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Building Information Modeling (BIM) in Green Building Projects

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Abstract

Building Information Modelling (BIM) is a digital approach that involves creating and managing a comprehensive database of all the information related to a construction project. This includes the design, construction, and operation phases. BIM provides a collaborative platform for all stakeholders involved in a construction project, including architects, engineers, contractors, and owners. It allows for the visualization of the project in 3D and enables real-time collaboration and communication, resulting in reduced errors and improved efficiency throughout the construction process. The use of BIM has been globally recognized since its inception in 2000. This is a crucial strategy included in the Twelfth Malaysian Plan (2021-2025) to ensure a better future for the Malaysian construction industry. Achieving certification for green buildings can be complex and requires meticulous planning. However, utilizing BIM can simplify the process and make it more efficient. With BIM, architects and builders can create detailed 3D models to identify potential issues and plan accordingly, resulting in a building meeting the requirements for green certification. This technology can help ensure that all aspects of the building, from energy usage to materials selection, are optimized for sustainability and environmental friendliness, making green certification a more attainable goal. The primary objective is to conduct a detailed analysis of the current research on Building Information Modeling (BIM) and its relationship with sustainable or "green" building practices. The review will emphasize significant discoveries and conclusions within this field of study.

Keywords: Green building, Building Information Modelling, project phases

Introduction

Architecture Engineering and Construction (AEC) has utilized Building Information Modelling (BIM) since the 1970s. Various scholars have come up with the definition of BIM. For instance, Succar (2009) defined BIM as an emerging technological and procedural shift within the

Architecture, Engineering, Construction, and Operations industry. BIM's main objective is to facilitate building design, planning, construction, and management once construction projects are completed. In addition, Eastman et al. (2011) and Wong and Zhou (2015) described BIM as a socio-technical system that ultimately involves broad process changes in design construction and facility management. BIM is an innovation method that allows various parties involved in construction projects to share and work with data seamlessly and efficiently (AbuMoeilak et al., 2023). With BIM, the construction of green building projects has been completed on time and within budget, leading to greater efficiency and productivity. However, Li et al. (2019) stated that the construction industry's impact on the environment can be observed throughout the entire building lifecycle, from the processing of raw materials to the construction, operation, and maintenance stages.
Since the impact of the construction harms the environment, the solution to overcome the problem is to construct green buildings. Green Buildings can positively impact the environment and reduce adverse effects throughout their lifecycle. Green buildings have brought significant innovation to the construction industry to overcome the negative environmental impact. Research by Chan et al. (2017), Huang et al. (2020), Marzouk et al. (2021), and Wong and Zhou (2015) discovered that constructing green buildings can lower energy and water usage, decrease expenses for mechanical equipment, and lessen the consumption of natural resources and materials. Several factors must be considered when evaluating whether or not a building is environmentally friendly.
Recently, research has been done to integrate BIM into green buildings (GhaffarianHoseini et al., 2017a; Lu et al., 2017a; Mohammed, 2020; Wong & Zhou, 2015). This research aimed to incorporate BIM and green evaluation into the construction process seamlessly, set industry benchmarks and practices, and create a framework for scrutinizing and assessing eco-friendly structures. Nevertheless, researchers and professionals must come to a mutual understanding of how to apply BIM in developing sustainable buildings during every stage of the project. Hence, it is vital to identify the attributes associated with BIM in green buildings.

Methodology

The purpose of this document is to provide a comprehensive analysis of current literature, focusing mainly on relevant journal articles, books, magazines, reports, and other relevant documents related to this research. The aim is to present a thorough review of the existing research and highlight key findings in the field, mainly on BIM and green building. The investigation is focused on delving into the current research surrounding Building Information Modeling (BIM) within the context of green building projects. The goal is to analyze the existing analysis and identify the essential attributes of BIM and its relationship to green building to facilitate successful green building projects. To gather data for this paper, the search terms utilized were "BIM and Green Building," "sustainable building," and "success factors of BIM in Green Building," among other related combinations. These keywords were chosen to ensure a comprehensive and informative topic exploration.

Building Information Modelling

Building Information Modelling (BIM) is a collaborative process that enables construction stakeholders to plan, design, construct, and manage a building using a three-dimensional model. The origin of BIM can be traced back to 1974 when Eastman et al. created the Building Description System (BDS), which was later improved and renamed to Graphical Language for Interactive Design (GLIDE) in 1977. In 1999, Eastman replaced GLIDE with the Building Product

Model (BPM), followed by the introduction of the Generic Building Model (GBM) in 1995, which was later improved and renamed BIM in the 2000s (Sinoh et al., 2020).

Building Information Modeling (BIM) is a process that aims to incorporate precise and relevant information into the BIM model throughout the design-build process. BIM is divided into four specific maturity levels from 0 to 3. Each group represents a degree of maturity in the use of BIM technology.

Level 0 represents a state in which an organization does not use BIM technology at any point in a building's lifecycle. This implies that the organization relies on traditional design, construction, and maintenance methods, which may limit its ability to optimize the building's performance and efficiency. Professionals utilize BIM tools to develop 2D CAD drawings and 3D models in the first level of BIM maturity. These models are primarily used for visualizing and presenting building data more comprehensively and engagingly. They allow for a more detailed representation of the building's layout and design, which can aid in improved communication and collaboration between stakeholders. At the initial project stage, called level 1, project teams begin creating and implementing 3D models. As the project progresses, the team advances to level 2, the most advanced Building Information Modeling (BIM) stage. The team collaborates and works in a shared model space at this stage, allowing for seamless communication and efficient project delivery (David Shepherd, 2016).

BIM has received much attention in academia and the construction industry due to its potential and ability to achieve performance improvements and high-quality construction. It has been gradually applied in massive construction projects worldwide (Zhang et al., 2020). Many researchers have discovered the ability of BIM in construction projects. BIM is a game-changer for the construction industry. By creating a 3D model of a building and its systems, BIM ensures that every component is coordinated and integrated. And that's not all. With BIM, potential clashes can be identified in advance, saving time and money. It's no wonder that (Doan et al., 2018; Mirpanahi & Noorzai, 2021; Raouf & Al-Ghamdi, 2018; Zian et al., 2019) have all confirmed the effectiveness of BIM in detecting any clashes inside the building system. Moreover, BIM also can simulate (Ansah et al., 2019; Farahaneza et al., 2018; Gao et al., 2019; Memon et al., 2014; Wen et al., 2020) energy efficient analysis (Ghaffarianhoseini et al., 2016; Mirpanahi & Noorzai, 2021; Raouf & Al-Ghamdi, 2018) which in line with the goal of green building projects where to minimize the uses of energy of the building.

BIM has been proven as a very beneficial approach in reducing uncertainties and improving the efficiency of the construction process (Cao et al., 2022; Eadie et al., 2013; Memon et al., 2014; Pu & Wang, 2021; Sacks et al., 2018), increasing the speed and utility of activities and improving the interaction between stakeholders (Huang et al., 2020b).

Green Buildings

According to the Global Alliance for Buildings and Construction report, the building sector accounted for 36% of global end-use energy consumption and 37% of global energy-related CO_2 emissions in 2020 (Hamilton & Kennard, 2021). Hence, green buildings are crucial to minimize energy consumption in the building sector. Green buildings are not just an option; they are a necessity. The building sector consumes a massive amount of energy, making it critical to invest in sustainable architecture. Energy use will be reduced by indirectly prioritizing green buildings and creating sustainability for future generations.

Green buildings are evaluated using specific criteria and assessment tools. To achieve this, criteria and assessment tools have been developed to measure a building's sustainability and energy efficiency. Adapting these methods to different regions is possible by considering the variations in climate conditions and regional differences. There are several established sustainability rating systems in other countries, such as Building Research Establishment's Environmental Assessment Method (BREEAM) in the United Kingdom, Leadership in Energy and Environmental Design (LEED) in the United States of America, Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan, Sustainable Building Tool (SBTool) in Canada, Beam Plus in Hong Kong, Green Mark in Singapore, Green Star in Australia, and Green Building Index (GBI) in Malaysia. These rating systems are crucial in promoting sustainable building practices and ensuring that buildings meet specific environmental standards. Green Mark has been a compulsory requirement for a new facility in Singapore since 2008 (Y. et al., 2011). There are five (5) green building rating tools in Malaysia: GBI, PHJKR, MyCrest, GreenRE, and Melaka Green Seal. Regarding green building assessment, various criteria are considered, such as energy efficiency, indoor air quality, material and resources, water efficiency, innovation, and more. Several green building assessment tools worldwide use these criteria as their basis for evaluation. The table below presents an overview of these assessment criteria used in various green building assessment tools.

Table 1:
Assessment Criteria for Green Building Worldwide

Assessment Criteria	**LEED**	**BREEAM**	**GREEN STAR**	**BEAM PLUS**	**GREEN MARK**	**GBI**	**CASBEE**	**SB TOOL**
Energy Efficiency	/	/	/	/	/	/	/	/
Indoor Air Quality	/		/		/	/	/	/
Sustainable Site Planning & Management	/	/		/		/		
Material and Resources	/	/	/	/		/	/	
Water Efficiency	/		/	/	/	/		
Innovation		/	/	/	/	/		
Carbon footprint	/							/
Health and wellbeing		/		/				
Transport		/	/					
Pollution		/	/					
Management		/	/					/
Land use and ecology			/					
Integrated design and construction management				/				
Environmental Protection					/		/	/
Social, Cultural, and Perceptual Aspects								/

According to the assessment criteria in Table 1, the top priority for green buildings is energy efficiency, followed by indoor air quality. Despite varying requirements, the ultimate goal remains the same - to achieve successful green building projects.
The combination of green building and building information modeling in construction has received positive feedback from construction players worldwide. Numerous research studies have been conducted on the matter, highlighting the benefits of integrating sustainable building practices with BIM technology. Research by Olawumi & Chan (2019b), (2019a), (2020); Shukra & Zhou (2020); Wong & Zhou (2015); Xu et al. (2019) are some of the researchers who studied the potential of BIM in green building projects. (GhaffarianHoseini et al., 2017; Raouf & Al-Ghamdi, 2018) havobserved that Building Information Modelling (BIM) can play a crucial role in constructing sustainable, eco-friendly buildings. BIM technology can assist in designing, constructing, and managing green buildings throughout their entire lifecycle, from planning to demolition. Its use can significantly improve energy efficiency, cost savings, and reduce environmental impact.

Conclusion
To successfully implement BIM in green building or sustainable projects, it is essential to ensure that the project team is knowledgeable in BIM and green assessment criteria. Achieving green building certification is a rigorous process, making it exceedingly challenging for construction organizations that rely on conventional construction methods. The complexity of the standards and regulations governing green building necessitates a more sophisticated approach to construction that accounts for environmental impact and sustainability. As such, BIM should be integrated into the structure of green buildings (Ayman et al., 2019; Lu et al., 2017; Olawumi & Chan, 2019c). The synergistic combination of BIM and green evaluation is poised to revolutionize sustainable building construction. BIM's distinctive attributes confer a competitive edge for constructing environmentally friendly edifices. By integrating these two approaches, stakeholders in the construction industry can collaboratively strive towards erecting more sustainable structures in the coming years.

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