engineering proceedings

MDPI

Proceeding Paper

Assessing the Impacts of Using Building Information Modelling Among Professionals in the Construction Industry †

Babatunde Fatai Ogunbayo * and Clinton Ohis Aigbavboa

cidb Centre of Excellence & Sustainable Human Settlement and Construction Research Centre, Faculty of Engineering and the Built Environment, University of Johannesburg, Johannesburg 2092, South Africa; caigbavboa@uj.ac.za

* Correspondence: tundeogunbayo7@gmail.com

† Presented at the 1st International Conference on Industrial, Manufacturing, and Process Engineering (ICIMP-2024), Regina, Canada, 27–29 June 2024.

Abstract: The need to adopt BIM and its usage to keep up with new construction trends has impacted construction works and made its activities much easier and more accurate. This has influenced construction industry professionals, prompting this study to evaluate BIM's effects to establish its significance within the field. To gather data on the effects of BIM in the South African construction industry, structured questionnaires were administered to professionals in Gauteng province using a systematic random sampling method. Questionnaire data were analysed descriptively, applying a statistical equation to calculate a valid mean item score. Each item was ranked, and standard deviations along with Cronbach's alpha were determined for reliability assessment. The results of this study indicated that the highest-ranked impacts of using BIM professionals in the construction industry were saving construction time, integrated design systems, accurate designs, construction risk management, reliable working procedures, and keeping track of past corrections. This study concludes that construction professionals' institutions and bodies should continue training and retraining their members toward deriving BIM benefits for different construction activities. This study advocates that special attention should be given to supporting construction SMEs in adopting BIM technologies with relevant training, resources, and financial incentives from relevant government agencies.

Keywords: building information modelling; construction industry; industry professionals; South Africa

Citation: Ogunbayo, B.F.; Aigbavboa, C.O. Assessing the Impacts of Using Building Information Modelling Among Professionals in the Construction Industry. *Eng. Proc.* **2024**, *76*, 90. https://doi.org/10.3390/engproc2024076090

Academic Editors: Golam Kabir, Sharfuddin Khan, Mohammad Khondoker and Hussameldin Ibrahim

Published: 26 November 2024

1. Introduction

In the dynamic construction industry, adopting Building Information Modelling (BIM) has become a game-changer, redefining how professionals plan, design, build, and oversee projects within built environments [1,2]. Ref. [3] argues that digital tools like BIM have revolutionised the construction industry, improving numerous project development and management aspects, such as design accuracy, collaborative efficiency, resource optimisation, and overall project outcomes. With its capacity to enhance collaboration, streamline workflows, and provide a holistic view of projects, BIM has garnered significant attention from practitioners, researchers, and policymakers [4,5]. In recent years, the construction industry has experienced a major shift with the broad implementation of BIM technology [6]. By digitally representing a building's physical and functional attributes, BIM has transformed how professionals approach planning, design, construction, and project management [7,8]. Across the globe, BIM adoption has rapidly gained momentum due mainly to its potential to impact construction projects. Ref. [9] postulated that while the benefits of BIM are widely recognised, there remains a need for comprehensive empirical studies to evaluate its actual impacts on construction professionals involved in construction projects. This study, therefore, aims to explore the various effects of BIM usage among construction industry professionals, focusing on its influence on project outcomes, operational

efficiency, and stakeholder collaboration in meeting project goals. Eventually, this study aims to inform future strategies for optimising BIM utilisation among construction professionals and fostering sustainable improvements in project delivery and overall construction industry performance.

2. Literature Review

As noted by [10], BIM is an innovative design-oriented technology applied across all phases of a construction project's lifecycle, offering substantial benefits to construction projects. The construction industry, renowned for its complexity and intricacies, has witnessed a paradigm shift with the introduction of BIM [11,12]. Traditionally, siloed approaches and fragmented information workflows have been pervasive, leading to inefficiencies, miscommunication, and suboptimal project outcomes [13]. BIM, which digitally represents the physical and functional aspects of a built asset, aims to tackle these persistent challenges by enhancing collaboration, increasing data precision, and supporting informed decision-making across the project lifecycle [14]. Ref. [15] noted that BIM technology helps save time and keep track of past revisions in construction work. Ref. [16] postulated that BIM impacted construction professionals' expected project outputs through an integrated system for project design development, leading to guided working procedures. Ref. [17] emphasised that using BIM for construction will produce accurate designs and track early project correction. BIM can guide professionals on risk management and reliable working procedures during construction [18].

The study of [19] indicated that producing quality information improves management processes and record changes, which were the perceptions of BIM usage's impact among construction operations professionals. Ref. [20] signified that the degree of use of BIM for construction purposes will impact the quality of the construction process, early error detection, and accurate estimates. The use of BIM for construction activities has a relevant impact on the process of cost reduction, integration of complex components, and increased coordination of documents [21]. Ref. [22] asserts that using BIM for construction activities allows construction professionals to develop accurate project estimates. Its usage for construction operations during planning and construction enhances project estimate accuracy and the integration of complex processes [23]. BIM usage by professionals will lead to efficient construction document coordination and avoid unnecessary errors during operations [24]. The studies of [1,25] established that using BIM for construction projects includes increased profitability, effective communication, and team transparency. The studies [25,26] posit that using BIM for the construction project process will impact the construction environment toward waste management within the project sites. By applying BIM during the design and planning phases, its influence may also help minimise risks and hazards throughout construction [25]. Also, the study of [23] affirms that its impacts would create effective stakeholder communication during the planning and execution stages of projects. As outlined previously, it is essential to recognise the influence of BIM among construction professionals to underscore its significance in the construction process and operation. Also, it is critical to identify these impacts as they can be applied during the planning, designing, and construction stages of construction activities in projects.

3. Methodology

This research was conducted in Gauteng province, focusing on professionals in the South African construction sector. Participants included construction experts specifically from industries located within Gauteng, selected for their experience and engagement with BIM in construction activities. Gauteng province was selected for this study due to the high number of active construction projects utilizing BIM technology. Using a systematic random sampling approach, 100 questionnaires were distributed to participants, with 70 complete questionnaires returned. The systematic random sampling method was chosen for this study as it provides a straightforward approach and reduces the likelihood of clustering, unlike cluster sampling, which divides the population into various clusters

and then selects a random sample from each one. This method ensures even coverage of all elements [27,28]. The questionnaire was structured on a 5-point Likert scale, with ratings as follows: Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, and Strongly Agree = 5, achieving a 70% response rate. Data analysis for this study was conducted using the SPSS software, version 29.0. Data from the 70 respondents collected via Google Forms were exported to an Excel spreadsheet and then analysed using SPSS software version 29.0. This analysis produced the mean item scores, standard deviation, Cronbach's alpha, and rankings [29]. Prior to data analysis, the collected data were screened and cleaned to identify and, if necessary, correct any errors. Respondents provided information regarding their professional roles, highest qualifications, and years of experience in the construction industry. The questionnaire also asked respondents to evaluate fourteen impacts of BIM use among construction professionals in the industry, as outlined in the literature. Descriptive analysis, including percentage, frequency, mean item score, and standard deviation, was performed to assess the results of this study's Likert-scale questions.

Following computation, the identified impacts of BIM use among professionals were ranked from highest to lowest. The study analysis utilised the survey participants' responses, assigning weights to each answer for every question. It was further aligned with the scores selected by respondents, collectively recognised as the analytically validated indicators of relative importance. This facilitated this study's evaluation of BIM's impact on professionals within the construction sector. Likewise, Cronbach's Alpha assesses internal consistency, indicating the measurement tool's reliability. The coefficient is most effective with Likert scale data, which were employed in this study to gather responses from the targeted participants. Cronbach's coefficient ranges from 0 to 1, with values nearer to 1.00 considered acceptable. Therefore, the Cronbach's Alpha value of 0.966 obtained in this study is appropriate.

4. Study Findings Results

The demographic details of the 70 study participants indicate that 17.14% (12) held a master's degree, 34.29% (24) had a bachelor's degree, 27.14% (19) possessed an honours degree, and 21.43% (15) had a national diploma as their highest level of qualification. Additionally, the results show that 30% (21) of respondents were quantity surveyors, 12.86% (9) were architects, 21.43% (15) were construction managers, 17.14% (6) were construction project managers, 8.57% (6) were contractors, and 10% (7) were engineers (covering civil, mechanical, and electrical fields) in the construction industry. Table 1 presents the respondents' rankings on the effects of BIM usage among construction industry professionals. The results highlight both the highest- and lowest-rated impacts. Respondents were asked to assess the impacts of BIM on industry professionals using a five-point Likert scale ranging from "Strongly disagree" to "Strongly agree" in the questionnaire. According to the results, "saving construction time" was ranked first with a mean score of 4.34 and SD of 0.915; "integrated design system" and "accurate project designs" were ranked second with a mean score of 4.24 and SD of 0.859 and 0.970, respectively; "construction risk management", "reliable working procedures", and "keep track of past corrections" were ranked fourth with a mean score of 4.20 and SD of 0.791, 0.844, and 0.926; "produce quality information" was ranked number seven with a mean score of 4.19 and SD of 0.921; "improves management processes" was ranked eighth with a mean score of 4.16 and SD of 0.895; "efficient record changes" was ranked ninth with a mean score of 4.14 and SD of 0.967; and "quality construction process" was ranked tenth with a mean score of 4.13 and SD of 0.900. Also, "early error detection" and "accurate project estimates" were ranked eleventh with mean scores of 4.11 and SD of 0.826 and 0.910; "reduce production costs", "Integrating complex processes", and "increase document coordination" were ranked thirteenth with a mean score of 4.09 and SD of 0.847 and 1.018; "effective stakeholder communication" and "increased profitability" were ranked sixteenth with a mean score of 4.07 and SD of 0.953; "transparency among construction team" was ranked eighteenth with a mean score of 4.01 and SD of 0.985; "wastage management" was ranked nineteenth with a mean score of 3.90

and SD of 0.935; and "reduces accidents and hazards" was ranked last with a mean item score of 3.86 and SD of 1.026.

Table 1. Ranking of impacts of using BIM among professionals in the construction industry.

Impacts of Using BIM Among Professionals	MIS	SD	R
Saving construction time	4.34	0.915	1
Integrated design system	4.24	0.859	2
Accurate project designs	4.24	0.970	2
Construction risk management	4.20	0.791	4
Reliable working procedures	4.20	0.844	4
Keep track of past corrections	4.20	0.926	4
Produce quality information	4.19	0.921	7
Improves management processes	4.16	0.895	8
Efficient record changes	4.14	0.967	9
Quality construction process	4.13	0.900	10
Early error detection	4.11	0.826	11
Accurate project estimates	4.11	0.910	11
Reduce production costs	4.09	0.847	13
Integrating complex processes	4.09	0.847	13
Increase document coordination	4.09	1.018	13
Effective stakeholder communication	4.07	0.953	16
Increased profitability	4.07	0.953	16
Transparency among construction teams	4.01	0.985	18
Wastage management	3.90	0.935	19
Reduces accidents and hazards	3.86	1.026	20

5. Discussion of Findings

This study assessed the impacts of using BIM among professionals in the construction industry. The results of this study indicated that saving construction time, integrated design system, accurate project designs, construction risk management, reliable working procedures, and keeping track of past corrections were the highest-ranked (1st–4th) impacts of using BIM among professionals in the construction industry. The findings align with [16,17] that the impact of using digital technology tools such as BIM by construction professionals for construction will increase the saving of construction time, integration of construction design, and quick assessment of the risk involved in construction projects. The finding is also similar to the study of [14], which states that the impact of BIM on construction professionals leads to accurate design in the pre-planning stage and monitoring of corrections during the production stage of the project. The findings imply that the impact of using BIM for construction processes and operations was to increase construction project designing accuracy, leading to reliable procedures for the execution of the projects with a reasonable basis for early corrections of errors guided by an efficient risk management process for construction projects at the design and construction stages.

The findings also indicated that producing quality information, improving management processes, efficient record changes, quality construction process, early error detection, accurate project estimates, reducing production costs, integrating complex processes, and increasing document coordination were mediumly ranked (16th–20th) impacts of BIM usage among professionals within the construction industry. This study asserts [7,19] that the impact of using BIM by construction professionals for construction is that quality information will be made available, and construction management processes and adjustments

will be efficient. The findings align with [20,21], who found that using BIM for construction activities will lead to a quality process with early detection of errors in construction procedures. The findings also assert [22–24] that BIM for construction activities allows construction professionals to integrate complex construction processes, effective construction document coordination, develop accurate project estimates, and reduce production costs. This study's findings imply that the impact of using BIM for construction processes and operations was to provide quality information, leading to an efficient management process and record amendment during production and quality construction process. It further implies that it will help create the integration of complex construction processes that will lead to better coordination of the construction documents toward accurate project estimates, reducing the production cost and early error detection in the construction planning and execution. Further, the findings revealed that effective stakeholder communication, increased profitability, transparency among construction teams, wastage management, and reduced accidents and hazards were the lowest-ranked (12th–14th) impacts of using BIM among professionals in the construction industry. This supports [6,11,23] that the impact of using BIM by construction professionals was for effective stakeholder communication and increased profitability of construction projects. The findings also concur with [1] that it improves communication and transparency among construction teams. The findings are also similar to [25] that the impact of professionals using BIM for construction can lead to cost and production waste management. It also agrees with [25] that it would reduce accident hazards during production, including during construction materials on site. This finding implies that using BIM for construction processes and operations improved stakeholder interaction through a digital platform based on BIM pictorial outputs, which can guide transparency among construction teams toward increasing profitability, wastage management, and accident and hazard reduction.

6. Recommendations and Conclusions

This study evaluated the impact of BIM utilisation among construction industry professionals. It identified saving construction time, integrated design system, accurate project designs, construction risk management, reliable working procedures, and keeping track of past corrections as significant impacts of using BIM among construction professionals. The findings of this study underscore the positive contributions of BIM to construction project collaboration, coordination, and overall efficiency. The improved management processes, clash detection, and design and construction processes highlighted in this research showcase how BIM enhances the quality and delivery of construction projects when used by construction professionals. This study also stresses the essential role of BIM in data-driven decision-making, enabling construction professionals to leverage project data strategically throughout the project lifecycle. This study's findings affirm that professionals across different built environment disciplines have benefited from working collaboratively on a centralised digital platform, improving communication, reducing errors, and streamlining workflows. It further indicated that integrating BIM by professionals into design and construction processes has facilitated better decision-making, clash detection, and constructability analysis, ultimately resulting in higher-quality built environments and construction project output. It is also established that BIM has revolutionised data management and decision support in the construction industry operations, empowering professionals to make more informed and strategic decisions throughout the project lifecycle by providing robust guidelines for organising and analysing project data, leading to improved project outcomes, cost savings, and enhanced risk management practices. Hence, this study recommends that there is a need for increased investment in training and education programs to equip professionals in construction with the skills and knowledge necessary to use BIM effectively. Also, professional bodies should provide continuous professional development opportunities to ensure construction professionals remain current with the latest BIM methodologies and technologies. This study suggests that construction industry stakeholders should promote a culture of collaboration and knowledge sharing

among themselves to facilitate the effective implementation of BIM in construction projects with platforms for sharing best practices, lessons learned, and case studies established to enable professionals to learn from each. This study advocates that special attention should be given to supporting construction SMEs in adopting BIM technologies with relevant training, resources, and financial incentives from relevant government agencies. This study concluded that for construction professionals to continue enjoying the impact of using BIM for construction projects, government, ministries, departments, and agencies (MDAs) should consider implementing policies and incentives to encourage the widespread adoption of BIM in the construction industry by requiring BIM for public projects, offering tax incentives for BIM investments, and setting up BIM standards and guidelines. This study was limited to construction professionals within a province in South Africa; further research should be carried out in other provinces among construction professionals to understand the impact of using BIM within the country better. Also, future research should employ rigorous economic evaluation methods to assess the financial implications of BIM adoption for construction projects.

Author Contributions: Conceptualization, B.F.O.; methodology, B.F.O. and C.O.A.; software, B.F.O.; validation, B.F.O. and C.O.A.; formal analysis, B.F.O.; investigation, B.F.O.; resources, B.F.O.; data curation, B.F.O.; writing—original draft preparation, B.F.O.; writing—review and editing, B.F.O. and C.O.A.; visualization, C.O.A.; supervision, B.F.O. and C.O.A.; project administration, B.F.O. and C.O.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This study did not require ethical approval.

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: The original contributions presented in this study are included in the article; further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

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