Leveraging Building Information Modeling (Bim) To Stimulate Civil Engineering Skills Development

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Abstract

Integrating Building Information Modeling (BIM) into civil engineering represents a transformative shift in the educational and professional landscape. This paper explores the potential of BIM as a catalyst for enhancing civil engineering skills development. The participants were 51 students enrolled in the civil engineering department at the National Institute of Construction Technology and Management, Uromi, Edo State. The study employed a quasi-experimental approach with two groups. The t-test analysis revealed a significant difference in civil engineering skills between the experimental and control groups. In conclusion, the paper posits that BIM is an essential tool in the civil engineer's repertoire, capable of stimulating significant advancements in skill development, project management, and collaborative work. By leveraging BIM's capabilities, educators and industry professionals can foster a more dynamic learning environment and prepare the next generation of engineers for the complexities of modern infrastructure projects.

Keywords: Simulation software, BIM, engineering skill, civil engineering

Introduction

The instruction of students in developing and exploring creative, workable conceptual solutions to civil engineering challenges is a crucial aspect of civil engineering education. 3D and 4D computer-aided design (CAD) techniques are increasingly greatly enhancing, if not wholly replacing, traditional methods for conceptual design communication, such as sketching, physical modeling, or 2D drawings. While traditional CAD tools are helpful for intricate technical design articulation, they can also stifle the originality of inexperienced designers in the early stages of architectural creative design. (Ibrahim & Pour Rahimian, 2010) According to Chang et al. (2016), using 3D CAD for design has a good effect on students' creative performance and may also be able to compensate for representational deficiencies such as inadequate hand sketching abilities.

Over the past decade, a new concept known as Building Information Modelling (BIM) has been rising and developing as a new construction management tool in the AEC industry (Shibani et al., 2020). Building Information Modelling (BIM) is a digital representation of a facility's physical and functional qualities and a common knowledge resource for facility information. It is a trustworthy foundation for choices throughout its life cycle (NIBS & building SMART, 2015). The Building Information Modelling (BIM) methodology is currently the leading digital platform in construction (Zhang, 2019). A BIM project is developed over a technological platform in which all experts create, manipulate, and add the required information generated in the context of the work of each professional involved (Sacks et al., 2018). The construction industry has played an essential role in successfully assisting stakeholders in transferring construction practices to BIM-based technology(Othman et al., 2021). According to Volk et al. (2014), this process aids in the development of the project's various components, permits sufficient interoperability between particular systems linked to different kinds of analysis or simulation, makes budgeting, building, maintenance, and management tasks more accessible, and regulates the process for potential demolition.

Building Information Modeling (BIM) is widespread within the engineering and construction industry, with huge strides in both usage and technological advances in the past two decades (West & Liu, 2021). The quality of the projects produced, founded on efficient process integration and evident cooperation amongst partners connected to the various specializations essential to construction, demonstrated its advantages as soon as they were realized. The development of the project's various disciplines is greatly aided by BIM computational tools, which provide parametric modeling and simple access to all the data gathered in the BIM model developed as the project progresses.

Building Information Modelling (BIM) is an approach to managing construction project design, construction, and facility management. Its implementation has become more widespread in the construction industry for producing data-rich models of buildings and structures. BIM is currently used by the architecture, engineering, and construction (AEC) industry (Latiffi et al., 2015). BIM helps digital design models that allow construction industry players to visualize the

buildings before the physical implementation occurs. This push has been accompanied by the release of many BIM software systems now available in the market (Abanda et al., 2015).

Numerous research has underscored the benefits of implementing BIM in all areas of the engineering ecosystem. (Ahankoob et al., 2022; Al-Ashmori et al., 2020; Barlish & Sullivan, 2012; Doumbouya et al., 2016; Hire et al., 2021; Li et al., 2023; Lidelöw et al., 2023; Musa et al., 2019; Olbina & Elliott, 2019; Yang & Chou, 2019). Construction owners, designers, builders, and managers have verified the benefits of adopting the BIM methodology in all construction areas. Theoretical developments in Building Information Modelling (BIM) suggest that not only is it useful for the geometric modeling of a building's performance, but it can also assist in the management of construction projects (Bryde et al., 2013). Due to this reality, it is becoming increasingly accepted globally, which has prompted governments to set guidelines and deadlines for public construction projects. Furthermore, educational institutions must employ BIM as a crucial pedagogical approach to equip upcoming engineers with the foundational knowledge of various construction-related issues.

Civil engineers must comprehend the construction process and know the language employed in construction projects. This aids in enhancing their communication of designs with the builders and construction workers implementing the plans. Civil engineers with extensive expertise in construction projects are considered more well-rounded job applicants. This is a common element found in the resumes of experienced civil engineers. Newcomers to civil engineering should focus on gaining construction project experience to match the requirements of the roles they seek. Working knowledge of AutoCAD Civil 3D is the most common complex skill civil engineers require. Understanding AutoCAD Civil 3D is crucial for civil engineering roles. AutoCAD Civil 3D is a computer program enabling architects and engineers to design and plan structural engineering projects. It is supported by Building Information Modeling (BIM) and makes it easy to collaborate on projects with a team and predict any potential problems before they happen. It is the bedrock of software requirements for the civil engineering field.

In the Nigerian Civil Engineering and Construction sector, the adoption of BIM has grown steadily, and most significant operators in the sector acknowledge the many advantages that can be made possible through the early adoption of BIM. Thus, civil engineering students are exposed to contemporary software-based engineering operations to enable them to fit into the industry. Civil Engineering education focuses on Building Information Modeling (BIM). As the primary educator of future engineers, it is the school's responsibility to incorporate BIM as a fundamental concept in the curriculum to support new subjects with BIM-based digital tools. The demand for BIM skills in the industry has prompted an educational awareness of the societal need, resulting in a gradual adjustment of pedagogical approaches. This study seeks to evaluate the role of BIM in stimulating civil engineering skills among undergraduates.

Method

This study aims to evaluate how incorporating BIM simulation software enhances the engineering skills of civil engineering students. A quasi-experimental method was used to compare two groups of students: one group was exposed to Autodesk BIM software (experimental group), and the other group followed the usual curriculum (control group). Fifty-

one participants were selected from the civil engineering department of the National Institute of Construction Technology and Management in Uromi, Edo State. Both groups underwent a pre-test evaluation to evaluate their initial project design skills by completing a standardized Autodesk design task, including designing a building project. The experimental group used Autodesk BIM software for building simulations and design tasks, whereas the control group followed their usual coursework. Following the intervention period, a post-test was given to both groups to assess circuit design skills using activities comparable to the pre-test. A t-test was used to analyze and compare the average scores of the experimental and control groups.

Result

Table 1 shows the mean and standard deviation scores for the group.

		Pre-test		Post-test		
Group	N	Mean	Standard Deviation	Mean	Standard Deviation	Mean Gain
Experimental	26	40.19	10.54	49.16	13.81	8.97
Control	25	39.71	11.29	42.57	13.58	2.78
MD		0.48		6.59		

The pre-test mean difference is 0.48, as shown in Table 1, where the mean for experimental conditions is 40.19, and the mean for control conditions is 36.79. No statistically significant variation was observed in the participants' mean scores regarding their skill levels in circuit design. Conversely, the post-test analysis demonstrates that the control condition had a mean score of 42.57, while the experimental conditions had a mean score of 49.16, representing a mean difference of 8.59. The respective gain scores for the two conditions were 2.78 and 8.97. Therefore, the outcome demonstrates that the participants' exposure to the SPICE software enhanced their interest in circuit design under the experimental conditions.

Table 2 shows a t-test comparison.

Source of variation	N	Mean	SD	df	*t*	Sig
Experimental	26	40.19	13.81			
Control	25	39.71	13.58	71	6.212	000

To determine whether the Autodesk BIM software would spur students' skills in building design, a t-test analysis was conducted on the data. In building project design, the analysis revealed a significant difference between the experimental and control conditions (MD = 6.59, t (71) = 6.212, p =.000). Thus, the result provided insights into how Autodesk BIM software enhances students' abilities in practical building project design.

Discussion

This study examined the role of BIM simulation software in increasing engineering skills among civil Engineering Students at the National Institute of Construction Technology and Management, Uromi, Edo State, Nigeria. The result showed a significant difference between the students taught building project design skills with the Autodesk BIM software and those prepared with conventional methods. For the pre-test and the post-test study conducted, the mean and standard deviation scores showed that exposing the students to Autodesk BIM software significantly influenced their project design skills in the post-test study (M = 49.16, SD = 13.81)

compared to the control group (M = 42.57, SD = 13.58). The probable explanation for this outcome is that BIM for civil projects improves outcomes with its ability to investigate multiple scenarios, providing data-driven assurance that projects can be delivered on schedule and budget. BIM offers shared information throughout the project life cycle, driving compelling results. The findings of this study demonstrate that employing 3D building modeling with BIM as a pedagogical method improves students' ability to engage in the modeling process and ultimately aids students in improving the quality and correctness of their building model.

Insinuation suggests that simulation programs consistently helped students find errors in their models that were hard to spot in a non-simulation setting. Walking through the building helped students better understand the spatial layout of rooms, circulation spaces, stairways, etc. Informal discussions during laboratory sessions revealed that students who participated in the simulation activity demonstrated a profound comprehension of building arrangement and exhibited advanced conceptual design thinking regarding user interaction with spaces, material finishes, and the effects of varying lighting conditions.

Conclusion

This finding adds to existing evidence that the use of virtual environments can be a highly accessible method for engaging with engineering and construction and, as such, could be an essential tool in the delivery of teaching of civil engineering and construction methods at the tertiary levels. Observation of the current trends in BIM technologies in the Civil Engineering and construction sector suggests a strong dedication to incorporating digital workflows. BIM-enabled software is now essential for enhancing the design process and engaging with civil engineering activities. Exposure to these technologies and software tools is crucial for both users and developers in the present and future of civil engineering education.

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