FROM INFORMATION TRANSMISSION TO ENGAGEMENT IN PRACTICE: A STUDY ON BIM ENABLED CONSTRUCTION PROJECTS

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Building information Modelling (BIM) is proposed as a way of dealing with fragmentation through improving information transmission within project working environments. In early studies information transmission was seen objectively as transferring data from one place to another. However, mere information transmission is not enough to improve engagement in practice. Instead, using information transmission need to create meaning for project participants to carry out their work. Increasingly, BIM is been used to deal with the complex actives in construction projects. However, there have been questions on challenges during transmitting information and its failures. This research establishes challenges of information transmission and explores how meaning is created from information in BIM enabled construction projects. Data has been collected through conducting twenty semi-structured interviews and a case study approach which encompasses two fully integrated BIM enabled construction projects which fall between £30-100 million. Findings showed that information overload, information retrieval and information asymmetry are common problems faced in BIM enabled construction projects which make information difficult to transmit within the project environment. It is concluded that communicative, inherent, symbolic and contextual meanings need to be considered together with information to enable engagement in practice.

Keywords: BIM, engagement, information transmission, meaning

INTRODUCTION

Information transmission is important in construction projects where success of the project depends on identifying, collecting, transferring and storing quality and efficient information. Thus, information transmission is considered as a major activity to maintain and transfer an efficient information throughout the whole lifecycle in construction projects. Nyquist (1924) initially established the information theory through focusing on the intelligence and line speed of the communication systems. Later, Harley (1928) concentrated on transmission of words as a measurable quantity and how it affects receiver's ability to differentiate sequence of symbols from others.

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With this fundamentals Shannon-Weaver (1949) has been motivated by problems in communication and considered Information transmission as a process of sending information from one person to another or from one source to another source. In other words, his intention was to identify the quickest and most efficient way to transfer information from one place to another through communication process. In this fast-moving world most information is becoming digital which means they have started to move away from analogue systems. Even though using information technologies has been highly promoted in information management, its uptake has been slow in construction practice and it is seen as delivering only a partial communication. At the same time, solely considering Shannon-Weaver's model of information transmission is not sufficient in this digital world due to drawbacks such as linearity, no allowance for dynamic change, ignorance of unintentional and social communication, less importance for context. Hence, the aim of the study is to explore how meaning is produced and improved beyond information transmission in BIM enabled construction project.

LITERATURE REVIEW

Information Transmission

Information in early days has been defined in three different ways by philosophers and mathematicians. Firstly, philosophers in a narrowest sense have considered information as a data. Later, they have extended the idea to depict the meaning of the data presented. On the other hand, mathematician Shannon (1948) considered information as a degree to reduce the uncertainty through using symbols. Transmitting is an act of sending the information (message) from one spot to another, from one person to another or from one device to another (Shannon and Weaver, 1949). Therefore, the fundamental idea of information transmission is to carry data to the desired destination. Signals, signs, messages and information are various aspects of information transmission embedded in communication process hence it is inseparable from the process of information transmission (Beijer, 2014). Information transmission is transferred in many ways such as paper documents, drawings, emails, images, videos and voice (eg: discussion, telephone conversations). The quality of the information and the time it takes to reach the other person(s) will depend on the way they chose to transfer the information.

Over the years, number of information transmission models were generated to understand the specific concepts and steps within the process of information transmission. Harold Lasswell's 5W model proposes 5Ws for information transmission which established the basic framework of communication research. 5Ws refer to Who, What, What channel, Whom and What effect (Lasswell, 2012). Shannon-Weaver model proposed the communication system in a different perspective. It sends out the information from the source, transmits and in the third step, channel is interrupted with 'noise'. Then it returns to the information flow process, reach the receiver and gets transferred to destination (Shannon-Weaver, 1949). Schramm model stated that information is transmitted through five stages: source, encode, signal, decode and destination (Schram, 1984). In these models information transmission is considered in a linear way and communication is considered in an objective manner. These views have been criticised for this reasons.

Projects in construction involve number of activities; hence transferring information from one person to the other has become complex and challenging. Otjacques *et al*., (2003) state that information overload, information retrieval and information

asymmetry are experienced while transferring information from one place to another. Farhoomand and Drury (2002) argue information overloaded is due to two main reasons. Firstly, it happens when people are provided with more information than they can absorb. Secondly it occurs when information demands on additional time of an individual rather than the allocated time for that proceedings to interact more to complete a task. According to Otjacques *et al*., (2003) information retrieval is related to the information structuring and ease of access. They argue that this happen when information is stored and extents the structure according to the fundamental importance and cognitive effort required by the users. Information asymmetry occurs due to number of people dealing with a given problem and participants having different level of information about the same object. This could lead to distortion due to loss of information integrity and incompleteness due to missing information pieces during communication process. Information asymmetry in most cases results through improper management of the information which is generally poor synchronisation of information while working in groups.

Notion of Meaning

In early days the notion of meaning originated from the art of understanding and the meaning of discourse. Both interpretation of language and thoughts influenced understanding and necessity in terms of both linguistic and subjective representation to appreciate the spoken or written discourse (Schleiermacher, 1998). According to Lash (2003) meaning is fundamentally initiated from the self-productive organic system that is language. In this digital age people, information and activities are connected therefore, generating a meaning is crucial to carry out day-today activities. Meant (2003, 204) has defined meaning as ‘‘the connection existing between the received information and the constraint of the system’’.

Signals in information process can refer number of interpretation therefore understanding the concept of meaning and information is important. Beijer (2014) in his study has considered the notion of meaning through four different orientations. Firstly, communicative meaning is generated through communication between parties which can be negotiable when the process is not linear (Watzlawick *et al*., 1967 and Schulz von Thun, 1981). In this validity, conditions and newness of information within the communicative intent are considered during the action of receiving (Weizsäcker and Weizsäcker, 1998). In this notion both pragmatic and supplement information are considered (Watzlawick *et al*., 1967 and Schulz von Thun, 1981). However, this pragmatic information only makes sense when it is neither entirely new or endorses the past experiences. In this, notion of the meaning is limited to an objective meaning; however inclusion of pragmatic view confirms whether the receiver has understood the message or not. Moreover, this can be evident through the triggered actions or changes of receiver’s structure or behaviour (Schulz von Thun, 1981). Secondly, inherent meaning has a part of communicative aspect however it is not fully depend on the communicative intent. Instead, life pattern of communicators and their background knowledge affects the meaning. In other words, their past experiences drive their thinking and doing (Wittgenstein, 1958). Thirdly, Symbolic meaning is intangible which is beyond the physical objectives such as objects, events and processes. The symbolic meaning is produced in the world which is not physically available; world subjectively created by humans. Although humans can explain the symbolic meaning it is not necessary to follow the purpose of objects, events, processes or purpose of symbols. Symbolic meanings are detached from material utility and generally produced when people are compelled, interested or

thinks that it is worthy for their process (Baudrillard, 1998). Finally, Contextual meaning is created from actor's experience on deeper meaning of ontological structures (Lash, 2002). Even though this is intangible, this is different from symbolic meaning because it considers two-way thinking paradigm where actors produce their meaning by expressing the properties of their past experiences (Lash, 2002). In other words, contextual meaning assumes engagement of subject with objects, events and processes from one-world paradigm. Therefore, contextual meaning is created from clarifications through actor's direct experience where engagements plays an important role. These four notions of meaning can be categorised in to tangible (communicative and inherent) meanings and intangible (symbolic and contextual) meanings. By making meaning out of these objective and subjective ways of information transmission we can enable practice through engagement.

Engagement

In practice, engagement is crucial to deliver tasks and achieve project outcomes. Wenger (1998) believes engagement is beyond a matter of an activity and refers to it as community building, inventiveness, social energy and emergent knowledge ability. Engagement is a direct experience of regimes of competences which can be done as an individual or as a group of people (Wenger, 1998). This experience of identifying the competences or incompetence leads to development of participation or non-participation. Apart from this, engagement allows individuals to interpret their ideas to a group of people while they are engaged with a group. Mutuality, competence and continuity has been considered to form the infrastructure of engagement process (Wenger, 1998). According to Bakker *et al*., (2008) employees who are engaged have high energy levels and enthusiasm in their works. Even though engagement enables people to learn, it is a narrow concept which does not include any expansive images of history, possibilities or complex systems. Moreover, having a multi-actor engagement and steer agent responsible for effective communication in common platform are challenging (Kraatz, 2014). Constructing an image within this world is vital to position ourselves among others, reflect on the situations and to explore new possibilities (Wenger, 1998). Therefore, from cognitive perspective individual's engagement in most routine activities in workplaces is about reinforcing or improving what is already known (Anderson, 1982). Engagement in practice is important to deliver tasks that are assigned to achieve project goals. However, having information without creating a meaning will not help to move towards engagement. Therefore, meaning needs to be seen beyond communication; this has not been considered in the information transmission models.

Information Transmission in BIM Enabled Construction Projects

BIM plays a key role in construction industry which is primarily a three dimensional digital representation of a building and its intrinsic characteristics. According to Xu (2017) BIM adaptation in construction projects can maintain a meticulous management of information without waste being produced to ensure construction quality and progress. Similarly, Zhang and Hu (2011) believe BIM facilitates an integrated method of information flow in all stages of project through the collaborative use of 3D digital models. Moreover, they believe it also helps to visualise and analyse the construction project to the nearest real-life fidelity. Mitchell and Lambert (2013) believe engagement in BIM construction projects supports decision making, shares knowledge among others, brings all participants together in the early stages (Mitchell and Lambert, 2013). However, BIM enabled construction

projects are affected by several factors such as volume of meaningful knowledge (Forsythe *et al*., 2013), involvement of software (Barlish and Sullivan, 2012), mature application system for research and development, relevant policies, industrial rules and regulations (Xu, 2017). These challenges show that transferring information is solely not enough and needs to produce meaning out of information for engagement in practice. The next section explains the methodology that has been chosen for this study.

METHODOLOGY

This study has adopted critical realism which is a philosophical view about reality and human knowledge (Bhaskar, 2008). According to critical realist unobservable structures causes the observable events therefore people need to recognise the structured events to understand the social world. This study is concerned with engagement and information transmission in BIM construction environment which is part of studying about human information actions in the context. Therefore, critical realism is considered as most appropriate to distinguish, in the most categorical way, between human actions (interactions) and social-cultural structure (tasks and activities within the context). Therefore, in this research context the perspective of critical realism considers the BIM technology as existing independent of people who interact with it and having influence in development of engagement which are socially constructed. Consequently, a qualitative approach is adopted in this study to address the challenges in information transmission in BIM enables construction projects. In doing so, the study discovers how meaning is produced during information transmission in BIM construction projects and how it can be improved. Data for this study have been collected through conducting twenty semi-structured interviews and a case study approach which includes two fully integrated BIM enabled construction projects which fall between £30-100 million.

Semi-structured interviews for this study were conducted with professionals who had a minimum of two years of working experience in BIM construction projects. The purpose of these interviews is to understand the significance of information transfer among BIM professionals. Interviewees involved in this study falls under the roles of BIM coordinator, BIM technician and BIM managers and interview with each professional took approximately 40-50 minutes. In semi structured interviews open-ended questions were employed to get a wider view of the situation and interpretation was done along the way. Two pilot studies have been conducted with construction professionals working with BIM to refine interview questions. Interview questions focused on collecting BIM professional's views and concerns about information transmission during the implementation of BIM in construction projects. The collected data are transcribed and coded using Nvivo. Nvivo is a tool to organise data and helps to interrogate it.

BIM is highly a practical concept therefore case studies of two different BIM construction projects, focusing specially on the information transmission process during BIM implementation were chosen for the study. The purpose of the case study approach is to understand real-life challenges related to information transmission while providing a meaning to the people involved. Case study one selected for this study is a 100,000-square foot extension to the previous building built in 2015. This is a £31 million project which engages over 3,000 students and members of staff and features more than 650 rooms, a student hub and lecture theatres. This high-tech university project has used Level 2 BIM for its deliver and detailed planning and

anticipated to complete in mid of 2018 for the new academic year. Case study two is conservatoire for a well-known university. This is a £57 million project featuring 9,000 square foot designed for media and art students for teaching, rehearsal and state of art performance space. This building has included facilities such as jazz club, a 450-seat conference hall, an intimate 150 seat recital hall, 100 seat practice and rehearsal hall, organ studio and complete AV digital interconnection. Like case one, this project has also adopted Level 2 BIM and has been completed in September 2017. Both projects chosen for the study is a fully integrated BIM construction projects which has used BIM technology for their day to day activities. Data collected from these projects showed that information transmission has a greater impact on making decisions and defining tasks. However, number of challenges in information transmission were noticed while achieving the desired outcomes.

FINDINGS AND DISCUSSION

Information transmission in projects plays an important role in delivering tasks and to achieve the final project goal. However, information transfer solely does not make desired meaning to the receiver who gets the information. Therefore, following scenarios were purposefully chosen from the case studies to explore the difficulties faced during information transmission especially in BIM enabled construction projects.

Scenario 1: Case study 2: clash detection

A design meeting with the project team was arranged by the BIM coordinator to discuss about issues in the model where the projectors in 'Egg theatre' clashed with everything on its way and following that ceiling also clashed with the frames from both sides. BIM coordinator has identified the clash through clash detection process in 3D BIM model. Team members during this meeting have requested to show the visuals of identified clashes to further discuss about the problem. While discussion was taking place project engineer with his previous experience spotted projectors are also clashing with ductwork, ceilings and finishes. Team felt that this clash is too complicated. Therefore, architect mentioned that it is better to approach a specialist within the organisation to sort out this issue. However, architect suggested that similar to a past project ceiling could be move to the right to avoid the clash between the frames.

In this scenario, team members collecting and sharing the information through the visual representation and verbal discussion show that information is transferred from one place to another where communicative meaning is generated. During this, meaning is negotiable because of the continuous communication between the team members. This is also evident when Interviewer-17 stated ''One of the important thing is everyone should have a clear communication between the project participants''. Following that, project engineer's identification of related clashes shows his experience on deeper meaning of the BIM model. In this case it helped the team members to identify errors in the early stage of the project. Team members through agreeing to hire the specialist to deal with this complex issue symbolically shows that they are not competent enough to handle this issue themselves even though they have not blatantly said it. However, a solution suggested by architect to move the ceilings to the right illustrates the creation of contextual meaning through his experience. In this scenario, BIM coordinator is more focused on the models and clashes, project engineer in understanding what can affect the overall model and architect is concerned about the design. This shows the inherent meaning produced by

their backgrounds and previous experiences. Even though, meaning is produced through these notions to eliminate the clashing projectors in the model, at the end of the project this issue took longer time to be resolved. This is because of having different views from number of stakeholders and the specialist involved. This has been agreed by Otjacques *et al*., (2003) and has stated this as 'Information asymmetry'.

Scenario 2: Case study 1: positioning of windows
BIM coordinator in another situation has identified a window which was situated between two columns and discovered that there was no steel work to connect it. Therefore, to clarify this design BIM coordinator arranged a meeting with relevant team members. In the meeting, issue was explained to other team members through the visuals pulled out from the 3D model and 2D drawings. After this was explained to the team members in the meeting, site engineer on site was contacted through a phone call while meeting was taking place. During the conversation with the site engineer BIM coordinator collected more information on the setting out dimensions particularly for window and the steel connected to it. BIM coordinator through talking with the site engineer also double checked that the information they have got is correct. After analysing on the elements on site through site engineer the specification provided was checked against the collected information and the model designed for the window. This exploration with the team members have led the BIM coordinator to identify that the sill needs to be raised to rectify the identified error. Moreover, during this discussion architect suggested that glazing for the window needs to be split into several sizes (six or four, no longer than 3000mm and 1800mm wider including the constraints).

In this scenario the information flow occurred through collecting information from 3D models, 2D drawings and project specifications. During this discussion, having more than one information source not only helped the team members to generate the communicative meaning but also to make connections between the information available in each source. BIM coordinator's conversation with the site engineer to collect information about the window, steel setting out and dimensions shows the direct participation to solve this issue. This clarification generates the contextual meaning during the information transmission process. In this discussion BIM coordinator's suggestion to lift the sill and architect's suggestion to split the glazing into several sizes show that their focus is different to each other to solve this problem. This inherent meaning produced is due to their backgrounds, roles and responsibilities and experiences. Throughout the conversation between the BIM coordinator and site engineer the word 'Setting out' was highly used. Even though setting out can mean different thing, in this conversation it symbolically means the mark ups for windows and steels connected to it. During this situation BIM coordinator referring to the documents and collaborating with other team members after talking with the site engineer shows that he has not got the holistic understanding about the issue. It is mainly caused by loss of information integrity and incompleteness due to missing information pieces during communication process. Importance of holistic understanding is also evident from Interviewer-9 stating " In my opinion I would say that there must be some holistic understanding in BIM overall process". Even though site engineer has given the BIM coordinator all the information he still has not gained the meaning of what he wanted and this challenge is referred as ‘Information retrieval’ (Otjacques *et al*., 2003).

Scenario 3: Case study 1: Data assignment
During one of the project meetings, issues related to data assignment to the federated BIM model was picked up. Project manager stated that even though they have set up a federated model and started assigning the data, the problem raised is that they have quite a lot of data to be assigned to the model. Moreover, he said change in the systems and materials is a repetitive process. Therefore, due to this uncertainty he complained that in some situation they must do the exercise from the scratch rather than keep doing the same thing. On the other hand designer mentioned that even though most of the things have been constructed they still get emails regularly about the updates which make the process more difficult. Following this discussion BIM coordinator raised a question to project manager asking when they are going to be in BIM Level 2. For this project manager answered that most of the allocated works complies with BIM level 2 as far as there is no concerns about any updates. However, during this, BIM auditor indicated that information is always passed to the relevant team when they are in the position to do so.

In this scenario information was transferred through verbal communication between the team members presented in the meeting. The communicative meaning produced through this communication process helps to understand the difficulties that other team members are facing in terms of assigning the data to the model. In contrast to scenario 1 and 2 in this situation both project manager and designer are complaining about the same issue which is about huge amount of information while assigning the data to the model. However, project manager is more concerned about the overall data whereas designer is just focused on the data which is related to the design. This inherent meaning generated in this situation is due to different backgrounds and roles and responsibilities. Project manager answering to the question regarding to level 2 BIM shows that he has enough experience to assume that other works in the project will comply with Level 2 BIM. This contextual meaning produced during this meeting helped the other team members to focus and design their jobs in terms of complying with Level 2 BIM. However, according to Interviewer- 8 ‘‘it is very rare to find a fresh highly educated practitioners who has deeper experience in the industry’’. However, early indication in this scenario helped to minimise the errors in the project. During this discussion BIM auditor mentioning that 'information will always passed to the relevant team when they are in the position to do it' symbolically shows that team members will keep on getting information if that is relevant to them. In this even though BIM auditor did not say that changes are unavoidable he has symbolically said that team members should cope with the changes that happens in the project. As it is obvious the main issue regarding information transmission in this situation is information overload. In this scenario it mainly occurred when providing more information than participant can absorb. According to Farhoomand and Drury (2002) and Otjacques *et al*., (2003) this is the most common problem faced during information transmission process.

These scenarios discussed above show that making meaning out of the information is not solely through communication. Instead both tangible meanings such as experiences, backgrounds and responsibilities and intangible meanings such as people's views, emotions and thoughts have an impact on meaning making process. This will not only help the receiver to achieve a meaningful information but also helps to produce a meaning without errors. On the other hand, moving information transmission away from an objective view helps participants to think outside their comfort zone. Most importantly this will help to achieve engagement which is crucial

for practice. Furthermore, producing a meaning from an information helps to build community, inventiveness, social energy and developing ability of knowledge. This then enhances engagement in practice. As the scenarios show, challenges such as information asymmetry, information retrieval and information overload are encountered in the process of information transmission in BIM enabled construction projects. However, this could be minimised by holistically considering communicative, inherent, symbolic and contextual meanings while making meaning from information transmission.

CONCLUSIONS

Information transmission in early days was considered solely as transferring information from one place to another. This was considered as a linear process which was highly based on communication between two parties. However, in the fast-moving digital world activities are becoming more complex and challenging. Therefore, engagement is important for practice. Engagement is beyond an activity and includes community building, inventiveness, social energy and emergent knowledge ability. Therefore, seeing information transmission from an objective manner is not sufficient to make a meaning out the information that is transferred. Therefore, process of information transmission needs to be seen beyond the information flow. The scenarios that have been explored in this study show that meaning is created through communicative, inherent, symbolic and contextual meanings. For example, communicative meaning in BIM construction projects is produced through communicating with project team members with the aid of integrated 3D BIM model that has access to all the information related to the project. Subsequently, Inherent meaning in BIM construction projects is noticed when participants apply their experiences and background and professional knowledge to resolve conflicts that arises in the project. However, symbolic meaning is not an easy one to observe, since it resides in the social domains and hard to objectify into events or tasks; however it is generally produced while providing opinions to other team members. Finally, contextual meaning is generated when project participants are directly involved in site visits, project meetings and in workshops to choose the appropriate materials for their project. Therefore, in addition to hard information both tangible (experiences, backgrounds and responsibilities) and intangible meanings (eg. people's views, emotions and thoughts) need to be taken into consideration to produce meaningful information. This can help not only to build up a meaning but also to improve engagement in the project information centric world. Engagement then enables project participants to successfully participate in project practices.

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