The Implementation of Agile Project Management Using BIM Influences on the Construction Industry in The UAE Sector

تنفيذ إدارة المشاريع الرشيقة باستخدام نمذجة معلومات البناء التي تؤثر على قطاع الإنشاءات في الإمارات العربية المتحدة

by

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ABSTRACT

This paper will explore the application of Agile project management principles in the construction industry using building information modelling (BIM) to examine the outcomes in the UAE industry sector by performing quantitative research. Certain principles of Agile project management and BIM which are highly related to the success of the construction projects were tested. Participants were asked to rate on a 5-point Likert scale how effective having an iterative process, flexibility, and collaborative culture which are the independent Agile variable factors being studied. Furthermore, participants were asked to rate their belief on how BIM can contribute to enhancing time management, resource management and waste reduction, which are the dependent variable factors being studied. A correlation is made between time, resource, and waste reduction with the agile factors in the UAE construction industry. It was found that applying Agile project management through the aid of BIM can have positive implications such as reducing projects' duration cycle and enhance resource management and reducing waste in the UAE construction industry.

Keywords: Construction; Agile project management; BIM

ملخص

تستكشف هذه الدراسة تطبيق مبادئ إدارة المشاريع الرشيقة في قطاع الإنشاءات باستخدام نمذجة معلومات البناء في دولة الإمارات العربية المتحدة من خلال إجراء بحث كمي. وقد تم اختبار بعض مبادئ إدارة المشاريع الرشيقة ونمذجة معلومات البناء التي ترتبط ارتباطًا وثيقًا بنجاح مشاريع البناء. طُلب من المشاركين تقييم مدى فعالية العملية التكرارية والمرونة والثقافة التعاونية على مقياس ليكرت المكون من خمس نقاط، وهي عوامل متغيرة مستقلة يتم دراستها. علاوة على ذلك، طُلب من المشاركين تقييم اعتقادهم حول كيفية مساهمة نمذجة معلومات البناء في تعزيز إدارة الوقت وإدارة الموارد وتقليل النفايات، وهي عوامل متغيرة تابعة يتم دراستها. ثم تم عمل ربط بين الوقت والموارد والحد من النفايات مع العوامل المرنة في قطاع الإنشاءات في الإمارات العربية المتحدة. وقد وجد أن تطبيق إدارة المشاريع الرشيقة من خلال نمذجة معلومات البناء يمكن أن يكون له آثار إيجابية مثل تقليل دورة مدة المشاريع وتعزيز إدارة الموارد وتقليل النفايات.

كلمات مفتاحية: قطاع الإنشاءات، إدارة المشاريع الرشيقة، نمذجة معلومات البناء

DEDICATION

This dissertation is dedicated to my beloved father who has always imparted wisdom and supported my educational journey

I also dedicate this dissertation to my family, my mom, my sister and my brothers, their encouragement and faith in me have constantly made me succeed at anything

Finally, Special thanks and appreciation to my academic supervisor, Dr. Khalid Al Marri for all the Guidance and motivation to remain on track from the beginning to completion

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Words cannot express my gratitude to my dissertation supervisor Dr. Khalid Al marri for his invaluable patience and feedback. I also could not have undertaken this journey without the construction management faculty, who generously provided knowledge and expertise.

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LIST OF DEFINITIONS AND ABREVIATIONS

BIM: building information modeling

UAE: United Arab Emirates

CM: construction manager

CHAPTER 1

1.0 Introduction

1.1 Research Background

The world is always developing and expanding which results in continuous non-stopping construction projects that need to be executed at a fast-paced delivery schedule. The construction project market has a significant contribution to the world GDP; For instance, the construction project market in the United Arab Emirates (UAE) awarded construction projects with an overall value of $53.8 billion US dollars in the year 2019 making it one of the main markets (Khan, Singh, Kaur, & Arumugam, 2020). The larger the construction market is, the bigger consequences that need to be taken into consideration. For instance, it is very rare to find a project in the UAE delivered and finished within the assigned project delivery schedule or the project budget and not have any cost overruns. Therefore, different methods are being applied to mitigate and reduce the probability of such risks from occurring. One of these contemporary methods is agile construction project management, that breaks the project into multiple different segments and deals with the project one segment at a time not in full one complete project phase as in the traditional construction project management.

The concept of agility was first introduced post the Second World War after the restructuring of the Japanese industries; however, it wasn’t until 2001 that agile project management has been applied after the Toyota development method (Owen & Koskela, 2006). There are multiple definitions of agility; however, one of the originators would define it as the following (Dove , 1996):

"The Ability of an Organization to Adapt Proficiently (Thrive) in a Continuously Changing, Unpredictable Business Environment."

The above definition fits the construction field since construction is volatile, unpredictable and changes are inevitable. Moreover, the main benefits of agile project management are that it decouples points, embraces changes, adapts proactively, and the management structure is team-based. However, it was until 2010 that agile project management was proposed to the construction project management by Daneshgari. Applying agile principles to construction can be challenging because of the volatile factors involved in construction such as labor, supply chain and the uncontrolled environment. Unlike the other industries like the industrial for example where a product can be produced in a more controlled and supervised environment, construction industry is not the case; however, it is the decision at which stage to apply agile construction project management in a project. The construction industry can simply be divided into the design and the actual construction stages. And it is believed that agile project management is most effective during the project design stage (Han, 2013). This is due to the fact that less volatility occur during design stage and changes can be accommodated with less consequences.

As defined previously that agile construction project management allows for mitigating the construction project process as the project progress; however, applying this method alone isn't sufficient to achieve an ideal as planned construction project execution therefore other system are always incorporated. In the modern construction era, Building Information System (BIM) has been a very efficient tool used to allocate and monitor resources. Building information modeling (BIM) is a system that is supported by multiple other technological tools that helps it in generating and managing the physical and practical scope of construction project management. The essence of BIM is that it can simulate a visual 3D reality of the project design including all parameters providing all-important frameworks including construction duration, construction cost, building sustainability, and even risk management.

Furthermore, in May 2014, Dubai Municipality has mandated the use of BIM in the construction project industry specifically to building projects of over 40 stories or that is more than 300,000 ft^2, and for its very own governmental projects (Mehran , 2016). This new rule has resulted from the continuous big projects that are awarded to Dubai for instance EXPO 2020 and with the focus of reducing/eliminating waste and the possibility of improving quality and profitability. However, this rule only applies to the emirate of Dubai and not to the other emirates even though the plans are present to have BIM also in other emirates since the construction project industry is quite big in other emirates as well such as Abu Dhabi. This topic will further be discussed with case studies in the body of this paper (Zhabrinna, Uda, & Wibowo, 2018).

In addition, nowadays it is crucial to think of the environment in every project that is being done whether it was at a small or large industrial scale. The situation of global warming is in a constant incline phase with extreme ongoing climate change. There have been numerous numbers of conferences and workshops that have been done to address the current increase in surface temperature over the last 5-10 years; however, if actions are not being taken then all these conferences are not very productive nor are they useful. Unfortunately, the construction industry has a very strong contribution to world global warming, in which it is responsible for the use of 40% of the global energy, 25% of global water, 40% of global resources that are emitted as greenhouse gases (GHG) to the atmosphere, and the consumption of 60% of the world's electricity during the building phase. The CO_2 gas emissions are released during the whole lifecycle of a building from the initial production stage to construction to operation and even at the very end demolition stage. Additionally, air emissions, use of water and discharges, land use, waste generation and energy consumption are all environmental impacts that needs to be addressed (Sharrard, Aurora L.; Matthews, H. Scott; Ries, Robert J., 2008).

The use of agile construction management along with BIM in the construction project industry can be an efficient optimizing solution that can be more environmentally friendly in addition to fulfilling any construction projects' goal which is finish on time within budget. Finishing on time within budget translate to green construction since less time needed to finish a construction project means less labor, machinery, energy consumption used. Moreover, there have been multiple case studies that have studied the effect of agile construction management on the efficiency of the projects and other research that investigated the use of BIM in the industry; however, there hasn't been a study combining both agile construction management along with BIM to observe the outcomes and address the environmental impact.

1.2 Research Aim and Objectives

The main aim of this research paper is to evaluate the different factors of agile and BIM that can potentially aid in the success of construction projects in the UAE.

1) Agile construction management and the methodologies within it aiding in the projects' success
2) Utilization of BIM as a tool aiding in the success of the project
3) The effect of combining both agile construction management with BIM to examine the projects' success

This paper will be addressing the below research questions:

1) How can agile construction project management aid in projects' success in the construction project industry in the UAE?
2) Is BIM an effective tool that can be a factor of projects' success in the UAE?
3) What are the benefits of using the combination of both BIM and agile construction management in the construction industry?

1.3 Conceptual Framework and Hypotheses

A conceptual framework is a methodical means used to explain the main objective of the study in a narrative method or/and graphically. The variables, factors and hypothesis can be demonstrated showing the presumed relationship among them which helps explain the research aims and purpose clearly.

Figure 1 below shows the independent variable (Agile Project Management) having three factors which were chosen for this research based on their importance according to the literature review done for this study. The dependent variable being examined is BIM with three chosen factors (time, resource management, and waste reduction), also based on their importance according to the literature review. It is assumed that using agile factors in BIM would have a positive impact on time, resource management, and waste reduction in the construction industry in the UAE. In addition, this can reflect positively on the carbon emission levels being reduced.

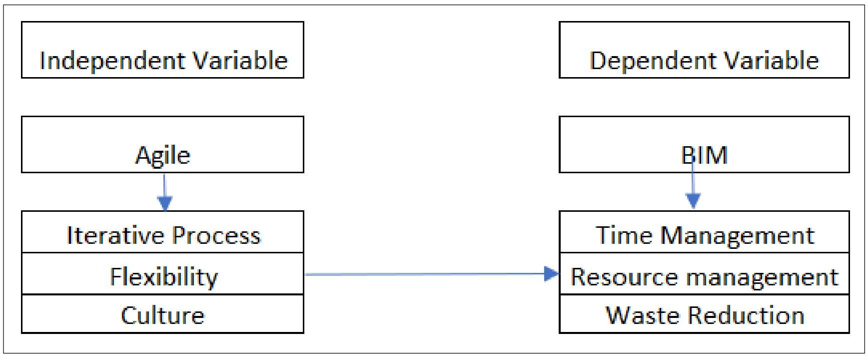

Figure 1 Conceptual Framework

Below is the research hypothesis which was derived from the conceptual framework shown above:

- H0: Agile project management principles using BIM aid in projects' overall success

CHAPTER 2

2.0 Literature Review

2.1 Agile project management iterative process

The success of any construction project is dependent on how well the risk associated with the projects is anticipated and accounted for. These risks could include project delays, cost overruns, quality assurance, and much more. Therefore, it is important to select and follow the correct project management method based on the type of project that is involved which for the construction industry is preferred to be agile construction management. Unlike lean construction management, agile acts as a response to the complexity that is a method of adapting the project management based on the constant changes and unpredictive environment of the project; therefore, it is considered as a proactive adaption to a project compared to a reactive lean construction project management.

Moreover, Agile is concerned in using an iterative technique to breakdown the project into increments (sprints) also can be referred to as iterations. These sprints usually have a duration of two to four weeks, hence providing a room for continuous improvement by having the sprint team learn what works and what doesn't based on the sprint retrospective as the project progress and adjust as needed. In addition, people are more efficient and productive when they are given short durations to finish certain tasks (Mahomad, S., 2018)

There are multiple practices and frameworks within agile construction project management that could be considered as a method of applying it and one of the most common ones are scrum and extreme programming. However, scrum is one of the most popular methods especially in complex projects as it acts as an iterative software model that is structured based on a set of roles, responsibilities, and meetings. The figure below identifies the different positions and frameworks that are involved within scrum (Streule, Miserini, Bartlome, Klippel, & Garcia De Soto, 2016):

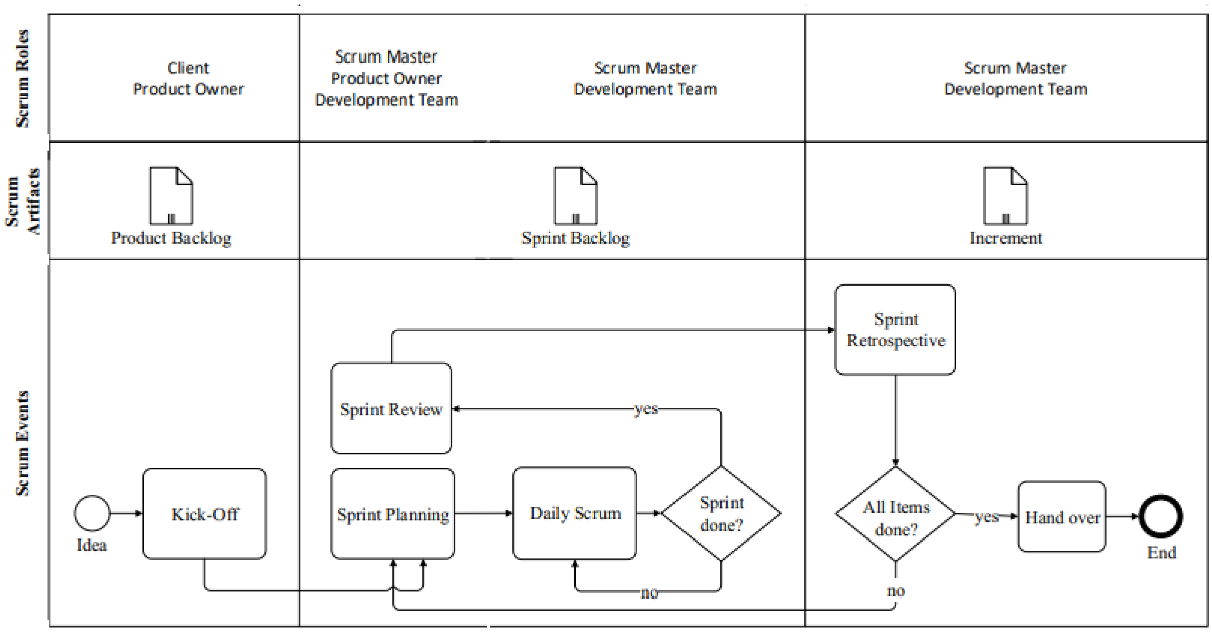

Figure 2 Scrum Project Management Framework

As observed from the above figure, scrum consists of a three-membered team that is Product Owner, Development Team, and Scrum Master:

1) Product owner: is the sole representative that is in direct connection with the client and is also involved with the stakeholders and oversees creating, updating, prioritizing the project work log. In addition, the product owner is also responsible for maximizing the value of the product by managing the project budget and cost and considering all possible risks that are involved.
2) Development Team: are the players that are at the field and are doing the actual work that is set by the Product Owner. The beauty of the scrum development team is that it

considers the whole members as one team without having one project manager and everyone is held responsible regardless of their field of expertise.

3) Scrum Master: This is the top eye of the project that assures the proper flow of work from the development team in which the master would assure that everyone in the development team understands the framework and the constant changes that are being applied in the project. In addition, the scrum master is also responsible for avoiding and removing any obstacles that might be caused by surrounding teams to the development team that might cause a slowdown in their operation and work. The scrum master is also in charge of communicating with the product owner about the status of the project and if there is any topic that requires the client's attention.

Part of the scrum construction project management is sprint planning; sprint is defined as the specified timeframe for the development team to set a plan for reaching the state of completion for each item. The sprint meeting is done daily between the development team and the scrum master for 15 minutes. This meeting is led by the scrum master that asks three main questions that address what was done from the previous sprint meeting, what needs to be done till the next sprint meeting, and what are the obstacles that prevented the development team and the scrum master from reaching the set goals and targets. All members of the development team are expected to be present in every sprint meeting and to come prepared in answering these questions.

The classification of the scrum team demonstrates the importance of teamwork; in which, the project is dependent on the whole team and the sprint meeting and everyone’s contribution and perspective on the current situation and progress of the project. In addition, trust in the relationships between the team is a key factor in the success of the scrum project management. For example, one of the research articles that further investigated the benefits of scrum construction project management that took into consideration different surveys that were done concluded that even if the development of the relationship between the team might be slow initially; however, it was the phrase of “learn-by-doing” that further established the relationship and allowed the whole team to have perfect control of the project and how best to organize and prioritize the project goals (Hidalgo, 2019).

Cultural differences are one of the main topics that are investigated in scrum construction project management since it is highly dependent on teamwork. One of the research articles further researched this topic by conducting an hour-long interview with senior managers who have a long experience in international projects. Various results were concluded presenting both advantages and disadvantages to the project, for instance, having cultural diversity in a scrum team can result in better knowledge sharing and problem-solving that is supported by the different business methods that are proposed. On the other hand, the diversity in the culture of the team can also propose difficulties that could be as simple as miscommunication due to language differences or more complicated difficulties that are based on culture shock and adaption of the team to one another for as simple as their different living conditions (Kivrak , Ross, & Arslan, Effects of Culture Differences in Construction Projects: An Investigation Among UK Construction Professionals , 2008). This culture diversity within the scrum team if resulted in disadvantages and disputes can cause projects to get delayed and even have cost overruns; therefore, the scrum master needs to avoid such disputes between the whole scum team to achieve the sprint goals and deliver the project as planned and even better.

Another research article also measured the effect of cultural differences in construction project management; however, cultural differences in terms of experience and competence of the scrum team and not in terms of cultural background differences. The research findings were based on interviews that were done for 11 senior professionals from international companies that have over 20 years of experience in international construction projects and these professionals include all different positions from directors, project managers, group managers, and even construction managers (Kivrak, Ross, Arslan, & Tuncan, Impacts of Cultural Differences on Project Sucess in Construction, 2009). The research concluded that in some cases scrum team undergoes delay in projects due to the different experiences of the team members in which some might suggest approaches to follow that wouldn't be practical and some wouldn't be able to perform the required sprint goal due to their incompetence for the job required. Therefore, the culture of the team in terms of experience and qualifications is also a key player in the success of construction project management. This research also addressed the topic of having some of the projects where the scrum master or project owner does not account for these differences in experience are not taken into consideration as a key factor which results in facing problems and during the project management and not meeting the set goals of the construction project. As a result, the scrum team integration overall is the definite player on how the construction project management follow and the success of it will.

2.2 Agile project management flexibility

Moreover, one of the most important aspects of agile project management is its flexibility in delivering projects. As Qamar et al., (2018) mentions, recently the automotive industry in the UK prioritizes flexibility over performance, which is interesting because so far performance has been an essential success indicator in any project. The better, faster, and more efficient the performance is, translates to delivering objectives in a timely manner and with least cost overruns. Many studies addressed the performance of the project manager in terms of leadership, motivational, and team player skills; however, few addressed the topic of flexibility which agile project management provides if/when applied to a construction project. Nonetheless, as in any project, changes are inevitable, and they can arise from several factors, such as stockholders, supply chain, and environmental conditions. Thus, adopting to changes and being flexible is important to successfully achieve planned objectives.

What is flexibility? And why is it an important aspect in the construction industry? Hansson et al., 2006), defines flexibility as the firm's capability to respond to changes in a timely fashion which results in lower cost, better quality, and better time management. Therefore, efficiently utilizing resources and reducing waste especially when new activities/scope is proposed, or unexpected market demand arises. Thus, flexibility is important since the construction industry is complex and fragmented. The fragmentation comes from having different parties involved in the construction cycle. The construction process starts with the client/stakeholders appointing a consultant to provide a design proposal. After that the main contractor is appointed where he appoints different sub-contractors or suppliers to fulfill the project's scope. Hence, it is hard to manage all these parties by sticking to the traditional project management methods which lack flexibility and mainly rely on following one plan with some contingency budgets put aside in case changes arise.

Furthermore, Sharifi and Zhang (1999; 2001) underlines how agility in construction can also include preparing for the unforeseen market shifts/demand by performing new unplanned activities. It is all about being pro-active and plan for the unplanned. In addition, considering change as something positive which can be used to gain advantage rather than a downside which will affect the project negatively. This can be all done by adopting the agile mindset and applying the agile principles/scheme which in turn will provide more flexibility and room for mitigating variances in any project. The agile manifesto asserts important values which provides more elasticity such as: interaction of individuals over tools and procedures; stakeholders collaboration over contract arbitration; act in response to changes over following a blueprint (Loforte Ribeiro, F., & Timóteo Fernandes, M., 2010).

If one contemplates about the agile manifesto, one will notice that the main goal is to achieve the project's objectives as desired and without time or cost overruns. In addition, agile considers teamwork and imposing a friendly environment where everyone works toward the end result. It has been noticed that working as an individual is less efficient than in a group and that is because when a mistake is done, a single individual would try to cover it up, which can create a chain reaction of errors and miscommunication inaccuracies that leads to delays. Covering up mistakes creates a snowball effect which can be hard to control and thus parties in the project tend to protect themselves to retain their positions or avoid being blamed for their actions. Nevertheless, all the points mentioned above solely create a huge distraction from the main objectives and unnecessary wastage in time and resources. It is believed that flexibility aspect of agile can defeat such flows because mistakes are allowed to happen, in fact, mistakes are preferred to happen to learn and move forward stronger.

2.3 Agile project management organizational culture

The organizational culture of any project is considered a vital factor for success. When we talk about culture, we refer to the values of the staff shared among the team members which guide their behaviour (Tolfo et al., 2011). Hence, looking into the project's culture offers so many aspects which might help understand how a project can become more efficient regarding time, cost, and quality. Moreover, if we go back to the meaning of agile, agile revolves around responding to changes in timely manner and adopting to volatile competitive environment to enhance productivity; and culture plays a big role in that, because applying agile philosophy requires everyone having the same vision. Further in this section, agile culture will be highlighted and outcomes from having an agile culture will be associated to project's efficiency and productivity.

The organizational culture is mainly influenced by the company's history, or the working ways imposed by higher management on employees; it includes the traditions, habits, and shared values of people working in that company (Dennison, 1990). In other words, "it is the way things are done around here" as Johnson (1999) describes; it is the core beliefs of how the company runs its business. Such values can be clearly stated as the company's mission, however, not all the time. Employees come to assume the company's values after spending time working in a specific place; how things work and what is acceptable and what is not. In addition, Schein (1999) states three levels for the organizational culture which include the visible objects, the adopted values, and the underlying assumptions.

These levels can be seen in figure 2 below.

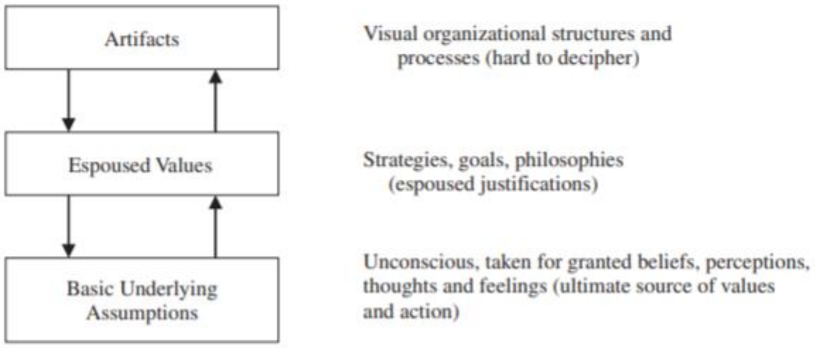

Figure 3 Organizational culture levels by Schein (1999)

The artifacts refer to the visible objects which includes sensed, seen, and heard things. In the first level, information is not as easy to understand as obtained. In addition, at this level aspects such as work routine, work environment, language, dress code, stories are dealt with (Schein, 1999). Furthermore, the espoused or adopted values refer to the member's values explained through their behaviour such as strategies, goals, and beliefs. Finally, the last level which is underlying assumptions deals with values shared among the group which translates to the way they perceive and feel about things. Nonetheless, each company is unique and has different values and group behaviour. Thus, adopting an agile scheme can unify cultures in different companies which is believed very crucial for the construction industry since fragmentation exists and many parties work hand in hand to achieve the same end goal.

Moreover, Hofstede (2001) describes the culture as onion layers with the values as the core and symbols as the outermost layer as shown in figure 3 below.

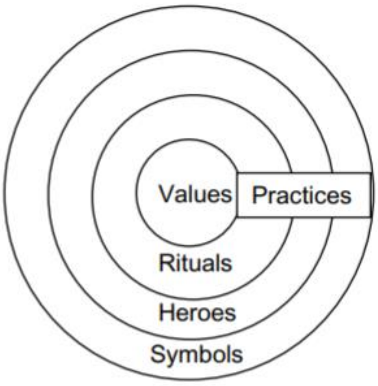

Figure 4 Layers of culture adopted by Hofstede

Symbols can be defined as acts, words, or persons' characteristics which are considered superficial and easy to change. Additionally, heroes can be a real or fictional person who has aspects which are highly appreciated in the culture and when things get tough, everyone counts on. Rituals are actions taken by people to fulfil a purpose such as greetings. Finally, values are biases to certain situations over others which are usually learnt while growing up as a child and are taken for granted. For example, principles which are considered morally respected, they are carried out and manifested through the unconscious mind. According to Hofstede (2001), heroes, rituals, and symbols are practices which are visible to people from the outside, but their meaning is invisible and depend on how these actions are interpreted by people from the inside.

Robinson and sharp (2003), states some examples of the four layers mentioned earlier developed by agile practices such as planning games, metaphors, and story cards. Such practices are believed to create a group belonging feeling among people in the culture and in turn create shared principles which manifest the agile practices within the firm.

Additionally, the agile culture needs collaboration between individuals within the same team and agile is more suitable for democratic organizations rather than vertical hierarchy structure which has no flexibility nor spontaneity. Having a horizontal hierarchy organizational structure allow participation, consensus, consultation and empower individuals (Siakas et al., 2007). Furthermore, Siaks et al., (2007) propose four agile organizational cultures are the clan, democratic, disciplined, and hierarchical as shown in figure below.

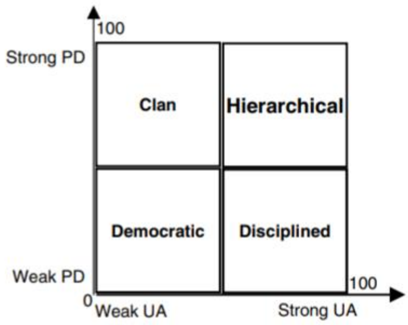

Figure 5 Agile organizational cultures proposed by Siakas

As noted from the figure above, each cultural group has two dimensions, the uncertainty avoidance (UA) and the power distance (PD). Clan for instance has strong PD but weak UA; this means that this cultural group can be described as traditional by having a flexible structure with leaders that can facilitate or advice. In the clan, everyone is encouraged to be involved and to co-operate which offers security and feelings of ownership, loyalty that keeps the team together. The second cultural group is the hierarchical, where PD and UA is high and depends on control and stability; in other words, a vertical hierarchal organizational structure exist with leaders and individuals embarking on assigned responsibilities. This type of organization is very formal, and people respect the status of individuals, and this type of organization can be described as product oriented. The third cultural group is the democratic which has weak PD and UA; this means the existence of horizontal hierarchy structure highlighting flexibility and encouraging impulsiveness. Leaders in this type of culture are responsible for organizing and coordinating tasks between teams. Employees contribute to the decision-making process and to the organization development overall. The fourth and final cultural group is the disciplined organization which has weak PD but strong UA, which means that this type has a formal structure and use rules to stay in control. Individuals in this group are disciplined and trusted with self-control and focused on efficiency by being task oriented. All the mentioned cultural groups fit different regions in the world based on cultural differences which exist between different nations. For instance, the clan fits African and Asian countries; the hierarchal fits most Latin Europe, Japan, and Latin America, as well as Arab countries; the democratic fits most the Nordic and Jamaica; finally, the disciplined fits Germany, Austria, and Switzerland.

It is important to consider cultural backgrounds when discussing agile, because agile cannot be applied in an environment where a vertical hierarchy management exist which goes against the agile core principles. Moreover, the organizational culture is composed of individuals with backgrounds influenced by the region they grew up in, hence, dealing with cultural differences to create a collaborative atmosphere is crucial for agile to success. Further in this paper cultural diversity, and the importance of strong employee bond will be highlighted and linked to enhanced productivity which in turn has positive effects such as carbon emission reduction in the construction industry.

2.4 Advantages of BIM in agile construction project management

Agile construction project management that follows the scrum methodology will have many sprint meetings that need to be conducted as discussed previously; therefore, a specific technological platform is required to be used to organize and register all these meetings. However, agile construction project management not only required BIM for the sprint meeting; however, requires it for various other reasons such as to oversee the whole lifecycle of the project and predict any possible risks that might be present to allow agile to adapt to these conditions proactively. The method of agile construction project management using scrum methodology can be seen as the independent variable of project management and the BIM as the dependent variable in which if it wasn't for the cultural differences that are seen in the scrum team there wouldn't have been for instance cost overruns that will be registered in BIM. However, with the lifecycle monitoring that can be done by using BIM proper resources allocation can be done and adjusted to account for all such situations.

There are multiple benefits of combining BIM with agile construction project management, one of which is that both have similar goals and achievements, some of which include:

1) Improved understanding and implementation of the construction project requirements
2) Improvement of the communication and cooperation that is set between the project stakeholders
3) Improving the overall team and project effectiveness
4) Avoiding and limiting project omissions and reworks
5) Minimizing the project time and overall cost

The success of BIM in agile construction project management is highly dependent on the understanding of it by the scum team in which one of the research articles have suggested the usage of BIM in dividing the construction project management into five different stages that include: initializing process, planning process, controlling process, executing process, and closing out process which can be seen in the below figure (Tomek & Kalinichuk, 2015):

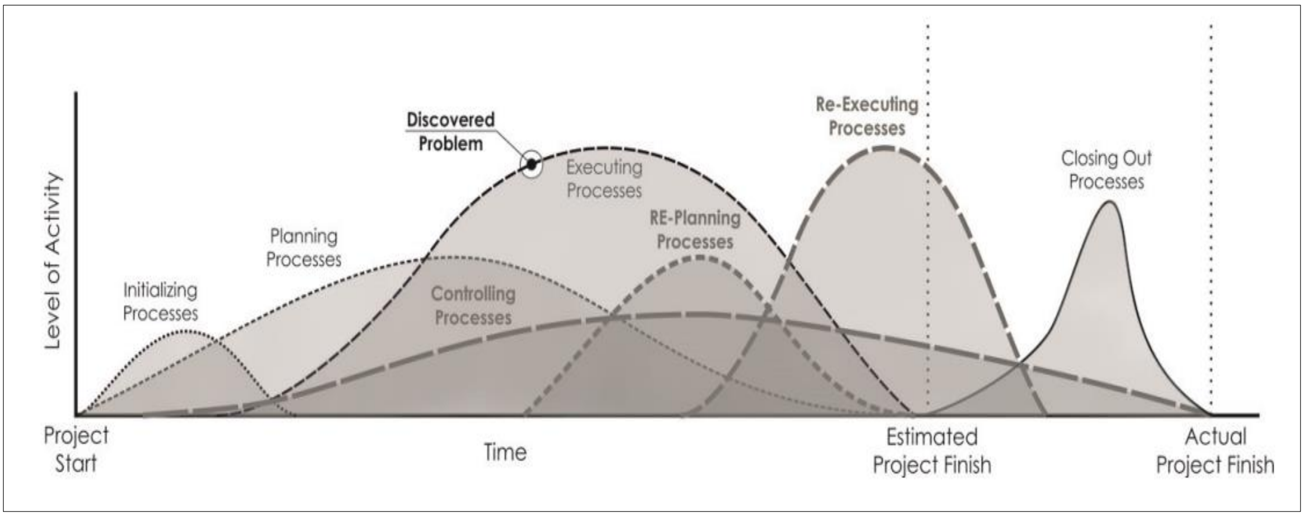

Figure 6 The 5 Different Stages of Construction Project Management in BIM

The BIM allows the project managers to break down the overall lifecycle of the project into dependent activities and overlapping activities. It is usually during the overlapping activities where the project delays occur because these activities overlap as they are dependent on information exchange to proceed forward. However, with the benefit of BIM, these overlapping activities can be predicted and prepared for initially in which no delays would occur during this exchange period and the whole project schedule just proceeds based on the set timeline for it.

Not only can time be managed correctly by using BIM; however, even the resources management and allocation are other benefits of using such a platform in agile construction project management. One of the case studies has experimented with the use of BIM in the construction of a green G+1 building. In this project, the team was highly dependent on the Primavera BIM platform in which every single stage was being selected, updated, and recorded starting from the work log sheet to the allocation of every single labor involved in the project and the work that they oversee doing. After completion of the building, it was found that there was a considerable reduction in the key resources required in the project that includes energy, water, and materials due to the efficient resource allocation that was being done using BIM (Subramani, Narasimhan, Abraham, Cherian, & S, 2020).

Since BIM is considered one of the most promising technologies that can achieve a cut down in project costs and waste, it was also applied in another major construction project that consisted of a 5-story building with an overall site area of 42,140 m2 (Li, et al., 2013). The use of BIM presented multiple advantages in which during the design stage of the project the BIM technology found more than 2,000 errors in the original design and through using error classification and conflict inspection errors over 500 of the most important errors were eliminated thus avoiding the reworking of the labors and saving of the project material. This research has found that 65 days have been saved due to the use of BIM technology during the construction project management with 2.91% in cost savings. In addition, another major advantage of BIM is that it can be customized based on the stage of the construction project management. In the very same project, the engineers and scrum team have changed and configured the BIM software based on the stage that they were in which initially they were inputting the drawings were errors were being found by the system thus resulting in minimization of material wastage since the project construction hasn't been started yet, and following to the design stage, the engineers have changed the configuration and input information to the second stage which in this project was the civil and MEP works. In addition, due to the latest advancement in technology the engineers that are involved in the project can generate a 3D BIM model of the project that can provide a detailed explanation of the work required by every development team member by observing every single detail and angle of the building thus reducing the explanation and drawing time and resulting with overall improved time management of the project.

In another research article that has studied multiple previous researchers have found that not only does BIM allow for better resources allocation and utilization however it also has other applications within agile construction project management. These applications include the management of quality compliance within the construction phase, the reduction in information exchange waste that would result in project delays, the sustainability of the project design and the building performance, risk assessment of the design of the facility, and the risks associated during the construction of the project, much more (Tahir , Haron, Alias, Harun, Muhammad, & Baba, 2018). All the above applications lead directly and indirectly to three main common problems that are seen in construction projects that are overruns in cost, delays in project handover, and overwork. Proper cooperation between the scrum team and proper usage of BIM would avoid all of the above three mentioned problems and if not avoid then definitely minimization of them as all of these problems are considered risks that are expected to be present in projects and with the BIM technology all of these risks would be displayed in the models that the software develops.

One factor that is extremely important to investigate in BIM is one of the disadvantages of scrum construction project management that is cultural differences. However smart or intelligent the BIM software is; however, it is still considered as a computer system that can never think in a human mindset. The meaning of this phrase goes back to the analogy that even though if the whole scrum team is using the same software; however, if the data that is inputted in the software is wrong then the system will automatically give wrong results and models. For example one of the research articles stated the importance of having a team cooperation mindset is extremely important in which if one of the team members decided to put their own designed items and not accept or accommodate the error in their model then that will automatically result in wrong conclusion and the reason behind that nonacceptance of change could be because of cultural background differences (Han, Fei, 2013). Therefore, everything needs to be connected in the correct way between scrum as a methodology to agile construction project management and BIM for the project to be managed and delivered as planned and even better. In addition, if all the inputted information to the BIM model is correct and is adaptive to the current situation of the project then all of the associated resources in the project are allocated most efficiently in the project without any wastage occurring.

Furthermore, Tserng (2014) highlights another advantage of BIM in construction which is time management. Using BIM allows the project's team to monitor performance progress in real life against the original plan. Hence, providing a chance to mitigate any delays faster by accessing real time data produced from the 3D model. This allows the agile team to execute new strategies to recover and improve the workflow to avoid delays and repeating the work. Moreover, there are many methods which are proven to be effective in supervising the project cycle such as Construction Progress Control (CPC)

(Garcia J.C., 2013). The CPC uses the project schedule imported from a spreadsheet and then compare it with the recorded completion percentages of tasks by site personnel using smart phone proving as-built updates. The beauty of this method is that it is very easy to apply and does not require high skills which is necessary because most workers in construction are highly hand skilled but might lack technological competences. In addition, BIM allows for direct access to accurate design information which result in better work quality and aid in faster progress by escaping the hassle of searching for the right information from the right person (Davis and Harty, 2013). At site, there are many revisions, thus many drawings which are outdated and replaced with new ones; due to the fast based nature of construction, many times the wrong drawings are used, hence, the wrong work is done. Therefore, rework must happen which is considered waste of resources and cause delay in time.

2.5 The effect of construction project carbon emission on the environment

Recently due to the increased global warming condition, the environment is one of the main factors that should always be considered in any project, and unfortunately, the building and infrastructure industry is one of the main negatively contributing industries since its environment mainly includes the usage of large quantities of material and large consumption of energy which is not from a renewable source. In addition, any building energy life cycle is divided into two sections:

1) Operational energy: that is used in the occupation or operation of the building
2) Embodied energy that is involved in the construction of the building, maintenance, renovation, and at a later stage the demolition of it. The embodied energy also consists of two different groups within it that are:

a. Direct Energy: that is used during the on-site construction of the project that involves the initial build of the building to the demolition of it

b. Indirect energy: this group of energy includes the energy that is required to provide the products and services for the construction operation.

The global construction industry has recorded 5.7 billion tons of CO_2 emissions for the year 2009 which is equivalent to 23% of the global economic activity (Huang, Krigsvoll, Johansen, Liu, & Xiaoling, 2017). The intensity of the overall CO_2 emissions that are referenced to the global construction industry is 0.67 kilotons/ million US dollars that is much larger than the average global economic activity that is 0.22 kilotons/ million US dollars. The below figure represents the direct and indirect CO_2 emissions from the global construction industry divided by countries/regions for the year 2009:

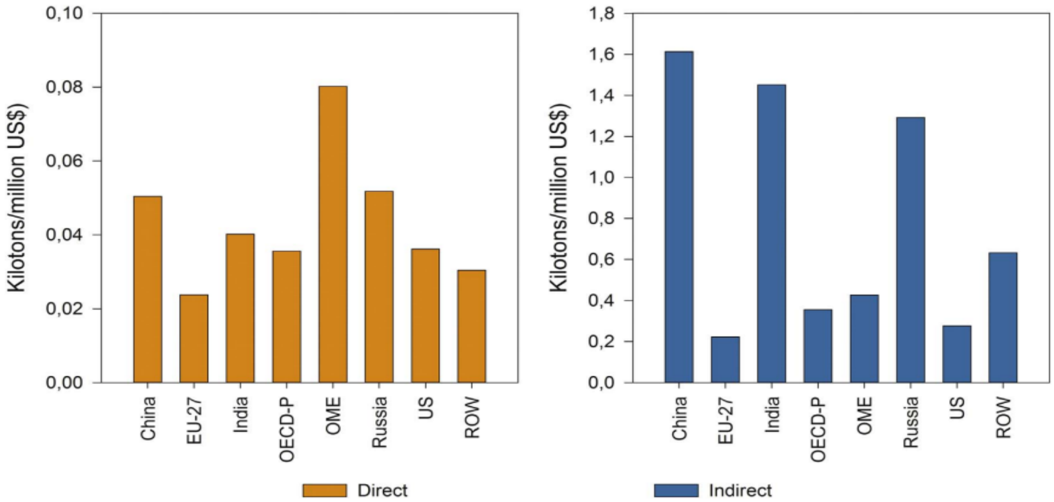

Figure 7 The Direct and Indirect CO2 Emissions from the Global Construction Industry for the Year 2009

One of the research studies reviewed the association of BIM in the reduction of carbon emissions, in which in the earlier section resources allocation through the use of BIM was discussed and has proven its efficiency. Theoretically thinking of the concept, as long as the resources are reduced in a project the carbon emissions are automatically reduced as well. For example, if a certain material quantity is being reduced in building work as a result of BIM modeling, then the energy that is associated with manufacturing that material and the delivery of it and the installation of it will automatically be eliminated. One of the research articles suggested the use of prefabrication that is based on BIM in the reduction of carbon emission especially during the materialization stage of the construction project (Hao, et al., 2020). The BIM divides the project into different stages and allocates the resources for each phase and with the help of the adaptive agile construction management team these resources and can be used efficiently and the installation of the prefabricated building components can further reduce the carbon emission as observed in one of the China constructions building projects that were done in the same research paper. It was proposed that if the government was to impose a 50% adoption rate of prefabricated components in construction projects, then the carbon released emission from these projects can be reduced by 15% throughout the materialization stage (Hao, et al., 2020).

The hybrid combination in the use of BIM and agile construction management should have a major effect in the reduction of carbon emission and can be considered as the solution in which this solution was confirmed in another research that highlighted its importance specifically in the design phase of the project. This research article suggested covering multiple factors during the design stage to result in a green building solution; these factors include (Xu & Wang):

1) The usage of energy-efficient and based materials
2) The creation of products and systems that would leave a very light footprint on the environment and not only during its construction phase but its complete lifecycle
3) The consideration of a green design process with the help of BIM
4) The adjustment and reduction of waste disposal in terms of the manufactured and delivered products
5) The determination of the environmental impact of the used products in terms of energy usage during the product overall lifecycle

The above main factors are suggested during the design stage of the project; however, once the project proceeds to the construction phase other factors such as visual management can be considered in the reduction of carbon emissions. It is through visual management that the scrum team can best structure their waste management which can indirectly result in reduced carbon emission and that is only one example that can be followed at the construction stage of a project.

A case study of the construction of three road projects two of which being primary roads and the last one being secondary road network in Abu Dhabi was studied to analyze the amount of carbon emission released during the construction of these projects. The research findings concluded a total estimate of 76 kg CO_2 emission /m^2/y for the secondary road and 1100 kg CO_2 emission /m^2/y for the primary road which is considered a very large number (Alzard, et al., 2019). These numbers indicate the importance of having a developed plan and strategy during a construction project to reduce carbon emissions even though it would sometimes be difficult with the budget that is set for the project. However, through the use of BIM modeling the project management team should be able to reduce these images. In addition, to the BIM modeling, the proactive response from agile construction management would further help in minimizing the carbon emissions during each stage as it would adapt to the situation that the project is undergoing and further allocate the resources in a smart updated way.

CHAPTER 3

3.0 Methodology

In this section, the gathered data of this study will be explained in terms of the type of study, variables and the analysis method used to validate the results. This research focuses on agile project management factors used in BIM to enhance productivity in terms of time, resource, and waste in the UAE. The independent variable is agile project management, and three agile factors were chosen to be tested which are iterative process, flexibility and the agile culture. The dependent variable of this study is BIM, and three factors were chosen which are time and resource management and waste reduction. These factors are believed to have major contribution in providing an efficient construction work environment and they are believed to have strong correlation among them based on the literature review.

Furthermore, this research is a systematic means with a case study, hypothesis, fact analysis, and provides a solution/conclusion regarding the case study presented. In addition, this research examines the relationship between agile implementation in BIM and its influence on projects' success. A quantitative research approach is used to study the data, because the quantitative scheme displays big samples and uses numerical measures to inspect associations among the variables. Moreover, questionnaire is selected to gather information due to its practicality regarding time, quantity of data that can be collected. Hence, SurveyMonkey website was used to expediate the survey distribution and collection of participants' feedback.

Surveys were conducted by reaching out to civil engineering professionals in the UAE construction industry and make them respond to a 5-likert scale survey about the agile and BIM factors. The participants vary in age, working experience, education and gender which gives a diverse overview regarding the subject. In addition, it is believed that incorporating agile factors (iterative process, flexibility and agile culture) will have a positive impact on BIM regarding time and resource management and will certainly reduce waste production in construction for the reasons mentioned in the literature review.

Furthermore, the questionnaire questions are primarily about the beliefs of the participants regarding factors' aspects based on their experience in the field. The software used to analyse the questionnaires data is SPSS and the validity of the questionnaire scale will be verified using a reliability test. Additionally, a scale is reliable, if it has a high internal consistency between the items (Huck, 2007, Robinson, 2009).

The common approach to measure reliability is computing the Cronbach Alpha coefficient, which is proven the most efficient when using Likert scales (Whitley, 2002, Robinson, 2009). Moreover, scholars' consent that an Alpha value of 0.7 is acceptable to prove a scale's reliability (Whitley, 2002, Robinson, 2009). Nevertheless, Straub et al. (2004), accepts an Alpha value of 0.6 for exploratory studies. Hence, an Alpha value of 0.6 and above will be considered reliable for this study.

Furthermore, the correlations between variables are measured using Pearson's method which indicates the strength and direction of the relationship between variables with a value ranging between -1 and 1. A value of [+1] denotes an absolute correlation; indicating that the variable value will increase if the other variable value increases. On the other hand, a value of [-1] denotes an absolute negative correlation. Additionally, a zero value indicates that the variables are independent. Furthermore, the correlation test examines the connection amongst two variables, it ascertains that a connection exists.

Pearson's method also provides a measure called significant value which indicates the confidence of the results, a significant value equal or less than 0.05 indicates a reliable result.

Lastly, a Bivariate regression analysis is used to associate between agile and BIM variables. Bivariare regression calculates the value of one variable if we have information about the other by creating a regression equation: hence, examining the cause and outcome of factors. Usually, the predictor is the independent variable being tested and used to predict the outcomes of the dependent variable. The regression test allows the to assess the strength of connection among a dependent variable and one or more independent variables. Additionally, it helps compute the value of a dependent variable using one or more independent variables. A r-square value represents the regression coefficient with a value ranging between 0 to +1. A value of +1 denotes that the equation formulated by the regression analysis is a strong predictor.

Based on the literature review, figure 8 summarizes variables, factors, questionnaire measurement items with the references. Hence, each variable has three factors, and each

No.	Variable	Factors	Questionnaire Measurement Items	Reference
1	Agile			
1.1		Iterative Process		
1.1a			Dividing the project into iterative processes reduces project's complexity	
1.1b			Delivering the project in stages provide the opportunity to test the success before the final delivery stage	Mahomad, Sawsan, 2018
1.1c			Dividing work activities into repetitive processes with specific objectives lead to a faster project delivery	
1.2		Flexibility		
1.2a			Flexible design affects the success of the project	Mahomad, Sawsan, 2018
1.2b			Timely responding to changes results in better quality, time management, and lower cost	Hansson et al., 2006
1.2c			Flexibility in construction cater for market shifts	
1.3		Agile culture		
1.3a			A cooperative work culture affects the success of the project	Mahomad, Sawsan, 2018
1.3b			A work culture with shared vision affects the success of the project	Robinson and Sharp, 2003
1.3c			A collaborative project culture enhances work productivity	
2	BIM			
2.1		Time Management		
2.1a			BIM provides real time performance monitor & aid in reducing durations & avoid rework	Tserng, 2014
2.1b			BIM provide access to latest design information which utilizes time during execution	Davies and Harty, 2013
2.1c			BIM provides an effective communication tool which aid in time management	
2.2		Resource Management		
2.2a			BIM aid in reducing resources by providing efficient resource allocation plan	
2.2b			BIM improve overall team efficiency	Subramani et al., 2020
2.2c			BIM reduces errors hence eleminates rework & resource waste	
2.3		Waste Reduction		
2.3a			BIM reduces waste by eleminating coordination mistakes & miscommunication during the project cycle	Li, et al., 2013
2.3b			BIM provide accurate data to make decisions hence reducing project's errors/waste	Tahiret et al., 2018
2.3c			BIM provide better work quality hence reducing waste	

Figure 8 Measurement Items

factor has 3 measurement items which reflect the information presented in the literature review. The independent variable is agile project management which has three factor, iterative process, flexibility, and the agile culture. The iterative process can be summarized in the sprint phase while performing scrum as discussed in detail earlier; sprints can be a cycle of one-month iterations in which no outside factors should interfere with the scrum team (Cervone, H. Frank, 2011).

Moreover, the scrum approach of agile is proven to be flexible because of its simplicity. As described by Cervone, H. Frank (2011), each members' role is defined, and they do not clash or intervene with each other. Thus, making each member have the room to innovate and held accountable for his/her own actions. In addition, the agile culture is a positive culture because of the effective communication being enforced while performing tasks which helps the team to be vision focused and aligned/organized with the project agenda, hence reflecting positively on productivity.

CHAPTER 4

4.0 Data Analysis

4.1 Demographics

Surveys were distributed to civil engineering professionals and 60 surveys were returned with responses in which the demographics of those respondents are discussed as follows:

- As shown in figure 9, 15 people ranging in age between 18-25 which contribute to 26% of the sample participated. Most participants range in age between 26-35 about 52% of the sample. Moreover, 18% of the sample include participants ranging between 36-50 in age, and only 4% of the sample include participants 51 and above years old.

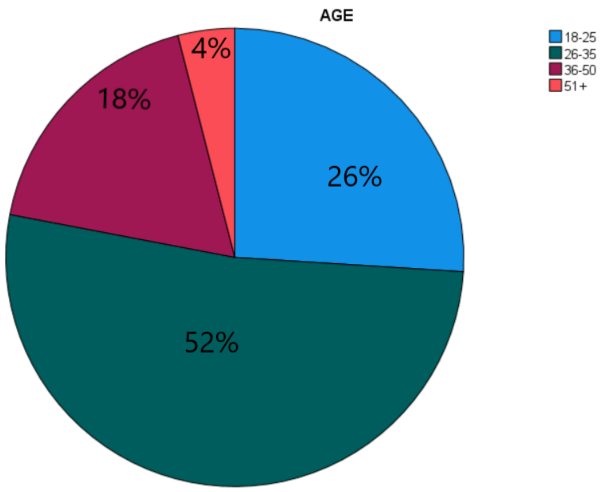

Figure 9 Age Demographic

- Figure 10 shows that most of the sample comprises of males in which 42 males participated and 18 females making the male versus female percentage 70 and 30 consecutively.

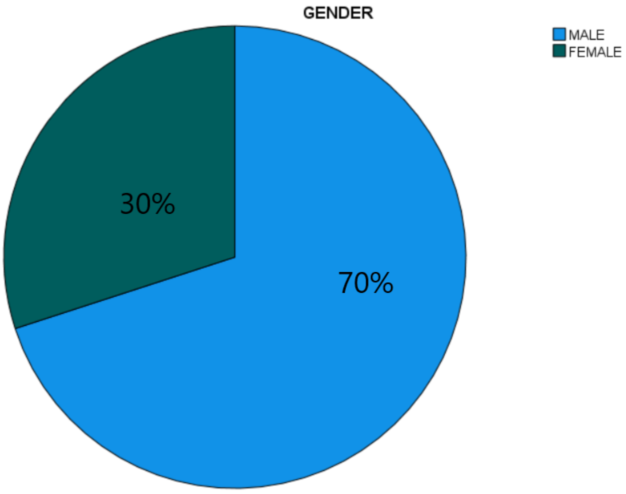

Figure 10 Gender Demographic

- Furthermore, 49 participants have bachelor’s degree versus 11 participants with master’s degree as shown in figure 9, which make up 82% of the sample having bachelors and 18% having masters

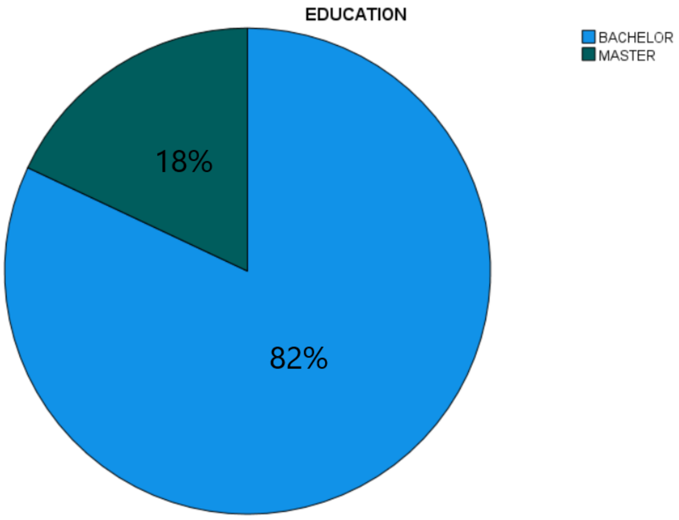

Figure 11 Education Demographic

- Figure 12 shows that 20 participants which is 34% of the sample have 2-10 years of work experience, 29 participants which is 48% of the sample have 11-19 years of work experience, 11 participants which is 18% of the sample have 20 or more years of work experience.

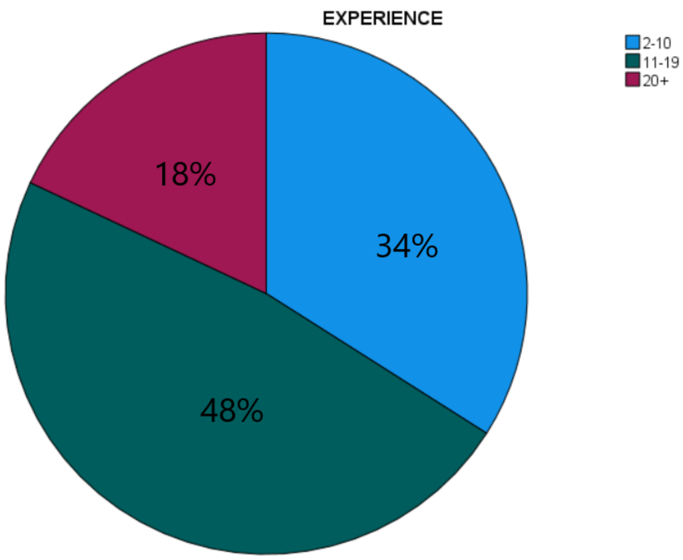

Figure 12 Experience Demographic

4.2 Reliability test

In order to validate the scale used for tis research, a reliability test was conducted to test the internal consistency and homogeneity of the variables, factors and items being studied. In order to test the reliability of agile implementation and BIM, the reliability test was conducted by computing the Cronbach's Alpha value for each factor and for the overall scale. The independent variable in this study is the agile project management having three factors which are iterative process, flexibility and agile culture. Each factor has two items which are reflected in the questionnaire. Moreover, the dependent variable being studied is BIM having three factors which are time, resource management and waste reduction. Each factor has two items reflected in the questionnaire. Below are the Cronbach's Alpha coefficients for each factor with explanations and the overall coefficient for the variables:

4.2.1 Cronbach's Alpha Coefficients

Figure 13 shows the Cronbach's Alpha coffecient for the three items of the iterative process factor to be 0.986; showing a consistency between the three iterative process items (IP1, IP2, IP3). Such coffecient value indicates that the paticipants responded in a uniform manner implying strong reliability of the iterative process items; higher than 0.6 which is considered acceptable according to the discussion presented in the methodology section.

Cronbach's Alpha	N of Items
0.986	3

Figure 13 Iterative Process Cronbach's Alpha Coefficient

Furthermore, Figure 14 shows the Cronbach's Alpha coffecient for the three items of the flexibility factor to be 0.866; showing a consistency between the three iterative process items (FLEX1, FLEX2, FLEX3). Such coffecient value indicates that the paticipants responded in a uniform manner implying strong reliability of the flexibility items; higher than 0.6 which is considered acceptable according to the discussion presented in the methodology section.

Cronbach's Alpha	N of Items
0.866	3

Figure 14 Flexibility Cronbach's Alpha Coefficient

In addition, Figure 15 shows the Cronbach's Alpha coffecient for the three items of the agile culture factor to be 0.965; showing a consistency between the three iterative process items (AC1, AC2, AC3). Such coffecient value indicates that the paticipants responded in a uniform manner implying strong reliability of the agile culture items; higher than 0.6 which is considered acceptable according to the discussion presented in the methodology section.

Cronbach's Alpha	N of Items
0.965	3

Figure 15 Agile Culture Cronbach's Alpha Coefficient

Also, Figure 16 shows the Cronbach's Alpha coffecient for the three items of the time management factor to be 0.922; showing a consistency between the three iterative process items (TM1, TM2, TM3). Such coffecient value indicates that the paticipants responded in a uniform manner implying strong reliability of the time management items; higher than 0.6 which is considered acceptable according to the discussion presented in the methodology section.

Cronbach's Alpha	N of Items
0.922	3

Figure 16 Time Management Cronbach's Alpha Coefficient

As well, Figure 17 shows the Cronbach's Alpha coffecient for the three items of the resource management factor to be 0.815; showing a consistency between the three iterative process items (RM1, RM2, RM3). Such coffecient value indicates that the paticipants responded in a uniform manner implying strong reliability of the resource management items; higher than 0.6 which is considered acceptable according to the discussion presented in the methodology section.

Cronbach's Alpha	N of Items
0.815	3

Figure 17 Resource Management Cronbach's Alpha Coefficient

Additionally, Figure 18 shows the Cronbach's Alpha coffecient for the three items of the waste reduction factor to be 0.755; showing a consistency between the three iterative process items (WR1, WR2, WR3). Such coffecient value indicates that the paticipants responded in a uniform manner implying strong reliability of the waste reduction items; higher than 0.6 which is considered acceptable according to the discussion presented in the methodology section.

Cronbach's Alpha	N of Items
0.755	3

Figure 18 Waste Reduction Cronbach's Alpha Coefficient

4.3 Correlation test

In order to test the strength and direction of the relationship between variables, Pearson's correlation coefficients were computed to test the hypothesis discussed earlier. Moreover, the significance of a relationship existence also will be measured using SPSS along with correlation coefficients. Hence, a correlation coefficient with a value of +1 indicates perfect positive relation which means that one variable is directly related to another.

On the other hand, a coefficient value of -1 indicates a perfect negative relation, which means that one variable is not related to another. Values in between range in strength and direction from strong positive direct relation to strong negative no relation at all. Moreover, the significant (2-tailed) value shows the certainty level of the association between variables; values that are equal or less than 0.05 shows that the relationship is not because of chance and that the correlation is highly significant. Below are the correlation coefficients with their significance values illustrating weather an association exist between the variables/factors or not:

Correlations									
		Iterative Process	Flexibility	Culture	Time Management	Resource Management	Waste Reduction	Agile	BIM
Iterative Process	Pearson Correlation	1	.655**	.679**	.709**	.852**	.751**	.620**	.651**
	Sig. (2-tailed)		0	0	0	0	0	0	0
Flexibility	Pearson Correlation	.655**	1	.556**	.510**	.820**	.579**	.650**	.679**
	Sig. (2-tailed)	0		0	0	0	0	0	0
Culture	Pearson Correlation	.679**	.656**	1	.639**	.773**	.834**	.720**	.779**
	Sig. (2-tailed)	0	0		0	0	0	0	0
Time Management	Pearson Correlation	.709**	.710**	.739**	1	.769**	.831**	.820**	.979**
	Sig. (2-tailed)	0	0	0		0	0	0	0
Resource Management	Pearson Correlation	.752**	.720**	.873**	.769**	1	.727**	.855**	.879**
	Sig. (2-tailed)	0	0	0	0		0	0	0
Waste Reduction	Pearson Correlation	.851**	.779**	.834**	.831**	.827**	1	.820**	.779**
	Sig. (2-tailed)	0	0	0	0	0		0	0
Agile	Pearson Correlation	.841**	.779**	.934**	.731**	.722**	.877**	1	.920**
	Sig. (2-tailed)	0	0	0	0	0	0		0
BIM	Pearson Correlation	.751**	.679**	.734**	.833**	.877**	.827**	.679**	1
	Sig. (2-tailed)	0	0	0	0	0			
** Correlation is significant at the 0.01 level (2-tailed).									

Figure 19 Correlation Coefficients

As shown in figure 19 above, the correlation between the variables/factors themselves is 1; iterative process would correlate with iterative process 100%, and the same goes for the rest. It can be noted that a value of 0.709 exist between the iterative process of agile method and time management using BIM indicating a strong relationship between them. The significance factor is also less than 0.01, demonstrating that 50% of time management variances can be explained by agile iterative process. Hence, implementing agile iterative process while using BIM enhances time management by 50%.

In addition, the value of 0.852 exist between the iterative process of agile method and resource management using BIM indicating a strong relationship between them. The significance factor is also less than 0.01, demonstrating that 70% of resource management variances can be explained by agile iterative process. Hence, implementing agile iterative process while using BIM enhances time management by 70%. In addition, the value of 0.751 exist between the iterative process of agile method and waste reduction using BIM indicating a strong relationship between them. The significance factor is also less than 0.01, demonstrating that 56% of waste reduction variances can be explained by agile iterative process. Hence, implementing agile iterative process while using BIM enhances waste reduction by 56%.

Moreover, the value of 0.510 exist between the flexibility of agile method and time management using BIM indicating a strong relationship between them. The significance factor is also less than 0.01, demonstrating that 26% of time management variances can be explained by agile flexibility. Hence, implementing agile flexibility while using BIM enhances time management by 26%. Moreover, the value of 0.820 exist between the flexibility of agile method and resource management using BIM indicating a strong relationship between them. The significance factor is also less than 0.01, demonstrating that 67% of resource management variances can be explained by agile flexibility. Hence, implementing agile flexibility while using BIM enhances resource management by 67%.

Moreover, the value of 0.579 exist between the flexibility of agile method and waste reduction using BIM indicating a strong relationship between them. The significance factor is also less than 0.01, demonstrating that 33% of waste reduction variances can be explained by agile flexibility. Hence, implementing agile flexibility while using BIM enhances waste reduction by 33%.

Furthermore, the value of 0.639 exist between the culture of agile method and time management using BIM indicating a strong relationship between them. The significance factor is also less than 0.01, demonstrating that 40% of time management variances can be explained by agile culture. Hence, implementing agile culture while using BIM enhances time management by 40%. Furthermore, the value of 0.773 exist between the culture of agile method and resource management using BIM indicating a strong relationship between them. The significance factor is also less than 0.01, demonstrating that 60% of resource management variances can be explained by agile culture. Hence, implementing agile culture while using BIM enhances resource management by 60%.

Furthermore, the value of 0.834 exist between the culture of agile method and waste reduction using BIM indicating a strong relationship between them. The significance factor is also less than 0.01, demonstrating that 70% of waste reduction variances can be explained by agile culture. Hence, implementing agile culture while using BIM enhances waste reduction by 70%.

Additionally, the value of 0.920 exist between the agile and BIM indicating a strong relationship between them. The significance factor is also less than 0.01, demonstrating that 85% of BIM factors can be explained by agile. Hence, implementing agile while using BIM enhances efficiency by 85%.

4.4 Regression test

A regression analysis was used to examine the connection between agile project management (independent) and BIM (dependent) variables. Regression analysis lets us compute the significance of one variable if we have information about another. But the accuracy of the estimate hangs on the strength of variables' association. Additionally, regression analysis examines the cause and the outcome of factors. Below are the results of the regression analysis investigation:

Model Summary			
Model	R	Adjusted R Square	Std. Error of the Estimate
1	.817a	0.787	2.32543
a Predictors: (Constant), Agile_Global_Factor			

Figure 20 Regression Analysis R-value

The R-value is a coefficient that denotes if there is a relationship existence between variables. A value of 0.817 shows a strong relationship between agile and BIM. Also, the coefficient of determination "R2" signifies the strength of the regression equation. A value of 0.787 of R2 indicates that 78.7% of BIM can be predicted by agile. Moreover, F and T values with having a significant value of zero, shows just how statistically significant the connection is between the two variables.

ANOVAa						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	582.757	1	580.757	103.918	.000b
	Residual	269.596	59	5.202		
	Total	852.353	60			
a Dependent Variable: BIM_Global_Factor						
b Predictors: (Constant), Agile_Global_Factor						

Figure 21 Anova F-value

The F-value, which is 103.918 and is significant when it is less than 0.01, indicates that using agile principles predicts BIM factors well.

Coefficients						
Model	Unstandardized Coefficients			Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.207	1.106		1.017	0.187
	Agile_Global_Factor	0.294	0.028	0.727	10.192	0
a Dependent Variable: BIM_Global_Factor						

Figure 22 Anova t-value

The beta value of 0.294 indicates that using agile supports the BIM factors, which recaps the results of the correlation test performed earlier.

4.5 Summary

The Cronbach's alpha study was used to check the reliability, the results show a high level of internal consistency between the answers which indicate that the survey used is valid for this research paper. Additionally, the correlation test shows a strong positive relationship between implementing the agile principles to BIM, also the regression test shows that BIM variances can be well explained by the agile factors.

Hence, the assumed hypothesis stated in the beginning of the paper are accepted; agile project management principles aid in finishing projects on time, utilize resources and reduce waste by means of iterative process, flexibility, and the agile culture. Moreover, BIM in construction is effective regarding time, resource, and waste management especially with the aid of agile principles. Hence, a project which uses agile principles by means of BIM can enhance the construction productivity and can have other effects like reduce net carbon emissions in construction by reducing the lifespan of the project and utilizing less resources in terms of manpower and machinery.

CHAPTER 5

5.0 Discussion

5.1 Introduction

This section is dedicated to discussing the hypotheses presented in this paper based on the outcomes of the study, data analysis, and literature review. The aim of the study is to inspect the influence of using agile principles using BIM as a tool and how it can affect projects' success.

This research presents synthesis of agile management and BIM in the construction industry and how practical it can be used with regards to its economic incentives which factors into time, resources and reducing waste production. Agile is very useful during the design stage of a construction project as it is easier to apply the scrum methodology since the design phase is less volatile than the actual construction phase. In addition, BIM is an effective tool to allocate resources especially when there are many overlapping activities during actual construction. As shown in figure 23 below, integrating BIM during the construction phase can reduce the rework that can result from poor planning. Thus, it is believed that using agile during the design phase to come up with a strong plan can even reduce the rework during actual construction even more since more accurate information can be used in hand (Tomek, Radan; Kalinichuk, Sergey, 2015). BIM allows the project managers to dissect the project lifecycle into dependent overlapping activities which utilizes time, resources and waste reduction.

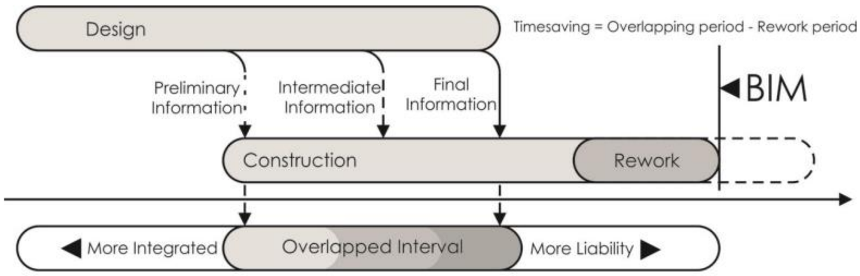

Figure 23 BIM and activity overlapping

Additionally, BIM can be described as the main link enabling agile to workout in the construction industry with its full output. Figure 24 below shows some advantages of using both methods (BIM and agile) in construction.

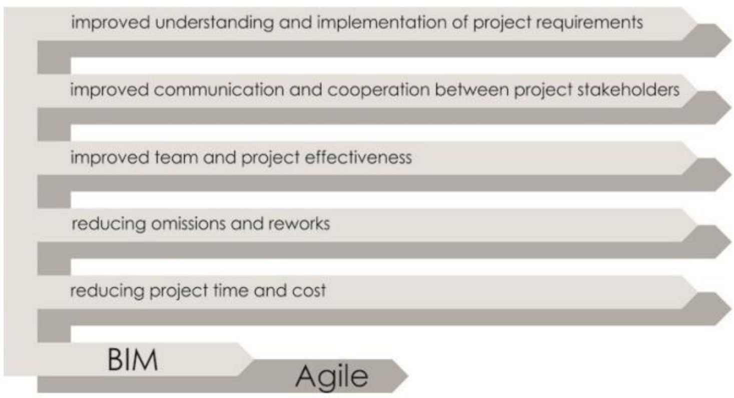

Figure 24 BIM and Agile

It can be noted that agile always highlights the importance of communication and cooperation between parties especially stakeholders because they are the ones whom most changes and volatility can arise from. Hence come the improved understanding so accurate project requirements can be implemented correctly. With improved team based working environment, an effective work dynamic can be created to reduce omissions and rework which in turn reduces time and cost of the project as presented in figure 24.

Moreover, agile and BIM can be considered as tools and techniques which are interconnected and can be categorized as organizational and technological tools (Tomek, Radan; Kalinichuk, Sergey, 2015). As an organizational tool, agile can postulate a framework for people and software (tools, machines, etc.) to work alongside including assisting multidisciplinary teams work, implicating all parties in the development process (Prasad B., 1996). On the other hand, BIM can be considered as a technological tool that enables the facilitation of simultaneous work within the organization. This includes communication and information technologies needed for integration, collaboration and concurrent working (Alastair W., 2011). Hence, information exchange is provided as an information model in a form which is documented, unified, accessible such as business analysis, policies of green buildings, building life cycle and economical buildings (Succar B., 2009).

5.2 Relationship between agile and time management using BIM

The results from both the Pearson correlation coefficients test and the regression test of this study indicated a significant positive relationship between agile implementation and BIM factors related to time management, the strong positive relationship denotes that using agile supports the efforts of BIM to enhance time management by reducing the rework that is very common during the actual construction stage as shown in figure 23.

In order to discuss time management using agile and BIM, a construction project will be divided into two major phases, the design phase and actual construction work at site for simplicity. The design phase has four stages: concept, schematic, detailed design, and construction document. Each stage represents the amount of information being provided from the designer/consultant hired by the client/investor/stakeholders.

During the concept stage, rough information is provided with minimal coordination between parties. Concept focuses on feasibility and whether the conceptual idea of the project is likable and feasible enough for stakeholders to invest. Applying agile during this stage is not very beneficial since too many unconcealed ideas and information is being deliberated between involved parties, however, the project manager is advised to follow the agile manifesto wherever applicable such as satisfying stakeholders, come up with a working software to measure progress, etc. Furthermore, more coordination and tuned information is required for the schematic stage including structural element sizes, working structural system, typical slab thicknesses, etc. It is important for the project manger to start applying the agile principles by setting out a plan with teams that perform tasks in iterative means and then retrospect and reflect on each iteration or cycle of timely phased task in order to provide more accurate information in the next timely phased task. In this way, more accurate coordination can be accomplished between different parties, and mistakes are expected to happen within these timely phased cycles; hence, learning from mistakes and recovering after each cycle can prosper. Being precise as much as possible in the schematic design is crucial before moving to the detailed design stage because once moving on it is hard to recover any miscoordination. The rework required would take much more time and in some case third parties might be needed to recover any mistakes to propose solutions since time is usually tight during this phase. In addition, the detailed design stage is where all the document proposed need to be completed with 100% complete information that will be used for pricing. Hence, less information presented in the document would result in underestimated pricing for the entire project which means big price variation during the actual construction stage affecting the anticipated feasibility. This can result in work being completely shut down, compromise on quality, or eliminating parts of the project's scope.

According to Tomek, Radan; Kalinichuk, Sergey (2015), major problems happen due to the changes and reactions during the project phases. However, agile reduces the time from start to end of the construction and reduces the investment process duration which is a big component in the entire control system. Moreover, a shorter duration means a less concern to any market instabilities or conditions which is one of the biggest risks that stopped and delayed many construction projects. Hence, using schedule compression techniques by the aid of BIM is essential to optimize time after getting the most accurate information using agile techniques earlier in the design phase which in turn will provide an economical advantage to the stakeholders by exposing them to less risks and higher return on their investment by reducing the project duration.

Furthermore, the research findings of this paper align with Layton, M. C. (2020) that mentions how agile helps in time management since the project's scope is not fixed, but time is fixed with a team creating conditions that will fit the time frame constrain. In addition, scrum allow teams to always reassess the amount of work that can be done in a specific time frame. Hence, allowing a room for mitigating mistakes and learning how to optimize work for the next stage. Additionally, Hayat et al. (2019) mentions how scrum allows to manage both cost and time at the same time because of the scrum methodology which gives the project manager a time frame within an interval with a specified budget, which overall enhances the progress and productivity of the firm.

5.3 Relationship between agile and resource management using BIM

The results from both the Pearson correlation coefficients test and the regression test of this study indicated a significant positive relationship between agile implementation and BIM factors related to resource management, the strong positive relationship denotes that using agile supports the efforts of BIM to enhance resource management by reducing the rework that is very common during the actual construction stage as shown in figure 23 and by accurately allocating resources.

In addition, resource management can be done very efficiently by utilizing agile principles after the construction design stage is completed where the tender document is issued for contractors to forecast the anticipated budget which considers required resources. The traditional method account for the number of hours required to finish a task with some contingencies to account for unforeseen conditions. However, agile break up the long main life cycle of the project into small segments of independent activities which dissect activities and allow for more realistic resource allocation and assignment to be recommended. Moreover, some activities are overlapping semi-independent; for instance, the activity cannot start without starting of another activity. Other activities are dependent which means the activity cannot start before another activity finish. Hence, overlapping of activities exist and this is where all delays and complications happen especially if poor resource management exist. The delay of one overlapping activity can cause the delay of other activities which if happened frequently can accumulate to cause a big project’s delay and cost overrun due to the need of utilizing more resources to finish the work. Thus, agile project management at the tender stage is essential to ensure that accurate and realistic information is provided at the time of actual construction with risk mitigation plans to ensure that overlapping activities are done on time. Additionally, unlike the traditional project management method, agile tolerate for a problem when it happens to be moved into the next succeeding activity in which it will not require a major replan of the whole project as shown in figure 25 below (Tomek, Radan; Kalinichuk, Sergey, 2015).

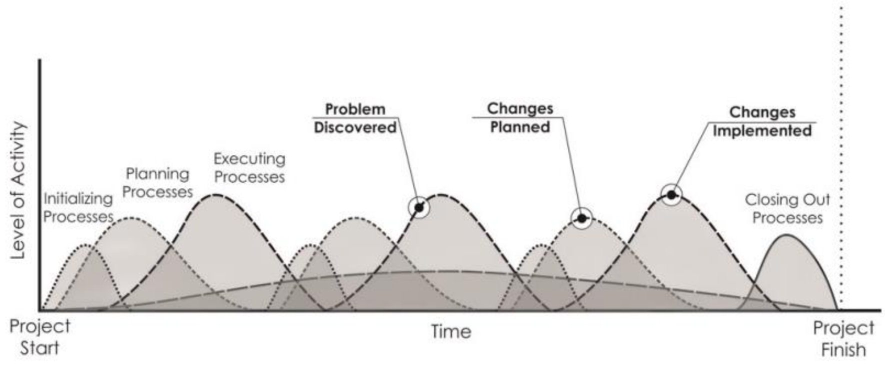

Figure 25 Agile handling requirement changes in a Project

Figure 25 illustrates how performing agile allow to move any obstacle faced in one cycle/iteration to the next one easily allowing BIM tools to accurately perform resource allocation. By having this advantage, whenever each overlapping activity is finished there is a complete part of the project which is completed. Hence, early on, major issues are discovered during the development process. Thus, stakeholders including designers, investors, contractors can give their feedback after every overlapping activity to redirect the project's goals into the right direction before any major cost and schedule expenditure.

It can be noted that agile is about figuring out issues early on in order to take the correct decision at the right time. By having the right information at the right time BIM can be utilized to its full potential. A major cost and time overrun contributor during the actual construction phase is delaying overlapping activities, hence, contributing to wrongful resource deployment. Too many resources would be deployed in activities that require less resources and too little resources would be assigned to activities requiring more resources. Usually, project managers realize such a thing after the activity has finished, however, too much damage by this time have been done.

The findings of this paper align with Zavyalova et al. (2020) study which compared the human resource architecture of firms using the traditional method and the ones using the agile methodologies. The findings showed that higher performance was the result of the firms using agile by means of motivation, opportunity enhancing and self-organized teams. Those agile firms were found also to be more diverse with professionals playing strategic role which led to innovative practices. Additionally, Nenad (2010) describes how integrating BIM in construction starting from the prefabrication of material stage to the material delivery would bring many advantages. By linking the supply chain through BIM to the contractor (agile implementation by involving all stakeholders through an integral system), in this way any problems arising can be resolved early on to avoid delays. For example, if a vendor is facing delays, through BIM the contractor can track the process and will reach out to other substitute vendors in order to stay on track regarding the project's duration. This provides site managers with the information needed for detailed planning of construction work. Moreover, each element in the project can be monitored following the same technique which can have a positive implication for progress reporting. Quantities and quantity projections can be studied by generating models allowing the project manager to compare planned and as build status and identifying current or forthcoming issues related to resource management

5.4 Relationship between agile and waste reduction using BIM

The results from both the Pearson correlation coefficients test and the regression test of this study indicated a significant positive relationship between agile implementation and BIM factors related to waste management, the strong positive relationship denotes that using agile supports the efforts of BIM to enhance waste management by reducing the rework that is very common during the actual construction stage and by accurately allocating resources. Hence, reducing the time needed for an activity to finish, which contribute to less waste production during the life span of the project.

Furthermore, construction waste can comprise of demolition due to rework, carbon dioxide emissions, and taking longer time to finish activities that utilizes manpower and machinery that result in more waste production. According to Kulatunga et al. (2006), during construction, large natural resources quantities are consumed which generate solid wastes. These resources must be moved from different places of the world due to availability, convenience, and commercial reasons. The movement contribute to waste production and the process of material extraction also is a contributor. It is believed that implementing agile and BIM at the right time during the construction phases would aid in waste reduction. As discussed earlier the construction cycle will be divided into the design stage and actual construction work stage to set a methodology of how agile and BIM can be used to utilize waste management.

During the design stage, a more controlled environment is presented where agile principles can flourish to their full potential. Implementing green building protocols by paying attention to the supply chain while doing the design is very important. Although stakeholders find it difficult to accept unconventional approaches, however the project manager must present traditional commercial approaches versus waste reduction benefits by using agile which emphasize on constant communication with all stakeholders through stakeholder management system. The optimal order of tasks is very difficult to be determined in the early stages, however by the help of BIM a realistic anticipation can be predicted that can aid the project manager to present realistic information to stakeholders. Moreover, green building requirement, energy-efficient materials, and light environmental footprint all and more must be considered as part of the agile iterations during the design stage. Sustainable design approach process information must have a control system to assist the project manager later during the actual construction stage to use BIM to utilizes the right material, resources, and waste management control.

During the actual construction stage, visual management and managers communication regarding keeping the construction site clean using signs, labels and codes is an effective method to reduce waste (King PL, 2009). The visual management and communication can be more effective by using BIM tools to come up with a structured waste management plan and a contract between the general contractor and sub-contractors to determine waste on site responsibility. For instance, color coded waste bins that allow the segregation of different materials that can be recycled can be controlled by a waste manager aided by BIM tools to handle disposal, storage and delivery of material on site. In addition, logs can be kept for record in which BIM tools can process the collected information to provide the project manger with a clear picture of how to improve waste management in the next construction cycle. Hence, enhance the construction waste management in the industry by effectively use resources, reducing variations and rework, reducing activities' duration, and by having an increased value and quality control.

The findings of this paper align with existing research regarding BIM and construction waste minimalization. O'Reilly (2012) discussed that during the design stage, BIM can be very effective in construction waste minimalization. Through enhanced coordination, on-site and demolition waste management at site using BIM can improve and achieve resource efficiency by aligning the project's lifecycle stages of the building from early stages to completion with BIM. In this case, carbon emissions can be reduced, and energy is utilized more efficiently.

5.5 Relationship between agile and projects' success using BIM

The results from both the Pearson correlation coefficients test and the regression test of this study indicated a significant positive relationship between agile implementation and BIM factors related to the projects' success, the strong positive relationship denotes that using agile supports the efforts of BIM to enhance the overall success of a construction project by tackling three main elements: time management, resource management and waste reduction. Those factors collectively contribute to achieving any construction projects' goal by avoiding time and cost overruns and omitting construction waste as possible.

Additionally, for high complex projects with constant requirement changes, agile is highly recommended because of task variability, different peoples' capabilities and the use of technology that could impact the value to be delivered. Moreover, success can be measured by many factors however for the sake of this paper, stakeholders' satisfaction in addition to achieving the project's goals will be the measure. Hence, time, resource and waste management reflect focal points of today's competing construction environment. And by controlling these factors using agile and BIM, success can be achieved.

CHAPTER 6

6.0 Conclusion

The relationship between agile project management and BIM has been examined in this research paper by investigating the agile factors that can be implemented using BIM as a mechanism. Moreover, to accomplish the research objectives and answer the research question, a conceptual framework was developed and a review for the literature was achieved.

By using the quantitative method, data was collected and analyzed using relevant tools such as SurveyMonkey to collect the sample and SPSS software to analyze the data. It was revealed that there is a strong positive relationship between agile and BIM implementation in the construction industry in the UAE. The study discussed factors related to agile iterative process, flexibility and culture; and BIM factors such as time and resource management and waste reduction. The proposed hypothesis stating, "Agile project management principles using BIM aid in projects' overall success" was accepted based on the literature review and the findings presented in this paper. Moreover, the study shows that using Agile principles in BIM has a great impact in utilizing time and resources and eliminating construction wastage. Agile and BIM are both powerful tools which if used together can create an effective work environment which enhances the success rate of any construction project in UAE. However, it is up to the project manager to decide what fits best from the agile manifesto to apply to each individual unique project alongside with BIM technology.

Furthermore, this research has promising implications on the construction industry in UAE. Theoretically, using BIM as a tool while applying the agile concepts should indeed aid in the projects' success. Practically, agile principles can be challenging to apply during the actual construction stage due to the volatility of the construction nature, design changes, construction variations, supply chain constrains, and market conditions. However, many construction companies and consultant design firms rely on BIM as a coordination tool for big projects since it is proven to be effective in avoiding coordination oversights, but agile is yet to be tested more thoroughly. Additionally, discovering new solutions to mitigate projects' complications can be worth investing in exploring more about this topic.

This paper contributes to the body of knowledge of the UAE construction industry being more efficient especially with all the new developments happening the past decade. The paper provides numerical data about how the industry is ready and believe in agile and BIM being used simultaneously. A methodology was discussed in this paper with examples about how agile and BIM can be implemented together, and it is up to each project manager to study and find the best way to approach any project since each project is unique on its own.

CHAPTER 7

7.0 Limitations, and research recommendations

Few factors could have limited this research from having more comprehensive data such as the difficulty in getting a bigger sample since out of more than one hundred surveys which was sent only sixty came back. Having a bigger random sample help in avoiding the unconscious bias being reflected in the results. Also, a bigger sample result in a data with less error, and aid in determining the mean value among samples. A larger sample size influences the precision of the mean which can help in easily pointing out the outliers. Additionally, the larger the sample the less the margin of error.

Furthermore, this research paper briefly explored how agile and BIM aid in carbon emission reductions. A future research recommendation is to focus on the relationship between agile, BIM and carbon emissions because it seems from the literature review that there is a positive connection. As discussed earlier, in theory, reduction of resources means less machinery/products omitting carbon. Hence, if agile and BIM reduce resources, carbon emissions are reduced in turn. For example, if a certain material quantity is reduced in building work because of BIM modeling, then the energy that is associated with manufacturing that material and the delivery of it and the installation of it will automatically eliminated. Hao, et al. (2020) discussed how prefabrication of construction material based on BIM resource allocation/utilization aid in carbon emissions reduction by allocating required resources for each construction phase accurately with minimal wastage. Additionally, Hao, et al., (2020) proposed a 15% carbon emissions reduction if government adoption is imposed for prefabricated components in construction projects. There are a lot of things to be explored regarding

BIM and agile resource allocation/utilization by means of prefabricated products and carbon emissions which is interesting to investigate.

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APPENDECIES

Dear Sir/ Madam,

- This questionnaire gives the chance to state your opinion on the effects of Agile Project Management implementation in BIM.
- Please note that there is no right or wrong answer.
- The questionnaire will be used to gather primary data for a research study. Hence, we ask your help to be open, fair, and honest in the responses.
- The researchers guarantees that no individuals will be identified from their responses and there are no requests for confidential information included in the questionnaire.
- The outcomes of the study will be used by the researchers for study purposes only.
- The questionnaire comprises three parts:
    1. Demographics
    2. Agile in construction project management
    3. BIM in construction project management

Thank you

Researcher

Part One: Demographics

Please tick one box for each question

No	Item	Category			
1	Age	18-25	26-35	36-50	51+
2	Gender	Male		Female	
3	Education Level	Diploma	Bachelor	Master	PhD
4	Experience Level	1 year or less	2-10	11-19	20+

Certain principles of Agile project management are highly related to the success of the construction projects. Please rate the following statements based on a 5-point Likert scale (Strongly agree, Agree, Uncertain, Disagree, strongly disagree).

Part Two: Agile in construction project management

Please tick one box for each question

No	Item	Strongly agree	Agree	Neither agree Nor Disagree nor disagree	Disagree	Strongly disagree
Iterative Process						
5	Dividing the project into iterative processes reduces the project's complexity.					
6	Delivering the project in stages provides the opportunity to test its success before the final delivery stage.					
7	Dividing work activities into repetitive processes with specific objectives leads to faster project delivery.					
Flexibility						
8	Flexible design affects the success of the project.					
9	Timely response to changes results in better quality, time management, and lower cost.					
10	Flexibility in construction caters to market shifts.					
Agile Culture						
11	A cooperative work culture affects the success of the project.					
12	A work culture with a shared vision affects the success of the project.					
13	A collaborative project culture enhances work productivity.					

Certain factors of BIM are highly related to the success of the construction projects. Please rate the following statements based on a 5-point Likert scale (Strongly agree, Agree, Uncertain, Disagree, strongly disagree).

Part Three: BIM in construction project management
Please tick one box for each question

No	Item	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Time Management						
14	BIM provides a real-time performance monitorand aids in reducing durations and avoiding rework.					
15	BIM provides access to the latest design information, which utilizes time during execution.					
16	BIM provides an effective communication tool which aids in time management.					
Resource Management						
17	BIM aids in reducing resources by providing an efficient resource allocation plan.					
18	BIM improves overall team efficiency.					
19	BIM reduces errors, hence eliminating rework and resource waste.					
Waste Reduction						
20	BIM reduces waste by eliminating coordination mistakes and miscommunication during the project cycle.					
21	BIM provides accurate data to make decisions, hence reducing errors and waste.					
22	BIM provides better work quality, hence reducing waste.					