Development of Integrated Framework Based on Agile Principles And BIM Functionalities

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ABSTRACT

Building information modelling implementation in construction industry requires changing the process and proper management approach to deliver successful projects in terms of design, construction, operation and manufacturing. This paper discusses alternative management approach to support BIM application in construction projects. Agile project management integrates with BIM in order to develop new two-dimensional framework to lead construction project teams into effective implementation of BIM functionalities and agile principles. The endeavour of integrating BIM and Agile is to deliver value in terms of minimizing wastes and rework, motivating individuals, early project delivery, better communication and collaboration, satisfying customer and effective adaptation of changes. This paper evaluates the associations between 12 agile principles and 13 BIM functionalities; and assesses how agile principles facilitate the implementation of BIM. This paper utilizes questionnaire survey to collect data from professionals in construction and software industries to verify the two-dimensional integrated framework. The main finding of the study include: (a) 75% of respondents agreed that BIM functionality of reusing of data model supports agile principle of customer satisfaction ; (b) 78% of respondents agreed that BIM functionality of construction simulation supports agile principle of welcoming changes; (c) 72% of respondents agreed that BIM functionality of visualization supports agile principle of priority of working product; and (d) 81% of respondents agreed that BIM functionality of automated cost estimation supports agile principle of simplicity.

Keywords: Agile Project Management, Agility Principles, Building Information Modelling

1. INTRODUCTION

Construction industry management approach is facing problems during project lifecycle. Researchers over the time developed an alternative management system to start overcoming these challenges. Meanwhile, agile project management left a positive and effective print in software and manufacturing industries. Therefore, Agile will be considered as the management method to be applied in construction industry. Moreover, the technology revolution in construction industry started to apply and develop better method of 3D and 4D modelling called BIM "Building Information Modelling". This paper will integrate agile project management principles with Building Information Modelling functionalities to develop an alternative management approach for construction industry. This paper will focus on "Enhancing agile application in construction projects using building information modelling". This paper will discuss Agile BIM framework development as well. BIM is considered not only as software but also a method that supports team members and provides a faster result to the management and construction team during project lifecycle.

2. AGILE BIM FRAMEWORK

Agile BIM framework identified in this paper is to show how to link between agile principles and BIM functionalities. This framework links between management, design, construction

and procurement phases. Agile BIM approach is not only about following the framework but it is also about how the teams behave within the framework. Uikey and Suman (2012) described project manager behaviour within agile approach as "In traditional project management, the role of the project manager is more of a command and control type, where the project manager is the commander and team members are the followers. Any type of change in the software development environment is managed by the project manager and necessary actions are directed to the team. But in today's modern project management approach, like agile, the role of the project manager is redefined as a guide and mentor, working together with the team. The teams in agile methodologies are self-organized and motivated, the role of the project manager is to support and help the team to accomplish the task" (Uikey and Suman, 2012). This study develops and verifies a conceptual integrated framework which maps the relationships between agile principles and BIM functionalities.

- First dimension is based on agile project management with 12 principles.
- Second dimension represent Building information modelling with 13 functionalities.

Building Information Modelling needs proper management system to ensure delivery of the project and collaboration between team stakeholders. Agile project management is proved as a successful management method for the past years in manufacturing and software industries. BIM functionalities and agile principles are studied and analysed with 32 interactions (Sacks et al., 2010). Managers, developers, construction executives, designers and management teams working in construction industry will be affected by the benefits of Agile BIM development strategy adaptation. A framework will be developed to ensure BIM and Agile fits and interact together (Sacks et al., 2010). Table 1 shows an integrated matrix between 12 agile principles and 13 BIM functions. Agile principles are motivating individual to support BIM functionalities and adding value to the management process. Table 2 presents a sample of 10 of these integrations between agile and BIM. Omar and Elhag (2019) studied agile principles and BIM functionalities. That research evaluated 32 relationships to develop 2D integrated framework in order to enhance application of Agile in construction projects using BIM (Omar and Elhag, 2019).

3. RESEARCH METHODOLOGY

This paper considered two research methodologies to obtain professionals experience and opinion in order to validate integration between agile principles and BIM functionalities.

3.1 Questionnaire Survey

Questionnaire survey is mostly used for collecting of information throughout a survey. The structure of the survey is designed through sequence of questions such as scaling data, rating questions, multiple choices and type of questions. The survey can be distributed into individuals in person or online (Cohen et al., 2013).

3.2 Framework

Framework is a study to serve and to build a proper understanding of a research. This paper covers a framework by listing 12 agile principles and 13 BIM functionalities. Agile BIM framework shows integrations between agile principles and BIM functionalities by numbering process to be discussed in Table 2. Framework is an understanding of a problem to be presented and specified in theoretical way to support the research. It also helps to analysis the research data and to choose research design (Grant and Osanloo, 2014).

Table 1 Agile BIM Integrated Framework

Agile Principles/BIM Functionalities	Visualization	Rapid Generation of Multiple design alternatives	Reuse of model data for predictive analysis	Automated cost estimation	Maintain of information and design model integrity	Automated generation of drawings and documents	Collaboration in design and construction	Rapid generation of construction plan	Construction process simulation	4D visualization of construction schedule	Online communication of product process	Computer controlled fabrication	Integration with project partners
Satisfy customer			24						12	15			
Welcome changes						14	8	10	13	16		22	29
Frequent Deliverables		3										23	
Working together							9				19		30
Motivate Individuals													
Face to Face Conversation											20		31
Priority for working product	1							11					
Sustainable Development					6		17					25	
Technical Excellence			4			7						26	
Simplicity				5						18		27	
Self-Organizing Teams											21		32
More effective Iterations		2										28	

Table 2 Agile BIM Framework Integration 10 to 19

10	Changes affect project plan. BIM rapid generation of construction plan allows agile project management to adopt changes and satisfy customer. BIM and Agile integration helps to generate plan and analysis effect on project duration.	(Sacks et al., 2010) - (Nir, 2014) - (Opelt et al., 2013) - (Eastman et al., 2011) - (Hardin, 2009)
11	BIM ability to generate continues plans will allow agile project management to support and provide customer with correct duration and completion date of the project. This integration will increase customer trust and satisfaction. Agile is enhanced by BIM functionality to adjust priorities of activities in order to deliver iterations as per work conditions.	(Sacks et al., 2010) - (Nir, 2014) - (Opelt et al., 2013) - (Eastman et al., 2011) - (Hardin, 2009)
12	BIM ability to simulate the project model during design and construction process by using 3D modelling of project structure supports agile management team to coordinate and collect more details about customer needs and requirements. This integration will increase customer collaborating and satisfaction.	(Sacks et al., 2010) - (Nir, 2014) - (Opelt et al., 2013) - (Eastman et al., 2011) - (Hardin, 2009)
13	BIM ability to simulate project design and construction process is supporting agile project management approach to implement changes required during project life cycle. Simulation functionality allows customer and Agile team to understand the effect of these changes on project process, cost and duration.	(Sacks et al., 2010) - (Nir, 2014) - (Opelt et al., 2013) - (Eastman et al., 2011) - (Hardin, 2009)
14	BIM automated generation of documents and drawings allows agile to implement changes. Agile team will be able to provide construction team with necessary drawings and documents affected by changes in short period of time. This integration provides accurate results and save time and effort.	(Sacks et al., 2010) - (Nir, 2014) - (Opelt et al., 2013) - (Eastman et al., 2011) - (Hardin, 2009)
15	BIM 4D visualization of construction process and scheduling is supporting agile team to provide customer proper understanding of cost, time and work process of the project.	(Sacks et al., 2010) - (Nir, 2014) - (Opelt et al., 2013) - (Eastman et al., 2011) - (Hardin, 2009)
16	BIM 4D visualization is supporting agile to implement changes and increase ability to evaluate effects of these changes. 4D visualization is supporting lean principles to eliminate wastes and non-adding value activities.	(Sacks et al., 2010) - (Nir, 2014) - (Opelt et al., 2013) - (Eastman et al., 2011) - (Hardin, 2009)
17	BIM functionality of collaboration between design and construction supports agile principle to involve stakeholders during design process to implement sustainable material, reduce wastes and to study project consumption of energy.	(Sacks et al., 2010) - (Nir, 2014) - (Opelt et al., 2013) - (Eastman et al., 2011) - (Hardin, 2009)
18	4D visualization of construction schedule is supporting agile principle of simplicity by providing less documentation and reports. BIM digital data obtained from model is used once needed by any parties involved in the project. This use of technology will save time and effort during project lifecycle.	(Sacks et al., 2010) - (Nir, 2014) - (Opelt et al., 2013) - (Eastman et al., 2011) - (Hardin, 2009)
19	BIM technology is providing online communication of product process that supporting agile project management to involve all stakeholders of the project. Communication between owner, designers, execution team, suppliers and manufacturer is required during design and construction process to ensure best quality and value to the project.	(Sacks et al., 2010) - (Nir, 2014) - (Opelt et al., 2013) - (Eastman et al., 2011) - (Hardin, 2009)

4. PROFESSIONALS RATINGS TO AGILE BIM INTEGRATIONS

This section discusses the integrated Agile BIM conceptual framework. The questionnaire survey targeted construction professionals representing clients, contractors and consulting organisations. The survey received 70 responses out of 120, with response rate of 58%. The following questions are discussed in depth according to the experiences and opinions of the respondents on the relationships between BIM functionalities and Agile Principles. The following questions only covers part of the survey conducted to verify and confirm all 32 integration.

4.1 BIM functionality of reusing of model data for predictive analysis will support agile principles of customer satisfaction and technical excellence.

This question targeted professionals in construction industry to evaluate their rating toward Agile BIM integration between BIM functionality of reusing of data supporting agile principles of customer satisfaction and technical excellence. Figure 4.1 shows that 75% of respondents rated the integration between reusing of data model and customer satisfaction as agree and strongly agree. Also, 86% of respondents rated integration between reusing of model data and technical excellence as agree and strongly agree. Facility management after project completion are using BIM model in the operation system and to generate accurate As-Built drawings (Eastman et al., 2011). This integration is supporting the customer during operation stage of the project and provides more satisfaction. Also, BIM is meeting owner needs and requirements in term of quality by providing a model that is comply with contract specifications (Liu et al., 2016). This model will be reused during project lifecycle by different stakeholders who will allow controlling project quality. Agile project management team will be enhanced by this functionality of reusing the model data by different stakeholders in the project and provides more satisfaction, good design and technical excellence to the customer and the project.

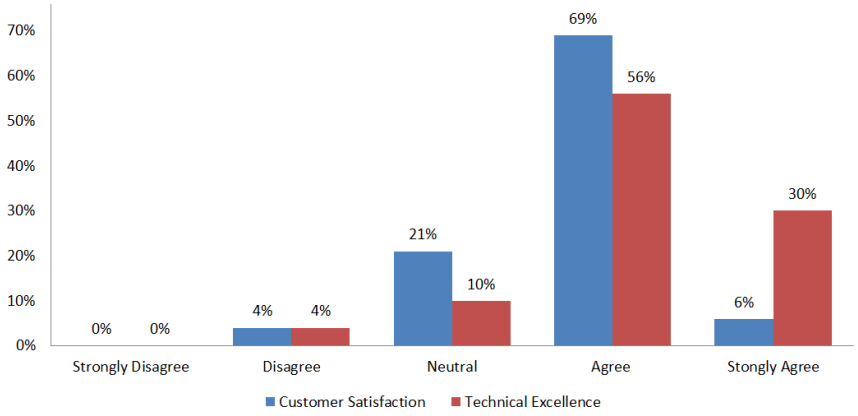

Figure 4.1 BIM functionality of reusing of model data for predictive analysis will support agile principles of customer satisfaction and technical excellence

4.2 BIM functionality of construction process simulation will support agile principles of customer satisfaction and welcome changes

This question targeted professionals in construction industry to evaluate the support of BIM functionality of construction process simulation toward agile principles of customer satisfaction and welcome changes. Figure 4.2 shows that 76% of respondents rated customer satisfaction supported by construction simulation between agree and strongly agree. Meanwhile, 78% of respondents are rated welcome changes supported by construction

simulation between agree and strongly agree. This paper discussed BIM efficiency in adopting changes and providing visualization throughout process of simulation to the customer and stakeholders in order to provide better understanding and information sharing (Eastman et al., 2011). Agile defined as "Accept changes in requirements even late in development. Agile processes use changes to the competitive advantage of customers" (Opelt et al., 2013). Moreover, Agility allows agile team to manage customer needs and requirements in order to satisfy end user needs (Goodpasture, 2010). On the other hand, BIM enables engineers to simulate the work by more than one discipline (Arayici et al., 2012). BIM technology is providing virtual simulation for project operation system and helps stakeholders to understand owner needs and changes (Eastman et al., 2011).

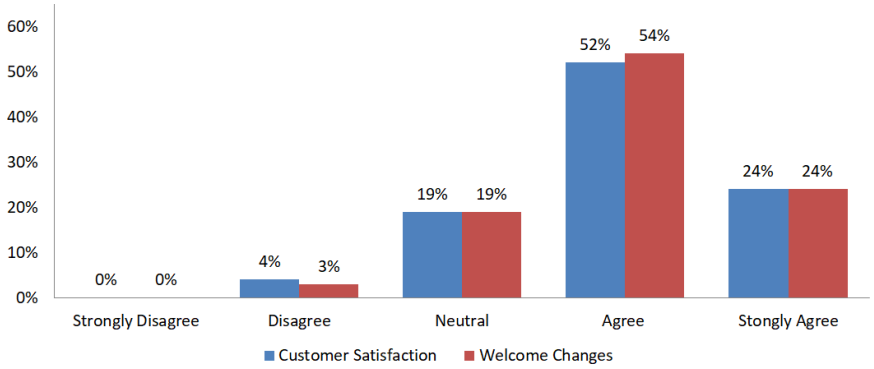

Figure 4.2 BIM functionality of construction process simulation will support agile principles of customer satisfaction and welcome changes

4.3 BIM functionality of visualization will support agile principle of priority of working product

This question targeted respondents in construction industry to evaluate their opinions regarding the integration between BIM functionality of visualization and agile principle of priority of working product. Figure 4.3 shows that 72% of respondents agreed and strongly agreed with BIM visualization functionality supporting priority of working product.

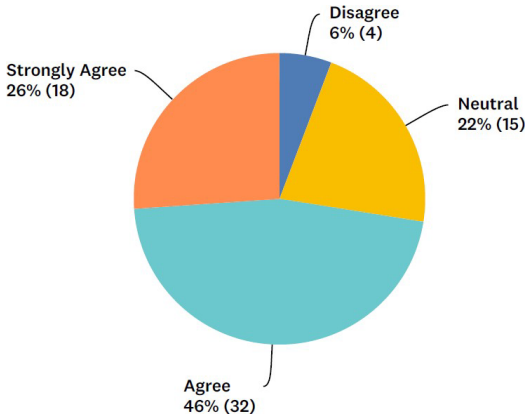

Figure 4.3 BIM functionality of visualization will support agile principle of priority of working product

BIM technology of modelling and visualization is bringing the project to life by providing enough results to the investor, designers and agile management team to have better visualization and understanding of the project functionalities and construction process data

(Tomek and Kalinichuk, 2015).Moreover, visualization helps design and management teams to understand customer requirements by simulating the project model and applying changes required (Bloomberg, 2013). BIM defined as "BIM was most frequent perceived of as a toll for visualizing and coordinating AEC work and avoiding errors and omissions" (Barlish and Sullivan, 2012). Agile principle of delivering early product is a priority to the agile team in order to satisfy the customer and making success (Opelt et al., 2013). BIM functionality allows agile team to visualize construction process and adopt changes required by customer in order to finalize iteration to be delivered to the customer.

4.4 BIM functionality of automated cost estimation will support agile principle of simplicity

This survey targeted professionals in construction industry to evaluate the support of BIM functionality of automated cost estimation supporting agile principle of simplicity. Figure 4.4 shows that 81% of respondents agreed and strongly agreed with BIM cost estimation supporting agile simplicity. BIM technology provides cash flow for better understanding of cost estimation during project lifecycle (Eastman et al., 2011). Moreover, BIM is providing advantages to construction projects such as project cost estimation, proper analysis and cost reduction, supporting reduction in insurance claims (Hardin, 2009). Although, BIM is capable to provide better financial control and cost minimizing during construction project (Arayici et al., 2012). On the other hand, agile methodology of project management had a principle of simplicity which is defined as "Simplicity. The art of maximizing the amount of work not done is essential" (Opelt et al., 2013). Agile principle of simplicity is to add value to the project by reducing the cost (Highsmith, 2010).

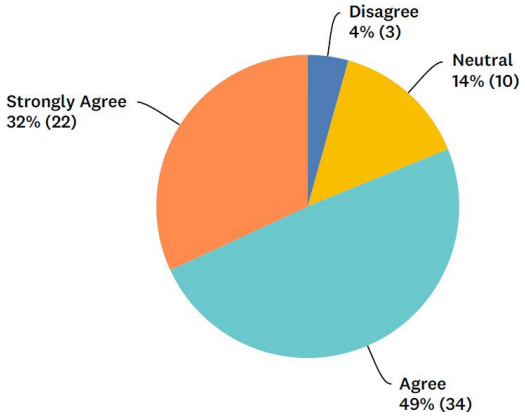

Figure 4.4 BIM functionality of automated cost estimation will support agile principle of simplicity

4.5 BIM functionality of rapid generation of construction plan will support agile principles of welcome changes and priority for working product

This question targeted opinions of professionals in construction industry to evaluate the support of BIM rapid generation of construction plan toward agile principles of welcoming changes and priority of working product. Figure 4.5 shows that 74% of respondents agreed and strongly agreed with BIM functionality to support agile principle of welcoming changes. Meanwhile, 78% of respondents' agreed and strongly agreed with rapid generation of construction plans to support priority of working product. BIM responding to the market changes by providing continuous plans as per changes occur during project lifecycle (Eastman et al., 2011). BIM technology can adjust construction process by providing planning and controlling over industry development implementation within construction

project (Nowotarski and Pasławski, 2016). Agile aims are to keep priority to deliver progress during construction projects. Agility defined delivery of working product as "Our top priority is to satisfy customer though early and continuous delivery" (Opelt et al., 2013). All these studies conclude that BIM provides support to project management teams to develop updated plans during adoption of changes.

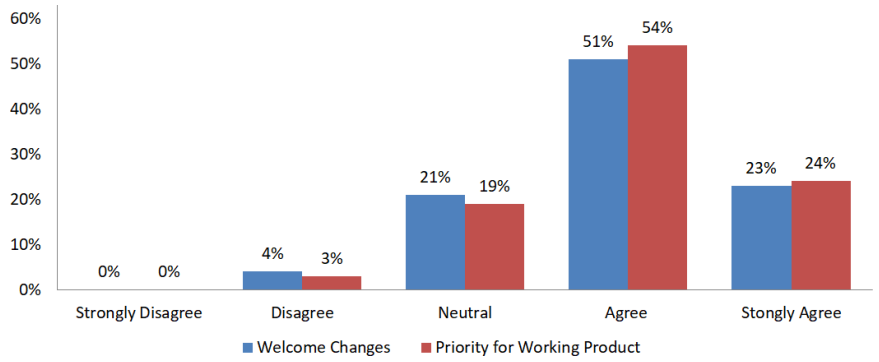

Figure 4.5 BIM functionality of rapid generation of construction plan will support agile principles of welcome changes and priority for working product

4.6 BIM functionality of 4D visualization of construction schedule will support agile principles of customer satisfaction, welcome changes and simplicity

This survey targeted respondents of professionals in construction industry to rate BIM functionality of 4D visualization supporting agile principles based on their experience in the industry. Figure 4.6 shows that 81% of respondents agreed and strongly agreed that 4D visualization will support agile principle of customer satisfaction. Although, 90% of respondents agreed and strongly agreed that 4D visualization will support agile principle of welcome changes. Also, 82% of professionals agreed and strongly agreed that 4D visualization will support agile principle of simplicity.

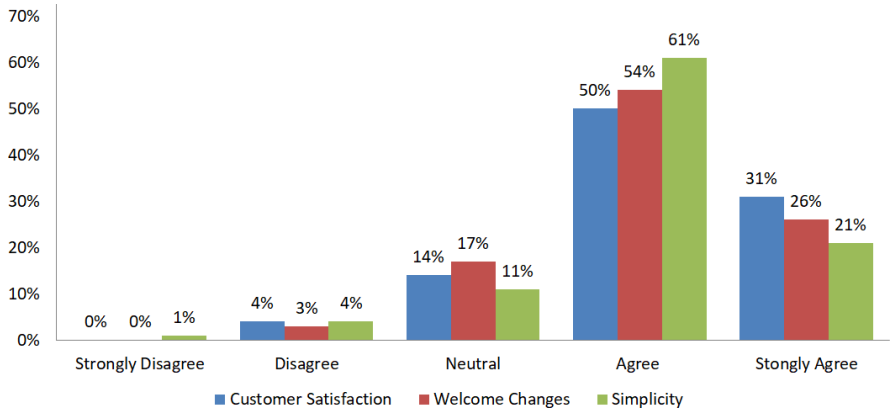

Figure 4.6 BIM functionality of 4D visualization of construction schedule will support agile principle of customer satisfaction, welcome changes and simplicity

Agile project management team are supporting designer by providing more flexibility and simplicity to receive changes (Bloomberg, 2013). BIM 4D visualization is supporting agile team by its technology and data analysis. During project construction, the hardest thing to do is to make changes. But BIM 4D visualization is solving this issue for customer and stakeholders (Bloomberg, 2013). Moreover, BIM technology is providing 4D modelling that helps in planning system in construction industry. Also, it provides simulation of building

construction that enables stakeholders to know the activities day by day (Eastman et al., 2011). Agile principles are welcoming changes at any time by applying simplicity during accepting and removing of non-necessary activities (Nir, 2014). BIM functionality of 4D visualization is supporting and providing a tool to the designer and management team to satisfy customer needs and requirements.

4.7 BIM functionality of automated generation of drawing and documents will support agile principles of welcome changes and technical excellence

This survey includes a question of Agile BIM integration to be rated in order to validate the 2D framework developed in this research. Figure 4.7 shows the results of respondents' answers regarding BIM functionality of automated generation of drawings and documents supporting agile principles of welcoming changes and technical excellence. 75% of professionals agreed and strongly agreed toward BIM functionality supporting agile principle of welcoming changes. Meanwhile 70% of respondents agreed and strongly agreed on the support of BIM functionality toward agile principle of technical excellence. BIM helps to provide 2D drawings for all plans and elevation at any time or stage during project lifecycle (Eastman et al., 2011). Also, BIM is providing accurate 2D drawings (Arayici et al., 2012). BIM allows stakeholders to share the digital model data in order to generate 2D drawings, fabrication of material and sharing accurate information (Ghaffarianhoseini et al., 2017). Moreover, agile project management methods of handling construction projects are by accepting changes at any time and maintaining good design and technical excellence (Nir, 2014). BIM is supporting agile during construction stage by providing flexibility once changes applied to generate accurate drawings. Although, BIM functionality of automated drawings at any time or stage supports quality of drawings and data shared between stakeholders. This is leading into technical excellence during construction stages.

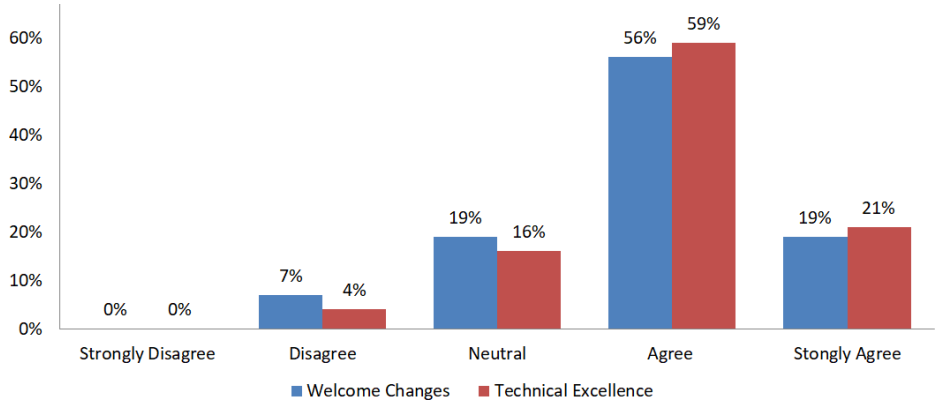

Figure 4.7 BIM functionality of automated generation of drawing and documents will support agile principle of welcome changes and technical excellence

5. CONCLUSION

This paper covers questionnaire surveys data collection and analysis distributed among professionals in both software and construction industries to obtain their opinions and answers regarding this research. The results are analysed and compared with other researches to validate objectives of this study. This type of the survey included general questions about agile, BIM and traditional project management approach. The results supported effectiveness of agile to manage construction projects. Also, professionals agreed with BIM effectiveness

in collaboration and coordination between multiple disciplines during design and construction stages.

6. REFERENCES

1. Arayici, Y., Egbu, C. and Coates, P., (2012), *Building information modelling (BIM) Implementation and remote construction projects: issues, challenges, and critiques*, Journal of Information Technology in Construction, 17(1874-4753), pp. 75.
2. Barlish, K. and Sullivan, K., (2012), *How to measure the benefits of BIM − A case study approach*, Automation in Construction, 24, pp.149–159.
3. Bloomberg, J., (2013), *The agile architecture revolution: how cloud computing, rest-based SOA, and mobile computing are changing enterprise IT*, John Wiley & Sons.
4. Cohen, L., Manion, L. and Morrison, K., (2013), *Research Methods in Education*, (8th edition), London, United Kingdom: Taylor and Francis Ltd.
5. Eastman, C., Teicholz, P., Sacks, R. and Liston, K., (2011), *BIM Handbook a Guide to Building Information Modelling for Owners, Managers, Designers, Engineers, and Contractors*, (2nd ed.), Canada: John Wiley & Sons.
6. Grant, C. and Osanloo, A., (2014), *Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your ―house*, Administrative Issues Journal, 4(2), p.4.
7. Goodpasture, J.C., (2010), *Project management the agile way: making it work in the enterprise*, J. Ross Publishing.
8. Ghaffarianhoseini, A., Tookey, J., Ghaffarianhoseini, A., Naismith, N., Azhar, S., Efimova, O. and Raahemifar, K., (2017), *Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges*, Renewable and Sustainable Energy Reviews, 75, 1046-1053.
9. Hardin, B., (2009), *BIM and Construction Management*, (1st ed.), Canada: Wiley Publishing, Inc.
10. Highsmith, J., (2010), *Agile Project Management*, (2nd ed.), Boston, United Status of America: Library of Congress.
11. Liu, R., Du, J., Issa, R.R. and Giel, B., (2016), *BIM Cloud Score: Building Information Model and Modelling Performance Benchmarking*, Journal of Construction Engineering and Management, p.04016109.
12. Nir, M., (2014), *Agile Revolution Beyond Software Limits*, (1st ed.), United States: CPSIA.
13. Nowotarski, P. and Pasławski, J., (2016), *Lean and Agile Management Synergy in Construction of High-Rise Office Building*, Archives of Civil Engineering, 62(4), pp.133
14. Omar, N. and Elhag, T., (2019), *Agile BIM Framework for a New Management Approach*, International Conference on Innovation, Technology, Enterprise and Entrepreneurship, ICTEE 2019, Kingdom of Bahrain, p.p 375-384.
15. Opelt, A., Gloger, B., Pfarl, W. and Mittermayr, R., (2013), *Agile contracts: creating and managing successful projects with Scrum*, John Wiley & Sons.
16. Sacks, R., Koskela, L., Dave, B.A. and Owen, R., (2010), *Interaction of lean and building information modelling in construction*, Journal of construction engineering and management, 136(9), pp.968-980.
17. Takim, R., Harris, M. and Nawawi, A.H., (2013), *Building Information Modelling (BIM): A new paradigm for quality of life within Architectural, Engineering and Construction (AEC) industry*, Procedia-Social and Behavioural Sciences, 101, pp.23-32.
18. Uikey, N. and Suman, U., (2012), *An empirical study to design an effective agile project management framework*, Proceedings of the CUBE International Information Technology Conference, pp.385–390.