The Effects of BIM Technology on Reducing Cost in Building Construction

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Abstract

Controlling cost construction has been among one of the most researched areas in the field of engineering. Since the past recent decades, there have been constant attempts by engineers, contractors and clients to find out means to reduce construction cost. One of the central instruments that play crucial key roles in this area is engineering software technology. Particularly, building information modelling (BIM) has attracted growing attention regarding the reduction of cost construction. The ultimate goal of this review paper is to uncover the potential relationship between BIM and construction process, and seek out the key roles that this system plays in reducing the building budget. This paper outlines the significances of the BIM which leads to the remarkable impacts on cost construction by reviewing two published papers along with a book based on qualitative analysis. This is done through summarizing and evaluating the before-mentioned references and an analogy between them. Results highlight the differences between this current technology system and traditional, previously used system; underline the efficiency of BIM in engineering projects, and the findings show an outgrowing prediction of immense implementation of this system in future projects.

Keywords: BIM, cost management, reducing cost, building construction, construction waste

1.Introduction

Cost management in construction projects is the most important factor of project management triangle, and among the other factors are time and quality. The procedure of cost management includes financing, planning, funding, budgeting, estimating, and cost control. Generally, cost is a key factor in choosing and selecting from various available alternatives (Jung & Joo, 2011).

In the last decades, engineering software programs that help with the solution of construction problems have developed (FRANÇOIS & W., 2019). One of the modern systems that provide architecture, engineering, and construction (AEC) professionals the ability to be more efficient with building construction is building information modelling (BIM) (Becerik-Gerber & Kensek, 2010).The process of BIM is an intelligent system of technology that aids in construction management, especially cost reduction (Suermann & Issa, 32009).

BIM technology and cost

Building information modelling (BIM) is a computer-based system which is utilized to design, comprehend and illustrate physical features and functional specification (Moon, Choi, Kim, & Ryu, 2011). BIM has a great influence on project construction management in terms of time and cost-efficiency (Hwang, Zhao, & Yang, 2018). BIM system has many advantages in cost efficiency. With BIM, projects have fewer errors and lower construction cost. Furthermore, engineers have better insight in controlling construction cost, reducing cycle time which in turn helps with cost reduction (Ghaffarianhoseini, et al., 2016).

The 4D [time] and 5D [cost] in BIM

There are many differences between BIM and other traditional systems; among them is the addition of 4D and 5D models that organize cost management. This is done by giving the users visualization of the temporary components of the project which have a role in bettering health and safety of construction projects. This 4D model provides a schedule to help make more accurate decisions. In case of changes in the project schedule, BIM models will automatically update the project progress (Moon, Choi, Kim, & Ryu, 2011).

This BIM 4D model is able to work with the major planning software like Primavera and Astra to create project planning and evaluate methods of building construction. The 4D [time] model is indirectly related to construction and as a result reduces the cost project (Hwang, Zhao, & Yang, 2018).

5D [cost] model can determine the exact project budget with minimal time by computing material quantity takeoff and item price automatically (Sacks, Eastman, Lee, & Teicholz, 2018).This model provides life-cycle cost (which affects operating and construction of the buildings) and another form of cost which is known as whole-life costs which influences building activity (Moon, Choi, Kim, & Ryu, 2011).

This review paper discusses reducing cost in building projects through using building information modelling technology and reviewing three related references—two review paper and a book— by making the comparison, evaluating, critique and analyzing.

2. Data collection and methodology

In this paper, the data are collected from various sources such as libraries, academic website publishers, and net libraries. Different types of references are used—books, article review papers and scientific research papers. The review procedure consists of three main steps as shown in fig (1): (a) selecting the research area to be the research scope; (b) the data collection and analyzing; and (c) analyzing the selected papers and books which are chosen for reviewing.

In the first stage, the area of the study was selected and the scope of technology was defined which was the (BIM) and its effect on a variable which was building construction. The second stage began here, and we conducted the keywords search to identify related published articles and books on the web.

There were 2030 scientific articles from the engineering and computer field on the web search relating to building information modelling and construction in the English language. In addition, searching on web by using building information modelling and (BIM) combining with building construction cost keywords, we explored that only 46 scientific articles contained the cost management as variable.

After noticing the title, abstract, and the conclusion and filtering out the chosen 46 articles, just 29 of them remained to study. Five of them were reviewed paper which were used as data references and analyzing methodology. In other 24 research papers, we chose two of them for reviewing in our study and others used as references and general information.

For the books was the same; 16 books about BIM and construction were collected; 11 of them related to cost management; and we used one of them for reviewing with other two selected papers and the rest were used as references.

All the selected items for reviewing (two scientific articles and a book) relating to building information modelling and cost management in building construction, after identifying the gap in (all books and published articles), we selected our paper review title (The Effects of BIM Technology on Reducing Cost in Building Construction), and we began to search broadly in web to detect if there was other papers or books under the same title. After confirming, we fixed the title as a gap within collected searched books and titles.

Selecting our review paper's title and choosing three references for reviewing, steps for analyzing the content of three references started. The method of analyzing and exploring the facts execute by evaluating the sources, making comparisons, and critiquing the contents. The next step was discussing the findings and results .The next steps were identifying the gaps in researches and making the future recommendation(s)

3.The research problem

Construction cost management in traditional systems includes both losing information as well as construction wasting and it yields passive, ineffective, and weak cost management; this, in turn, results in affecting the constructions cost remarkably (Yin & Qian, 2013). This review paper deals with this current problem by the comparison between BIM and other traditional systems.

4.The question and aim of the paper

The study aims to identify the weak points of traditional systems for managing cost in construction and uncovers the potential relationship between BIM and construction process to seek out the key roles that this system plays in reducing the building budget through answering the paper question which is 'Is

BIM technology system can reduce the waste of project costs during the construction process, and if it is possible, how can it do this?

5.The research hypothesis

The hypothesis states that the BIM system can reduce the construction cost by providing better project management, arranging and updating engineering system working automatically.
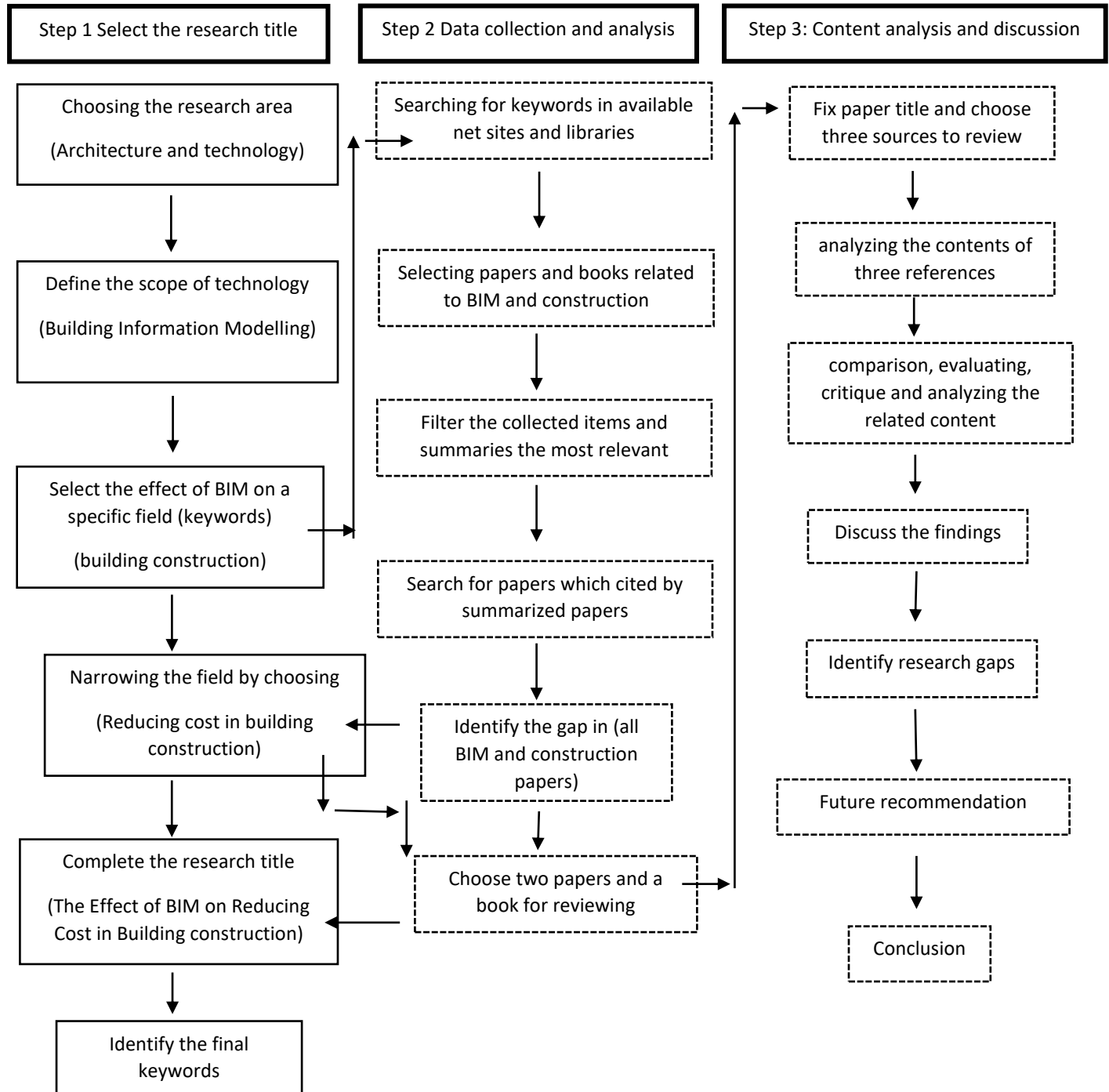
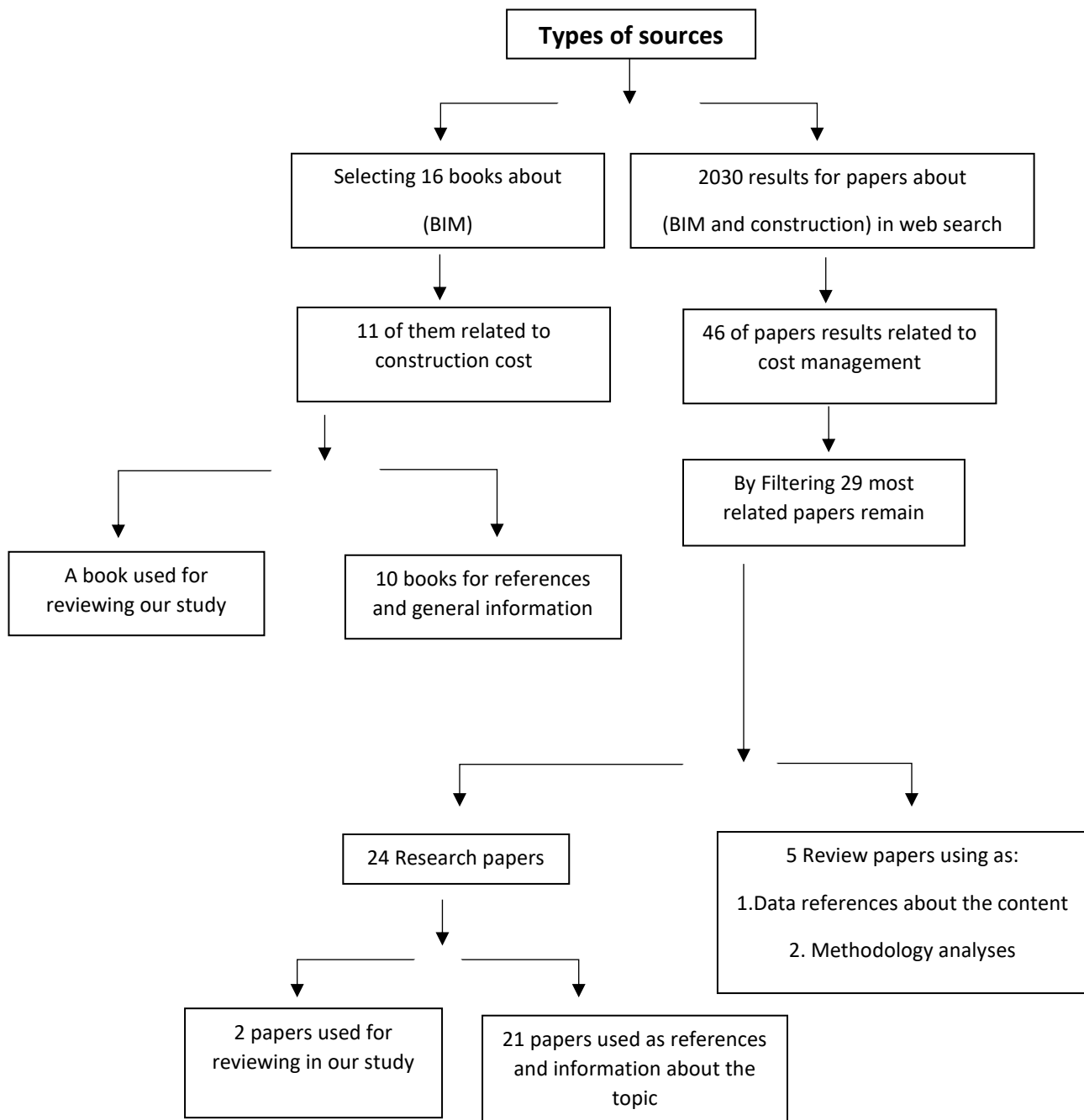| Step 1 Select the research title	Step 2 Data collection and analysis	Step 3: Content analysis and discussion
Choosing the research area (Architecture and technology)	Searching for keywords in available net sites and libraries	Fix paper title and choose three sources to review
Define the scope of technology (Building Information Modelling)	Selecting papers and books related to BIM and construction	analyzing the contents of three references
Select the effect of BIM on a specific field (keywords) (building construction)	Filter the collected items and summaries the most relevant	comparison, evaluating, critique and analyzing the related content
Narrowing the field by choosing (Reducing cost in building construction)	Search for papers which cited by summarized papers	Discuss the findings
Complete the research title (The Effect of BIM on Reducing Cost in Building construction)	Identify the gap in (all BIM and construction papers)	Identify research gaps
Identify the final keywords	Choose two papers and a book for reviewing	Future recommendation
		Conclusion

Fig (1) the review procedure study

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Types of sources

Selecting 16 books about (BIM)

2030 results for papers about (BIM and construction) in web search

11 of them related to construction cost

46 of papers results related to cost management

By Filtering 29 most related papers remain

A book used for reviewing our study

10 books for references and general information

24 Research papers

5 Review papers using as:

1.Data references about the content

2. Methodology analyses

2 papers used for reviewing in our study

21 papers used as references and information about the topic

Fig (2) the second of review procedure (collecting and analyzing data)

6. Overview of reviewing references:

Reference [1]: The first reference that has been used in this review paper is (Smith, 2016) which is mentioned in the reference list. The paper is about construction cost management facing practical issues in the implementation of different computer software. This study focused on the opportunities that BIM offers for construction cost professionals for improving project speed, qualities, and accuracy. The objective of this paper is to discover the issues that engineering firms facing to choose the best procedure, strategies, and practice that firms are following. The paper methodology is doing interviews in detail in Australia with Quantity Surveying firms. The results illustrated the firms that the study interviewed are spending a lot of energy and time to develop their skills in relation to underlying problems and what was necessary for their successfulness. as shown in Table (1).

Reference [2]: The second reference is the book (Gao & Pishdad-Bozorgi, 2019), which is mentioned in the paper's reference list. This book has been written to support students and learners of construction management to comprehend the meaning of big data and building information modelling and how to practice on the BIM projects. This book introduced high-profile building information modelling. The source illustrated the integration of BIM technology and construction cost management responsibilities. In addition, the book combined practical examples with academic and professional experiences. In conclusion, the reference discussed that the future of BIM technology in construction management is bright despite existing challenges. as shown in Table (1).

Reference [3]: The third reviewed paper is (Yin & Qian, 2013), which is mentioned in the reference list discusses the cost management in project contraction depending on building information modelling technology and illustrates that the BIM system improves the construction industry effectively. The purpose of this paper is to establish project cost management in China and develop strategies with building information modelling. The study gives two plans to manage cost in construction industry depending on the BIM system. As the result, according to this source, the BIM system has improved the construction cost management industry. as shown in Table (1)

7. Research discussion and findings

7.1 Discuss methodology

The first reference depends on making interviews for five different size quantity surveying firm in Australia. Three of the firms were medium size with 20-30 employees and two others were large size with extra 30 employees. Four of the quantity surveying firms used BIM and determining quantity automatically while the other one used the traditional, manual way for the same reason. These two different working ways have good contrast in preparing the bill of quantity documents. Various types of questions were asked about quantity surveying with BIM and automated way.

Whereas the second reviewed reference is a scientific book which has a descriptive method style for exploring facts depending on 241 different references. This is about the effect of building information modelling and big data on construction cost management in different ways. The book was well divid

into ten sections, in three main sections, directly described the reducing construction cost in projects and in other sections the same matter was mentioned indirectly.

Table (1) Information about the reviewed references

Comparison	Reviewed reference (Smith, 2016)	Reviewed reference (Gao & Pishdad-Bozorgi, 2019)	Reviewed reference (Yin & Qian, 2013)
Type of reference	Research paper	book	Research paper
Publish year	2015	2019	2013
Reference title	Project cost management with 5D BIM	BIM and Big Data for Construction Cost Management	Construction Project Cost Management Based on BIM Technology
General content	Discovering the issues that engineering firms facing to recognize best procedure, strategies, and practice that firms are executing.	The effect of building information modeling and big data in managing industrial construction cost.	Establishing project cost management in China and developing strategies with building information modeling. Using the paper's result for improving construction cost management.
Methodology	This paper has been conducted based on an interview in Australia with Quantity Surveying firms.	Like every scientific book, this technology book has its specific writing.	In this study, the methodology is not discussed. The paper relies on the description in methodology.
future strategies	Changing BIM models, provide better construction data, improving collaboration between engineering staffs and as-build exciting building	BIM can be used from moveable computers, staffs working mor efficiency, detecting errors and clashes, and making more cost planning for the parametric and algorithmic concepts	This reference has not any expectation for the BIM future.
References	15 references have been used, including: books, formal websites and published papers.	The richest source is this book, depending on 241 different references, including: books, formal websites, and published papers.	This paper used only nine references, which are books, webs, and published papers.

The third reference did not discuss the methodology for the study in a dependent paragraph, and the study method depends on describing other references, as shown in Table (1). As the result, the first and the second have specific and clear method way of writing whereas the other is not clear in term of methodology.

7.2 Discussing citation and references

The first reviewed paper (Smith, 2016), consisted of eight pages relying on 15 sources in different categories such as a books, websites, and research papers. In addition, executing surveying in the field

made the paper richer relating to citing and references. The second reviewed reference (Gao & Pishdad-Bozorgi, 2019) with the 179 pages uses 241 different sources and consider the richest reviewed reference for getting information about our title. The last reviewed reference (Yin & Qian, 2013), is a paper with seven pages using only nine sources including books, papers, and websites. To conclude, the second reference is the richest one relating to the content and citing while the third resource used least sources.

7.3 discuss cost reduction results

In the first reviewed paper (Smith, 2016), the result of firm interviews showed the great impact of using BIM system on cost management and six important points mentioned to manage the project construction cost as the result of the surveying which affected on reducing cost. We abbreviate the main points in; (1) collaboration and making trust between project's staff, (2) this system generates accurate and valuable data in minimal time, (3) utilizes automated quantities for construction and avoiding manual errors, and (4) the 5D model creates a living project cost plan as the result cost decision can early make,

The second reference (Gao & Pishdad-Bozorgi, 2019) discussed the cost management more widely and discovered more benefits of BIM technology and its impacts on reducing cost comparing with two other sources. The book discussed the matter in a broad range. We summarized the results in these points. This system (1) is an effective way to enhance low productivity and can tackle with poor quality and extreme wasting material as well as overrun in project costs, (2) identifies the clashes and errors of architectural design and overcomes inherent problems by reducing fragmentation, (3) offers safety management, (4) expresses the design and construction idea to client by providing a reliable 3D model, (5) minimizes design and construction staff,(6) is efficient in the documentation and reducing shop drawing, and (7) reduces reworking and change orders.

The third reference (Yin & Qian, 2013) source contained limited information about impacting BIM on reducing construction building cost and discussed the matter briefly in some sentences. The results of the effect of BIM on reducing cost abbreviate in two main points: (1) exchanging information efficiently and provide a high level of collaboration, and (2) reducing cost thorough schedule and cost control.

7.4 Discuss future strategies in reviewed papers

The first and the second reviewed paper (Smith, 2016) and (Gao & Pishdad-Bozorgi, 2019) provide a significant part for future strategies and give insight for BIM technology improvements and its working way to make construction more accurate and reduce cost while the third reference does not take care about what is up-coming to BIM and its future and the reference has no prediction for this systems improvement.

The first reference discussed the future direction of this system and what is facing cost management by using building information modelling in terms of determining quantity. We summarized the paper's vision in these points: (1) In BIM atmosphere, models will change. This change has both advantages and disadvantages, In the same time Building information modelling standards will remain significant with a high level of clarity during all stages. (2) Clients will provide better construction cost data by quality surveying professionals through quantity take-off and automatic measurement models. (3) In the future, the modelling variance standards problem will continue for construction cost management, and this will lead to enhancing by improving collaboration between engineering staffs. (4) Building information modelling standards will remain significant with a high level of clarity during all stages and BIM system will be more important for as-build exciting building especially for renewal and large-scale building projects and modelling process will tie remote team.

The second reference contains a chapter for discussing BIM and quantity surveying and predicting a significant growth of BIM cloud and computational BIM. This is a great assistance to make quantity surveying which finally affects the cost-reducing in project construction. We discuss the book's predicting for BIM future briefly in these points: (1) BIM will spread efficiently due to Cloud BIM and professionals can use BIM from their moveable computers, and they can access the system for making decisions. (2) BIM will utilize real-time data which Engineers and contractors can work efficiently together and make the decision easily. (3) BIM will connect with cloud mobile features as result, errors and clashes can detect easily and anyone in construction site can access to the system and it is expected that BIM cloud adopts big information which quality survey needs. (4) BIM has the computational power, in the future; the system will allow making more cost planning for the parametric and algorithmic concepts and future analysis will be easier with BIM because this system supports data and can link with plug-in easily.

To conclude, the first and second reference discussed the developing of BIM technology in the future. This will impact in preparing the bill of quantity for projects which make projects spend less cost whereas the third reviewed paper has no expectation for BIM future.

8.Study gaps and Future recommendations

The reviewed references in this study explored many aspects of construction management related to reducing cost, but still there are many effects of BIM remain to debate and the reviewed sources did not discover. As the research gap we mention other BIM benefits for reducing building construction cost in brief points;

1. Using BIM technology for preconstruction and modular technology in project construction
2. BIM for (MEP) which includes mechanical, electrical and plumbing, rarely discussed in reviewed resources which are significant part of the system.

9.Conclusion

Computer-based BIM system is utilized for planning, designing, and construction. It has shifted the traditional, manual ways in managing project cost; reorganizing the engineering system into an automatic form; added 4D [time]; and 5D [cost] for designing and constructing. Searching excessively through the web and books relating to BIM and construction, it is concluded that reducing cost was worth to shed a light on. This paper gathered information from three different sources and tackles with cost management in construction projects under the light of significances of BIM technology. Analyzing, evaluating, and comparing the findings of the sources indicate that the utilization of BIM technology outnumbers the effects the manual, traditional ways previously used in cost management. It also highlights that this is system generate precise data automatically far from errors, omissions, and clashing in minimal time. As the results have predicted, in the following years to come, architects, engineers, and contractors emphasize the more utilization of this technology in a broader perspective so that they would control cost and time in the projects. For better understanding the BIM technology and its ultimate roles on construction, future studies could revolve around using modular and pre-construction in BIM system, and the effectiveness of mechanical, electrical and plumbing (MEP) in BIM on construction is highly suggested in future studies.

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