Towards formal usability approach for BIM applications

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ABSTRACT

Building Information Modelling (BIM) is claimed to be the first truly global digital construction technology, which started becoming deployed widely. Hence, applications supporting BIM are in continuous development to support various activities involved in a construction project. However, effective development requires sufficient usability considerations to ensure a value-delivery to the end-user. Current research efforts demonstrate limited emphasis of usability considerations in relation to BIM technology, which can have an influence on the usefulness of this technology in the construction industry. This paper aims to inquire into the usability considerations given to the BIM technology, exploring some of the potential complexities associated when conducting the usability tests. Evidence has been demonstrated using both existing literature and semi-structured interviews with one of the BIM software vendors. The gathered results demonstrate the need for formal usability considerations, which require multi-disciplinary construction stakeholders. The practical implications suggest that incorporating multi-disciplinary stakeholders can support further developments of BIM technology. Future work involves examining the analysis proposed within this paper.

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Key Words: Software Usability, Construction Management, BIM, Usability Attributes.

1. INTRODUCTION

BIM has helped melding the way buildings are designed, analysed, constructed and managed. Currently, many theories of its potentials associated with various tools to its application are available. It could be the answer to many problems faced by construction manager. However, using it seems to be misleading. It frustrates users and owners to the extent of not desiring to use it again (Hardin, 1980). Although technical advancement of BIM in the field of construction management is important, capturing lessons learned and best practices are critical to improve the usefulness of this technology. It cannot be refined unless users get involved and share their experiences with others. Therefore, tackling non-technical barriers is needed to bridge the gap between technology, end-users and their processes. It can be approached by conducting usability tests. By inviting user involvement, capturing better decisions relating to usability can generally be obtained (Hayat et al. 2015).

2. METHODOLOGY

This research aims to explore how usability is perceived with respect to BIM technology for the construction industry. The methodology consists of two parts: literature review and semi-structured interviews. The literature takes critical insight into BIM technology and software usability. Additionally, a BIM software vendor has been interviewed to obtain a direct insight into usability aspects. It is claimed that using qualitative research for computing related research is useful to understand casual processes (Kaplan and Maxwell, 2005), which can be hard to describe using quantitative methods. It is important to emphasize that size of the research sample did not pose any issue, as quantitative analysis are not desired.

2.1 Literature Review

This section reviews the existing literature in relation to the areas being investigated in this paper. The literature begins with a general overview of BIM technology, emphasizing its benefits to the construction industry. It then follows with reviewing various applications of BIM technology, with drawing emphasis on the approaches used to evaluate it. The section concludes with discussing usability and its measurement acknowledging the complexities associated with it.

2.1.1. BIM Technology

Construction is considered to be one of the highly fragmented industries, as it consists of differentiated stakeholders with disparate approaches influenced by varying professional practices (Feige *et al*. 2011). BIM was introduced as an enabler of more integrative design processes, promoting multiple stakeholder collaboration and efficiently present complex concepts to aid fast and effective decision-making (Ahmad *et al*. 1995). According to Aranda-Mena *et al*. (2009), BIM is seen as an evolution of Computer Aided Design (CAD) systems, which provides intelligent and more importantly interoperable information. In addition, it represents an approach to create and manage information over the whole life cycle (production, construction, building in user and end of building's life) of a building, which allows better collaboration between project stakeholders (Liu *et al*. 2012). It is important to point out the ambiguity associated with the term 'BIM', as it can be described as a process for designing and documenting building information, or a whole new approach that requires new policies, or a software application (Aranda-Mena *et al*., 2009). As for the purpose of this paper, and to avoid any possible confusion, it will be looked at software applications that support BIM process.

There are many research efforts that demonstrated the usefulness/impact of various BIM applications within the construction industry. A study conducted by Suremann and Issa (2009) has demonstrated the positive impact of BIM on pre-defined construction key performance indicators (KPIs), which primarily focused on quality, cost, schedule, productivity and safety. Another study by Becerik-Gerber (2010) showed the uses of BIM for various aspects such as clash detection, construction sequencing and facilities management. However, Hartman *et al*. (2012) claimed that one of the major challenges faced by BIM software tools is aligning its capabilities to be balanced across various project lifecycle. On the one hand, it is claimed by Eastman *et al*. (2011) that BIM requires highly specialised skills, which potentially can cause issues within teams, as different members often possess different BIM capabilities. Furthermore, Eisenmann and Park (2012) highlighted that maximizing BIM benefits is directly related to the experience of those who use it. On the other hand, the issue of interoperability between different BIM applications is considered to be a major issue, which affect BIM adoption within construction projects (Olatungi, 2011). Although the literature has acknowledged the benefits of BIM technology, yet it has not been demonstrated how they have correlated towards evaluating the usability of the BIM applications. More importantly, these evaluation approaches are quantitative based, which do not emphasize how it would contribute towards the technological development for BIM software applications.

2.1.2. Software Usability

This study focuses on measuring usability of BIM technology in the field of construction management. Nevertheless, measuring usability is complicated. It is not a specific property; rather, it is an emergent property that is dependent on interactions among users, products, tasks and environments (Hertzum, 2010). Since 1979, the first recorded use of the term usability was made in the context of software development in an article published by Bennett; various definitions for usability have been published. At present, the definitions of the concepts of usability that are widely used are those of the International Organization for Standardization (ISO), particularly those specified in ISO 9241-11 (ISO, 1998) and ISO/IEC 9126-1 (ISO/IEC, 2001). ISO 9241-11 specifies usability to refer to "the extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a specified context of use", and ISO/IEC 9126-1 (ISO/IEC, 2001) defines usability as "The capability of the software product to be understood,

learned, used and attractive to the user, when used under specified conditions" (Seffah et all, 2003). Several individual usability researchers, such as Jakob Nielsen, John Carroll, Andrew Sears and Larry Constantine have written extensively on usability engineering, and have also provided their own definitions. Of these, the usability components identified by Nielsen (1994) are widely recognised as classical attributes. These are the software being easy to learn, efficient to use, easy to remember, having few errors, and being subjectively pleasing. Newer definitions however went further by specifying the attributes of not only effectiveness, efficiency, error tolerance and being easy to learn, but also being engaging Gonzales et al. (2010). In effort to unify the several models investigated, Dubey et al. (2012) provided "an integrated model for usability." They specified the usability attributes to: effectiveness, efficiency, satisfaction, comprehensibility, and safety. Table 1 below gives brief definition of each attribute as mentioned in by Dubey et al. (2012).

Table 1: Definitions of the four chosen usability attributes (Dubey et al., 2012)

Attribute	Definitions
Effectiveness	"The degree to which the software facilitates the user in accomplishing the task for which it is intended with precision and completeness while avoiding most errors in varying contexts of use"
Efficiency	"The performance of the software in accurately and successfully completing a task in return for the user effort, finances and resources that are invested."
Satisfaction	"The degree to which the software is likeable, comfortable, attractive and trustworthy for the users."
Comprehensibility	"The degree to which the software has clarity, is easy to learn and remember and includes appropriate help/documentation."
Safety	"The degree to which risk/damage derived from the use of the software can be avoided."

2.2 Semi-structured Interviews

Three interviewees were involved in collecting data: Product Manager, Senior Developer and a Developer. Although usability is expected to have similar understanding within particular software's environment, the authors have intended to explore perspectives on usability based on different roles. As mentioned in the literature, usability is considered to be complex, and interviewing individuals' worldviews from different roles would potentially support capturing more comprehensive knowledge (Morse, 1991), which increases the possibility of detecting conflict of opinion. The use of the interviews in the context of same software environment plays an important role in shaping meaningful analysis, which can have some practical implications.

As mentioned before, the interview questions have aimed to derive direct yet comprehensive reflections on usability and its related aspects. There are five areas that the interview questions include, and are listed as below:

1. Different perspectives of software usability.
2. Importance of software usability test.
3. The current software usability test used for the application.
4. When the software usability test is conducted.
5. How the software usability test is conducted.

The gathered answers have been tabulated with respect to the mentioned themes above, and are presented in the next section.

3. RESEARCH RESULTS

This section presents the data collected using interviews with the Product Manager, Senior Developer and a Developer. Results are presented in a table form, allowing ease of knowledge interpretation. Table 1 presents the individuals' responses with respect to the areas mentioned in the previous section.

Table 2: Responses gathered from the interviews conducted with the Product Manager, Senior Developer and a Developer

Participant	Usability considerations				
	Perspective on usability	Importance of usability	Usability tests currently in use		
			What	When	How
Product manager	It is easy to make assumptions about features but by putting it in a usability test it gives a distance from developer vision and users' (people) visions.	Very important It is a way to get feedback to iterate.	We have not done any formal usability test yet	It depends on the feature. If it is a fresh concept, it might start with a wireframe or just a random informal interview since requirement stage.	Feedback loops
Senior Developer	You do not know what the customer wants until you talk to them. Sometimes the customer themselves do not know what exactly they want until a piece of software is being used by them.	Very important If the software does not satisfy the technical need that is a failure but if does not satisfy the ability to how to learn how to use it or discover it	Expert analysis	All the time. In a sense we have an idea. Then we sit down and write up the software and we run it and test it out immediately. Trying to focus on one thing at a time for as long as we can. Make it feel and work as well as possible to satisfy the needs that we have identified	Feedback loops
Developer	Usability means understanding how people use software. Developers are disconnected from users until usability tests are conducted	Very important	Off-site Alpha and Beta testers Web-based program for adding feedbacks and adding questions	All the time In iterative process	Feedback loops

4. DISCUSSION AND PRACTICAL IMPLICATIONS

This section introduces the practical implications derived from the results presented in the previous section. Primarily, the discussion undertakes two themes that would potentially set the ground for further work prior to this research. The first theme discusses the complex nature of 'usability' whereas the second theme argues the need to establish a more formal approach for 'usability' tests to be applied for BIM software applications.

4.1 The complex nature of 'usability'

The results presented in the table 2 demonstrate that even within the same working environment usability can be perceived differently. It is important to acknowledge that both role and expertise have influenced the view of usability. Looking at the Product Manager's view, usability is viewed as a strategic tool to drive the developer's vision by understanding the users' vision. As from the senior developer's perspective, the user's experience of the application defines the usability. Finally, usability from the developer's side has been defined as the main connection between users and the software developers. It can be realised that these views can be interpreted differently, which mainly depends on the parameters that are used during this interpretation. In other words, whilst the product manager's view seems to drive a more holistic and inclusive view of usability, yet when commenting on the importance of usability, it was mentioned that "It is a way to get feedback to iterate", which almost complies with two of the usability attributes: effectiveness and efficiency. The senior developer's view seems to be driving the 'satisfaction' attribute, which demonstrates an objective predefined view of usability. It can be argued that the developer's view of usability is hard to interpret when compared to the previous two views, as no measures of performance (objectives) have been mentioned. As a result, it can be claimed that the nature of usability and how it is tested is complex to be holistically considered, and establishing a formal approach towards it is needed.

4.2 The need for a formalised 'usability' tests for BIM application

Following on the previous section, an insight into usability from different perspectives showed the need for a more holistic consideration of it. Drawing on the answers mentioned in table 2, it is apparent that there is no common opinion on what usability test is being conducted for the current BIM application. Whilst the product managers argued that there is no formal usability test, both senior developer and the developer have mentioned that they conduct a usability test. However, both mentioned usability tests (expert analysis and the web-based feedback) are loop-natured, which do not provide enough clarity to when and why these tests are being conducted. It is noticed that the timing of these feedback loops are not well-defined, apart from the Product Manager who mentioned that interviews could take place when releasing a new function or concept. It is important to note that the interviewees have not acknowledged the importance of multi-disciplinary user consideration when deciding to conduct the usability test. The literature showed that the previous evaluations (Suremann and Issa, (2009); Becerik-Gerber (2010) of BIM technology for the construction industry have acknowledged the usefulness of it from interdisciplinary stakeholders during different construction stages. Consequently, it is desired that a consideration of these evaluations should contribute towards establishing a formal usability tests to acknowledge the complexity of such technology for the use by construction industry. Potentially, formal testing would involve a set of users (from different roles) during one of the construction stages. The nature of the test would then depend on the activities being performed by the technology and users either talk or give feedback about it.

CONCLUSION

To sum up, the paper has taken an insight into usability for BIM applications using both literature and a selected BIM software vendor. It is critical to capture various expectations of different stakeholders of BIM to increase its usability, allowing further quality development and encouraging user's engagement. The objective for this paper was to emphasize the importance of non-technical aspects of BIM due to its criticality in building a knowledge sharing system, which will refine the best practices of this technology. Future work involves inquiring into further analysis, as this will assist

further investigations in testing usability for other BIM applications, which can support the technology development for this technology.

REFERENCES

Dubey, Sanjay Kumar; Anubha Gulati and Ajay Rana. (2012). Integrated model for software usability. International Journal on Computer Science and Engineering, vol. 4, no. 3, pp. 429-437.

Fischer, M. and Kunz, J. (2010) 'The scope and role of information technology in construction', CIEF Technical Report No. 156. CIFE Stanford University: CA.

Gonzalez, Maria Paula; Chesnevar, Carlos Ivan; Pinkwart, Niels & Lucero and Mauro J. Gomez. (2010). Developing argument assistant systems from a usability viewpoint. Proceedings of the International Conference on Knowledge Management and Information Sharing, pp. 157-163.

Hayat, H., Lock, R. and Murray, I. (2015) Measuring Software Usability. BCS Software Quality Management Conference, Loughborough University

Hertzum, M. (2010) Images of Usability. International Journal of Human-Computer Interaction, 26(6), pp567-600

Kaplan, B. and Maxwell, J. A. (2005) Qualitative Research Methods for Evaluating Computer Information Systems. In Anderson, J. G. and Aydin, C. (Eds). *Evaluating the Organisational Impact of Health Care Information Systems.* Springer Science + Business Media Ltd.: New York, pp. 30 – 55.

Morse, J. M., (1991) *Qualitative Nursing Research: A Contemporary Dialogue*. SAGE Publications: London.

Seffah, A. and Metzker, E. (2003) The obstacles and myths of usability in software engineering: Avoiding the usability pitfalls involved in managing the software development life cycle. Communications of the ACM, 47 (12): 71-76

Song, S., Yang, J. and Kim, N. (2012) 'Development of a BIM-based Structural Framework Optimization and Simulation System for Building Construction', Computers in Industry, 63, pp. 895 – 891.

Aranda-Mena, G., Crawford, J., Chevez, A. and Froese, T. (2009) 'Building information modelling demystified: does it make business sense to adopt BIM?', *International Journal of Managing Projects in Business*, 2(3), pp. 419–434.

Liu, X., Eybpoosh, M. and Akinci, B. (2012) 'Developing As-Built Building Information Model Using Construction Process History Captured by a Laser Scanner and a Camera', in. American Society of Civil Engineers, pp. 1232–1241.

Feige, A., Wallbaum, H. and Krank, S. (2011) 'Harnessing stakeholder motivation: towards a Swiss sustainable building sector', *Building Research and Information*, 39(5), pp. 504 – 517.

Ahmad, I., Russell, J. and Abou-Zeid, A. (1995) 'Information Technology (IT) and integration in the construction industry', *Construction Management and Economics*, 13, pp. 163 – 171.

Suremann, P. C. and Issa, R. R. A. (2009) 'Evaluating Industry Perceptons of Building Information Modeling (BIM) Impact on Construction', *ITcon*, 14, pp. 574 – 594.

Eastman, C., Teicholz, P., Sachs, R. & Liston, K. (2011) *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*. New Jersey: John Wiley & Sons Inc. Publishers.

Eisenmann, S. and Park, B. (2012) 'Building Information Modeling's Impact on Team Performance Associated Schools of Construction', *Conference Aston*, Birmingham, pp. 1 – 9.

Olatunji, O. A. (2011) ‘Modelling the costs of corporate implementation of building information modeling’, *Journal of Financial Management of Property and Construction*, Vol. 16, No. 3, pp. 211 – 231.

Becerik-Gerber, B., & Rice, S. (2010) ‘The perceived value of building information modeling in the U.S building industry’, *Information technology in Construction*, 15(2), 185 – 201.

Hartman, T., van Meerveld, H., Vossebeld, N., & Adriaanse, A. (2012) ‘Aligning building information model tools and construction management methods’, *Automation in construction*, 22, 605 – 613.