organisational model of innovation. These three models have in common the influence of external environment on innovation process and outcome within SMEs. The authors go on to find that, typically smaller organisations innovate in an ad-hoc fashion by ‘learning on the job’ and are motivated by a willingness to survive, which underlies a general lack of strategic vision. They establish a correlation between the size of the network within which SMEs evolve, which dictate exposure to innovative technologies, and willingness to innovate. The authors also find that SMEs are more willing to adopt and implement technologies that have a proven track record and with which they can see immediate benefit, rather than radical technology shifts, such as BIM, which are deemed more risky. This speaks to the lack of strategic approach to innovation, which is symptomatic of SMEs in the AEC industry.

A constant factor underlying these models is the highly contextual nature of innovation (Stewart et al., 2004). For instance, Pries and Janszen (1995) and Mitropoulos and Tatum (2000) draw a
clear relationship between innovation, the industry context, the organisational context and the outcome of innovation. Harty (2005, 2008) adopts a distributed and multi-centered view to innovation across project networks, as opposed to a singular, uniformly driven process view. Accordingly, this enables recognition of the ‘complexity of the contexts of construction’, orients ‘towards inclusiveness rather than simplification’ (Harty, 2005, p. 521) and pushes to focus on the process of interactions between innovation and current practice. Taylor and Levitt (2007) look into the alignment of innovation and its implementation within project networks. The authors look into alignments between organisational, technological and contextual factors, which mediate the rate of innovation deployment. They highlight the mediating force of the geographic and market context on innovation use and diffusion. Bossink (2004) identified a series of Innovation drivers and managerial actions driving these innovations. The author also identified three levels at which innovation drivers are active within the AEC industry: the organisational level (intrafirm), the project network level (interfirm) and the industry level (transfirm). To summarise, the importance of the environment and context within which innovation occurs is paramount in influencing the course of innovation within an organisation. BIM is one such innovation that is seen as highly context dependent.

**Building Information Modeling**

BIM is seen by many as being a disruptive innovation, which is bringing about the reconfiguration of practices in the AEC industry (Crotty, 2011, Eastman et al., 2011). Past research on BIM has looked into the factors affecting BIM adoption and implementation, the mechanisms driving the process and its impact from a variety of perspectives. These factors and mechanisms and their impact have been enquired into at various levels (industry (Becerik-Gerber and Rice, 2010), organisation (Kaner et al., 2008), project (Bryde et al., 2013, Fox and Hietanen, 2007)), at various stages in the project lifecycle (design (Manning and Messner, 2008), construction (Akinci and Kiziltas, 2010), operation (Javier et al., 2011)) and for different stakeholders in the supply chain (owners (Giel et al., 2012), designers (Arayici et al., 2011), contractors (Ku and Taiebat, 2011)). Eastman et al. (2011) and Smith and Tardif (2009) offer a comprehensive overview of BIM adoption and implementation different stakeholders by identifying specific factors affecting the adoption and implementation process and their respective benefits. In essence, a lot of ground has been covered in the literature concerning
BIM adoption and implementation. However, certain trends emerge when considering this growing body of knowledge such as: the attempt to decontextualise and generalise findings from research projects, the underrepresentation of SMEs and their perspective on BIM adoption and implementation and the focus on BIM from the owners, designers and general contractor’s viewpoint. Lastly, the specialty contractor perspective is sparse, in particular at the organisational level.

Past research has identified means and methods for implementing BIM at the project level. Dossick and Neff (2010) performed an ethnographic study of the MEP coordination process for two projects and identified factors which hinder the close collaboration between team members working in a BIM environment, notably organisational divisions and competing obligations of individual project team members. Staub-French and Khanzode (2007) provide a detailed approach to implementing both 3D and 4D modeling and coordination in a project network from a technological, organisational and procedural perspective. They go on to discuss the impact of this implementation on project performance and relate the benefits that come from the implementation of BIM in a project setting. Khanzode (2010) presents an Integrated, Virtual Design and Construction and Lean (IVL) method for coordination of MEP systems. The results of four case studies where either Virtual Design and Construction (VDC) or Lean methods (or a combination of both) was implemented for MEP coordination are presented. The author provides empirical evidence of the benefits in increased productivity and reduction of waste for the MEP contractors at the project level. However, little is said about the implications of the adoption and implementation process at the organisational level.

A recent study by Boktor et al. (2013) reports that nearly 49% of mechanical contractors in the US are not using BIM. The authors reveal three key factors of BIM adoption for mechanical contractors: First, there is a correlation between a firm’s size and it’s usage of BIM, between a project’s size and the amount of staff dedicated to BIM as well as the number of years of experience using BIM and the organisation’s expertise. Second, the cost of implementing BIM varies quite significantly, with the average at 1-2% of total project costs (no indication is given as to what is included in the calculations of these costs). Third is the emergence of two main focus areas for investments: the creation of in-house BIM procedures and the marketing of BIM to customers. This study reveals that there are great expectations within the MEP field concerning
the potential benefits of BIM and there is a desire to get involved with BIM in the near future. However, there lacks insight into these specialty contracting SMEs in light of BIM’s disruptive nature and the radical transformations that are required to successfully go about adopting and implementing BIM. This study aims to address this gap.

Research Methodology

The objective of this research was to investigate the BIM adoption and implementation process within a specialty contracting SME working in the mechanical contracting field (the Organisation). The aim was to uncover and document the factors mediating the BIM adoption and implementation process, the mechanisms that were put in place to facilitate this process and to assess the perceived impact from the Organisation’s perspective. A mixed-method, longitudinal case study approach, rooted in the interpretivist paradigm, was employed to study the BIM adoption and implementation process and its impact on the Organisation over time (Stake, 1995, Stake, 2006). This particular research approach was adopted due to its ‘inductive development of patterns of meaning’ and an emic approach to the understanding of phenomena within the cases under study (Avenier, 2010, Creswell, 2003). This provided the research team with an in-depth viewpoint and allowed them to uncover the various phenomenon brought on by the transition to BIM from the perspective of the organization and its personnel. The case study took place over a period of 18 months, between April 2012 and October 2013.

The Organisation studied was founded in 2004 and operates in the Vancouver, British-Colombia area. It has 50 employees and is deployed along a project-based organisational structure across two divisions: 13 office based employees (project managers, coordinators, estimators as well as administrative staff) who form the project management team and 37 site based employees (superintendents, foremen, journeymen). Since 2004, they have completed over 50 projects ranging from $100k to $12M contract value. The research team studied both the Organisation and its supply chain. Under the interpretivist paradigm, the unit of analysis is subsumed by the historical event under observation (George and Benett (2005) in (VanWynsberghe and Khan, 2008)), in this case the adoption and implementation of BIM within the Organisation. The units under observation were the personnel involved with the BIM adoption and implementation
process within the permanent organization (PO) and within each temporary project organizations (TPO) (figure 1). These units of observation were chosen due to their proximity, involvement and relationship to the BIM adoption and implementation process. Semi-structured interviews, lasting between 30 and 90 minutes, were carried-out on two different occasions with the same personnel over the 18 month period in order to gain insight into the evolution of the adoption and implementation process. The personnel interviewed within the Organisation were the president & general manager (who also acts as senior estimator), the construction manager, three project managers, the BIM manager and the principal BIM coordinator. At the project level, the client representative for project 01 (Large institutional (university) district energy project – See table 1) was formally interviewed to gain insight into the client’s view of the implementation of BIM by the Organisation and its perceived impact on project outcome. Three themes related to BIM adoption and implementation were developed during the interviews: the technology, the organisation and the process. The interviews also touched on both the organisational as well as the project level adoption and implementation efforts. The interviews were subsequently transcribed and coded in Nvivo (QSR International, 2013). Two coding cycles were performed during the analysis stage (Saldaña, 2013, in Miles et al. (2013)). The first cycle of coding allowed the research team to establish the emerging contexts of the adoption and the implementation process. The second cycle allowed the research team to define the various factors, mechanisms and their perceived impact across these different contexts.

INSERT Figure 1 – Longitudinal Case Study research approach

While the interviews constituted the primary source of qualitative data informing the research project, other sources such as: observation of meetings, field notes and informal discussions with project team members were collected and analysed. Furthermore, the monthly BIM steering committee meetings were attended over the course of the research project, field notes were taken during these meetings and the minutes reviewed. The research team also performed direct observation of the personnel, namely the BIM coordinator and site super intendant on a
large building renovation project. **Quantitative data included project documents such as Request for Information (RFI) and Change Order (CO) logs, budgets and cost reports, schedules, plans and specifications as well as models and employee timesheets.**

At the project level, four projects were targeted for data collection. These embedded case studies are described in Table 1. The research team attempted to attend as many coordination meetings as possible for these projects, however lack of consent on the part of external project team members on certain projects limited access to these meetings on certain projects. The nature of Projects 01 and 02, mainly the ‘lonely’ BIM approach, meant that the use of BIM was not formalised in coordination meetings, but was deployed in a more informal fashion, transacting directly with the personnel on site.

Data analysis was approached from two perspectives. First, the longitudinal data collected within the Organisation was analysed to uncover variations through time of the effects of the BIM adoption and implementation process within the Organisation. Second, the cross-case analysis of the multiple embedded cases allowed literal replication across the study for elements pertaining to the project context and its influence in the BIM adoption and implementation process. **Furthermore, adopting a mixed-method approach allowed the research team to triangulate data source. For instance, claims made during the semi-structured interviews were substantiated through document review where possible (i.e. contractual requirements). Some claims were also substantiated through direct observation (i.e. relationships with external stakeholders). Asking multiple interviewees the same questions on document quality, for instance, validated claims pertaining to quality of documentation, which were further confirmed through on-site observations and document review. This was done in an effort to increase both reliability of the findings and construct (internal) validity through ‘convergence of evidence’ (Yin, 2014).**

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**INSERT Table 1 - Project Context and Data Collection**

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Embedded Contexts of Innovation: the BIM Adoption and Implementation Process

Analysis of the case study data has highlighted four distinct yet embedded contexts mediating the BIM adoption and implementation process for the Organisation studied, as illustrated in figure 2. Each context exerts its own influence on this process by introducing specific factors. The Organisation has developed mechanisms to counter or enhance these contextual factors according to their impact on the BIM adoption and implementation process. However, not all factors are possible to manage. The interface between the organisational and project context is characterised by the organisational push (ie. opportunities, intent & incentives) and project pull of BIM (ie. project BIM Requirements & uses, procurement & project incentives) and the organisational pull with regards to learning and assessment. The following section describes each context in relation to the Organisation, the factors inherent to that particular context and their impact on the BIM adoption and implementation process within the Organisation.

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INSERT Figure 2 – Embedded Contexts of BIM adoption and implementation

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The Industry Context

The industry context encompasses the geographic and market context, which includes the regulatory and legal contexts. It acts as an external force on the Organisation and to a certain degree dictates the relevance of the organisational BIM adoption and implementation process. In this case, the Organisation performs most of its work in the medium to large commercial and institutional sectors. In trying to establish relationships with its client base, it caters mostly to larger institutional owners, private owners and larger general contractors (GC) in the Vancouver, British-Colombia, Canada area. The influence of the industry context emerged as one of the biggest challenges to BIM implementation for the Organisation.

The main industry level factors which impeded the adoption and implementation process were the lack of demand for BIM from clients (owners and general contractors alike), the low level of maturity within the market segment (mechanical engineering and contracting) and the relative
stand still of the adoption of BIM over time within the industry (inertia) as discussed by the general manager:

*The biggest challenge I think has pretty much been being ‘lonely BIM’ on all the jobs we have done. We have yet to be on a fully integrated BIM project. Even ones that we were told would be [fully integrated] during tendering, have not proven to be, such as [project 04], where we are basically driving the bus. We are getting very limited support from anybody else.*  - GM

The proximity to the US market and the lessons learned from the adoption process there as well as the ever-increasing availability of tools and training by vendors is allowing the Organisation to push forward with the adoption and implementation process in light of the current limitations highlighted above. *In other markets, such as the UK and Singapore, BIM is becoming mandatory. This is not the case within the Canadian context, where industry-level mechanisms have yet to be put forth. Furthermore, in Canada, there lacks this transition to BIM by large public owners seen elsewhere such as in the US and the UK.* However, the Organisation has noticed an increasing demand for BIM within their market segment. The impact of this has been the slow progress made in overall BIM adoption and implementation. On the other hand, this has provided a considerable opportunity for the Organisation to market itself as a leader in the field:

“And so I still think it was a good decision [to adopt BIM]. We’re “leaders of the pack” so to speak and that is bringing us a lot of opportunity. So that was one of my primary motivations in jumping on the BIM band wagon, it was to get ahead of the pack, gain a competitive advantage and I think we have achieved that.”  - GM

The Institutional Context

The institutional context is defined by the practices, policies and procedures implemented by the various stakeholders in the AEC supply chain. It is also characterised by the various vocational backgrounds, which comprise the AEC supply chain. In this case, the Organisation evolves in a distinct institutional context due to the presence of personnel, coming from various backgrounds, performing concurrent tasks within the organizational context and within the project context. As such, the institutional context intersects both the organisational and project
contexts. This is illustrated by the presence of mechanical engineers within the Organisation and consulting engineers within the project team.

Several factors, originating from the institutional context, hinder the BIM adoption and implementation process within the Organisation. The practice turn that is required on the mechanical consultant’s part when implementing BIM marks a shift in responsibility between the mechanical engineer and the contractor. Indeed, it was observed that the mechanical contractor was either making decisions or prompting them to be made through increased involvement in the modeling process. This phenomenon was seen as being exacerbated by the project delivery mode.

In addition, many interviewees perceived the quality of the drawings obtained from the mechanical consultants as lacking. The Organisation thus had to spend time translating these drawings into 3D models and spool drawings, while ensuring the constructability of the design intent:

*BIM is driving us to develop our own engineering capabilities so that we can enhance the design we are getting because they are not very buildable in a lot of cases, or there are serious issues with the drawings we are receiving from engineers* - PM, project 04

The Organisation’s management observed an internal struggle between office and field personnel in certain instances. This hints at diverging individual priorities within the project delivery setting, even within the same organisation. This was attributed to the increased involvement upstream in the planning process of the field personnel and thus their varying vocational and disciplinary backgrounds. This points to a need to reevaluate the project delivery process and target the interventions and exchanges between field and office personnel:

*[…] office people are just focused on one thing versus a field guy who’s focused on a hundred things. They have to learn that they aren’t the centre of the universe as far as the field goes. The universe revolves around the site and the guys in the crew, and [the BIM department] is accessory to that. That’s a learning curve. I think the part of the timeline we have to get better at we need to get ahead of the curve more.* - GM
In terms of institutional mechanisms, the primary means through which these factors could be mitigated, identified during interviews, was education and training as well as the involvement of professional associations in developing specific codes of practice for their members suited to the emerging realities of BIM, such as those developed in the UK (SEC-NSCC, 2013) and Australia (AMCA, 2014). A firm definition of the standard of care and elements such as level of detail, coming from an institutional source, instead of being established on a project basis, could mitigate the aforementioned factors.

The impact of BIM adoption and implementation within the institutional context is the increasingly blurred boundary between the Organisation’s role as part of the innovation infrastructure and its increasing role as systems integrator, as presented by Winch (1998). With the transition to BIM, the Organisation is seen as evolving in both respects within the supply chain. In addition, the difficulty in finding adequate resources to further the BIM adoption and implementation process within the Organisation is seen as stemming from a lack of support and direction from the educational sector.

The Organisational Context

The organisational context is characterised by the permanent nature of its structure. It encompasses the Organisation’s management, its president and general manager and its construction manager, and the employees, both field and office personnel, who perform daily project delivery tasks. Multiple organisational factors were identified throughout the case study, most of them consistent with past research, which were determinant in guiding the BIM adoption and implementation process within the Organisation. In terms of mechanisms deployed by the Organisation to guide the BIM adoption and implementation process, the creation of the BIM Steering Committee as a middle ground where the employees and management could discuss and review this process was seen as key. The impact of the BIM adoption and implementation process within the Organisation was mainly perceived in the changing workflows and emerging roles and responsibilities of the personnel involved with BIM.

The size of the Organisation adopting and implementing an innovation has long been held as a key success factor (Acar et al., 2005). While large organisations have considerable resource, SMEs are seen as being much more agile in their capacity to innovate (Oke et al., 2007). The
Organisation under study displayed agility in navigating the market and choosing which projects to get involved in and to what extent they implemented BIM. Furthermore, as developed in past research (Lehtinen, 2012, Liu et al., 2010, Won et al., 2013), leadership from the Organisation’s management was key in driving the adoption process, notably in creating the vision. On the other hand, leadership by key individuals amongst the employees was seen as critical in broadening the implementation process. The Organisation’s management also created the long-term vision by developing a road map for BIM adoption and implementation:

“That’s part of the end product that we are shooting for with BIM, to become a prefabricator. So, we have seen a lot of market opportunity there, not just for our own needs, but to pre-fabricate products for other firms, particularly in the North. We have seen lot of opportunities. So probably in 5-10 years from now we could have a manufacturing business as significant as our contracting business.” - GM

Buy-in principally came from the personnel’s interests and enthusiasm in the potential shown by BIM. As such, natural champions emerged within the Organisation. The size of the Organisation also played a role in ensuring buy-in from the employees seeing as though individual efforts were more likely to be noticed by management.

The primary mechanism deployed by the Organisation to facilitate the BIM adoption and implementation process was to establish a BIM steering committee. Exchanges between managers and employees were facilitated through the committee, which headed the BIM implementation effort by reviewing and selecting the appropriate software and hardware packages, managing the technology and implementing BIM in a pilot project. A substantial part of the decision making process was delegated to the personnel that would be using BIM, in essence empowering them. The venue offered by the BIM committee for management and user base to meet and exchange on issues was critical in establishing and communicating clear expectations, intentions and actions within the Organisation. The findings of this study point towards a balance top-down and bottom-up approach to BIM adoption and implementation, over one approach rather than the other (Arayici et al., 2011).

An equally important mechanism was the alignment of the Organisation’s business strategy and its BIM implementation strategy. This has long been held as a key feature in transforming an
Organisation’s operational context (Venkatraman, 1994). In this case, the organisational strategy considered three key elements: (1) Increase visibility and market-share, (2) Focus on design-build and design-assist type projects, and (3) increase quality and productivity through modeling and pre-fabrication. This strategy was consistent with the high level of commitment that management showed towards BIM. In light of this, consideration given to BIM on a project basis is now related purely to the scope and extent of modeling to be performed:

“We pretty much mandate it now internally on any significant projects we get, that we are going to “BIM” the mechanical rooms at a minimum. Bigger jobs, we are going to do more, as much as we can, given time and staff but by all means the mechanical rooms. But our intent and our focus is to focus on larger projects. So that would entail typically would be more opportunity for BIM.” - GM

Moreover, the steering committee set clear, measurable and attainable goals relating to the BIM adoption and implementation process. These goals were incremental. The short term goals involved the actual adoption and implementation of BIM while the longer term goals involved an overall strategic approach to improving productivity in the field through increased use of technology and pre-fabrication. Two key mechanisms put in place to ensure that these goals be attained were: the allocation of appropriate resources and proper investment in technology, which are seen as key to a successful adoption and implementation process (Won et al., 2013). The training and hiring of additional personnel is also targeted to ensure success. One of the objectives is to train all project coordinators in BIM. However, this is being done on an ad-hoc basis due to availability of personnel and awarding of BIM projects. While this is seen as a key element in ensuring continuity, it is also seen as a challenge:

We recently (2013) hired a second BIM coordinator, they are harder to find and it’s a challenge. Our volume keeps going up, it keeps going up dramatically faster. So we try to keep “irons in the fire”, and word is out there we are looking for good BIM people and good project people as well. - GM

The Organisation educated and informed their field personnel on the opportunities presented by BIM and its impact on their work. This was done in an effort to garner enthusiasm for BIM across the Organisation, and not confine it to the office. Another issue that emerged was that
performance assessment and return on investment of BIM are key considerations for the
Organisation. Isolating the impact of BIM is extremely challenging due to the quantity of factors
that influences the project delivery process. BIM plays only a limited part in the overall process.
Developing a rigorous and continuous tracking mechanism is a challenge for an SME, as this
represents a process, which is as difficult as BIM adoption itself. For the moment, the
Organisation is motivating the adoption and implementation process mostly based on faith that
the transition to BIM will produce a positive outcome:

_We don’t know yet. We are doing it on faith so far and this is why questions arise like this costs_
_analysis of the BIM cost versus our labour productivity to see if there is any correlation there. The_
_very first job we did [where we used BIM] we felt we probably would have lost our shirt if we_
_hadn’t of ‘BIM’ed’ it, but that’s anecdotal, we don’t have any measurement of that, but that’s_
_our gut feeling. So our gut feeling is still telling us that this is a smarter way to build and more_
_efficient way to build. We are seeing that our budgets for BIM engineering are not sufficient. It is_
taking longer than we envisioned and I don’t know whether that’s because of the models we are_
getting are poor or whether we are just going up on the learning curve and not as productive yet_
as we will become hopefully._                   - GM

The impact of BIM within the Organisation was felt in the transformation of workflows, which
occurred on three levels: First, in-house modeling capabilities had to be developed from
nothing. **Second, internal information flows and workflows between office and field personnel
had to be reworked (figure 3 and figure 4).** Third, information flows with external project
stakeholders had to be redefined. In light of this, company standards and templates were
developed to ensure consistency in the modeling process. Furthermore, whereas detailed
execution was traditionally resolved by the site foreman in the field through trial and error, the
introduction of BIM has shifted the detailed execution and conflict resolution process to the
office. The information is now being produced in the office and communicated through more
precise fabrication and assembly drawings. In light of this, ensuring that the information
produced in the office gets to the field and distributed to workers in an efficient manner has
become a priority for the Organisation. A communication protocol is being established to
transfer and diffuse information on site while ensuring feedback to the office personnel to
better inform the process through which plans are analysed, models built and validated and finally documentation produced and distributed.

Another impact on the Organisation has been the creation of specific BIM roles to take on the new responsibilities and workloads. This develops the need for personnel with a specialised set of skills. For example, the role of BIM coordinator has emerged from the need to perform modeling and additional project coordination tasks introduced by BIM. This is in addition to the traditional role of project coordinator. Ideally, the same person would fill both roles, however, time constraints and capability issues have made it difficult to do so thus far. It is however questionable whether both roles will be completely integrated in the near future due to the sheer effort needed to accomplish both tasks on any job. These new roles and responsibilities are evolving over time, as capabilities are developed and experience is acquired:

*I guess from the beginning my role was fairly, how do I say... fairly sparse. I just kind of did this and that and everything in between kind of thing. I don’t think my role has developed too much, but it has definitely become a lot more structured. It is more developed in the sense that, my goals are much clearer. In the beginning it was trying to figure out what your goals are. And now it is definitely more developed that way.* - BIM coordinator

Technology management has also become a considerable endeavor for the Organisation. The technology implemented in the past by the Organisation was straightforward and worked independently, the transition to BIM requires considerable expertise and investments to upgrade and maintain both hardware and software capabilities. For instance, the choice of the BIM software represents a major commitment due to subsequent issues such as suitability,
interoperability, training and support. In this case, the Organisation chose a leading software platform, based on its popularity within the market. A second software suite had to be introduced, however, in order to overcome the severe limitations of the first software in respect to fabrication level detailing (figure 5).

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**INSERT Figure 5 - Software Outputs**

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**The Project Context**

The project context is characterised by the temporary nature of its structure and the specificity and uniqueness of its setting (requirements, contracts, scope, etc.) (Winch, 2010). Central to the project context is the project team which encompasses the external project team, comprised of the external stakeholders forming the supply chain and the internal project team, comprised of the Organisation’s office and field personnel working on a given project. While the organisational context is key to the BIM adoption and implementation process, the project context mediates the extent of this process by influencing the scope to which BIM can be implemented. Furthermore, while the adoption of BIM represents a radical innovation for the Organisation, the further development of capabilities related to BIM represent incremental innovations at the project level (figure 6).

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**INSERT Figure 6 – Incremental innovations relating to BIM capability development**

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This analysis of the data highlighted factors such as contractual requirements, project delivery modes, maturity levels, project team expectations, etc. which have influenced the extent of collaboration and the establishment of a collaborative BIM environment within the project team, as identified in past research (e.g. Dossick and Neff, 2010). More importantly, contractual requirements dictating specific requirements for BIM implementation, or absence thereof, were
seen as a prime factor mediating the level of BIM implementation process at the project level. Of the four projects studied, only one had any mention of BIM in the contract, but no set requirements. Indeed, as BIM is a relatively new process, contractual requirements are often vague and not well defined. This lack of contractual clarity and control over BIM greatly impacts the potential for collaboration and value generation through BIM implementation (Taylor and Bernstein, 2009) and contributes to waste within the project delivery setting (Dubler et al., 2010). For the Organisation, this has resulted in them having to build their own models, instead of benefitting from a model developed up stream:

It is a bit of little disappointing to be honest with you. We have been given the consultants model to use as the baseline for our model. And their model is, I guess the best word to say “Incomplete” or full of conflicts, and we receive very little support from either [the consultants of the general contractor] to do anything about it. So we have been given a fairly good architectural and structural model to work within, but rather lackluster mechanical model to use as the base for our fabrication model. - PM (speaking of project 04)

The findings also highlighted a conflict between the use of BIM at the design, construction and operations phases. As such managing the expectations towards BIM, which represent the project team's beliefs and intent towards the model and the process, has emerged as key to successful and effective deployment of BIM within the project context. There still remains, however, a large gap between project expectations and actions:

Even on jobs like [project 04] that supposedly are all designed, and the rooms are all scanned, we get the models and they aren't. And so instead of being able to get right into BIM design, we are backtracking and going out in field measuring. - GM

This also highlights a lack of mutual understanding of the BIM process and the time required to develop models and communicate intent is still lacking within the project setting. This leads to scheduling conflicts and tension due to unfulfilled expectations:

BIM is still not well understood I guess from the perspective of the owners and the general contractors. They all like the beautiful pictures and the 3D models and all that. But they have no appreciation of the lead-time that we need to get it there. - PM
Where specific BIM requirements are lacking, relationships with external project team members were seen as a key factor in the successful implementation of BIM. However, the Organisation’s increased involvement in the modeling and design validation process has put them in a position to question design decisions upfront, which is creating tension within the project team:

*We are experiencing a lot of resistance from the mechanical consultant to engage us, when we have suggestions or when we point out things that we need clarification on and we are a little bit unsure what that resistant is rooted in or sourced in, but we are definitely experiencing it as part of trying to get buy in to from all parties to work with us on BIM. I don’t know if it is a defensive thing. They don’t want to hear that, and us showing them in a very understandable 3D BIM environment than what they have designed is needing to be revised or addressed from a constructability point of view.*

- PM, project 04

The brings to light the issues of trust within temporary project teams, which has been thoroughly discussed elsewhere (e.g. Emmitt, 2010). Indeed trust has emerged as an important factor in the deployment of BIM within the project context. In this case, the question of trust relates to specific issues such as reliability and accuracy of information input by others, i.e. trustworthiness. In parallel, the question of trust in the capability of external project team members to deliver as per the project requirements plays a central role in establishing the relationships amongst project team members. The Organisation has partly dealt with this issue of trust by establishing long-term relationships with a limited number of suppliers and providers.

While BIM is now being implemented by the Organisation on almost every project, its extent and scope is being determined on a project-by-project basis. In a lonely setting, this is determined through potential gains. In a more collaborative setting, this will be dictated by the contractual requirements and procurement mode. Within those requirements, the internal project team will establish the level to which BIM is deployed. For the Organisation, this question of suitability is being influenced by the potential for pre-fabrication and productivity gains. In spite of the procurement mode dictating the timing of the Organisation’s integration into the project team, the use of BIM has generally allowed the Organisation to play a more predominant role within the project setting. In a more integrative procurement setting, such as Design-Build where the consultants fall within the Organisation’s supply chain, more control can
be asserted on the deployment of BIM across the project team. In a more traditional setting, the Organisation will only have control over their own supply chain:

*It has been an opportunity for us on projects to push our sub trades and see them start to develop their BIM capacities. Our sheet metal sub has stepped up in particular. So there are benefits from that. So we are developing our network along with it* - GM

This points to another important mechanism implemented by the Organisation which has been to foster the project team’s commitment to the BIM effort. To achieve this, the Organisation has developed relationships and a network of sub-trades (namely HVAC and fire protection), which have been developing their own BIM capabilities. In that sense, the Organisation is creating their own ‘constellation of actors’ (Linderoth, 2010) with whom they can develop long-term relationships and develop their BIM capabilities concurrently. For example:

*With the [project 04] we did work with our sub-trades that was actually it went fairly smoothly, like with [the sheet metal sub-trade] we managed to work in the same environment and be able to collaborate …* – BIM Coordinator

The impact of BIM adoption and implementation at the project level manifests itself in the transformation of interactions with external project team members, such as owners, design consultants, general contractors and other specialty trades. Interactions now take place through the 3D model and its outputs (figure 5). Furthermore, as a result of the Organisation having to rework the models that they had obtained or build their own models from 2D drawings, the Organisation has consistently been developing their BIM capabilities. This has resulted in the Organisation now being able to offer more services to various client bodies, which is perceived as a positive outcome by the Organisation. To continuously develop these BIM capabilities, the Organisation has implemented a continuous innovation process within the project context. This process is characterised by the development of specific capabilities, such as pre-fabrication, laser scanning and increased scope of modeling at the project level and at the organisational level. To do so, a “triggering” process is adopted through which specific projects are targeted to incrementally develop BIM capabilities while maintaining the over-arching strategy towards BIM developed by the steering committee. This presents the Organisation with the opportunity to increase their involvement on a project, which in turn translates to an increase in marketing.
power for the Organisation and their appeal to clients. Figure 6 illustrates the project-based evolution and triggering approach taken by the Organisation. It is important to note that figure 6 serves for illustration purposes and that it does not represent a teleological view of capability development for the Organisation.

Conclusion

This article reported the findings of a research project which adopted a longitudinal, mixed-method case study approach, rooted in the interpretivist paradigm. The research project aimed to investigate the BIM adoption and implementation process for a specialty contracting SME in the Canadian AEC industry. Through analysis of the qualitative data collected over the course of the research project the research team uncovered and investigated several factors, mechanisms and their perceived impact, which were seen to influence, either positively or negatively, the adoption and implementation of BIM by the Organisation under study. While past work has looked at the innovation process (Barrett and Sexton, 2006) or BIM adoption and implementation within SMEs (Arayici et al., 2011), sparse work has attempted to bridge both research domains. By bridging these domains, this article distinguishes four distinct yet embedded contexts, which were found to mediate the BIM adoption and implementation process: (a) the industry context; (b) the institutional context; (c) the organisational context; and (d) the project context. While its importance has been highlighted in the innovation process (Rankin and Luther, 2006, Winch, 1998), this contextual view was seen to be lacking from the literature on BIM adoption and implementation. The article further identifies several factors, mechanisms and their impacts across these different contexts. (Rankin and Luther, 2006, Winch, 1998) Several particularities of the BIM adoption and implementation within the context of a specialty contracting SME were highlighted, namely that it represents a radical change, a drastic departure from traditional project delivery for this SME. Within the Organisation studied, this radical change prompted and compounded more incremental innovation. While the findings indicated an overall positive perceived impact on project performance at a high-level, further work is required to validate these findings. In fact, the question of benchmarking and performance assessment is an important one that needs further attention with respects to the BIM adoption process. Work is currently being carried-out to collect data on the performance
assessment and evaluation of BIM on project outcomes and return-on-investment (ROI) within the same Organisation.

The practical implications of this research point towards two elements: the need for clear policy at the industry level to guide the deployment of BIM and the importance of a strategic approach to the BIM adoption and implementation process at the organizational level. The findings from this study indicate that even if public policy or contractual requirements are lacking, a specialty contracting SME can still reap benefits from BIM if a clear vision and strategy guiding the adoption and implementation process has been put in place. Limitations of this study are found both in the interpretivist paradigm’s relativist perspective and in the case study approach adopted. While this approach allows the discovery and emergence of findings grounded in practice, the question of external validity (generalizability) due to the interpretative nature of these findings is always an issue. Through triangulation of data sources, the research team attempted to bolster the robustness of the findings. Further work could be carried out in other geographic and market (industry) contexts to validate these findings. In addition, the specialised nature of the Organisation studied (a mechanical contracting SME) raises questions of generalizability of findings to other specialty contracting SMEs in the AEC industry. As such, further work is needed to study other specialty contracting SMEs in the same given industry context. Further work could also look into refining these embedded contexts in light of the various realities facing specialty contracting SMEs. To conclude, a single model of innovation cannot easily explain the adoption and implementation of BIM. It represents a disruptive and radical innovation, yet as it develops, smaller, incremental innovations can take place which support the overall process. Furthermore, this process is seen as highly contextual in that it is industry and discipline specific. This article takes a step in developing these contextual factors and mechanisms that can be put in place to mediate the BIM adoption and implementation process.

Acknowledgments

This research study was funded by the Canadian National Research Council – Industrial Research Program (NRC-IRAP) and the Centre Facilitating Research and Innovation in Organisations with
Information and Communication Technology (CEFRIO). The authors would like to acknowledge the contribution and continued support by all the members of the Organisation.

References


Liu, R., Issa, R. R. A. & Olbina, S. Factors influencing the adoption of building information modeling in the AEC industry. International Conference on Computing in Civil and Building Engineering, 2010 University of Nottingham.


Longitudinal Case Study research approach

70x26mm (300 x 300 DPI)
Embedded Contexts of BIM adoption and implementation

112x68mm (300 x 300 DPI)
Figure 3 – Internal Workflows (Pre-BIM) – Design-Bid-Build
Figure 4 – Internal Workflows (Post-BIM) – Design-Bid-Build
Figure 5 - Software Outputs
Incremental innovations relating to BIM capability development

215x166mm (300 x 300 DPI)
Table 1 - Project Context and Data Collection

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
<th>Data Collection</th>
<th>Delivery mode</th>
<th>Contractual BIM req.</th>
<th>BIM Use</th>
<th>Capabilities developed</th>
<th>Factors</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project 01</td>
<td>Large institutional (university) district energy project</td>
<td>Interviewed 6 project stakeholders - Project data</td>
<td>DB</td>
<td>None</td>
<td>Modeled all building services to perform clash detection - Targeted areas with most potential for conflict - Better grasp of modeling tools - Coordination with other disciplines through self-performed model - Used for visualization only</td>
<td>Initial modeling and 3D coordination capabilities - Laser scanning - On-site prefabrication from spool drawings</td>
<td>Pilot project - No previous drafting or modeling capabilities</td>
<td>Minimized loss and rework due to upstream conflict resolution - Rapid resolution of issues due to easy visualization - Project &quot;would of almost been impossible without BIM&quot;</td>
</tr>
<tr>
<td>Project 02</td>
<td>2 story wood-frame institutional (health-care) building</td>
<td>Interviewed 3 project stakeholders - Project data</td>
<td>DB</td>
<td>None</td>
<td>Modeled 4 Energy Transfer Stations - Initiated prefabrication in the shop from spool drawings</td>
<td>Prefabrication moved off-site - Developing expertise in district energy projects</td>
<td>'lonely BIM' - No contractual requirements for BIM - Coordination issues with design professionals - Not all specialty contractors on board with BIM</td>
<td>Organization took a leadership role in the project team - Input at the design stage due to DB - Resolved a major headroom clearance issue before going to site</td>
</tr>
<tr>
<td>Project 03</td>
<td>Medium size municipal district energy project</td>
<td>Interviewed 3 project stakeholders - Field observations - Project data</td>
<td>DBB</td>
<td>None</td>
<td>- Obtained models from consultants - Targeted areas with most potential for conflict</td>
<td>- Co-creation and integration of models from other sub-trades - Level of development (LOD) of model for fabrication - Use of tablets in the field</td>
<td>- Traditional DBB project so little interaction with design professionals</td>
<td>- Modeling and fabrication of Energy Transfer Stations is becoming streamlined - Efficiencies are being perceived in the field</td>
</tr>
<tr>
<td>Project 04</td>
<td>Renovation of a large commercial building</td>
<td>- Field observations - Project data</td>
<td>DBB</td>
<td>Limited to visualisation</td>
<td>- Developed expertise in district energy projects</td>
<td>- Need for additional qualified staff for modeling and coordination of BIM - Lack of control on supply chain at the consultant level - Lack of buy-in from project team on BIM</td>
<td>- Traditional DBB project so little interaction with design professionals</td>
<td>Better integration of sub-trades - Reduced conflicts in the field (expected) - Reduced re-work (expected)</td>
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<tr>
<td>Reviewers Comments to Author</td>
<td>Authors Response to Reviewers Comments</td>
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<td><strong>Reviewer 02</strong>&lt;br&gt;Relationship to Seminal Literature:&lt;br&gt;Yes, from a US and Canadian perspective...&lt;br&gt;However, the recent work in the UK in respect of the governmant mandate to require Level 2 BIM has not been considered.</td>
<td>We have addressed this comment by discussing these mandates from other countries, these have been included into the discussion on the 'industry context' – see page 11, line 22</td>
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<td><strong>Reviewer 02</strong>&lt;br&gt;Results:&lt;br&gt;Yes. However, the basis is from a very limited number of case studies. There are still questions raised in respect of validating the benefits of BIM on projects.</td>
<td>The authors agree with the reviewer that further work is needed in validating the benefits of BIM on projects. The authors are working on a follow-up paper discussing this very item. Validating the benefits of BIM wasn't the objective of this particular paper.</td>
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<td><strong>Reviewer 02</strong>&lt;br&gt;Implications for research, practice and/or society:&lt;br&gt;Many of these questions have not been adequately answered in the paper.</td>
<td>We have attempted to rectify this and address these particular questions, namely in the conclusion. – see page 23, line 08</td>
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<tr>
<td><strong>Reviewer 03</strong>&lt;br&gt;Relationship to Seminal Literature:&lt;br&gt;Yes, the paper demonstrates an adequate understanding of the relevant literature in the field and cites an appropriate range of literature sources. I suggest add an additional context regarding “regulatory authority”. In countries such as Singapore and UK, mandatory BIM submission has been rolled out in the recent years. More countries may follow suit. This would surely accelerate BIM adoption in the MEP engineering processes, and subsequently affect the BIM adoption and implementation of SME specialty contractors. The authority context would play an important role in the researched topic.</td>
<td>We have addressed this comment by discussing these various guides and protocols in various other countries, these have been included into the discussion on the 'industry context' The regulatory authority context suggested is embedded within the industry context. It has been highlighted in the paper. The specific guidelines have been introduced into the institutional context as they relate specifically to the mechanical contracting field. – see page 11, line 22</td>
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<tr>
<td><strong>Reviewer 03</strong>&lt;br&gt;Research Methodology:&lt;br&gt;The research methodology is based on</td>
<td>We have added the diagrams as per the recommendation – see page 17 – figures 3 &amp; 4</td>
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qualitative interviews. Considering the subject matter, it is generally suitable. However, the study could be enhanced in the following aspects: 1) Suggest add some descriptions/diagrams for the traditional and the BIM work flow in the “Research setting” or a separate section, to illustrate the changes caused by BIM integration;

**Reviewer 03**  
**Research Methodology:**  
The research methodology would be more balanced if some quantitative data could be provided through the questionnaire of BIM user perception, e.g. on the major constraints of BIM adoption/implementation.

We believe that many other works have looked into the quantification of challenges and factors mediating BIM adoption/implementation through survey-based methods at the industry level. Our research focuses on the specialty contracting SME. In light of this, given the small sample size within the organization (people involved with BIM within the organization), the need to conduct a survey/questionnaire wasn't deemed necessary since the data could be collected and analyzed on an individual basis through interviews. Quantitative data was obtained with regards to performance measurement and will be the subject of a subsequent paper on performance measurement and assessment. We believe that for the purposes of this paper, the results from the interviews and our analysis of the contextual factors mediating BIM adoption from the specialty contracting SME should remain the focus of the paper.

**Reviewer 03**  
**Results:**  
When discussing research findings, be more specific and try to identify the root causes. For example, in the second paragraph on Page 20, “In terms of capabilities within the project team, the Organization has thus far demonstrated superior BIM capabilities, which has resulted in the Organization’s project team having to build their own models, instead of benefitting from a model developed up

We have addressed the reviewer's comments by providing more detail where applicable. In this instance we have reviewed and rewritten the sections of the article when necessary. - see page 19, line 7
stream”, the authors did not disclose the underlying causes. It could be attributed to one or several issues, e.g. (a) poor quality of BIM model provided by the upstream, (b) lack of modeling details, only LOD300 available rather than LOD400, (c) not the latest model. The authors should pay attention to these details and provide a list of constraints for future improvement.

**Reviewer 03**
**Results:**
Figure 2 should be illustrated in greater detail. For example, what are “project pull” and “Organization push & pull”, in particular relating to the BIM workflow?

We have revised the figure to address the reviewers comments – see page 10 – figure 2

**Reviewer 03**
**Implications for research, practice and/or society:**
Suggest the authors add a section to discuss “best practices” and “lesson learned”. This would definitely provide more values to those SME specialty contractors who want to adopt and implement BIM in their own processes.

The conclusion section has been rewritten to highlight the lessons learned, the precise research findings the paper offers; the link back to seminal literature; the precise nature of the assumptions made; the validity of findings, and has better delineated the research limitations. The authors feel that, with regards to best practices, this wasn't part of the papers objectives. – see pages 22 & 23

**Reviewer 04**
**Paper type needs incorporating beneath keywords within your paper.**

This has been added – see page 1

**Reviewer 04**
**English spelling is needed not America, e.g. organisation and many more.**

This has been done – see where applicable

**Reviewer 04**
**Please remove reference to gender e.g. ‘her’ etc.**

This has been done– see where applicable

**Reviewer 04**
**There are some minimal areas of ‘tabloid journalism’. Please remove and rewrite from a scientific perspective.**

We have removed and rewritten – see where applicable
<table>
<thead>
<tr>
<th>Reviewer 04</th>
<th>We have removed most instances where these conjunctions were deemed to create confusion. – see where applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reviewer 04</td>
<td>This has been done – see page 7, line 12</td>
</tr>
<tr>
<td>Reviewer 04</td>
<td>We have addressed the reviewer's comments by providing more detail where applicable. In this instance we have expanded the research method section to include the epistemological approach adopted and then justified the approach by aligning the research problem to the research approach. We also present how and why the units of analysis and observation were chosen and what these are more precisely. – see pages 7 through 9</td>
</tr>
<tr>
<td>Reviewer 04</td>
<td>We have addressed the reviewer's comments by providing more detail where applicable. In this instance we have added detailed explanation about the type and instances of triangulation used in this particular study. We have given examples of said triangulation. – see page 9, line 31</td>
</tr>
<tr>
<td>Reviewer 04</td>
<td>We have reduced the table to one page</td>
</tr>
<tr>
<td>Reviewer 04</td>
<td>This has been clarified – see page 7, line 36</td>
</tr>
<tr>
<td>Reviewer 04</td>
<td>Learning is introduced. Perhaps it might be useful to include the Link to Learning Organisations? Just a thought.</td>
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<td>Learning in this instances relates to the innovation process as a whole and constitutes a piece of the process. Due to limited space, the authors chose to not expand on the subject of organizational learning, which is in and of itself a considerable field of research.</td>
</tr>
<tr>
<td>Reviewer 04</td>
<td>There are a number of cases where a new section has been introduced, supported by several sub-sections. An example of this is on Page 10 onwards. Please try to concatenate.</td>
</tr>
<tr>
<td></td>
<td>We have removed the sub-headers in each section and structured the text to flow better. – see where applicable</td>
</tr>
<tr>
<td>Reviewer 04</td>
<td>Please try to refrain from the overuse of quotations as this somewhat detracts from the message.</td>
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<tr>
<td></td>
<td>Given the qualitative case study approach rooted in the interpretivist paradigm, we believe that the quotes serve to reinforce our findings. We have tried to limit them as best as possible.</td>
</tr>
<tr>
<td>Reviewer 04</td>
<td>A lot of information is provided in this paper. Whilst this reviewer doesn’t have a particular issue with this, it is also important to consider the wider readership. It might be better to condense some of the discussion into seminal sound bites, so that a message can be more readily conveyed.</td>
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<td></td>
<td>While we agree with the reviewers assessment that there is alot of information presented in this paper, we believe that the structure of the paper is suited to the research approach and its objective. We have tried to rewrite the conclusion to more readily convey the main message of the paper.</td>
</tr>
<tr>
<td>Reviewer 04</td>
<td>Conclusions heading should just be Conclusion.</td>
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<td></td>
<td>This has been done – page 22, line 12</td>
</tr>
<tr>
<td>Reviewer 04</td>
<td>The conclusion section needs to identify the general approach and supportive rationale. This needs to be extended to tease out the precise research findings this paper offers; the link back to seminal literature in this respect; the precise nature of the assumptions made; the validity of findings in respect of generalisability, repeatability, etc. Research limitations also need to be stated. Whilst it is acknowledged that part of these have been</td>
</tr>
<tr>
<td></td>
<td>The conclusion section has been rewritten to identify the general approach and supportive rationale, highlight the lessons learned and the precise research findings; the link back to seminal literature; the precise nature of the assumptions made; the validity of findings, and has better delineated the research limitations. – see pages 22 &amp; 23</td>
</tr>
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</table>
included (in a pseudo limitation way), the delineation needs to be made clearer.