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BUILDING INFORMATION MODELLING (BIM) FOR PROJECT PLANNING: MEASURES TO IMPROVE ITS ADOPTION

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ABSTRACT

The Architecture Engineering and Construction Industry (AEC) uses Building Information Modelling (BIM) to simplify and enhance sustainability in construction projects. The industry experiences difficulties in achieving project success globally and nationally due to insufficient planning. Technology is required to address this issue by incorporating it into the project planning phase. Therefore, BIM is considered the necessary tool to bridge this gap. This research aims to examine the advantages of implementing BIM during the project planning stage of construction projects. To gather data, a quantitative research approach was employed, and professionals in the South African built environment were surveyed using a questionnaire. The data collected were analysed using descriptive and inferential analysis. Findings from the analysis discovered that the top three measures to improve BIM implementation for project planning in the construction industry are competitive advantage, cost and time savings, and collaboration among AEC professionals. The research concluded that these measures could encourage the adoption of BIM among construction professionals in South Africa.

KEYWORDS

BIM, built environment, collaboration, management, project planning.

INTRODUCTION

Various authors such as Adekunle et al. (2022a), Demirkesen & Ozorhon (2017) and Akinradewo et al., (2021), had submitted that professionals in the AEC community are not accustomed to collaboration. Sakikhales & Stravoravdis, (2017) noted that this is the case even in the early stages of a project. During the project planning stage, architects, engineers, and contractors work individually which eventually leads to double handling of some activities. Requests for Information (RFI), stagnation of work as drawings gets finalised, plant hired not being utilised all adds to the cost of a project (Azmy, 2012). Innovative technologies such as building information modelling (BIM) which has been adjudged to be effective in construction project management can be useful in this regard (Akinradewo et al., 2022). Although, Wang &

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Chien (2014) discovered that BIM is widely used for visualisation and simulation of construction project. However, countries like the United Kingdom (Gledson, 2016) and United Arab Emirates (Mehran, 2016) are benefitting from BIM usage heavily due to its implementation in the early stages of the construction project. This saw BIM moving away from being a visualisation and simulation software to being used as a design and project planning tool.

Traditionally, each member in the construction industry looks out for their best interest (Hardin and McCool, 2015). The incentive for the assessment of BIM in project planning provides the building blocks which may provoke unification of AEC members. Technology is constantly evolving through updates and BIM is no different (Migilinskas, et al., 2013). Sakikhales & Stravoravdis (2017) stated that to effectively use BIM, it must be implemented in the early stages of the project life cycle. Project initiation and planning are regarded as the most crucial stages in a project life cycle by the authors, and they further explain the importance of integrating agile project management during these phases to realise profound results of ensuring quality is met during the planning phases. According to the Project Management Institution, a project life cycle has five stages (Akinradewo et al., 2022a). These five stages are project initiation, followed by project planning, followed by project execution, followed by project monitoring and control, and the last stage is project closure. Furthermore, Hardin and McCool (2015) agreed with this notion and suggest that to fully leverage BIM and its tools, the industry must adopt a modernised and collaborative project delivery method. While there are various studies carried out on BIM usage in the construction industry, majority of these studies focused on the adoption but not specifically on the applicable stages of its adoption. This research work presents a novel contribution to the field of construction by evaluating measures to improve the implementation of BIM in the project planning phase of construction projects. This research has not been carried out before in the research study area being a developing country with limited capacity to fully adopt BIM for construction projects. This is envisaged to help promote the awareness of BIM and how it is useful in achieving construction projects to time, cost, quality in an efficient manner.

BIM FOR CONSTRUCTION PROJECT PLANNING

The spread of an innovation, such as BIM, is dependent on methods to increase its growth after its initial acceptance. Implementing BIM necessitates a technical dramatic transformation in both developed and poor countries (Migilinskas, et al., 2013). Almost every step of the planning and design process can now be done digitally, with data being transferred and shared in a standardized digital format. Recent years have seen an increase in the proportion of data handled by BIM software. BIM is revolutionizing the AEC and the way buildings are built (Turka & Klincb, 2017). In a bid to promote the implementation of an innovation, Olarewaju & Ibrahim, (2020) outlined a requirement for positive and constructive policies as the driving force behind the construction industry due to the possibility for improved economic growth in their study. Adoption of BIM necessitates strategy, therefore, planning and coordination needs the use of these tactics. The challenges associated with design management and project delivery, as pointed out by Senthilkumar and Varghese (2013), have led to the adoption of BIM. BIM challenges existing methods like on-site modifications, project delivery approaches, and lack of standardization. BIM promotes the use of standardized “objects” and pre-fabrication, as noted by Davies et al. (2015). During the design stage, BIM transfers power upstream and reduces variation on the construction site, leading to a more uniform outcome. Altering the project managers traditional role in the process (Sakikhales & Stravoravdis, 2017).

According to Wibowo (2009) and supported by Adekunle et al. (2022b), the construction industry’s economic importance stems from the fact that it benefits multiple parties involved, resulting in a snowball effect that contributes to overall economic growth. Hence, Odubiyi et al. (2019) discovered that embracing BIM within the parties involved in the supply chain is key factor in stimulating the acceptance of BIM in the industry. Akinradewo et al. (2022b) highlighted that the public sector is the largest client for the construction industry in any given country. As Wong et al. (2010), Smith (2014), and Davies et al. (2015) noted, governments in countries such as the USA, UK, and Scandinavia can mandate the use of BIM to increase its adoption. Additionally, the private sector plays a vital role in creating new business techniques and opportunities (Akinradewo et al., 2021). Therefore, a collaborative effort between the public and private sectors, as proposed by Odubiyi et al. (2019), could promote greater adoption of BIM. Although Building Information Modeling (BIM) Level 2 has been widely adopted, there are still some indications that SMEs are slow to adopt the technology. Because of the delay in adoption, small and medium-sized enterprises (SMEs) in the public sector now face a competitive disadvantage (Awwad, et al., 2020).

Smith (2014) outlines that the possibility of BIM success is more likely when the client drives the implementation. NBS, (2020) reported a lack of customer demand being the most prevalent hurdle in the implementation of BIM. The report further stated that the client plays a substantial role in data management environment, associated with BIM. This prompts the need for more research since the available research does not focus on how to incentivise the client. According to Windapo and Cattell (2013), the construction sector contributes to economic growth, job creation, innovation, and business opportunities while enhancing the quality of life for its customers.

To operationalise the identified measures to the improve the implementation of BIM for Project Planning, Table 1 highlights the identified variables and their sources. These articles were extracted from SCOPUS database using the following keywords: "BIM" AND "Project Planning", "BIM" AND "Project Management", and "BIM" AND :Planning". This search yielded 47 documents but only 42 were accessible and therefore adopted for this study.

Table 1: Identified variables for measures to improve the implementation of BIM for Project Planning

S/N	Measures to Improve	Authors
1.	Policy	Sibiya, Aigbavboa, Thwala, (2015); Olarewaju & Ibrahim, (2020)
2.	Agile Project Management	Senthilkumar & Varghese (2013), Davies et al. (2015); Sakikhales & Stravoravdis, (2017)
3.	BIM Requirements for construction supply chain	Wibowo, (2009); Odubiyi et al. (2019)
4.	Government Intervention	Gerbert et al. (2016); Davies et al. (2015)
5.	Private Sector Intervention	Succar (2009); Odubiyi et al. (2019)
6.	Increase BIM Awareness	Froise & Shakantu, (2014)
7.	Subsidies for SME's	Awwad, Shibani & Ghostin, (2020); NBS, (2020)
8.	Client Incentivisation	Smith, (2014); NBS, (2020); Windapo & Cattell, (2013)
9.	Adoption of BIM standards	Awwad, Shibani & Ghostin, (2020)

RESEARCH METHODOLOGY

The objective of this study was to contribute to the existing knowledge on the effective implementation of BIM in the early planning stages of construction projects, using a quantitative research methodology. Quantitative research is useful for gathering data from a significant population and providing numerical measurements of specific aspects of phenomena. The study surveyed quantity surveyors, project managers, engineers, construction managers, and architects in the Gauteng province of South Africa using a pre-designed questionnaire with a 5-point Likert scale in two sections. The first section extracted information about the respondents' demographics in which three questions were asked. The second section focused on the identified latent variables to measure the benefits. In total, four questions were asked in the close-ended questionnaire. The choice of Gauteng province was because it houses the majority of the professionals within the country who are adopting modern technologies for construction activities. 189 questionnaires were randomly distributed to professionals within the study area between September and November 2022, and 167 questionnaires were recovered totalling 83% response rate. All the questionnaires recovered were deemed to be suitable after being reviewed for completion. The Mean Item Score (MIS), Standard Deviation (SD), and Exploratory Factor Analysis (EFA) were used to analyze the data obtained from the questionnaire. The reliability coefficient of the data collection instrument was determined using Cronbach's alpha, with a cutoff alpha of 0.70. The analysis revealed a coefficient of 0.91, indicating high reliability of the retrieved data.

FINDINGS AND DISCUSSION

According to the findings from the analysis conducted, majority of the respondents work at a consultancy firm with the data indicating a total of 48% while professionals working with contracting firm are 28% of the population sample. Also, tertiary students and government employees both make up 12% each. The most common qualification among respondents was the bachelor's degree (32%). In second place were Bachelor Honour's degree (28%) and Diploma (28%). Highest qualification possessed by the respondents was the master's degree (12%). An overwhelming majority of the respondents have worked for 0-3 years (60%), this indicates that the population sample is quite young in the industry, followed by 4-8years of experience (28%) while 8% of the sample has 9-15 years of experience. Only 4% of the respondents have worked for more than 15 years. This is an indication that the respondents possess above average knowledge to provide tangible answers to the research question.

Table 2 captures measures to improve the implementation of BIM for project planning in accordance with the opinion of the respondents. The highest ranked measure is Training workshops for BIM (MIS= 4.48, SD= 0.823), followed by Introduction of faster hardware and software (MIS= 4.32, SD= 0.802), in third there is tie between top management support (MIS= 4.28, SD= 1.208), and Increase BIM awareness (MIS= 4.28, SD= 1.137), in fifth the need to make BIM more user friendly (MIS= 4.20, SD= 0.913), was expressed by the respondents. The last five ranks are occupied by Shift to a collaborative project delivery method (MIS= 3.80, SD= 1.118), Adoption of BIM standards (MIS= 3.88, SD= 1.269), Client Incentivisation (MIS= 3.68, SD= 1.376), Subsidies for SME's (MIS= 3.60, SD= 1.323), and Altering project management role (MIS= 3.12, SD= 1.364) respectively.

Table 2: Ranking result of measures to improve the implementation of BIM for project planning

Measures	Mean Item Score	Std. Deviation	Rank
Training workshops for BIM	4.48	0.823	1
Introduction of faster hardware and software	4.32	.0802	2
Top management support	4.28	1.208	3
Increase BIM awareness	4.28	1.137	3

Make BIM more user friendly	4.20	0.913	5
Introducing Policy that encourage BIM usage	4.16	1.106	6
Raising BIM benefits awareness	4.08	1.038	7
Making BIM a mandatory requirement to construction supply chain	3.96	1.172	8
Government Intervention	3.88	1.269	9
Private Sector Intervention	3.88	1.301	10
Shift to a collaborative project delivery method	3.80	1.118	11
Adoption of BIM standards	3.76	1.332	12
Client Incentivization	3.68	1.376	13
Subsidies for SME's	3.60	1.323	14
Altering project management role	3.12	1.364	15

In addition, the collected information underwent exploratory factor analysis to identify how the variables were related based on the participants' opinions. The findings indicated that the KMO measure of sampling adequacy was 0.607, which is an acceptable value for conducting factor analysis since it is greater than 0.6. Bartlett's test of sphericity also produced 0.000 significant value, indicating the degree of multivariate normality of the distribution set. The total variance of the measures to improve the implementation of BIM for project planning revealed four components which had eigen value of above 1 namely (5.238, 2.429, 1.601, and 1.424). The components eigen value defined the 34.922%, 16.193%, 10.677%, and 9.496% respectively of the variance which indicates 71.288% of the total variance of the data set. The requirement that the combined proportion of variance in the extracted components should be 50% has been met, indicating that the four sets of factors can sufficiently represent the views of experts in South Africa. The research employed PCA-based factor grouping and direct oblimin rotation. Table 3 presents the pattern matrix which highlights how the factors have been clustered together.

Table 3: Exploratory factor analysis pattern matrix for measures to improve BIM implementation for project planning

	Component			
	1	**2**	**3**	**4**
Client Incentivization	0.859			
Subsidies for SME's	0.664			
Private Sector Intervention	0.557			
Government Intervention		0.867		
Top management support		0.805		
Making BIM a mandatory requirement to construction supply chain		0.776		
Training workshops for BIM		0.680		
Raising BIM benefits awareness		0.500		
The need for faster hardware and software			0.919	
Make BIM more user friendly			0.888	

Increase BIM awareness		0.539	
Introducing Policy that encourage BIM usage		0.491	
Altering project management role			0.821
Shift to a collaborative project delivery method			0.775
Adoption of BIM standards			0.617
KMO Value			0.607
Bartlett's TOS result	Chi-Square value		197.772
	Degree of freedom		105
	Sig.		0.000

Based on the opinion of the respondents, the clusters were named thus.

Component 1: Economic Stimulus Measures. BIM can help businesses and governments save money and be more productive by facilitating the timely completion of projects. As a result, the construction and technology industries stand to grow, and more people will find employment as a result.

Component 2: Implementation Initiatives. Efforts to implement BIM software in the building sector are becoming increasingly vital. Through the implementation of cutting-edge technological methods, these endeavours hope to boost teamwork, accelerate workflow, and finalize projects with better results. The construction industry is pushing for the widespread use of building information modelling (BIM) through a combination of government intervention, executive buy-in, mandated requirements, and educational events like workshops.

Component 3: Adoption and Promotion Efforts. The expansion and improvement of the building sector will be impossible without the widespread use of and enthusiasm for Building Information Modelling (BIM). Making BIM more accessible to the general public, spreading the word about its many advantages, and enacting policies that promote its use are all initiatives with the same goal in mind. BIM can significantly boost project outcomes and fuel economic growth by fostering better collaboration and cutting down on inefficiencies.

Component 4: Implementation in Project Delivery Processes. The use of Building Information Modelling (BIM) is critical to the success of today's project delivery methods. Project management is different now than it was before the widespread adoption of BIM standards and the move toward collaborative project delivery. By simulating and visualizing building projects in real time, BIM helps architects, engineers, and contractors head off major problems before they arise, saving valuable time and money.

Notably from the clusters is that some clusters like component 1 are well defined based on the variables that makes up the component, while the other clusters suggest that the needs are systemic and highly interrelated. This is allowed in EFA depending on the responses retrieved from respondents (Osborne & Costello, 2009). The findings of the measures to improve the implementation of BIM aligns with the opinion of authors in the body of knowledge. For instance, Davies et al. (2015) opined that it is widely regarded that government involvement is a key measure to improve the implementation of new technologies. Consequently, the findings of this study also ranked government intervention highly. Similarly, Odubiyi, et al., (2019) identified that making BIM a mandatory requirement to construction supply chain, will aid in the uptake of the software which also aligns with the findings of this study. Even though integrated project delivery method was identified as integral to the usage of BIM for project planning, respondents ranked it as the one least measure to increase BIM uptake for project planning. These findings are suggesting the need for education for BIM because most of the highly ranked measures are related to an investment into R&D. To increase awareness, people either have to see or hear about it. Respondents unequivocally agree that training workshops are an important measure to the implementation of BIM. Hence, education is key to ensure the longevity of BIM. Prominent companies, stand to gain the most from BIM for project planning as reported by Gledson, (2016) and Wang & Chien, (2014) who stated that BIM is more mature as a pre-construction design tool. However, as the biggest client, the government's involvement is required as well.

CONCLUSIONS

BIM is a technology that is getting much popularity among professionals in the construction industry. BIM enhances collaboration, planning, design, and project management. However, the widespread adoption of BIM is a challenging process, as it requires the industry to standardize its practices and information. Consequently, the support and involvement of both the public and private sectors are crucial to the success of BIM. The government, as the construction industry's biggest client, has a pivotal role in promoting the adoption of BIM, while the private sector drives its advancement by developing innovative business practices and opportunities. This study aims to evaluate measures to improve the implementation of BIM in the project planning phase of construction projects. The study used a quantitative research approach, employing a questionnaire survey to collect data. The data was analyzed using both descriptive and inferential analysis. The findings from the analysis revealed that training workshops, improved hardware and software, and top management support are the primary measures to enhance BIM's adoption for project planning. Based on the respondents' opinions, the study identified four main components of measures: Economic Stimulus Measures, Implementation Initiatives, Adoption and Promotion Efforts, and Implementation in Project Delivery Processes. The study concludes that there is a consensus on the importance of various measures to improve BIM's implementation in the construction industry. The findings align with previous studies emphasizing the importance of education and investment in research and development to promote BIM's usage. The study recommends that the government must be involved in promoting BIM's adoption, and professionals in the industry must be engaged in workshops and training. The study is limited to professionals in the Gauteng province of South Africa, and further research is required to get a more general opinion from professionals across South Africa.

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