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Impact of BIM Technology on the Construction Project Management Process

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The complex process of Construction Project Management (CPM) is overwhelming because it involves many participants and multiple disciplines requiring vast information processing. In this context, Construction Project Managers benefit from all tools or models available to improve this process. Building Information Modeling (BIM) technology is one of the models gaining awareness in the construction industry. Its collaborative essence is one of the most appreciated benefits because it facilitates communication and collaboration between the project stakeholders. This study investigated how BIM technology enhances the CPM process to achieve project objectives more efficiently. The research began with a review of existing literature to identify the main characteristics of BIM technology, as well as the key factors that determine an efficient and effective CPM process. The researcher selected a quantitative survey methodology. An electronic questionnaire gathered data about CPM professionals' knowledge and experience regarding using BIM technology on projects. The analysis results indicated a positive relationship between BIM and CPM process. The research findings suggested that construction companies and professionals should consider adopting or expanding the use of BIM technology.

Key Words: Construction Project Management; Building Information Modeling Technology; BIM; Process; Improve; Enhance; Efficiently.

Introduction

The impressive growth of the construction industry has notably impacted the Construction Project Management method and procedures. Projects have not only become more extensive, but they are also more complex (Bryde, Broquetas, & Volm, 2013)due to the increased number of project stakeholders and the necessity of communication and collaboration to ensure the project's success. Furthermore, the Architecture, Engineering, and Construction (AEC) industry is increasingly linking the projects' success to the efficiency and effectiveness of project management. The Project Managers and their teams' responsibilities have been increasing to the point that the expectations have been reached unfairly toward the project managers. Fortunately, technology has been growing faster and developing new ways to solve these different problems by introducing new computer design models in the last two decades. Building Information Modelling (BIM) technology is one of the most accepted models

of use in the construction industry because it assists in all the different stages of the construction process (Bryde, Broquetas, & Volm, 2013). More optimism foresees that BIM's virtual design will allow designers to simulate a project before construction entirely (Bryde, Broquetas, & Volm, 2013). However, there is still a gap that construction professionals and stakeholders will need to fill to take real advantage of all BIM benefits. Therefore, there is a need to investigate how Building Information Modeling (BIM) technology could enhance the Construction Project Management (CPM) process to achieve the project objectives more efficiently.

This study begins the investigation with a literature review to understand better BIM technology characteristics and the main factors of an efficient project management process. The next step is to use this information to develop and distribute a short electronic survey questionnaire to construction professionals to gather information about their knowledge and use of BIM Technology on construction projects. The researcher uses a quantitative methodology approach to analyze the data and obtain responses and conclusions.

Literature Review

This research divided the literature review into three parts. The first part studied BIM technology concept, main characteristics, and implementation. The second part focused on the Construction Project Managers' competences importance on the Construction Project Management process. The last part reviewed the interconnection between BIM and the CPM process.

Building Information Modeling (BIM) Technology

BIM is a virtual application process popular in the construction industry because it allows project managers and stakeholders to collaborate in the entire project process. Introduced in the 1970s as the concept of virtual buildings, Building Information Modeling (BIM) technology has developed over the years. Despite all the time and research on the topic, experts have yet to agree on a clear definition of BIM (Xiao & Noble, 2014). While the market leader Autodesk defined BIM as the process of building an asset by piecing together, creating, and managing information, multiple authors have tried explaining BIM. Some researchers (Xiao & Noble, 2014) focused on BIM's collaborative and organizational nature and how it impacts project delivery. In contrast, others looked at it only as 3D modeling technology. Either way, to understand BIM technology better is necessary to identify its characteristics.

Experts agree that one essential characteristic is that BIM technology is a virtual process rather than a tool (Mesároš & Mandičák, 2017). For this reason, all parties involved need to share as much information as possible. This virtual process includes all projects' disciplines and systems, allowing all players to communicate, accurately work, and collaborate using one single model. (Ilozor & Kelly, 2012). Furthermore, after the completion of the project, all the parties can take advantage of the relationship created around the model and team up on future projects (Baoping, 2011). Recent findings agree that BIM is a trendy discussion topic, but its use rate is still meager (Mesároš & Mandičák, 2017). Researchers also agree that BIM is already well-established in the construction industry however, there are no evident changes in project management, possibly due to the lack of preparation for BIM and inexistent organizational support (Xiao & Noble, 2014).

Construction Project Management Process

Previous studies suggest that a positive relationship exists between project management process success and successful project managers' competencies. An effective Construction Project Management process requires managers, employees, technical resources, and even materials to follow a series of relative processes successfully (Mesároš, Mandičák, & Behúnová, 2022). Researchers and practitioners recently paid more attention to success in Construction Project Management (Carvalho Alvernanga, Rosa Branco, Azevedo Guedes, Pereira Soares, & da Silveira e Silva, 2019) also, some studies suggested that the order of the process influences the project's success. At the same time, several authors (Carvalho Alvernanga et al., 2019) have also discussed the personal and professional competencies or qualities that a Construction Project Manager should have to be considered successful. The list is long, unfair to fulfill and still growing. These competencies are evaluated typically very subjectively, with standards set by the industry, but usually determined by the supervisors of the Construction Project Managers evaluated. Hanna *et al.* (2018) highlighted that researchers agree that the evaluation needs to be more objective.

(Carvalho Alvernanga et al., 2019) presented an update on the discussion proposing downsizing the number of competencies to fewer, more relevant items. Their analysis identified eighteen competencies organized into seven groups: Leadership, Self-management, Interpersonal, Communication, Technical, Productivity, and Managerial. At the top of the list are the Leadership competencies, while Productivity and Managerial competencies, the most traditional competencies attributed to project managers, are at the bottom of the list. Since the Construction Project Management team, especially the Project Manager, is crucial in meeting the project's expectations and objectives (Hoseini, Ghannadpour, Noori, & Yazdani, 2019), Construction Project Managers should focus on the critical competencies list to improve their abilities and recognize their strengths and weakness (Hanna, Iskandar, Lotfallah, Ibrahim, & Russell, 2018). Furthermore, other researchers (Carvalho Alvernanga et al., 2019)emphasize that industry experts should review and update the Construction Project Management education and training to prepare Project Managers for the extensive competencies required in real-life projects.

Interconnection between BIM and the CPM process

The literature review indicated a positive interconnection between BIM and the CPM process impacting project success. Applying the Building Information Modeling (BIM) technology in the development and management of construction projects could solve some model and technological problems of traditional management (Baoping, 2011). In order to make this process effective, project managers should establish BIM technology as the core component of the CPM process of the information, communication, and collaboration of the project (Baoping, 2011), from planning to construction operations. Not only during the construction but even after its completion (Ge, Gao, Mo, & Peng, 2021)**.** The main reason for implementing Building Information Modelling (BIM) Technology in the architecture, engineering, and construction (AEC) industry is to efficiently maintain the project management three-way relationship of scope, cost, and time (Van Tam, Quoc Toan, Phong, & Durdyev, 2021).

BIM technology researchers agree that BIM is an appropriate process for management that project managers should consider implementing in their projects. Working with this concept could contribute to various aspects of project management and help achieve the goals more efficiently (Hoseini et al., 2019). Recent findings have shown that there are still some difficulties and challenges that professionals and companies must face in implementing BIM appropriately. One of them is training

and education. Xiao and Noble (2014) concluded that Project Managers who understand how to bring BIM's functions and benefits to the project could become the key player.

Methodology

The study used a survey method to collect demographics and information on knowledge, experience, and thoughts from the participants about using BIM technology on construction projects. The researcher developed a cross-sectional survey instrument using a simple web-based tool, ®Qualtrics. The questions were formulated from this study's research questions and objectives and the findings of existing literature related to the topic. The survey questionnaire, which included 20 open and closed questions, was distributed in April 2023 via e-mail and LinkedIn. This study's survey instrument used a multiple choice, five-point Likert scale with various labels to engage with participants. Researchers from different disciplines, including Construction Management, have used Likert scales when conducting research studies (Jebb, Ng, & Tay, 2021). The researcher used a quantitative research methodology approach to conduct the data analysis. The survey instrument was subjected to statistical best practices using statistical application software to test reliability and validity scores. The research used Cronbach's Alpha test to determine the reliability of the survey questions. The researcher also used the Pearson bivariate correlation to assess the association between questions to assess the validity of the survey questions. After testing the reliability, validity, and normality, the author organized and analyzed the questionnaire responses to identify patterns, evaluate the current conditions, and explore facts.

Data Analysis and Results

This research study examined the positive impact of BIM technology on the construction project management process. The study used primary data from a survey distributed to construction professionals receiving twenty (20) responses. The survey instrument was subjected to statistical best practices using statistical application software to test reliability and validity scores. The research used Cronbach's Alpha test to determine the Reliability of the survey questions. Vogt Paul (2007) considered values Cronbach's Alpha test of 0.7 or higher satisfactory for most purposes. This study's Cronbach's Alpha Reliability Test results (Table 1) show values higher than 0.7, suggesting that the Likert-scale questions are reliable and internally consistent. The researcher also used the Pearson bivariate correlation to assess the association between questions to assess the validity of the survey questions. The results indicated that the correlation for each question is significant at the 0.05 level (2-tailed), confirming the validity of the survey instrument.

Table 1. Cronbach's Alpha Reliability Test

All Likert questions Reliability Statistics		**Project Management Questions Reliability Statistics**		**BIM questions Reliability Statistics**	
Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items
.914	16	.712	6	.891	10

The quantitative analysis of the demographics' critical questions, as shown in Figure 1, concluded that of the total of the twenty participants in this study's survey, fifteen participants were Construction Project Managers, two Architects, two Engineers, and one a Project Manager.

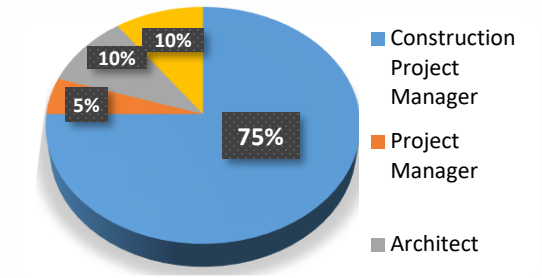

Figure 1. Participants' work specialization

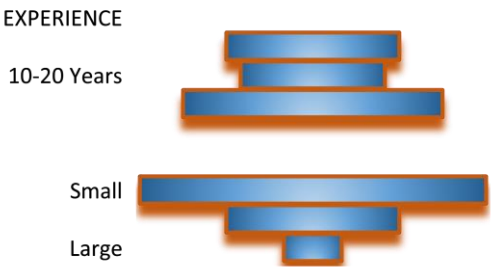

Figure 2. Years of experience and company size

The findings indicated that most participants (45%) have over twenty years of experience, 30% have 1 to 10 years of experience, and 25% have 10 to 20 years of experience. At the same time, it shows that twelve (12) of the twenty (20) participants in this survey work in small size companies, and only two worked in large companies. The demographics also explored which types of BIM software the 20 construction professionals prefer and their BIM expertise. The results (Figure 3) show that Autodesk-Revit is the most commonly software used by the participants, and their level of expertise is mostly average. Also, some participants mentioned project review software such as MicroStation and Navisworks, while others claimed not to be familiar with BIM. The study also revealed that 65% of the participants work or have worked with BIM on various projects. Figure 4 also shows that all of them had extremely or somewhat satisfied experiences working with BIM and that 16 (80%) of the total participants agreed that large-scale projects benefit more from BIM.

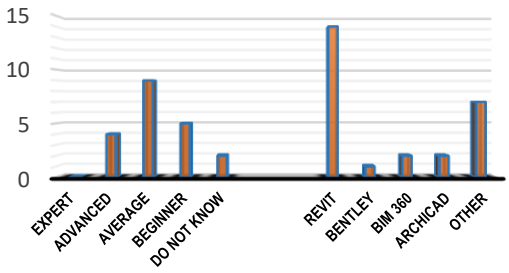

Figure.3 BIM software knowledge and use

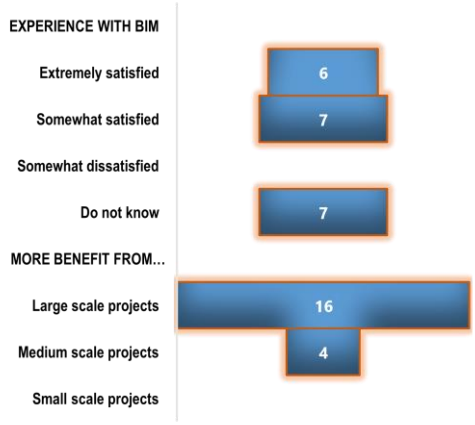

Figure 4. Participants' experience with BIM

The survey questioned professional participants about their opinion BIM impact and benefits on the Construction Project Managers productivity and Construction Project Management process compared with traditional methods. The results in Figure 5 below show mostly affirmative responses.

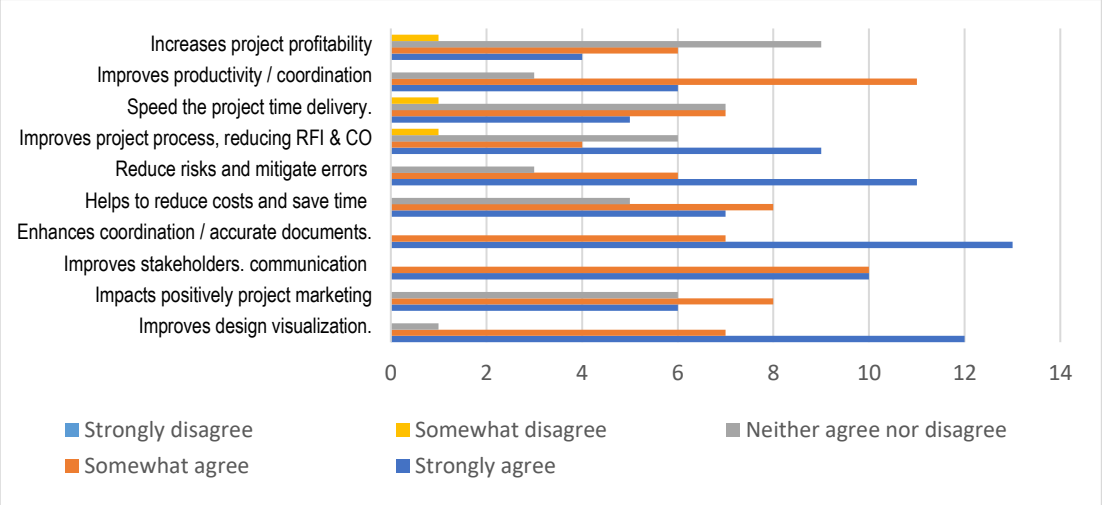

Figure 5. BIM impact and benefits

Participants agreed that the best benefit of BIM is that it could enhance project coordination and produces accurate documents. They also agreed that BIM could improve design visualization, refining the relationship between Owner and Designer as well as stakeholders' communication. Another recognized benefit of BIM is that it could help reduce risks and mitigate errors. Respondents also believe that BIM could reduce the number of Requests for Information (RFIs), and Change Orders would improve the project's process and help reduce costs and save time. In reference to project profitability most participants are not convinced that BIM could help to increase profits.

Construction professionals also provided feedback about why companies and project managers would adopt or not adopt BIM technology on their projects. (Figure 8) The responders agreed that the main reason for adopting BIM was to obtain better and more accurate construction documents and project visualization. In second place was better multiparty communication and coordination followed by better operations processes, fewer productions of change orders and RFI's, and increased productivity. At the bottom of the list are potential project profitability and the delivery time cycle reduction.

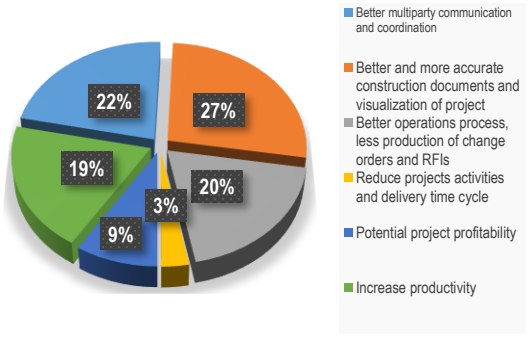

Figure 8. Companies adopt BIM technology

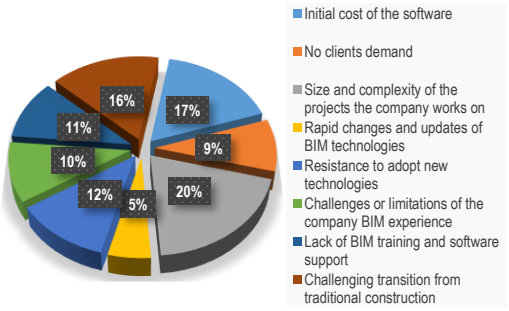

Figure 9. Companies would NOT adopt BIM

On the other hand, the reasons for not adopting the use of BIM vary from the size and complexity of the projects the company works on to rapid changes and updates of Building Information Modeling (BIM) technology. Respondents, as shown in Figure 9, also include the initial cost of the software,

challenges in the transition from traditional construction, limitations of the company BIM experience, lack of BIM support and training, and the fact that there are no clients' demands for BIM usage. Regarding the future of BIM in the construction industry, the survey asked respondents if they think the use of Building Information Modeling (BIM) technology will become more widespread and if companies should offer training and support their employee's needs to use BIM effectively; 85% responded positively.

This research used a statistical application to test the Normality of the dependent-related questions with a 95% confidence interval using Kolmogorov-Smirnov and Shapiro -Wilk tests. In Table 2, the result suggested that the dependent-related survey data is likely normally distributed.

Table 2. Normality Test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CPMP	.184	20	.075	.948	20	.343

a. Lilliefors Significance Correction

Both tests show a p-value greater than 0.05. As a result, the researcher could use parametric for the statistical analysis. The correlation results determined by the Pearson Correlation Test (.850), Table 3, showed that the relationship between the dependent and independent variables is statistically significant ($p < 0.001$). Therefore, sufficient evidence supports that BIM positively affects the Project Management process.

Table 3. Pearson Correlation Test

		CPMP	BIM
Pearson Correlation	CPMP	1.000	.850
	BIM	.850	1.000
Sig. (1-tailed)	CPMP	.	<.001
	BIM	.000	.
N	CPMP	20	20
	BIM	20	20

This study also used the Single Linear Regression Model to identify a linear equation to represent the relationship between the dependent and independent variables to determine if BIM could predicts a positive impact on the Construction Project Management Process. The Model Summary (Table 4) results indicated a highly positive relationship between the dependent and independent variables ($R = 850$). Also, the R^2 suggests that 72.2% of the variance of the dependent variable could be explained by the independent variable, which denotes a good fit for the model.

Table 4. Model Summary Table

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.850[a]	.722	.706	.25607	.722	46.729	1	18	<.001

a. Predictors: (Constant), BIM

b. Dependent Variable: CPMP

The results in Table 5, ANOVA, and Table 6, Regression Coefficients, show that the BIM could enhance the Project Management process, and their relationship is statistically significant.

Table 5. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.064	1	3.064	46.729	<.001[b]
	Residual	1.180	18	.066		
	Total	4.244	19			

a. Dependent Variable: CPMP

b. Predictors: (Constant), BIM

Table 6. Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.972	.481		2.022	.058					
	BIM	.780	.114	.850	6.836	<.001	.850	.850	.850	1.000	1.000

a. Dependent Variable: CPMP

Conclusion

Even though the sample size is small, the findings of the pilot study of this research study provided evidence to suggest that Building Information Modeling (BIM) technology could enhance the Construction Project Management process, achieving project goals more effectively. However, this research would help to get exploratory results to expand the construction industry's significant sample size. This survey results established that the construction professionals' respondents agree that BIM enhances collaborative teamwork, owner and designer relationships, and stakeholders' understanding. The use of BIM also increases the accuracy of budgets and schedules. The participants responded affirmatively concerning the productivity increase when using BIM compared to traditional methods. Furthermore, 85% agreed that BIM enhances project managers' ways to plan, organize and execute projects, and responders agreed that BIM helps improve job site performance. Despite all this positive feedback and the understanding that adopting BIM in their companies could improve their work, participants have several reasons for not implementing it. These motives vary from the cost of BIM to the challenges of a continuously changing technology that requires training and owners' and players' engagement. In any case, BIM is finding its place and will become more spread in the construction industry. Therefore, construction professionals, especially Construction Project Managers, should focus on engaging the project team members to learn and exploit BIM, helping companies to see the growing opportunities through collaborating with a more effective multi-disciplinary team. Future research opportunities could focus on reducing the gap between technology and the application of BIM in construction projects.

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