BIM Technology: A Comprehensive Overview of Definitions, Benefits, and Implementations

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INTRODUCTION

In recent years, the demand for Building Information Modeling (BIM) has increased in the construction industry. BIM is becoming a vital tool for streamlining processes throughout a building's life cycle. While implementing BIM into the design process may present several challenges, it can be highly beneficial to the Architectural, Engineering, and Construction (AEC) industry when effectively adopted. Additionally, BIM is a process that involves designing, constructing, and operating a building or infrastructure asset using an electronic, object-oriented information model [1]. One of BIM's main roles is to introduce new dimensions, enabling integration between the 3D model and the necessary data. Moreover, this study aims to explore the definitions, benefits, implementations, and ways BIM is transforming project construction. Additionally, the paper presents the results of BIM adoption across various case domains. The findings highlight the use of BIM in architectural and structural applications, 3D model design, and architectural visualization to improve work and project life cycles.

Keywords: Building Information Modeling, 3D Design, (AEC).

METHODOLOGY

To meet the study's objectives, the research conducts a comprehensive review of scholarship on definitions, benefits, and implementations, using a clear selection process as the criteria, along with collecting several studies involving BIM technology. This approach employs qualitative case study designs, followed by an effort to develop an understanding of the effectiveness of BIM implementation in the AEC industry [2]. The findings of this approach highlight three main categories in the research: definitions, benefits, and implementations of the BIM technology.

DEFINITIONS

BIM is being rapidly introduced into the AEC industry and is considered a cutting-edge technology [3]. The concept of BIM was introduced in the 1970s to refer to a 3D drawing, along with associated information. Additionally, BIM technology enables the dynamic interrelation of data for a specific project to be stored in a single file. The information needed to add includes capital costs, time program, life cycle costs, capital allowances, etc. [4]. Therefore, BIM could function as a platform to manage different categories of data. BIM is generally defined as the following:

● *BIM* is a process for creating and managing all the information on a project before, during, and after construction [5]. The output of this process is the BIM model, a digital representation of every aspect of the built asset. For instance, it can be utilized as an advanced tool in designing framing systems in normal and steel buildings [6].

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● *BIM* is a process that begins with the creation of an intelligent 3D model to capture, explore, and maintain consistent and coordinated planning, design, construction, and operational data to better information decision making for building and infrastructure projects [7].

BIM BENEFITS

The key benefit of BIM is its accurate, geometrical representation of a building's components within an integrated data environment [8]. Several studies on the adoption of BIM technology in the AEC industry emphasize its benefits, including conceptual design, design documentation, project communication and collaboration enhancement, pre-fabrication construction, and life cycle costs. One example of this approach is the use of BIM in the early-stage design process of residential buildings to analyze energy efficiency, serving as designerly decision support [9]. Figure 1 shows the benefits of using BIM for construction projects.

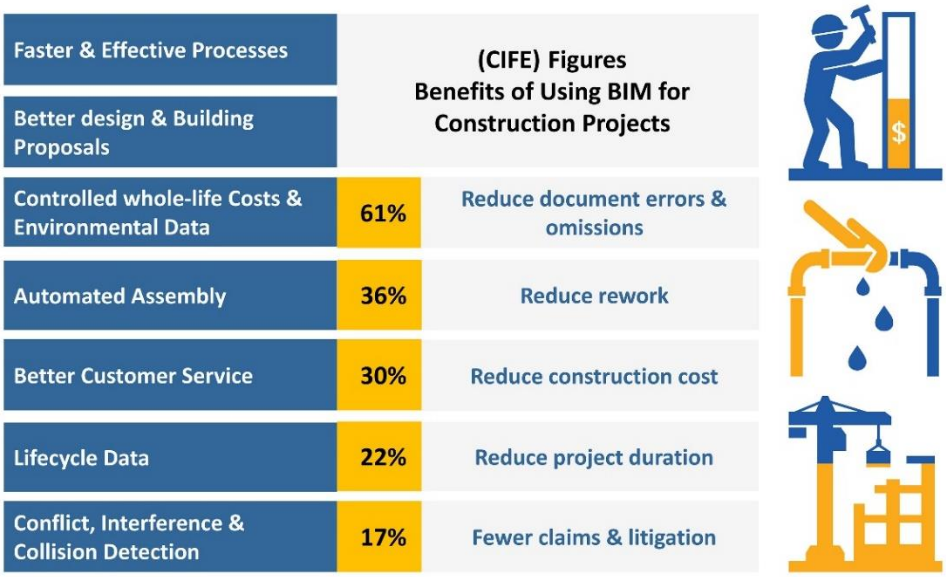

Figure 1: Benefits of using BIM.

BIM PURPOSES AND IMPLEMENTATIONS

BIM exceeds the scope of 3D modelling, moving into a file-based collaboration and library management [10]. BIM models are data-rich, object-oriented, intelligent, and parametric digital representations of a facility, tailored to meet the needs of various users. Additionally, these models can be extracted and analyzed to support design and construction-related decisions [11]. Moreover, building information modeling tools and models can be utilized for multiple purposes, as shown in Table 1.

Table 1: Purposes for using (BIM) Models

	BIM Purposes	
1	Design visualization	
2	Fabrication and shop drawings	
3	Code reviews	
4	Forensic analysis	
5	Facilities management	
6	Cost estimating	

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7	Construction sequencing	
8	Conflicts and collision detection	
Moderate Importance	High Importance	Highest Importance

Initially, the key purpose of BIM implementation is the management of information in parallel with the collaboration of stakeholders (owners, engineers, contractors, and facility managers). Implementation of BIM can be classified into several levels (Modeling, Collaboration, and Integration) [12], as shown in Figure 2.

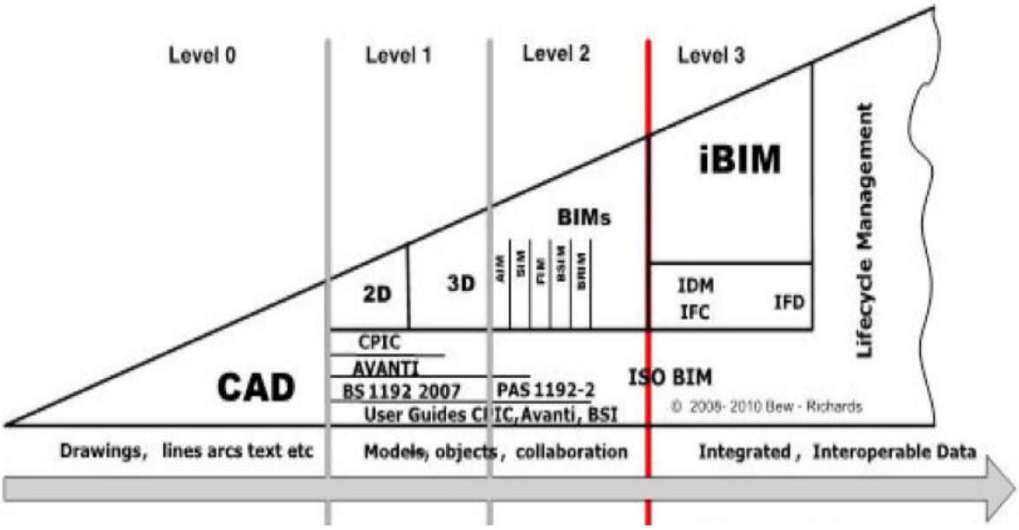

Figure 2: BIM Levels.

BIM PLATFORM

Advanced IT technologies in the industrial field

The rapid advances in information technology and the electronic industry have laid a strong foundation for revolutionized artificial intelligence applications and interdisciplinary projects. These advances have a significant impact on all sectors of the economy. Additionally, they are rapidly expanding in various domains, particularly in architectural projects, such as innovative housing design and construction practices [13]. Moreover, the technology of building information modeling is closely tied to these innovations and continues to evolve in response to recent trends. Examples of how advanced IT technologies are integrated with BIM can be seen in Cloud Technology, Smart Homes, Advanced Landscape Design, VR/AR (Virtual and Augmented Reality), 3D Scanning of terrain, 3D Printing, and Artificial Intelligence [14].

BIM GROWTH

According to Autodesk, one of the leading companies in the BIM software market, the world currently operates in an era where BIM processes and information sharing are crucial to the project life cycle, extending even to urban design development. Additionally, CAD represents the first era of documentation, and now we are in the era of optimization with BIM. Table 1 offers insight into the three levels of BIM.

Table 2. Building Information Modeling (BIM) levels.

BIM Level	Definition
Level 0	It is defined as an unmanaged CAD, likely to contain 2D design papers, information from traditional drawings, and separate sources of information.
Level 1	It is described as a mix of 2D and 3D information with a collaboration tool providing a common data environment (exchange of information in different formats).
Level 2	It is described as collaborative BIM. Federated?? Model information is shared within a Common Data Environment.
Level 3 (I BIM)	It is likely to be a fully integrated model with interoperable data where all participants work from a single stored model (web service or cloud).

Furthermore, the integrated BIM models provide a comprehensive description, facilitating effective management and ensuring a high level of collaboration among all project participants throughout the development and implementation phases. This technology enables users to visualize and analyze future objects made from the selected materials. Additionally, it provides numerous tools for managing cost estimation, optimizing the construction phase, detecting clashes, extracting architectural solution information, utilizing spreadsheets, and developing an intelligent model for the facility's future operations. These features likely enhance the project's value throughout its entire life cycle. On the other hand, BIM plays a crucial role in transforming urban design by providing a comprehensive and collaborative approach in the whole project lifecycle [15]. BIM acts as a digital backbone, promoting efficiency, accuracy, and communication among various stakeholders in the urban design process. In the early stages, BIM enables precise site analysis and visualization, helping urban designers develop detailed 3D models of the current environment [16]. This supports informed decisions about spatial relationships, zoning, and land use. As projects advance, BIM facilitates collaborative design by enabling seamless communication and coordination among architects, engineers, and planners. Real-time updates and shared data improve teamwork, reduce errors, and optimize design outcomes [17]. BIM's ability to combine data on energy use, material consumption, and environmental effects supports sustainable urban design. It enables designers to make eco-friendly decisions, aligning projects with current sustainability goals. Essentially, BIM is a transformative tool for urban planners, offering a comprehensive, data-driven approach that enhances efficiency, collaboration, and sustainability throughout the urban design process. Thus, the BIM model can be considered a multidimensional platform with various scenarios and applications. Furthermore, the components of BIM technologies can be tied to the planning, design, construction, and further operation stages.

RESULTS AND DISCUSSION

Building Information Modeling (BIM) is gaining popularity as an innovative technology that revolutionizes the construction process. As the use of this tool expands, collaboration among all project participants is expected to grow accordingly. As demonstrated in this study, the AEC industry is rapidly adopting this technology to achieve substantial improvements in efficiency and cost control. Meanwhile, the academic community approaches this trend more cautiously. The goal of the architecture and engineering departments is to prepare professionals for their future roles in the AEC industry. As part of this effort, engineering education should highlight advances in Information Technology tools (IT). Therefore, students need to acquire new knowledge and skills. To meet this need, universities should introduce new advanced courses, organize professional workshops on this essential technology, and build strong partnerships between universities and industry. In short, the authors, as educators, are committed to integrating this innovative platform into academic programs, encouraging students to adopt this new technology.

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CONCLUSIONS

The study showed that BIM technology can be very valuable to the AEC industry. Additionally, using data-rich objects encourages a more innovative design and analysis process. Therefore, academia and industry should collaborate closely to facilitate effective knowledge transfer. Ultimately, educational institutions must play a key role in increasing BIM understanding and promoting the development and adoption of this vital technology. This can be achieved by training new professionals who will incorporate BIM into their future careers in the AEC sector.

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