

Proposed Integration of Building Information Modeling and Database Management Systems for Start-Up Construction Firms

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ABSTRACT

This article investigates the potential integration of Building Information Modeling (BIM) and Database Management Systems (DBMS) to enhance the operational efficiency and competitiveness of start-up construction firms in the Philippines. The research aims to assess the current levels of awareness and utilization of these technologies among start-ups, identifying both the benefits and the barriers to their adoption. Using a mixed-methods approach, including quantitative surveys and qualitative interviews with construction professionals, this study seeks to gather comprehensive data on the subject. The proposal introduces a phased integration framework tailored to address the specific challenges faced by start-ups, such as cost and complexity, and proposes a hybrid satisfaction-challenge index to quantitatively measure the impact of BIM and DBMS on project management efficiency. The expected outcomes include valuable insights and practical guidance for start-up construction firms, construction managers, technology providers, policymakers, and the academic community, with the ultimate goal of optimizing construction management practices and fostering sustainable development in the Philippine construction industry.

Keywords: Building Information Modeling, BIM, Database Management Systems, DBMS, start-up construction firms, technology adoption, project management efficiency

INTRODUCTION

In the rapidly evolving construction industry, integrating technological innovations like Building Information Modeling (BIM) and Database Management Systems (DBMS) is crucial for enhancing operational efficiency and competitiveness. This is particularly significant for start-up construction firms facing intense competition and the need for technological adaptation to meet increasing demands for quality, safety, and timeliness (Kiu et al., 2022). BIM offers a comprehensive three-dimensional digital representation that facilitates collaborative and efficient project management (Fernández-Mora et al., 2022), improving decision-making, reducing errors, and enhancing outcomes (Zhang, 2024). However, realizing BIM's full potential requires a robust DBMS infrastructure to ensure data integrity, accessibility, and usability (Wang & Chen, 2023).

DBMSs are critical in this technological ecosystem, serving as the backbone for storing, retrieving, and managing project data efficiently (Krysik, 2024). They facilitate complex queries, real-time data analysis, and ensure data security and integrity, enabling seamless information flow and fostering collaboration (Mullins, 2023). Despite their advantages, BIM and DBMS adoption in start-up construction firms faces challenges like limited awareness, perceived high costs, and the need for specialized training (Msawil et al.,

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2022). In the rapidly growing Philippine construction industry (Biswas, 2023), start-ups must adopt these technologies to achieve operational excellence and competitiveness.

To stay competitive, start-up firms must navigate the complexities of technology adoption, understanding potential barriers and developing strategies to overcome them (Farhadi, 2024). This study aims to assess the current awareness and utilization of BIM and DBMS among start-up construction firms, identify their benefits, and propose an implementation framework. By exploring these aspects, the research seeks to uncover factors influencing the adoption of these technologies, providing insights to enhance project management capabilities and overall competitiveness.

OBJECTIVES

The general objective of this research is to enhance construction management in start-up firms through the integrated use of Building Information Modeling (BIM) and Database Management Systems (DBMS), aiming to improve project efficiency, accuracy, and competitive advantage.

Specifically, this study aims to:

1. Determine the level of awareness among start-up construction firms about Building Information Modeling (BIM) and Database Management System (DBMS).
2. Identifying the benefits in utilization of using BIM technology alongside of the Database Management System.
3. Proposed an implementation framework for start-up construction firms to integrate the Building Information Modeling (BIM) and Database Management System (DBMS).

RESEARCH FRAMEWORK

BIM and DBMS are increasingly becoming standard practices in the global construction industry, with many developed countries mandating their use for infrastructure projects. This study focuses on integrating BIM and DBMS for start-up construction firms, addressing issues and challenges largely attributed to traditional construction practices. The slow adoption of these technologies is primarily due to a lack of awareness about their capabilities, which is a significant barrier. Recognizing and promoting the specific benefits of BIM and DBMS in construction are key drivers for their adoption.

In the context of start-up construction firms in the Philippines, adopting BIM and DBMS technologies is essential for enhancing industry performance. This study aims to explore these technologies and gain insights from Filipino construction professionals. Through this investigation, the research intends to develop a tailored methodology that meets the specific needs and challenges faced by start-up construction firms in the Philippines. This approach aims to equip these firms with the necessary tools and strategies to effectively utilize BIM and DBMS, thereby improving their operational efficiency, productivity, and sustainability in construction projects.

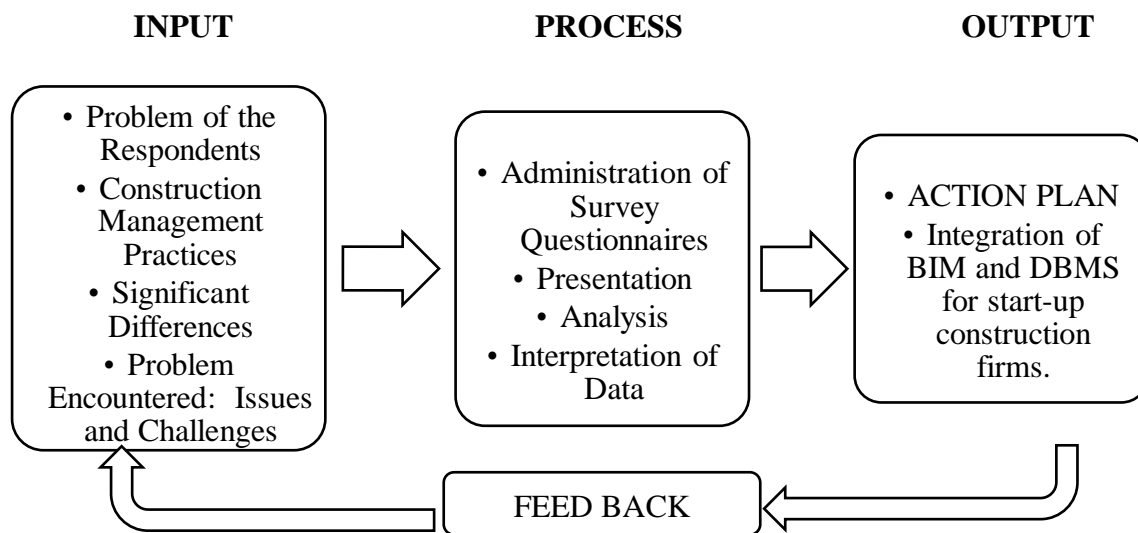


Figure 1. Research Framework

LITERATURE BACKGROUND

Construction Industry

Table 1. Issues and Challenges in the Construction Industry

Construction Issue	Literature
Change Orders	(Alraie et al., 2022) (Waty & Sulistio, 2022), (Khosro et al., 2019)
Bidding and Tendering	(Zhang & Li, 2022), (Zhou, 2012), (Dumo O. & Mac-Barango, 2022),
Client Satisfaction	(Alshihre et al., 2020), (Oluwaseun & Abiodun, 2021), (Rahman & Alzubi, 2015)
Communication Gaps	(Gamil & Rahman, 2023)
Cost Overruns	(Kamaruddeen et al., 2020), (Xie et al., 2022), (Shibani & Arumugam, 2015)
Design Changes	(Muhamad & Mohammad, 2018), (Aslam et al., 2019), (Mishra & Aithal, 2022)
Scheduling Delays	(Pinamang et al., 2018), (Abbas et al., 2023), (Hansen et al., 2023)
Site Safety	(Kiral & Demirkesen, 2023), (Chung et al., 2023), (Hire et al., 2021)
Waste Reduction	(Bang & Andersen, 2022), (Mohammed et al., 2021), (Liu et al., 2020)
Data Management / Documentation Management	(Tanga et al., 2022), (Mohite, 2020), (Kozlovska et al., 2016), (Senaratne & Mayuran, 2015)

The construction industry has experienced revolutionary changes due to technological advancements (Regona et al., 2021). These innovations have fundamentally redefined design, planning, and execution processes (Wang et al., 2023). Despite these advancements, the industry remains one of the least productive sectors (Phillips, 2023). Integrating technology has introduced methodologies and tools that optimize the construction lifecycle, providing data-driven insights to streamline workflows and improve project outcomes (Pan & Zhang,

2020). Globally, construction faces challenges impacting both developed and developing nations (Boadu et al., 2020). In countries like the Philippines, these issues are exacerbated by social and economic problems, resource shortages, and institutional weaknesses. The lack of familiarity with new technologies hinders competitiveness and access to innovative solutions (Jithinvisnu & Gokuldeepan, 2020; Tam et al., 2024). Addressing these challenges is crucial for meeting evolving demands and enhancing sector performance (Abioye et al., 2021). The construction industry undeniably plays a vital role in enhancing the economic activities and overall well-being of a country, especially in developing nations. However, the current practices and methodologies seem insufficient to handle the advancement of the construction industry. In smaller firms, adopting new innovations and technology happens slower than in others. Meanwhile, developed companies are actively advancing and deploying a variety of technologies and innovations. This research aims to evaluate how startup construction firms integrate BIM and DBMS to effectively use the technology to minimize and eliminate issues.

Building Information Modeling

Table 2. Benefits of BIM in Construction (Stannard, 2023)

Benefits of BIM in Construction	
Early detection of problems	By identifying conflicting components in a building design early on in the modeling process, costly alterations during construction are avoided.
Improvement in scheduling	Intelligent modeling allows for more effective sequencing of project aspects, opening the door to more methodical scheduling.
Construction automation	Workers can concentrate on specialized activities as the software identifies tasks that can be easily automated.
Enhanced construction processes	BIM software automatically creates workflows, and for every modification made during construction, the process is automatically updated for all site users.
Increased worker safety	Employees are more focused and risk-aware since they have direct access to detailed information about every task.

Building Information Modeling (BIM) is a digital process for creating and managing comprehensive 3D representations of buildings (Ding et al., 2014). It spans the entire lifecycle of a building, from design to maintenance (Eadie et al., 2013), facilitating improved collaboration, efficiency, and decision-making among stakeholders (Alizadehsalehi et al., 2020). BIM shifts from 2D drawings to detailed 3D models, providing realistic views of structures and enhancing project efficiency by identifying issues early (Yoon & Lee, 2023; Yaakob et al., 2016). BIM facilitates early problem detection, improved scheduling, construction automation, enhanced processes, and increased worker safety (Stannard, 2023). BIM is used throughout the project lifecycle, adding value at every stage (Stannard, 2023). BIM dimensions include 2D visuals, 3D modeling, 4D time, 5D cost analysis, 6D sustainability, and 7D management, with ongoing discussions about 8D safety, 9D lean construction, and 10D industrialization (Ellis, 2023; Harmony, 2023). Revit is a prominent BIM software used for designing, visualizing, and managing building projects (LLC, 2023; Kommana, 2024). Adoption of BIM in the Philippines has been limited due to high software costs. However, initiatives like TESDA's national certification program aim to enhance BIM skills among Filipino professionals (TESDA, 2023).

Database Management System

Database Management Systems (DBMS) are crucial for storing, retrieving, and managing data efficiently, reducing manual workloads (AppDynamics, 2024; Mullins, 2023). DBMSs ensure data is well-organized and easily accessible, essential for managing large volumes of data in construction projects (MDV Co., Ltd., 2021). A well-designed construction database serves as a central repository for project data, enabling project managers to make informed decisions and maintain project progress (Kolosky, 2023). A construction database enhances data storage, access, communication, collaboration, and data analysis (Kolosky, 2023). Software like ClickUp, OrangeScrum, and Wrike offer features that improve project management efficiency, collaboration, and data analysis (Demski, 2021; Das, 2023; Abdullahi, 2024).

Data Management System and Bim in Construction Companies

Data Management Systems facilitate BIM integration, enhancing project data management (Wang et al., 2020). Studies show that BIM combined with business intelligence tools improves decision-making, sustainability, and project deliverability (Rodrigues et al., 2022). However, interoperability issues and the need for blockchain technology to improve document management highlight ongoing challenges (De Gaetani et al., 2020; Kiu et al., 2022). Moreover, Huang (2021) noted that China has seen the widespread application of BIM to enhance project management, reflecting an irreversible trend toward its adoption. The integration of BIM technology and big data becomes imperative for effective construction project cost management. Rodrigues et al. (2022) developed a methodology combining data with BIM and business intelligence tools, demonstrating the capacity to provide a collaborative platform for accurate data analysis. De Gaetani et al. (2020) focused on interoperability issues between 4D models and Gantt charts, highlighting practical challenges. Kiu et al. (2022) explored the potential of blockchain technology in enhancing electronic document management within the construction industry, identifying current limitations and challenges. This literature review emphasizes the transformative potential of BIM and DBMS in the construction industry, particularly for start-up firms, by addressing key challenges and proposing integrated technological solutions.

MATERIALS AND METHODS

The research design provides a detailed plan for the proposed integration of BIM and DBMS in start-up construction firms. A mixed-methods approach combining quantitative surveys and qualitative interviews, along with case studies for in-depth exploration, is employed. By integrating these methods, the study aims to deliver a comprehensive understanding of current practices, challenges, benefits, and the impact of these technologies on firm performance, offering valuable insights for industry stakeholders and guiding future technology integration strategies.

The study's respondents are 100 start-up construction firms in the Philippines that have been in operation for five years or less, targeting those at a critical development stage where technological adoption could significantly impact growth and competitiveness. Insights and necessary data will also be collected from project managers, BIM coordinators, construction professionals, and other relevant personnel in these firms.

Various data-gathering instruments are employed to achieve the best results for the study. These include survey questionnaires distributed to start-up construction firms and informal interviews with firms that have deeper knowledge of technological adoption. Different research materials, such as books and thorough reviews of existing literature, will also be used. The structured questionnaire will cover BIM and DBMS awareness, perceived challenges, benefits, and satisfaction levels, distributed via online platforms like Google

Forms, email, and physical distribution at industry events. A sample size of 30 start-up construction firms identified through purposive sampling ensures diverse representation. The survey instrument incorporates Likert-scale items and open-ended questions, refined through pilot testing for enhanced clarity and reliability.

A mixed-methods approach will be used to collect quantitative and qualitative data comprehensively. Quantitative data collection involves administering structured questionnaires with Likert-scale items to measure awareness, satisfaction, and challenges. These will be distributed electronically or in paper format to selected respondents. Qualitative data collection involves in-depth interviews and detailed feedback from key stakeholders, such as project managers and construction professionals, with open-ended questions to capture their experiences, challenges, and benefits with BIM and DBMS.

Data analysis involves examining collected information to understand how BIM and DBMS are utilized and their impact. Quantitative methods will provide numerical data for analysis, using statistical methods to analyze survey responses and gauge awareness and satisfaction levels. Qualitative methods will gather insights and opinions from start-up construction firms, interpreting statistical findings within the study's theoretical framework and research objectives to draw meaningful conclusions and recommendations.

The study ensures the reliability, accuracy, and validity of the findings regarding the integration of BIM and DBMS in start-up construction firms by combining data from surveys, interviews, and document analysis. This comprehensive approach provides a detailed understanding of the integration process. The evaluation measures the effectiveness of these technologies in improving project management and outcomes, assessing ease of implementation and adoption by start-up construction firms, guiding decision-making and optimization efforts.

EXPECTED RESULTS

The expected results for this study are based on the anticipated findings regarding the integration of Building Information Modeling (BIM) and Database Management Systems (DBMS) in start-up construction firms in the Philippines. The findings are projected to provide insights into the current awareness and utilization of BIM and DBMS technologies, as well as the benefits and challenges associated with their adoption. These results will be categorized into key areas: *awareness, utilization, benefits, and challenges*.

1. Awareness of BIM and DBMS

It is expected that the study will reveal varied levels of awareness among start-up construction firms about BIM and DBMS technologies.

- **BIM Awareness:** It is anticipated that most firms will have a basic understanding of BIM, particularly its applications for 3D modeling and design visualization. However, there will likely be a lack of knowledge about its full capabilities, such as 4D scheduling, 5D cost estimation, and its integration with DBMS for better project management.
- **DBMS Awareness:** Start-up firms are expected to show a higher level of awareness of DBMS due to its foundational role in project data management. However, the study will likely indicate that many firms use basic data storage methods (e.g., spreadsheets) rather than adopting advanced DBMS technologies capable of supporting complex project management processes.

2. Utilization of BIM and DBMS

It is expected that the study will show a low rate of active utilization of BIM and DBMS technologies among start-up construction firms.

- **BIM Utilization:** The adoption of BIM in start-up construction firms will likely be limited, with only a few firms implementing basic BIM features like 3D design and

clash detection. The study may find that firms are hesitant to adopt BIM fully due to the high initial investment in software and training.

- **DBMS Utilization:** For DBMS, firms may be using basic solutions to store and organize project data but will likely lack integration with BIM or more sophisticated project management systems. The use of advanced DBMS functionalities like real-time data updates, project tracking, and advanced analytics is expected to be minimal in most start-up firms.

3. Expected Benefits of BIM and DBMS

The study is expected to highlight several benefits that start-up construction firms anticipate from integrating BIM and DBMS into their operations.

- **BIM Benefits:**
 - **Early Detection of Issues:** Firms are likely to recognize the potential of BIM for identifying design errors or conflicts early in the project lifecycle, which can reduce costly change orders during construction.
 - **Improved Scheduling and Sequencing:** The use of BIM is expected to lead to better project scheduling, as firms anticipate the software's ability to automate task sequencing and improve resource allocation.
 - **Worker Safety:** With the use of BIM, firms are likely to report an increase in safety awareness, as workers and project managers will have detailed information on site conditions and tasks.
- **DBMS Benefits:**
 - **Efficient Data Management:** Start-up firms are expected to acknowledge that DBMS technologies will improve the organization, retrieval, and management of project data, enhancing overall project tracking and decision-making processes.
 - **Collaboration and Communication:** Firms will likely report that DBMS enhances communication and collaboration among team members and stakeholders by centralizing project data, making it easier to access and share real-time information.
 - **Cost Efficiency:** The integration of DBMS with BIM will likely be seen as a key factor in reducing project costs through better data organization, minimizing errors, and streamlining workflows.

4. Challenges to BIM and DBMS Adoption

The study will also explore the barriers to the adoption of BIM and DBMS technologies, particularly for start-up construction firms. These challenges will likely include:

- **Cost:** The high initial investment required for BIM software licenses and DBMS infrastructure is expected to be one of the primary challenges for start-up firms, which often operate with limited financial resources.
- **Training and Expertise:** A lack of skilled professionals and the need for specialized training in both BIM and DBMS technologies is expected to be a significant barrier for start-up firms, as many small firms do not have access to the necessary expertise.
- **Resistance to Change:** Many start-up firms may be hesitant to shift from traditional construction practices to more technology-driven approaches due to the perceived complexity and unfamiliarity of BIM and DBMS systems.
- **Integration Complexity:** The integration of BIM with DBMS systems might pose technical challenges, particularly in terms of interoperability and ensuring that the systems work seamlessly together to support project management functions.

5. Proposed Implementation Framework

Based on the findings from the survey and interviews, the study will propose a phased implementation framework tailored to the specific needs and challenges of start-up construction firms. This framework is expected to outline:

- **Phase 1:** Introduction and awareness-building activities to educate construction firms about the potential of BIM and DBMS, focusing on low-cost, easy-to-adopt tools and software.
- **Phase 2:** Pilot implementation of BIM and DBMS technologies with small-scale projects to help firms gain experience and demonstrate the benefits of these systems in improving efficiency and reducing costs.
- **Phase 3:** Full integration of BIM and DBMS across all project phases, from design to construction, with continuous training and support to ensure successful adoption and long-term sustainability.

DISCUSSION

The findings of this study indicate that while start-up construction firms in the Philippines are becoming more aware of the potential of Building Information Modeling (BIM) and Database Management Systems (DBMS), their adoption and utilization remain relatively low. Awareness levels varied among the firms, with BIM being less familiar than DBMS, which is primarily recognized for basic data management purposes. However, this mixed awareness highlights an opportunity for further education and outreach efforts to raise understanding about how BIM can be leveraged for not just design, but also for cost estimation, scheduling, and site management.

In terms of utilization, the study found that only a small percentage of firms were actively integrating both BIM and DBMS into their processes. This low adoption rate can likely be attributed to the high upfront costs of software and training, which remain significant barriers for start-ups with limited financial resources. While some firms were in the exploratory stages of BIM implementation, many were hesitant to fully integrate the system into their projects due to the perceived complexity and the challenge of acquiring skilled personnel capable of operating such advanced technologies. The results also revealed that most start-ups were still relying on basic tools like spreadsheets for data management, suggesting that while there is recognition of the value of DBMS, firms are not yet fully capitalizing on more sophisticated systems that could support seamless data integration across project phases.

Despite these challenges, the study identified several benefits associated with BIM and DBMS adoption, which could drive future growth and efficiency in the sector. BIM was particularly valued for its ability to detect design flaws early, improve scheduling, and enhance worker safety. These benefits underscore the potential of BIM to reduce costly project delays and errors, which are crucial for start-ups trying to establish themselves in a competitive market. On the other hand, DBMS provided substantial advantages in terms of data organization, real-time communication, and collaboration among stakeholders, all of which can streamline project management and decision-making processes. The findings suggest that, although adoption is currently limited, the benefits of these technologies are recognized by those who have begun implementing them.

The study also pointed out several challenges that hinder the broader adoption of these technologies. One of the most significant barriers is the high cost of implementing BIM and DBMS, particularly for small firms that may not have the capital to invest in expensive software and training programs. Furthermore, the lack of technical expertise within many start-up firms was a major concern, with many respondents highlighting the difficulty of recruiting and retaining personnel with the necessary skills to effectively use these technologies. Resistance to change was also mentioned as a barrier, as many firms are accustomed to traditional methods and are reluctant to adopt new practices that may seem daunting or unfamiliar. Additionally, integrating BIM with DBMS was seen as a complex

task that could require significant technical support, further adding to the perceived difficulty of adoption.

To address these challenges, the study suggests a phased approach to BIM and DBMS implementation. In the first phase, firms should focus on raising awareness and educating stakeholders about the value of these technologies, particularly emphasizing the long-term benefits that can be gained from more efficient project management and improved resource allocation. The second phase should involve small-scale pilot projects where firms can test these technologies in a controlled environment, allowing them to experience the benefits firsthand without committing to large-scale implementation. Finally, the third phase would involve full integration of both BIM and DBMS systems across all project stages, with ongoing training and support to ensure successful adoption.

CONCLUSIONS

This study concludes that the integration of Building Information Modeling (BIM) and Database Management Systems (DBMS) holds substantial promise for improving the operational efficiency, project management capabilities, and competitiveness of start-up construction firms in the Philippines. While awareness of these technologies is growing, their adoption remains limited due to several challenges, including high initial costs, lack of skilled personnel, and resistance to change. Nonetheless, the identified benefits of BIM and DBMS, such as enhanced scheduling, early detection of design errors, improved data management, and better communication among stakeholders, clearly indicate their potential to streamline project workflows and reduce costly mistakes.

The research highlights that while the majority of start-up firms have not fully embraced BIM and DBMS, those that have begun integrating these technologies report significant improvements in project efficiency and collaboration. These positive outcomes, however, are often constrained by the limited resources and expertise available to smaller firms. The barriers to adoption—primarily cost-related and technical—suggest that a more gradual, phased approach to implementation may be necessary, beginning with awareness-building initiatives and followed by pilot projects to demonstrate the value of BIM and DBMS before full-scale integration.

The study also points to the need for more tailored solutions for start-up firms, with a particular emphasis on affordable software options, training programs, and technical support. It is recommended that both industry stakeholders and policymakers collaborate to foster an environment that encourages the adoption of these technologies, possibly through subsidies, training partnerships, or incentives for start-ups. As the Philippine construction industry continues to grow, embracing technological innovations such as BIM and DBMS will be crucial for firms looking to improve their competitiveness and contribute to the overall advancement of the sector.

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