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A REVIEW OF BUILDING INFORMATION MODELLING IN PROJECT MANAGEMENT

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ABSTRACT

Construction project management has seen widespread adoption of Building Information Modelling (BIM), largely due to its ability to enhance project outcomes and integrate stakeholders. Despite its significance, there has been no literature review exploring the relationship between BIM and construction project management. This research delves into the correlation between BIM and construction project management. Through a thorough analysis of the Web of Science database, the study has identified 30 peer-reviewed papers which indicate that BIM's integration into the literature of construction project management is still in its early stages. The research agenda has primarily been driven by traditional, developed English-speaking countries. The adoption of BIM in construction project management has evolved from monitoring and controlling traditional parameters, such as timelines, to encompassing more complex and multidimensional aspects, such as sustainability, lean construction, and continuous improvement. The integration of BIM has had the most significant impact on time and cost management in building project management. Unlike traditional project management literature that mainly focuses on the planning process, the most crucial process in BIM is its implementation, acting as a catalyst for the growth of project activities.

Keywords: Building Information Modelling (BIM), project management, construction

Introduction

Building Information Modeling (BIM) is more than just a technology or collection of applications that must be trained to use [1]. BIM stands for n-dimensional modelling, virtual prototyping, and virtual technological prototypes [2]. This phrase refers to the entire spectrum of activities related to a building's creation, from its initial design and planning stages to the actual construction process and final operation and maintenance. With digital tools, this system manages data about building design and project development, ensuring that it remains accessible throughout the project's lifecycle according to [3]. This feature facilitates the effortless integration of relevant parties in the Building Information Modeling (BIM) process, allowing them to smoothly incorporate, extract, update, or modify information as required [4, 5],

thereby enhancing information exchange and interoperability among stakeholders [6]. It also promotes stakeholder collaboration at various building life cycle stages [6]. To fully harness the potential of BIM, it is imperative to grasp its technological process and implementation, as well as the intricacies of stakeholder relationships that must be considered to balance their interests as emphasized effectively [4]. This involves configuring and aligning BIM tools, processes, and business models for project collaboration [7]. The deployment of BIM technology necessitates the engagement of all parties, with the customer wielding the most power, and the customer may persuade the other parties to use the BIM [8]. Building Information Modeling (BIM) is a construction technique that has gained significant importance in recent years. It involves the creation and management of digital representations of physical and functional characteristics of buildings. BIM has revolutionized the construction industry by streamlining the design and construction process and enhancing collaboration between stakeholders. However, despite its numerous benefits, BIM implementation is not without challenges. Several obstacles and hazards are associated with BIM adoption, ranging from technical issues to contractual and legal matters. Many firms have encountered impediments to properly using BIM, and success factors are gradually gained through experience and experimentation [4]. This has resulted in a fall in adopting new technologies among experts and decreased market sentiment .This project aims to conduct a comprehensive review of BIM-related research articles and propose a unique way of determining success criteria for effective BIM deployment. Furthermore, it provides in-depth knowledge and contributes to growing awareness of BIM use, associated issues, and success factors.

Literature Review

Many studies have been conducted on the effect, application, and usability of BIM in construction projects. The research analyzed the outcomes of two distinct segments of a project that utilized different degrees of Building Information Modeling (BIM) collaboration. The aim was to emphasize the substantial influence that BIM has on design collaboration. [9], while another examined two scenarios with and without BIM to assess the effects of BIM on program performance [10]. Furthermore, research assessed BIM at various phases of the project and determined that BIM integration is critical for processes [11]. In (2013) It was investigated how BIM was utilized in projects to enhance schedule, cost, and product quality, as well as cooperation and coordination [12]. In addition, she noted in 2015 that BIM enables team members to handle all information, allowing them to make educated decisions during the design and construction stages [13]. Research published in 2017 showed that encouraging owners to utilize BIM technologies can increase stakeholder engagement since BIM is a collaboration strategy that integrates complete management abilities in the building sector around a single model [14]. Another research presented a method for modelling building information simply and naturally using so-called "side models" [15]. The mention of a BIM model in literature is a significant event, marking the beginning of an extensive study of BIM. The number of BIM-related articles has increased exponentially since then. In a comprehensive scientific study, Zhao examined papers concerning BIM and found that research in this field has grown rapidly since 2010. [16]. According to another analysis of the BIM literature, more than 90% of the articles connected to BIM were published between 2005 and 2015 [15]. The year 2012 saw the greatest increase in the number of publications published about BIM applications, with the percentage reaching about 50%. This demonstrates the increased interest in BIM in recent years. A keynote essay on the role of BIM in construction management, which earned the most citations [17], The text describes a theoretical framework that is aimed at facilitating the implementation of Building Information Modeling (BIM) in the construction sector. To achieve this, the framework combines ontological models and visual knowledge to provide a comprehensive and effective approach to BIM implementation. The framework is designed to help stakeholders in the construction industry to leverage BIM technology to enhance their project management and decision-making processes. This

historical study has impacted numerous studies in the field of BIM. The primary textbooks of the BIM research, which garnered the majority of the common citations, created important publications on BIM and the unique "BIM Handbooks" series.

Research Methodology

This article, based on 50 relevant studies, presents an in-depth analysis of the challenges, dangers, impediments, and success factors of BIM implementation adoption. Fifteen research papers explored BIM problems, risk factors, influence, and adoption hurdles. Ten studies examined BIM success factors. This study provides a complete visualization of the link between success variables and other BIM literature, problems, hurdles, risks, and influencing factors by undertaking a thorough assessment of relevant issues in search engines and areas of interest to BIM application.

Definitions And Concepts Of BIM

BIM has been the subject of various definitions in the literature over time. However, despite the variations, there are certain keywords that encapsulate the core of BIM. By analyzing the diverse definitions of BIM, these keywords can be identified. Building Information Modeling (BIM) is often regarded as a comprehensive process that involves the creation, management, and sharing of digital models of a building or infrastructure project. It is a collaborative approach that enables architects, engineers, construction professionals, and other stakeholders to work together seamlessly throughout the project lifecycle, from planning and design to construction and operations. While BIM does involve the use of computer programs and tools, it goes beyond that to encompass a range of practices and methodologies that can enhance the efficiency, accuracy, and sustainability of construction projects [2]. Table 1. illustrates the different definitions of BIM presented by researchers.

Table 1: Definition of BIM by researchers.

Author	Definition of BIM
(Eastman et al., 2011).[18]	"Building Information Modeling (BIM) is a collaborative way for multidisciplinary information storing, sharing, exchanging, and managing throughout the entire building project lifecycle including planning, design, construction, operation, maintenance, and demolition phase"
(Lee, Sacks, Eastman, 2006).[19]	"A BIM system is a system or a set of systems that “enables” users to integrate and reuse building information and domain knowledge through the lifecycle of a building."
In 2010, Gu and London.[20]	"BIM is an IT-based approach that involves the use and maintenance of an integral digital representation of all building information throughout the various phases of the project lifecycle in the form of a data repository".
(Isikdag, Underwood, 2010)[21]	"The information management process throughout the lifecycle of a building which focuses on collaborative use of semantically rich 3D Building Information Models (BIMs)"

In addition, a number of organizations and standards have developed definitions and concepts for BIM as shown in Table 2.

Table 2: Definitions and concepts of BIM by organizations and standards.

Organizations and Standards	Definitions of BIM
(National BIM Standard United States, 2008)[22]	"BIM is a digital representation of the physical and functional characteristics of an object. As such, it serves as a common knowledge resource for information about an object, forming a reliable basis for decision-making throughout its life cycle, from inception."
(BS 8536-1:2015 based on PAS 1192-2:2013, 2015)[23]	"BIM is the process of designing, constructing and operating a building or infrastructure facility using object-oriented electronic information."
(bimdictionary.com, 2022)[24]	"Building Information Modelling (BIM) is a set of technologies, processes and principles (standards) that enable multiple stakeholders to collaboratively design, build and operate a facility in a virtual space"
(ISO 19650-1, 2022).[25]	"The use of a common digital representation of a built Asset to facilitate the design, construction and operation processes to provide a reliable basis for decision-making"
(ISO 29481-1: 2016, 2022)[26]	"BIM is the use of a common digital representation of a building object (including buildings, bridges, roads, manufacturing plants, etc.) to facilitate design, construction and operation to provide a sound basis for decision-making."

In contrast to other definitions that attempt to simplify BIM into a single concept, SMART has taken a unique approach by breaking down the acronym into three distinct ideas and defining them separately. BIM or Building Information Model is a digital representation of a building or facility that encompasses all its physical and functional characteristics. It is essentially a 3D model that contains a wealth of information about the building components and systems, including their geometry, materials, performance, and interrelationships. This information can be easily extracted, exchanged, and combined with other BIM files to support various decision-making processes throughout the building lifecycle, from design and construction to operation and maintenance. BIM enables stakeholders to visualize, simulate, analyze, and optimize different scenarios and outcomes, leading to better collaboration, coordination, and efficiency across the project team. The process of Building Information Modelling (BIM) involves creating and managing digital representations of a building's physical and functional features. The term Building Information Management (BIM) refers to a process that involves the effective management and supervision of investment procedures with the help of a digital building model that contains information about asset components throughout the investment process. The primary objective of BIM is to create a comprehensive and integrated database that tracks the life cycle of a building and can be utilized for various purposes beyond decision-making. In essence, BIM serves as a relational database that accompanies a building object from its inception to its demolition and can be used for several applications, such as construction planning, design optimization, and facility management. In fact, BIM has expanded to become Better Information Management in many fields, including AECO. This shift in perspective highlights a growing trend towards the importance of information management itself, regardless of the structure, facility or space being considered.

Evolution of BIM

The concept of BIM maturity encompasses the levels of quality, repeatability, and degree of excellence achieved through BIM utilization within an organization [17]. Mezzanine is a common method of measuring Utilizing both the Bew-

Richards and Succar models, BIM maturity was achieved [15]. Although the Bew-Richards model is more complex, the descriptions used to establish the borders between levels are similar In the realm of construction delivery techniques, there exist two primary levels of Building Information Modeling (BIM). The first level, otherwise known as Level 0, relies on traditional paper documentation and technical drawings to convey information. On the other hand, Level 1 involves object-based modeling where numeric objects are used to represent different structural parts and elements of the construction process. Model-based collaboration between various stakeholders participating in a building project defines Level 2. Finally, Level 3 refers to network-based integration and is a long-term aim for BIM deployment that comes before the completion of integration projects. Figure 1 illustrates the Pew Richards family of the BIM maturity model.

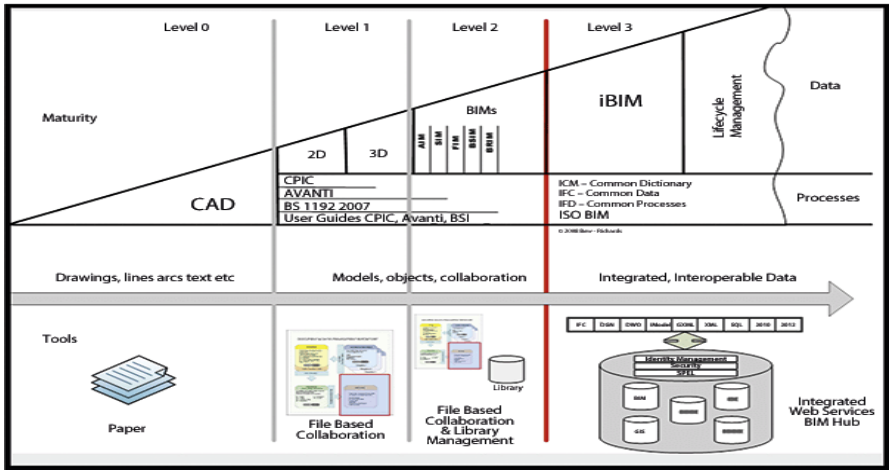

Figure 1. The Bew-Richards BIM maturity model [15]

Principles Of Building Information Modeling

In the construction industry, crucial project documents like specifications and graphics have traditionally been stored in physical media. However, over time, the industry has increasingly embraced digital technologies for managing and storing these documents. This shift towards digitization began in the 1970s with the introduction of software packages for computer-based building design, and has continued to evolve ever since. Today, digital tools and platforms are an essential part of the construction process, helping to streamline workflows, improve collaboration, and drive innovation. One of the early predecessors to modern BIM was the Construction Description System (BDS), which was proposed by Charles Eastman in the early 1970s. Before the advent of modern Building Information Modeling (BIM), there existed a system known as Building Description System (BDS), which shared some striking similarities with the former. BDS was a software tool that provided a user-friendly interface with graphical capabilities for storing and presenting different shapes of elements. It allowed users to interactively arrange elements in a design space using a graphical language. Additionally, it provided the functionality to create both perspective and spelling drawings. The tool also offered the ability to sort the database by attributes such as material type, which made it easier for users to manage and organize their designs. Since then, BIM has evolved through several stages, including the introduction of Graphical Language for Interactive Design in 1977, the Product Building Model (BPM) in the late 1980s, and the general construction model in the mid-1990s. When three-dimensional parametric modeling was established in the early 2000s, the concept of BIM took off, resulting in the contemporary BIM we know today.

Challenges And Barriers to BIM Implementation

Practices related to companies, applications, tools, project teams, procedures, and business models have a substantial impact on BIM deployment. Because the proper application of BIM

is yet unknown to industry practitioners, the general benefits of adopting BIM are not thoroughly established. A study explained that "the mechanism problem revealed in the implementation of BIM was based on BIM currently being presented as a project and not an innovation", She described the problem as "a failure to address the competence of key delivery agent BIM stakeholders" [4] . The implementation of Building Information Modelling (BIM) is no easy feat as it involves navigating through a myriad of challenges that can impede its effectiveness. These challenges include but are not limited to technical management difficulties such as integration with existing systems and software, environmental concerns such as energy efficiency and sustainability, financial constraints such as budget and resource allocation, and legal considerations such as intellectual property rights and liability issues. Addressing these challenges is crucial to ensure the smooth and successful implementation of BIM in construction projects [33]. Previously, a comprehensive analysis was conducted to thoroughly investigate the primary issues, obstacles, and outcome factors that provide a comprehensive understanding of Building Information Modeling (BIM) technology. The study emphasized the difficulties and potential risks associated with implementing BIM in the construction industry. Pilot research, for example, was done to analyze the hurdles and reasons driving the implementation of BIM in the Malaysian construction sector [34], while another study assessed the difficulties. The implementation of Building Information Modelling (BIM) has been significantly slowed down due to several potential legal issues surrounding it. A study has categorized these issues into areas such as model ownership, right of adoption, risk transfer, level of care, and compensation. These issues are widely agreed upon as significant obstacles to the widespread adoption and application of BIM technology [35]. A research study was conducted to evaluate the obstacles faced while seeking BIM accreditation and encountering collaboration issues. Based on the findings, a comprehensive BIM governance framework was developed, called G-BIM. This framework identifies various factors that are essential for achieving successful collaboration in BIM projects and ensures their effectiveness [36]. Despite the growing popularity of Building Information Modeling (BIM), there are still challenges that obstruct its effective implementation. The literature highlights several challenges that have a significant impact on the effectiveness of BIM application. To replace traditional construction techniques with BIM, it requires a collaborative approach between the industry and regulatory bodies, as well as incentives to encourage adoption. Based on the amended literature, there was general agreement that the policy outcomes greatly improved the degree of BIM adoption.

Success Factors for BIM Adoption and Implementation

In the early 1960, the notion of success factors was initially proposed [37]. It refers to the features, situations, or factors that, if correctly maintained, controlled, or executed, can have a substantial influence on a company's performance in a certain sector. When it comes to implementing BIM, success criteria are the key areas and outcomes that encourage professionals to transition from traditional project delivery methods that use CAD to a collaborative BIM approach, spanning from the initial design phase to facility management. These criteria serve as the benchmark for measuring the effectiveness and efficiency of the BIM implementation process, covering aspects such as improved communication, reduced errors, increased productivity, and better project outcomes [39]. Previous research has identified various success factors that contribute to the achievement of organizational goals. These factors include but are not limited to the effective use of software tools, the involvement of skilled individuals, the establishment of sound procedures, the adoption of appropriate business models, the development of effective policies, the consideration of available resources, and the successful completion of relevant projects. While some studies concentrate on analyzing BIM acceptance and improving implementation, others stress the relevance of crucial success criteria for long-term, sustainable BIM deployment [39]. Although various nations may have their own

frameworks for measuring BIM implementation success, some success indicators are common [40]. Policy, technology, and remediation are critical parts in effective BIM adoption, with each building classified into two or more group factors. It is advised that future research focus on the effects of policy development and technology on decision-makers' comprehension of the link between construction and BIM application in order to properly apply BIM.

Conclusions And Discussion

The adoption of Building Information Modelling (BIM) has gained immense popularity in recent years as it provides an advanced framework to manage complex construction projects and overcome various technical challenges. BIM facilitates the creation and management of digital representations of physical and functional characteristics of buildings, which allows stakeholders to collaborate efficiently and make informed decisions throughout the project lifecycle. However, the relationship between BIM and construction project management has not yet been thoroughly analysed from the perspective of a literature review. Thus, extensive research was conducted to explore the detailed relationship between BIM and construction project management, including its development and progress over time. The results of the study revealed that there is a growing interest in BIM along with construction management. The research agenda behind the application of modelling was influenced by Building Information (BIM) in the management of construction projects primarily in China, the USA, England, and Australia, which together make up a large part of the world's population. The literature on the application of BIM in project management has evolved from traditional purposes of monitoring and control, such as scheduling, to more complex and multidimensional topics such as sustainability, lean construction, and improvement. In recent years, the use of Building Information Modelling (BIM) in the construction industry has experienced a significant transformation in terms of its application. BIM has now become an indispensable tool for effective and efficient project planning and implementation. Its ability to provide accurate and detailed 3D models of buildings, along with the information on various components and systems, has made it an essential aspect of the construction process. With the help of BIM, project stakeholders can collaborate and coordinate better, which ultimately leads to better project outcomes. A review of this study revealed the specific themes of the project knowledge management body. She focused on the role of BIM in promoting procurement, stakeholders, and topics through specific topics such as productivity, safety, and sustainability. BIM is used to identify critical barriers and success factors driven by BIM-based collaboration in integration and communication processes. BIM is analysed for implementing resources and cost through three-dimensional models, including cost, and enhance productivity and efficiency through a lean project management approach. The role of BIM is focused on timely and quality topics by integrating four-dimensional models that include scheduling and implementing performance management from a lifecycle perspective. The most representative themes supported by the BIM application in the integration of construction project management, time, and cost demonstrate that BIM has a key role in facilitating integration by standardizing and integrating different project management activities and coordinating them through four- and five-dimensional models. In contrast, BIM still plays a primary role in identifying and monitoring scope, risk, and procurement management. The use of Building Information Modelling (BIM) in construction project management has brought about a shift in the traditional approach of project management literature. BIM has enabled the optimization of various processes that were previously assigned during the planning phase. Its role as a promoter of project activities according to plan has been highlighted in the literature. Moreover, the presence of BIM in the planning process has shed light on three important topics that play a crucial role in the successful implementation of construction projects: resources, cost and quality. These topics have been extensively discussed in the literature and are considered to be the key factors for effective project planning.

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