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Assessing Factors Affecting Building Information Model Usage Among Professionals in the Construction Industry

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Abstract

BIM is a cooperative approach utilising a computer-generated model to coordinate and manage information throughout the project life cycle. However, BIM usage among construction professionals is affected by different factors toward reducing wastage in the construction processes and operations. This study evaluates the factors influencing BIM adoption among construction industry professionals. To gather data, structured questionnaires were administered to a sample of 70 construction professionals in Gauteng province, South Africa, using systematic random sampling techniques, with a focus on identifying key factors impacting BIM utilisation in the industry. The questionnaire data were analysed using descriptive statistical methods. A statistical equation was employed to calculate the study's valid mean item score. The result of the study showed that lack of investment in BIM tools, lack of personnel training, high cost, and lack of basic BIM knowledge were the highest-ranked factors affecting BIM usage among professionals in the construction industry. In conclusion, the study established that professional bodies within the construction industry should train their members on the importance of using BIM tools for their construction processes and operations. It also indicated that the government should increase awareness of the use of BIM among construction professionals through ministries, departments, and agencies (MDAs).

1. Introduction

Eastman [1] postulates that BIM is a digital methodology that supports the development, organisation, and utilisation of data-driven models throughout the various stages of a project's life cycle, from initial planning and design through construction, operation and eventual decommissioning[2] postulates that the main purpose of adopting and using BIM in construction industries was to resolve issues faced within construction realm, such as low productivity, cost overruns, drastic competitiveness, ineffective communication, etc. BIM does not only look at the carrying out of 2D designs but also gives birth to other design processes that allow them to be carried out in 3D, 4D for programming and scheduling functions, and 5D for cost estimating purposes [3]. It makes construction professionals' work much easier [4].

The construction sector is in high demand; thus, it is essential to introduce new digital technologies for the construction process and operation [4]. The introduction of BIM has brought many changes in the construction industry in the past decades [4]. [4] posits that many challenges come with its adoption and usage among professionals within the construction industry [4]. [5] noted that BIM Usage is very costly and requires a lot of

practice among users, including construction professionals, before its adoption and usage for professional usage. In the construction process and operations, the usage of BIM is in the early stages of construction work [6]. Construction planners and designers in the early stage of the construction process use BIM tools like ArchiCAD and Revit to ensure that the design produced is suitable for specific work [6].

However, the benefits of BIM are used for construction processes and operations in construction projects among construction professionals. To keep pace with global trends, the South African construction industry (SACI) must establish an effectual construction process that leverages BIM for improved project effectiveness. Therefore, this study aimed to examine the factors influencing BIM adoption among professionals within SACI.

2. Literature Review

The application of BIM is increasingly crucial in SACI, where there is a need for improved efficiency, accuracy, and cost-effectiveness in project delivery [7]. The construction sector in South Africa faces challenges such as limited resources, high project costs, and delays, all of which can be mitigated by adopting BIM practices [8]. BIM enables better collaboration, reduces project documentation errors, and enhances building lifecycle management, which is essential in a developing context [9]. Furthermore, the global shift towards digital construction highlights a competitive gap in SACI. By understanding the factors affecting BIM adoption, stakeholders can implement strategies to overcome barriers, increase adoption rates, and fully leverage BIM's potential to transform the construction landscape [10]. Identifying these challenges is essential, ultimately helping foster a more sustainable and efficient SACI [8, 9].

Professionals in developing countries' construction industries have not efficiently adopted and used BIM for their construction operations and processes due to different factors [10]. One factor affecting BIM usage for construction processes is the willingness to invest in BIM adoption [10]. There is also a lack of motivation toward BIM adoption [11],[12]. The major barrier to using BIM among construction professionals is the insufficient involvement of stakeholders in BIM adoption and investment [13]. There is also a problem of BIM complexity and lack of professional knowledge and training [14]. The lack of involvement of professional bodies and lack of government agencies' involvement also contributes to the low usage of BIM among professionals [15]. [16] submitted that the usage of BIM, among other innovative technologies and tools among professionals, is affected by the lack of awareness and increased liabilities in usage. [17] argues that the resistance of different professionals to join forces, the lack of a legal system, and the lack of collaborative working processes make it impossible for BIM to work at its best among construction professionals. [18] & [19] asserts that issues such as cost, lack of highly skilled personnel, and low client demand for BIM usage in construction operations. [20] sustains that the poor usage of BIM in the SACI is due to the lack of knowledge regarding BIM and the lack of skills and government support.

[21] noted that BIM is a complicated process and requires proper handling and understanding. [21] concluded that BIM's complexity also contributes to the low usage of BIM among professionals. BIM requires well-trained personnel to produce better results since it creates large file systems [22]. [22] noted that the lack of proper training on BIM application for construction processes and operations affects the better understanding of its usage among construction professionals. [23] postulated that the complexity of BIM usage in the construction industry has led to construction professionals' unwillingness to learn BIM tools and usage. [24] noted that BIM usage among professionals is affected by the level of risks and who will be responsible for the risks. The ambiguity of legal culpability among the stakeholders affects its usage among construction professionals [22]. [25] sustains that BIM usage is also affected by contractual constraints among construction stakeholders.

3. Methodology

This study was conducted in Johannesburg, Gauteng province in South Africa, among construction professionals using emerging technologies and tools such as BIM for their construction processes and operations. The respondents were chosen because of their professional knowledge and experience in using BIM for their construction projects within the Gauteng Province. Gauteng province was chosen for this study due to the high number of active construction projects, both government and private, where industry professionals utilise BIM. A total of 85 questionnaires were distributed to participants using a systematic random sampling approach, with 70 complete questionnaires returned. This sampling method was selected for its simplicity, directness, and ability to minimise clustering, as noted in previous studies [26], [27]. The method also ensures even coverage of all elements [28]. The questionnaire, formatted on a 5-point Likert scale, achieved a 72% response rate, aiding the assessment of factors influencing BIM usage among South African construction professionals. Descriptive statistical tools, including Mean Item Scores (MIS), were used to analyse participant responses. According to [29], mean scores are valuable in descriptive research as they indicate the average rating given by participants on specific measures.

4. Results

The study shows that 54% of the respondents had a bachelor's degree, 34% had an honour degree, while a master's degree and a national diploma both have 7%. Moreover, 38.6% were quantity surveyors, followed by construction managers with 21.5%, 17.1 were engineers, 15.7% were construction project managers, and 2.9 % were architects. Town planners, real estate developers, and contractors account for 1.4% of the total respondents. Additionally, 68.6% of the respondents had an experience in the construction industry that ranged from 0 – 5 years, 17.1% had an experience that ranged from 5 – 10 years, 10% had an experience that ranged between 10 – 15 years, and 4.3% had experience ranging between 15 – 20 years. Also, 34.3% of the respondents worked for contracting firms, 25.7% for consulting firms, 24.3% for private organisations, and 15.7% for government.

Table 1 illustrates the respondents' ranking of factors affecting the usage of BIM among professionals in the SACI using a five-point Likert scale of 'Strongly disagrees' to 'Strongly agree' on the questionnaire. The result reveals the top and low-ranked factors affecting the use of BIM among the professionals within the SACI, and they include; 'lack of investment' with a mean $\bar{x}$ of 4.02 and a σX of 1.012, which was ranked first, 'inefficient involvement of stakeholders' and 'lack of trained personnel' both ranked second with a mean $\bar{x}$ of 3.96 and σX of 1.109 respectively; 'costly to put into motion; and 'lack of knowledge' were both ranked number four with a $\bar{x}$ of 3.94 and σX of 1.128; 'lack of government support' was ranked the sixth with a $\bar{x}$ of 3.93 and σX of 1.012. Table 1 further reveals the remaining fourteen factors in which 'lack of highly skilled personnel' and 'BIM complexity' were both ranked number seven with $\bar{x}$ of 3.89 and σX of 1.174, followed by 'client's low demand of BIM in their projects' ranked number nine with $\bar{x}$ score of 3.87 and σX of 0.962; 'contractual constraints' and 'lack of awareness' were both ranked tenth with a $\bar{x}$ of 3.83 and σX of 1.021 respectively; 'support from the legal system' and 'lack of professional bodies support' were both ranked twelveth with a $\bar{x}$ of 3.81 and σX of 1.171. Further, Table 1 reveals the remaining six factors in which 'lack of motivation' was ranked fourteenth with a $\bar{x}$ of 3.79 and σX of 1.203; 'Lack of collaborative working processes' was ranked fifteen with a $\bar{x}$ of 3.77 and σX of 1.119; 'The amount of willingness' was ranked sixteenth with $\bar{x}$ of 3.76 and σX of 1.069; 'increased liability' was ranked number seventeen with a $\bar{x}$ of 3.60 and σX of 1.197; 'level of risks' was ranked eighteenth with a $\bar{x}$ of 3.53 and σX of 1.113 and lastly is 'legal constraints' with a $\bar{x}$ of 3.46 and σX of 1.176 is ranked nineteen.

Table 1 *Factors affecting the usage of BIM among professionals in the SACI*

Factors affecting the use of BIM	$\bar{x}$	σX	R	Kruskal-Wallis test	
				Chi-Square	Asymp-Sig
Lack of investments	4.07	1.012	1	7.239	0.404
Inefficient involvement of stakeholders	3.96	1.109	2	7.527	0.376
Lack of trained personnel	3.96	1.109	2	6.003	0.539
Costly to put into motion	3.94	1.128	4	4.034	0.776
Lack of knowledge	3.94	1.128	4	3.514	0.834
Lack of government support	3.93	1.012	6	4.287	0.746
Lack of highly skilled personnel	3.89	1.174	7	3.954	0.785
BIM complexity	3.89	1.174	7	1.552	0.980
Client's low demand for BIM in projects	3.87	0.962	9	1.938	0.963
Contractual constraints	3.83	1.021	10	11.721	0.110
Lack of awareness	3.83	1.021	10	11.882	0.105
Support from the legal system	3.81	1.171	12	7.503	0.378
Lack of professional bodies support	3.81	1.171	12	5.858	0.558
Lack of motivation	3.79	1.203	14	12.835	0.076
Lack of collaborative working processes	3.77	1.119	15	5.992	0.541
The amount of willingness	3.76	1.069	16	4.974	0,663
Increased liability	3.60	1.197	17	2.179	0.949
Level of risks	3.53	1.113	18	2.906	0.949
Legal constraints	3.46	1.176	19	7.602	0.369

Thus, eighteen of the nineteen identified factors affecting the usage of BIM recorded MS values above 3.50, which implies the significance of the identified factor affecting the use of BIM among professionals in the SACI [30]. Table 1 presents a Kruskal-Walli test result that compares the respondents' views on BIM usage based on

their professional designations in the SACI. Based on the 95% significance level adopted for the Kruskal-Wallis test, the Kruskal-Wallis test suggests no significant difference according to respondents' perception towards the factors affecting the usage of BIM among professionals in the SACI [31]. Furthermore, the results presented in the table indicated that all the evaluated factors had mean values exceeding the threshold of 3.0. This implies that the respondents recognise all the identified factors as essential.

Table 2 *Factor loading of factors affecting the use of BIM*

Cluster Factor Groupings	Eigenvalues	Variance	Pattern Matrix[a]			
			1	2	3	4
Factor 1- Poor stakeholder involvement	6.986	36.767				
Lack of highly skilled personnel			0.913			
Lack of government support			0.885			
BIM complexity			0.820			
Lack of trained personnel			0.813			
Client's low demand for BIM in projects			0.806			
Lack of knowledge			0.747			
Inefficient involvement of stakeholders			0.681			
Lack of investments			0.659			
Factor 2-Poor BIM Management process	3.704	19.497				
Contractual constraints				0.896		
Support from the legal system				0.887		
Lack of professional bodies support				0.886		
Lack of awareness				0.885		
Lack of motivation				0.678		
Factor 3- Poor acceptance level	1.954	10.283				
Level of risks					0.895	
Legal constraints					0.850	
Increased liability					0.845	
The amount of willingness					0.794	
Factor 4- Poor collaboration	1.165	6.134				
Lack of collaborative working processes						0.903
Costly to put into motion						0.496
Total Variance Explained		72.689				

The factors outlined in Table 2 align with the perspectives and conclusions of various authors referenced in the study. For example, the authors of [11] &[13] discussed the poor stakeholder involvement in the application of BIM for construction project processes, which is caused largely by a lack of highly skilled personnel, lack of government support, complexity in BIM usage, lack of trained personnel, client's low demand for BIM in projects, lack of knowledge, inefficient involvement of stakeholders and lack of investments in BIM soft applicable to projects within the construction industry.

Also, the authors [14] & [17] delve into poor BIM management process application of BIM for construction project activities. As detailed in their studies, this is majorly caused by challenges that include contractual constraints, support from the legal system, lack of support from professional bodies, and lack of awareness and motivation on BIM usage. Moreover, authors [12] & [20] study examine the acceptance level of BIM for construction management and processes. The poor acceptance of BIM is due largely to the level of risks, legal constraints, increased liability and willingness to use. Similarly, authors [9] & [14] delve into poor collaboration as it affects BIM usage for construction operations and processes, which largely caused costly to put into motion and a lack of collaborative working processes.

5. Discussion of Findings

The study assessed the factors affecting the usage of BIM among professionals in SACI. The result indicated that lack of investment, inefficient involvement of stakeholders, lack of trained personnel, costly to put into motion, lack of knowledge, and lack of government support were the highest-ranked (1st - 6th) factors affecting the usage of BIM among professionals in the SACI. The finding aligns with [5] & [10] that poor investment in BIM among

stakeholders, lack of proper education, and poor government support were the leading factors affecting BIM usage among construction industry professionals. Similarly, the finding agrees with [11],[17]&[22] that poor stakeholder involvement in BIM usage, cost of procuring and lack of proper knowledge were the leading factors affecting the usage of BIM among professionals in the construction industry.

The findings also showed that lack of highly skilled personnel, BIM complexity, client's low demand of BIM in their projects, contractual constraints, lack of awareness, support from the legal system' and 'lack of professional bodies support were mediumly ranked (7th – 13th) factors affecting the usage of BIM among professional in the SACI. The study affirmed [15],[17],[20] &[22] that lack of highly skilled personnel, complexity in BIM usage, low client demand of BIM in their projects and contractual constraints were the factors affecting the usage of BIM among professionals in the construction industry. Further, the finding affirms [12],[13] &[14] that lack of awareness of BIM usage, poor legal support system for BIM adoption, and lack of support from professional bodies were the factors affecting the usage of BIM among professionals in the construction industry.

Additionally, the findings indicated that lack of motivation, lack of collaborative working processes, the amount of willingness'; 'increased liability, level of risks, and legal constraints were the least ranked (14th – 19th) factors affecting BIM usage among construction industry professionals. This supports [8],[9] &[14] that poor workers' motivation, the unwillingness of staff, and poor collaboration among professionals in the procedure for work were the factors affecting the usage of BIM among professionals in the construction industry. The study finding is also similar to [12][13] &[21] that liability due to usage, level of involvement in usage, and legal constraints in BIM implementation for construction projects were the factors affecting the usage of BIM among professionals in the construction industry.

6. Recommendation and Conclusion

The study assessed the factors affecting the usage of BIM among professionals in the SACI. The study identified a lack of investment, inefficient involvement of stakeholders, lack of trained personnel, cost to put into motion, lack of knowledge, lack of government support, lack of highly skilled personnel, BIM complexity, client's low demand of BIM in their projects, contractual constraints, lack of awareness, support from the legal system' and 'lack of professional bodies as the leading factors affecting the usage of BIM among professionals in the construction industry. Therefore, the study suggested increasing the usage of BIM among professionals in the construction industry. Construction firms and professional bodies should encourage the use of BIM among their staff and members by constantly training and retraining them on the importance of BIM usage. The study concluded that the government, ministries, departments, agencies (MDAs), and policymakers in the construction business should enact laws, policies, and strategies that will encourage the usage of BIM among construction stakeholders toward improving the construction processes and operations. The study concluded that the government should also increase awareness of the use of BIM among construction professionals through MDAs. The study contributes to the body of knowledge by making the professionals and government agencies involved in construction project delivery identify factors affecting the usage of BIM among professionals in the SACI. Stemming from the results of this study, future studies could examine the impact of BIM adoption on project outcomes and sustainability practices in SACI.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

All authors equally contributed to this manuscript.

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