CONTEXTUALIZING LEARNING APPROACHES WHICH SHAPE BIM FOR MAINTENANCE

Carmel Lindkvist

Faculty of Architecture and Fine Art, Norwegian University of Science and Technology, N-7491, Trondheim, Norway (carmel.lindkvist@ntnu.no)

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Abstract

Purpose: Studies of BIM examine the potential benefits in maintenance. There is also a perspective maintenance teams should be involved early in the building project process. There is little understanding on learning processes for BIM in maintenance in the early building project stage which this paper sets out to address.

Methodology: Case study is used to examine the context maintenance learn about BIM. Maintenance managers and project managers were interviewed where discussions centered on a new build project which introduced BIM and how it would impact current practices.

Findings: Learning happens at the early building project stage for BIM into maintenance influenced by external and internal contexts. The external context focuses on the UK government on being a catalyst for explorative learning. Meaning is added by maintenance teams through exploiting what is learnt from the external influence which is contextualized within current activities. Internal shaping of BIM is explored through building scenarios and exploitation learning occurs from past experiences of change which are inferred onto BIM. There is a necessary balance between exploration and exploitation learning in order to shape BIM for maintenance.

Research limitation/implications: The paper is limited to one case study however, it takes an in-depth look at the development of BIM in maintenance and how it is understood in maintenance.

Originality/value: The contribution of the paper examines the context of learning in which BIM is shaped in maintenance.

Keywords: Maintenance, BIM, Learning

Paper categorization: Case study

1. Introduction

BIM is a relatively new occurrence in maintenance. The UK government has been instrumental in the take up of BIM in projects and maintenance (Cabinet-Office, 2012) but the impact of this external influence is not fully understood on maintenance practices. Success of a changing environment requires learning through better knowledge and experience (Edmondson, 2002, March, 1991). Learning can be exploitive and explorative (Levinthal and March, 1993, March, 1991) but with technology change such as BIM needs to be considered in context (Harty, 2005, Linderoth, 2010). The handover process of information from design to maintenance can be problematic (Whyte, Lindkvist and Hassan Ibrahim, 2012) but BIM is viewed as a missing link for information between projects and maintenance. The gains of BIM in maintenance, which are predicted (Becerik-Gerber, 2010, Becerik-Gerber, Jazizadeh, Li and Calis, 2012, Wang, Wang, Wang, Yung and Jun, 2013), will not be fully realized for many years but maintenance managers are exploring ideas of how BIM will work within their context.

The aim of this paper is to examine how internal and external contexts shape exploration and exploitation of learning when implementing BIM in maintenance. This is done through examining a case where a maintenance team is involved in developing BIM during the early stages of a building project. Findings indicate exploration of BIM is viewed as necessary for future viability and maintenance managers explore BIM through building scenarios on how BIM could resolve current information gaps. Exploitation is based on past experiences where perceived similar changes occurred and inferences are imposed onto a new BIM context. Emphasis is on BIM impacting information processes rather than changing maintenance practices. The study therefore indicates a balance between exploration and exploitation learning is necessary in order for BIM to impact on maintenance practice.

2. BIM making links between project and maintenance

BIM offers a holistic approach to building projects across a number of practices. The client or asset owner has been credited as leading BIM adoption in projects as the value of information from BIM is for the life-cycle of a building (Bew and Underwood, 2010, Dinesen, 2010, McGraw-Hill, 2007, McGraw-Hill, 2008, McGraw-Hill, 2012). Projects are considered having a relatively short term benefit of using BIM with 80% of the cost of an asset spent in operations (Bew and Underwood, 2010 :26). The information which maintenance inherits from building projects has a value that occurs over a long period of time.

Information coming from projects is a key component to incorporate into the various and diverse activities of maintenance. Often the information which is handed over in projects is inaccurate, missing or not updated (Whyte et al., 2012). BIM is a technology with a process to close the information gap for maintenance and project teams. Previous guides for Integrated Project Delivery (A.I.A., 2007) mainly refer to communication of the owner, designers and construction teams – maintenance join the conversation in the period of closeout. BIM incorporates a process for maintenance to be involved at the early stages of building projects. In the UK, the involvement of facilities managers earlier in the project life-cycle has been promoted in Government Soft Landings (Cabinet-Office, 2012) as well as after care once a project is complete in order to ensure that the building is being used and maintained as designed (BSRIA, 2012). Early involvement of maintenance in the project and "after care" acknowledges the move of continuation of information rather than separation of information between project and maintenance life-cycles.

The UK government interest in BIM is emphasized within Building Innovation and Skills strategy reports (BIS, 2011, BIS, 2013). BIM is mandated on publicly funded projects until

2016. There are a number of demonstration projects which the UK government have to guide standards for BIM but lessons are still to be learnt. Much of the guidance of BIM is based on Construction Operations Building information exchange (COBie) which is an open standard originating in the US for capture and delivery of digital data as it is created during design, construction, and commissioning for use in operations (Jordani, 2010). COBie replaces sections of paper based documentation in Operations and Maintenance manuals in the handover procedure (East, 2009). Governmental strategies, projects and standards have an influence in developing BIM in maintenance at the early stages of building projects.

3. Contextual differences between project practices and maintenance practices

There are diverse skills, temporal goals in relation to the building and knowledge between practices involved in a project and practices of maintenance. Preparing BIM for use in maintenance is challenging within the project as it puts pressure on time and cost in converting files (Hardin, 2009, Kymmell, 2008). The decision to implement BIM for an asset owner is a potential change program within projects and maintenance teams (Love, Matthews, Simpson, Hill and Olatunji, 2014). Recent work has examined interaction of maintenance in the design stage where BIM is used to visualize the design and be an early indicator of issues that impact the operational phase (Wang et al., 2013). There are other studies indicating the potential of BIM for efficiencies on energy use, visualization of workspace and maintenance scheduling (Becerik-Gerber, 2010, Becerik-Gerber et al., 2012, Eastman, Teicholz, Sacks and Liston, 2008). At the other end of the scale are the different technology skills in maintenance compared to practices of construction (Anderson, Dossick and Neff, 2012, Bainbridge and Finch, 2009, Korpela and Miettinen, 2013). Currently, data is handed over to maintenance managers through handover procedures which is integrated into an Asset Management System (Whyte et al., 2012). Information from building projects is

received and then formatted to suit maintenance practices. When considering BIM, there is an implied change with dis-benefits such as interoperability issues, learning curves, user resistance and disruption to business activities (Love et al., 2014). Particular to maintenance is the fact that information is a key commodity but is also intangible (Love, Simpson, Hill and Standing, 2013). BIM may offer "added value" to services of maintenance which is key when introducing new technologies to maintenance (Lindkvist and Elmualim, 2010). Added value is considered through an optimization process rather than cost cutting where business returns are seen through effective planning and quality support services (Alexander, 1997, Cardellino and Finch, 2006, Mudrak, Van Wagenberg and Wubben, 2005). The main objective of maintenance is to maintain the building as designed – therefore the benefits derived from introducing BIM need to add value but may not be visible or tangible.

There are complications in developing information across practices which traditionally do not overlap but there are success stories on the implementation of BIM into maintenance. Penn State University in the US is a prominent early adopter of BIM for maintenance (Kasprzak, Ramesh and Dubler, 2013) and has established execution plans for BIM implementation on projects and maintenance (Anumba, Dubler, Goodman, Kasprzak, Messner, Saluja and Zikic, 2010, Messner, Anumba, Leicht, Krieder, Ramesh and Nulton, 2012). Lessons from this work focus processes such as the contract language necessary to accomplish goals to implement BIM (Chunduri, Kreider and Messner, 2013) and having a process in place to deliver high quality data to facilities management (Kasprzak et al., 2013). However, this type of implementation study focuses on the success and ignores the wider context of learning that accompanies BIM implementation to maintenance.

Studies coming from construction indicate that the technical factors of exchanging BIM information are successful but this success needs to be done alongside interpersonal

communication (Davies and Harty, 2013, Dossick and Neff, 2010). When it comes to the adoption of BIM, studies have argued practices and organizational relations in projects require change (Gu and London, 2010, Love et al., 2013). Changing practices interaction with a technology which is not static needs to be considered within the context it is used (Harty, 2005). There is an interplay between technology's feature and the context in which is it adapted depending on the practices that takes it up (Linderoth, 2010). Understanding the implementation of BIM in maintenance requires an understanding of the context in which it is being developed and not only focusing on the technical and procedural aspects of BIM. BIM clearly has external influences such as government in the UK and standards from the US. BIM is also expected to work in a new context of maintenance as a continuous link to construction projects where involving maintenance teams early in building projects is strongly encouraged. However, there is little understanding on the process of conducting these early learnings which aid in shaping BIM for maintenance practices.

4. Learning processes in context

Current literature on BIM in the UK indicate an external influence to introduce BIM to maintenance from government and industry as well as a need to understand the internal impact of BIM to maintenance. In order to understand how these external and internal contexts influence the implementation of BIM to maintenance a learning perspective is taken. This perspective is appropriate as organizational learning interests stems from the premise that the success of a changing environments requires learning through better knowledge and experience (Edmondson, 2002, March, 1991). Maintenance teams require learning to understand BIM within their own maintenance context. This approach to learning emphasizes situation cognition where learning is situated within a given context, culture or practice (Brown and Duguid, 2001, Lave and Wenger, 1991). It is important to consider how

individuals impose order, attribute meaning and provide explanations to make sense of their experience (March and Olsen, 1975) which is often based on the context of a situation. Practices develop, negotiate and construct their identities and common meanings around situations and objects within their evolving practices (Brown and Duguid, 2001, Gherardi, 1999, Gherardi and Nicolini, 2000, Lave and Wenger, 1991). Therefore, as changes occur internally to the practice and externally in the wider world, practices adapt and learning occurs in parallel to organizing.

Learning can be exploitative building on the experiences of the known ideas or explorative which is exploring new ideas (March, 1991). Learning tends to take more time, be more uncertain but tend to be greater in exploration than exploitation (March, 1991). There is a necessary balance between exploration and exploitation in learning. Experiences can be exploited but too much exploitation based on experience can limit change and exploration is also necessary to introduce variation (Levinthal and March, 1993). Exploitation ensures current viability and exploration ensures future viability but both learning processes are necessary to ensure returns in knowledge and to avoid obsolescence (Levinthal and March, 1993). Therefore when considering how BIM is shaped in maintenance context both exploitation and exploration learning processes are necessary to consider.

The external influence of BIM is considered here based on government initiatives and developing standards while the internal context is based within the organization introducing BIM with a focus on maintenance. Little is understood on how these contexts impact on the processes of explorative and exploitive learning in shaping BIM for maintenance. This paper examines how one maintenance team explore the new context of BIM based on their learnings from external influencers of BIM and also examine how these learnings are exploited based within their own practices of maintenance.

5. Research method

The research is based on a case study of Estates and Facilities Management department which incorporates maintenance and building projects. This department's organization is private and falls out of the remit set by the UK government of having BIM in publicly funded projects by 2016. The research focuses on a new building project, 'Utilities', where BIM is being implemented. This design/building project was due to start construction summer 2013 and complete in 2015. The established handover documentation is outlined in a document known as the 'Handover procedure'. Information from the handover procedure is integrated into the organization's Asset Management System. The data from maintenance system is extracted by different managers from maintenance who synthesize it for their own specific purposes.

5.1 Research design

The approach taken here is case study as it provides an opportunity to explore the context in which maintenance team engage in learning about BIM at the early stages of design/build projects. Case study is a particular approach appropriate for new topics (Eisenhardt, 1989) and is useful in examining human learning as advocated by Flyvberg (2001) where one is not just examining practices open to public scrutiny but also the backstage. This case presents a backstage view of maintenance practices in understanding their learning processes of BIM. Project managers of the case were also included in data collection to gain a comprehensive perspective of BIM introduction to the organization. The empirically evidence is gathered in its natural setting (Silverman, 1993).

4.2 Data collection and analysis

Data collection occurred at the point of tendering for construction contractors in February/March 2013. The data includes: formal transcribed semi-structured interviews; documents; three formal meetings and observation of the Building Management System. The formal interviews were conducted with seven members of estates and facilities department who represented the Utilities project and/or later responsible for the maintenance of the new build (Head of projects, Project Manager, Assistant head of estates and facilities, Technical maintenance manager, Workspace manager, Energy manager, Asset manager, Maintenance manager). The interviews protocol had a set format; 1) Current use of information tools, 2) Views and vision of FM on future use of BIM, 3) Steps to be taken to enhance BIM implementation in maintenance. Participants spoke about their understandings of BIM through experiences within their own practice as well as the external influence coming from government. Interviews were transcribed and analyzed using qualitative software. Coding for each interview focused on the main headings from the interview protocol and interpreted through the theoretical perspective of exploitive and explorative learning processes. The following sections outline findings on how internal and external context shape exploration and exploitation of learning when implementing BIM in maintenance.

6. External influence shaping BIM for maintenance

The UK government has been catalyst for exploration learning in the case study. The building Utilities project of the case study was due to start in 2013 and complete in 2015. Two years before maintenance teams can adopt BIM and a year before the government 2016 deadline for BIM in operations of public projects. The government is in process of learning which is reflected in developing BIM strategies (BIS, 2010, BIS, 2011, BIS, 2013). The

rational from drawing on the influences of the government is explained by the head of projects.

> *And the reasons we picked it, we could see it on the horizon that BIM was going to get more and more use [...]. And even if in a couple of years' time we look back and say, well, we have made a few mistakes on it, but we've learned from it, and we're in a better position for more projects to become BIM...(Head of projects)*

The government here is viewed as an indication of the future viability of BIM in projects and maintenance. Exploration occurs with great uncertainty but also with the expectation of great realization. Mistakes are viewed as being part of the learning process which can eventually be exploited. The future benefit is building on lessons learnt to be in a knowledgeable position in a future context to increase BIM in projects.

There is an expectation that the government will tell maintenance teams what to do but one manager seemed uncertain that the government was at a point where their learnings could be fully exploited.

> *Yes, and they [the government] could tell us exactly how to do it and that will be enormously helpful, but I'm not quite sure they are there yet (Assistant head of estates and facilities).*

The government is setting the agenda for BIM but at the same time, the role of the government is an obscure influence. The view expressed in the above dialogue is that BIM is being developed within a dynamic environment where there is still a lot of uncertainty. The project and maintenance teams are willing to engage in exploration within their practices but the external influence of government may change the shape of their learnings.

Project and maintenance teams are ready to prepare for BIM and while they would like guidance from government, there is a recognition that the government is still learning.

Therefore other external referents which are influential on the government agenda to BIM are sought for exploitation. One such external referent is the US COBie standard being developed for the UK context (http://www.bimtaskgroup.org/cobie-uk-2012/). The investigation into this standard led to one maintenance manager to contextualize it within his own experience but focused on difference between practices in the UK and US.

> *…the terminology's different, the formatting is all different, and what they [the US] capture is not necessarily relevant to what we want to capture (Technical maintenance manager)*

The acknowledgement of differences starts to be a way forward in understanding how this standard could be relevant and exploited in maintenance practices. The manager's learning from an external influence is contextualized by recognizing the differences through imposing order and understandings based on his experience. The maintenance team know what they want to capture with BIM but are trying to understand how to do this using COBie as a reference point.

The external influence of BIM in maintenance highlights the uncertainty in learning. However learning is necessary as BIM is viewed a future viability in building and maintenance activities. The UK government is a catalyst for exploration learning in the project and maintenance teams. There is a willingness to experiment through making mistakes and take lessons learnt that can be exploited within a future context. But learning activities are also restricted in terms of relevance as the external agenda is open to change. Government strategies and regulations are in development. There is still an expectation that the government will tell maintenance managers what to do but project and maintenance teams are learning in parallel to government learning in this area. In order to exploit what is known

from the external context, maintenance take guidance from the US COBie which is where the UK government is developing a standard for BIM.

7. Internal influences shaping BIM for maintenance

Managers conduct exploratory learning by adding meaning to BIM within their own context and building scenarios. One workspace manager goes through a process of exploring the benefits through the use of BIM, referring to fast access to more detailed information than what is currently available. However, the benefits breakdown when he thinks about how the information could be used in workspace planning in specific scenarios such as room booking.

... the question comes back to cost, how much is that worth? We've, we've got the timetable which gives us a worse-case scenario, how much is it worth to actually understand what the difference is between timetable and actual use (of the room)? Because in fact, whatever's timetabled you've pretty much got to provide a space for it (Workspace manager).

Added value of BIM to the services of maintenance is considered through saving money and optimal usability of information. In the above scenario, the use of information did not equate to the value of providing the information through BIM. Information from a BIM system could provide actual use but it would not come at a time to change the provision of a time-tabled space.

On the other hand, an energy manager spoke how BIM could provide information in a more coordinated way to their group than what is currently done. He gave a scenario of a boiler in a building in which he would like to use information from a BIM system to compare energy efficiencies with as-designed to actually operation. BIM would provide the opportunity to optimize information from maintenance which was previously difficult to access.

So for example there is a boiler that I've been looking at in a particular building that I know is 25 years old, now it would be really helpful if I knew categorically how it was installed, how it was designed with this expected load and then we could look at how that compared to the reality of what the load was, and the efficiency of the boiler when it was installed. (Energy Manager)

The above represents two diverse managers who rely on maintenance information for their services and explore the ideas of how BIM could impact their services. This impact is primarily based on added value from information either improving (or not) on provided services and information flows. The exploration of new ideas draws out potential consequences and implications on future actions within specific contexts. It is through this process of building on their experience of what is known that managers can explore where BIM is relevant to their current activities and where it breaks down.

Past experiences also enable exploitation of learning. Making inferences from what worked well and what did not work well in past changes in the data handover process between projects and maintenance enables learnings to be transferred to the new context of BIM. In the case study, inferences were made from a previous major change to the handover process when a paper based system was replaced by an electronic system. In this previous change, the paper based system was the trusted system and acted as information backup in case of problems with the new electronic system. A similar process of providing a duplicate system for the handover process was proposed where both the current handover system is provided alongside the new BIM system.

...in the case of [a previous project] we did one town house and one main block and the substations as separate paper files so that we could see the format was correct, and then once

we were happy with that everything else was electronic, […] because it was a duplication really (Maintenance manager)

In the case study, change of BIM seemed to impact more on information processing rather than impact on practice. The change of BIM was mainly viewed as a change in the format of how information was delivered and received and would not be a change in practices of maintenance activities. This was indicated by an asset manager responsible for inputting information into the maintenance system.

So the processes would certainly have to change so that people did know what they did if they were going to affect the models or how they would get that information across. But in terms of what we actually do, that wouldn't massively affect it, it's just another form of information (Asset manager).

The above dialogue has implications that the level of change as a result BIM would be minimal for maintenance teams. Focusing too much on exploitation of learning through which BIM can fit to current practices ignores the exploration of the advantages of BIM. This could lead to the introduction of BIM being obsolete where it is physically present but not used any differently to previous systems. One manager viewed BIM as already in the organization under the name of the 'Handover procedure'.

'*since we started the process of looking at BIM, well, we realize we already run BIM. It's just we do not call it BIM, we call it the projects handover procedure' (Maintenance systems manager).*

The project is still at an early stage and excessive exploitation can result in a change becoming obsolete. Excessive exploitation is noted in the case when BIM is viewed the same as the current process called the 'Handover Procedure'. Maintaining the known could lead to change not happening. Using past experience to build up scenarios and explore ideas opens

up variation where BIM can make real changes to the activities of maintenance. There is a necessary balance for exploration with exploitation of learning where changes can be contextualized.

8. Discussion

Maintenance teams of the case study are at an early point of the building project where learning is primarily explorative but within this exploration they also exploit what they already know to introduce and understand a change of BIM. The external context is a catalyst for projects and maintenance teams to learn through exploration to ensure future viability. The government is viewed as an obscure influence. Strategies related to BIM are continuously developed (BIS, 2011, BIS, 2013, BSRIA, 2012). There is uncertainty which strategies can be exploited within a maintenance perspective as they are open to change. In the internal context maintenance managers engage in exploration learning through building scenarios to imagine a future of BIM and identify where it would fit into maintenance practices and where it does not. Exploring ideas on the application of BIM in maintenance means that they try to make sense of BIM based on their experience. There are benefits and dis-benefits to BIM (Becerik-Gerber, 2010, Love et al., 2014) but they need to be seen in the context that BIM is being introduced as does most technology change (Harty, 2005, Linderoth, 2010). In the case, building scenarios enable an exploration of ideas to understand how BIM would be exploited in practice for adding value and for information coordination.

BIM is a future in the case so how can learning be exploited? There is a balance required which involves gaining from the returns on learning exploration and contextualising in the internal context through exploitation (Levinthal and March, 1993). In the external context, exploitation could be seen through the use of a reference point to contextualize learnings for maintenance practice. The US COBie standard was being used to understand

what information is expected to be captured and how it differs to what is wanted by the maintenance team. In the internal context, exploitation of learning is built on past experience which involves making inferences from the past. BIM is a potential change program within project and maintenance teams as seen in other studies (Love et al., 2014, Wang et al., 2013). Exploiting earlier learning from changes in the handover process was seen as relevant in facilitating change as a result of introducing BIM. While changing the handover process was seen as necessary, there is a reluctance to change practices in the case even though other studies argue that BIM adoption require a change in practice (Gu and London, 2010, Love et al., 2013). This reluctance was evident when BIM was compared to the 'Handover Procedure' documentation which inferred BIM being the same as the Handover Procedure. Trying to exploit BIM to fit current practices mean that no change to practice may occur.

There is a trade-off between exploration and exploitation in order for BIM to be shaped in the context of maintenance. Levinthal and March (1993) note there is an essential balance between exploitation and exploration but challenging in knowing where to strike the balance. Excessive exploitation can result in premature consensus and excessive exploration can result in new knowledge not being exploited. The case highlighted where exploration aided in new ideas being introduced and how exploitation based on inferences from past experiences contextualized ideas. However, too much on exploitation through imposing BIM in current procedures showed how BIM could be an obsolete change without building on the ideas from explorative learning.

9. Conclusion

There are studies which exemplify the successes of BIM for maintenance and highlight evaluation of BIM from the asset owner perspective, contractual procedures, technical aspects and the potential benefits of BIM (Anumba et al., 2010, Kasprzak et al., 2013, Wang

et al., 2013, Won, Lee, Dossick and Messner, 2013). Information from projects is a key commodity to incorporate into the various and diverse activities of maintenance (Love et al., 2013) but has often not been used in an optimum way (Whyte et al., 2012). There are also calls for early involvement of maintenance in projects to aid continuation of information from projects to operations (BSRIA, 2012, Cabinet-Office, 2012). However, studies do not consider the initial steps to adopt BIM for maintenance in these early project stages which involves learning. Technologies, such as BIM, are not static and influenced by the context they are used (Harty, 2005) and in terms of BIM, there is an interplay between the technology's feature and the context in which it is adapted depending on the practices that take it up (Linderoth, 2010). The contribution of this work demonstrates how the internal and external contexts shape exploration and exploitation of learning when implementing BIM in maintenance. In this way, the work moves beyond a focus on successes of BIM which are useful but emphasize the context of learning that is necessary to reach these success stories.

In the case study, exploration learning processes and exploitation in the internal and external context are considered. Involvement of maintenance in the early project stage is challenging as there is a long time horizon between design and operation of a building. In the external context, explorative learning is uncertain as political strategies are open to change but exploitation occurs when external learnings are contextualized to maintenance practice. In the internal context, exploration occurs through building scenarios of how BIM would impact on current services and exploitation occurs through inferences to other changes to the handover processes where parallels are drawn and developed for the new context of BIM. Both learning processes are necessary. Too much exploration mean that learning may never be contextualized into maintenance practice and too much exploitation may lead to too much

inference imposed on BIM to fit a current practice of maintenance without any real change happening.

The case study demonstrates that maintenance teams are being influenced by exploring and exploiting learning both in the external and internal context through exploring a future of BIM and building on experience. This is necessary in understanding the initial steps of learning processes for BIM in maintenance but further work is needed. What changes are necessary to integrate different perspectives of project and maintenance practices using the same information; what are the specific information aspects of BIM that add value to the diverse activities of maintenance and how do the diverse practices from projects and maintenance introduce BIM as policy and regulation develop in this area. There is a necessary step of not just focusing on the successes but capturing the lessons learnt in the dynamic environment of BIM.

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