A Study of the Quebec- Finland Gap in Building Information Modeling (BIM) deployment: A Critical Perspective Approach

by

Albert Lejeune (UQAM), Daniel Forgues (ETS) and Hamid Nach (UQAR)

Research-in-Progress

Research Objectives

In 2006, in the United States, large-scale public customers of the construction industry began to impose the use of digital three-dimensional model, or BIM - Building Information Modeling – on players in the industry. The aim was to improve project productivity during activities of design, management and construction. BIM is an integrated and dynamic process supported by a digital platform, which allows for all involved actors, to visually share key physical and functional characteristics of a building before and during construction (Azhar et al, 2008; Azhar, S., 2011; Succar, 2009). According to Itami and Numagami (1992), a set of technologies, such as a digital platform, is primarily a systematized body of knowledge based on the principles of behaviour of natural things and their interactions with artificial things. BIM is a logical system that combines a body of knowledge aiming at the satisfaction of basic human needs, such as building design and construct. As a logical system, BIM requires new knowledge and sharing spaces (Nonaka and Toyama, 2003). When implemented in knowledge spaces, BIM imposes high complexity associated with managing a virtual 3D mock-up design and its different views, which requires the actors to represent their actions at higher levels of abstraction and apply formalisms and standards that may question the performance of traditional business practices. In Quebec, the construction industry and consulting engineering firms master perfectly the knowledge related to project management, but are not succeeding with BIM. In contrast, Finland is one of the world's most advanced countries in the implementation of BIM. The question arises as to why there exists such a large gap between the deployment of BIM in Finland and Quebec. The current research project aims to answer the question on the Finland - Quebec difference in BIM implementation in the construction industries, and will do so by examining four distinct knowledge spaces: the space of the community and institutions; the space of business strategy; the space for innovation and project; and the space of individual work.

The main research question can be formulated as follows: What are the mechanisms and conditions of their emergence that best explain the difference between Finland and Quebec regarding the dissemination of BIM in their respective construction industries?

By observing the actors involved in their respective industries in Finland and Quebec, at different levels of knowledge spaces of secondary research questions are set out as follows:

- What are the specific mechanisms in respective construction business ecosystems of Finland and Quebec that may explain the observed difference in the dissemination and implementation of BIM?
- Are there specific mechanisms in digital strategies of firms in the construction industries of Finland and Quebec that may explain the observed difference in the dissemination and implementation of BIM?
- Is the ability to innovate in systems, processes and products offered by the construction industries in Finland and Quebec the basis of specific mechanisms that may explain the observed difference in the dissemination and implementation of BIM?
- Could the management of professional identities among members of the construction industries in Finland and Quebec be the source of specific mechanisms that may explain the observed difference in the dissemination and implementation BIM?

Through successive examination of these four knowledge spaces in both countries, we anticipate to discover certain mechanisms that, under certain conditions, are at work in Finland and explain the success of BIM in Finland, while of other mechanisms (or similar mechanisms which operate differently or with different objects) explain the stagnation in Quebec. It is crucial to examine what is happening, for example, in the area of community and institutions in Finland. Finland is a small country in terms of population and is strongly oriented towards digital innovation. In addition, its construction industry is integrated and based both on trust between the participants and the adoption of open standards and transparency. Such a context fosters the development of a digital infrastructure across an industry. In business strategy knowledge space, then, we could anticipate a greater ability to design and deploy digital strategies in Finland than in Quebec. In the innovation project knowledge space, some mechanisms related to national culture and the evolution of professional practices might explain the formation of a national consensus on the adoption of BIM in Finland. Finally, in the individual work knowledge space, members of different specialties and trades would be more likely in Finland to let information technology to set and change their professional identity. These are of course only research proposals, and the goal of this project is either to validate them or to discover new unfamiliar or difficult to observe mechanisms that explain this gap between Finland and Quebec in terms of adopting the BIM approach.

Study Background and Issues

Importance and originality

In 2012, Quebec's construction industry accounts for $ 51 billion of Quebec investments, 14% of Quebec's GDP and 234,000 direct jobs per month on average. The adoption of BIM should result in significant productivity gains in the industry. However, in their report to the Research Council of Canada on the use of technology to improve productivity in construction, Forgues et al. (2010) highlighted a growing gap in the mastery of BIM between Canada and the United States, which resulted in a significant loss of competitiveness between the two industries. An in-depth understanding of the causes of Quebec's setback would allow different players (construction industry, professional associations, regulators and customers) to identify the levers that could allow Quebec to better position themselves. To evaluate the delay of Quebec, we consider the construction industry in Finland as our reference point since this industry is a world leader in the implementation of BIM. We believe that a critical realism approach (Sayer and Sayer, 2000) will help explain the gap in the deployment of BIM between Finland and Quebec. This gap is an important event that requires explanations and must lead to identifying the causes. As a unit of analysis, we choose actors (managers, architects, engineers, customers and tradespeople) working in different areas of knowledge in construction industries of Finland and Quebec. Actors will help reveal the mechanisms likely to explain the causes of this discrepancy. The originality of this research lies in the adoption of critical realism as an ontological position on the one hand and the development of a social- cognitive approach to the study of BIM on the other hand. Even if literature in social sciences concerning construction industries is not abundant, the recent development in the field of construction engineering (Koskela, 2008; Azhar et al, 2008) has introduced ethnographic approaches derived from social sciences to better understand socio-cognitive dimensions of the construction process. But this incursion of social sciences in the field of construction remains relatively weak. Thus, current construction industry research, fragmented and focused on the technical and technological aspects of BIM, neither can meet the needs of the industry to generate new knowledge about emerging social practices around BIM, nor can it explain the socio-cognitive aspects of this transformation.

Situation in relation to academic work on the subject

At present, most research focuses on the technological aspects of BIM, such as data interoperability, management information exchange and the development of new tools and technologies to expand the capabilities of BIM. Therefore, the organizational, procedural and contextual aspects of a construction project, central to the creation of appropriate environment for the successful operation of BIM, have been largely neglected in the literature (Dossick and Neff, 2010; Jung and Joo, 2011). Few researchers stress that for successful deployment of BIM and to encourage innovation in the project networks, the integration of practical design, construction and organizational restructuring should happen in parallel with technological development (Harty, 2005 and Jung Joo, 2011; Taylor and Levitt, 2007). Literature shows that the construction industry is formed through project networks, consisting of differentiated social worlds that are built around practices (Taylor and Levitt, 2007), yet the knowledge on the subject is accumulating slowly (Niiniluoto, 1993). Building on critical realism and by examining the four knowledge

spaces in both countries, our research will identify visible or invisible mechanisms, presumably of socio- cognitive nature, and explain the delay in the implementation of BIM in Quebec on compared to Finland. This way, it will also contribute to more technology-oriented and system-oriented literature.

Relevance of the approach and the theoretical framework of the proposed research

In this research, we use critical realism as a philosophical perspective (Sayer, 1992). Critical realism is rapidly emerging as a viable paradigm for research in social sciences. The paradigm connects positivism and interpretivism. Like the positivist ontology, critical realism recognizes that the world has an objective and independent existence, and like interpretivist epistemology, critical realism assumes that our knowledge is a social construct and, as such, is fallible (Strong and Volkoff, 2010). In critical realism, reality is conceived as being stratified into three domains (Bhaskar, 2008). First, is the "domain of reality", which includes entities and structures of reality that have causal powers and is not directly accessible to people. Second, the "domain of the current", is a subset of the domain of the real, is accessible to people and includes events that occur when causal power of structures and entities is put into action. Third is the "domain of the empirical", which consists of events that we can observe and experiment. Human observations of these events are necessarily subjective.

The theoretical framework of our project links social cognition, activity theory and professional identity theory to the technologies that form BIM environment. *Social cognition* is the field of knowledge and know-how relating to relationships between people and between groups in social situations (Houde, 2003). *Activity theory*, developed in the work of Vygotsky and Leontiev, and later updated by Engestrom (2000), construes activity in terms of its context and its artifact; and takes into account the fundamental role of group interactions. Theory of *professional identity* refers to how an individual is defined in relation to his profession. It is this cognitive structure in which an actor not only apprehends himself as a professional, but also his own relations with others. Concerning BIM technology environment, the theoretical framework is adapted from the research of Nonaka and Toyama (2003, 2005, 2006) who describe the space and the time in which people create and apply knowledge. For Nonaka and Toyama (2003), the company is not static but an all fluid and alive entity, always in transformation. Knowledge space - or Ba in Japanese - exists at different levels. Four such levels are distinguished in the construction industry: the space of community and institutions (SCI), the space of the business strategy (SBS), the space of innovation and projects (SIP), and, finally, the space of individual workspace (SIW).

The proposed project aims to understand the interactions taking place - in Quebec and Finland - in four knowledge spaces, each exhibiting four main poles (Lillehagen et al, 2008). For Lillehagen et al. (2008) the poles within the community and institutions are: value, initiative, infrastructure and resources. At this level we can apply the concepts and theories of business ecosystems (Teece, 2007; Fransmann, 2010) to investigate who, i.e. actors persons or actors institutions, takes initiatives in the industry, with what resources, and how to install infrastructure to generate what value.

The poles within the business strategy knowledge space are: service, project, organization and network platform. At this level we apply the usual theoretical frameworks of positioning strategy and the resources theory, adding what is known about digital strategies (Woodward et al., 2013; Zalmanson Oestreicher- Singer, 2013; Mithas et al., 2013; Bharadwaj et al., 2013). Who are, at this level, the actors that form the organizational network able to carry out a construction project?

The poles of the innovation knowledge space are: product, process, organization and system. At this level, activity theory allows to observe the nuances between business processes and business routines. Professional practices are in effect built around tools attached to each specialty (Hatchuel and Le Masson et al 2002; Vinck, 2003, 2009; Engeström and Blackler, 2005; Blackler et al, 2000). BIM could be seen as an integrated and multidimensional platform replacing series of construction management practices and artifacts. Our research for this level is based on activity theory (Engeström, 2000), situated action and situated cognition (Star and Griesemer, 1989; Lave and Wenger,1991; Carlile and Christensen, 2004).

The poles of the individual work knowledge space are: information, task, view and role. The new BIM, which redefined individual knowledge space, questions the professional identity in the face of technological BIM artifact. This project therefore seeks to understand the role of the professional identity of the various stakeholders in a project that involves a group of inter-disciplinary workers. We focus on the role of identity in interaction with various stakeholders, the task, the technological artifact and the view of the data available to them at their level. We raise here the theory of professional identity in relation to the intensive use of IT in digital environments.

Impact that the proposed research will have within the research community

Simon (1996) and Schon (1995) were the first to question the positivist model of production and transfer of knowledge. In their view, the paradigm of natural science was not adequate for research on the production of artifacts that man surrounds himself in order to transform his environment. Our research will address these issues locally by developing the approach of critical realism that allows coexistence between positivist and interpretive paradigms (Sayer, 1992). For management researchers, this project will expand studies in social cognition, which typically specialized in the study of high-tech companies. Through our project we aim to increase knowledge in the field of professional identities and open a way to studies of more organizational character in the field of construction. The construction industry is a relatively new field that is opening to the social science research. Interactions between disciplines of engineering construction and social sciences will provide a fertile ground for the development of innovative and agile approaches adapted to the changing nature of the construction industry, particularly in Quebec.

Methodology

On the methodological level, the researchers involved in this project consider BIM and its interaction with various actors in the four knowledge spaces both as a reality and as a social construct. **The first phase** of the research constitutes conceptual and theoretical work relating events that can occur in four knowledge spaces in construction industries of Finland and Quebec. The aim of this phase is to co-design - by means of interaction among the researcher, the co-investigators and collaborators – an initial integrated framework built from the key concepts of social cognition, professional identity, knowledge management and activity theory from the perspective of critical realism.

The second phase of the research is exploratory in nature and is based on a series of 24 in-depth interviews with actors involved in the four areas of knowledge described above, in Finland and Quebec. Twelve players will be selected in each of the industries.

Data analysis will be conducted, as suggested by Langley (1999), by combining several techniques, such as "visual mapping", the temporal decomposition, quantification of the facts and the technique of "pattern- matching ", i.e. examination of alternative techniques of data interpretation and competing theories which might explain the same data otherwise (Yin, 2009). Interview data related to the implementation of BIM will be analyzed from the perspective of grounded theory (Strauss and Corbin, 1997). Each interview will generate a cognitive map (Davies, 2011; Lengler and Eppler, 2007) allowing the comparison of concepts and relationships between concepts. Emerging concepts will be analyzed and incorporated into the model as and when the advanced search. These comparative analyzes will aim to make a pattern emerge and allow the team to make proposals on the mechanisms - and their conditions of occurrence – that might explain the observed difference in the deployment of BIM in Finland and Quebec.

The third phase of the research is rather confirmatory in nature and occurs in three parallel steps:

1. **A survey** among stakeholders within the community and institutions in both countries, with a purpose of validating the research proposals. Based on the research questions 1 and 2, pertaining to the business ecosystems of Finland and Quebec and the respective digital strategies of firms, researchers and assistants will develop a questionnaire to be administered among 200 participants located half in Finland and half in Quebec, and who belong to the knowledge spaces mentioned above.

2. **Two case studies** in Finland and Quebec, conducted at the project innovation space level in order to understand in depth the integration of BIM in the construction process. Two qualitative case studies (Orlikowski, 1996) will be conducted with the objective to refine and validate aspects of the proposed model. Work sessions facilitated by BIM will be observed in Quebec, filmed, recorded and coded. In practice, researchers will participate as observers at each session. They will take notes and ensure that the image and sound of the full course of the meeting is correctly recorded. The transcripts will be coded according to the approach of activity theory (Engestrom, 2000) and social cognition (Landau et al., 2010).

3. **Two focus groups** carried out in only Quebec, designed to facilitate the understanding of the impact BIM has on the professional identity of architects and engineers on the one hand, and construction firm managers on the other hand. The role of professional identity in the adoption (or not) of BIM in the groups of designers, engineers and architects will be analyzed.

Conclusion

Critical realism approach involves a solid analysis of the organizational context and the socio- historical dimension, not to mention a conceptualization of BIM and its interactions, which goes beyond technology in its visible aspects. This broad conceptualization of BIM is borrowed from Orlikowski (1996) where BIM becomes, from its intrinsic characteristics, a malleable object, in constant interaction with knowledge spaces - emerging and distributed organizational structures - which are often a result of negotiations between users within the social network. This ontological position gives rise to mixed research methods sometimes belonging to positivism (survey), and sometimes to interpretivism (in-depth interviews, focus groups). Moreover, by conceptualizing construction industries as areas of knowledge through social cognition, this research project will generate a set of interpretations from which researchers will make the most plausible interpretation possible.

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