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Article

Identifying Barriers to Effective BIM Adoption in the Re-Engineering of Construction Business Practices in Developing Countries

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Abstract: Building Information Modelling (BIM) has been more popular in the construction industry as a consequence of the many advantages it offers, such as increased productivity, improved project outcomes, and reduced expenses. However, there are many obstacles that must be overcome before BIM can be widely used. This research uses a poll of construction industry experts to investigate the challenges associated with using BIM in projects. Cost of implementation, inadequate standards and procedures, and a lack of knowledge with BIM were some of the hurdles that were measured in the study. Statistical techniques were used to examine the data, and the findings indicate that the high cost of implementation and the absence of sufficient standards and procedures are the two main obstacles to the widespread adoption of BIM. Problems with supply chain management and a lack of experience with BIM are also mentioned as obstacles. The report also suggests solutions, such as a more focused teaching effort on BIM-related issues and the creation of a specialised BIM curriculum. Professionals in the construction industry may utilise the study's results to their advantage by expanding their knowledge of the obstacles standing in the way of widespread adoption of BIM.

Keywords: building information modeling; BIM adoption; construction business; developing countries; re-engineering

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1. Introduction

As a more in-depth conceptual approach, Building Information Modelling (BIM) [1] may include not only 3D visualisation, but also 4D, 5D, 6D, and 7D models. Construction firms are more interested in this cutting-edge methodology, and as a result, they are incorporating cutting-edge expertise and techniques into their projects. By streamlining and simplifying construction business delivery, BIM has shown its worth in the construction sector. The benefits of BIM in construction [2], however, are still primarily theoretical because of the many obstacles in the way of its widespread adoption in the re-engineering of construction business practises (RCBP) [3]. Politically, digital construction is a reaction to the construction industry's lack of competitiveness [4]. The goal of this strategy is to utilise BIM tools continuously throughout a project's life cycle, with an emphasis on sharing and reusing consistent digital data. The advantages of BIM have been extensively recognised, and it is currently being used in a variety of fields, including as urban planning [5], design [6], development [7], optimisation [8], safety [9], code compliance [10], and re-engineering [11]. Consequently, BIM systems have been proposed as a means to resolve issues with efficiency in the building industry [12]. BIM provides novel opportunities for boosting prefabricated building design [13] and is an essential integration point for prefabricated building [14]. However, there are still significant barriers that prevent BIM from being widely used in prefabricated building design and prevent its benefits from being fully realised. The introduction of BIM in 1987 was welcomed with excitement because of its promise to speed up the implementation of prefabricated modular construction [15], a novel strategic approach that departs from the norm of cast-in-situ technologies [16]. Room-sized volumetric pieces are assembled off-site in regulated factories, then transported to construction sites and stacked to create a full, sustainable infrastructure design as part of the re-engineering of construction industry practises.

The need to deal with the intricate and ever-changing conditions of the building sector inspired this investigation. Because of the rapid pace at which technology is changing the construction industry, it is crucial to test out new approaches like BIM to ensure that the sector maintains its competitive edge and makes the most of the opportunities presented by cutting-edge tools. Investigating BIM's potential to improve the sustainability and efficiency of the industry is critical in light of the rising worldwide need for sustainable and efficient building brought on by urbanisation and population expansion. Gaining a better grasp of the challenges associated with BIM implementation may help the construction industry as a whole become more competitive on a global scale by enhancing decision-making [17], strategy development [18], and resource allocation [19]. In addition to helping developed nations, this study hopes to aid underdeveloped nations by helping them better integrate BIM into their building industries and handle local difficulties. The findings of this research may aid in the standardisation of best practises, the promotion of more stakeholder engagement [20,21], the enhancement of communication, and the reduction of mistakes and inefficiencies in the building process by identifying hurdles to BIM adoption. In addition, this study may pave the way for more research on BIM adoption, encouraging further investigation of the topic and novel approaches to overcoming the obstacles mentioned. Smart, sustainable, and highly efficient practises are becoming the norm in the construction sector, making it more important than ever to use cutting-edge technology to accelerate development. In today's times, technology has played a crucial part in increasing productivity in many industries, including the building trade. The potential of BIM to aid in the re-engineering of construction industry practises has been widely recognised. However, there are many obstacles to overcome when putting BIM into practise. To meet the rising need for modern housing and infrastructure, several developing nations have renewed their interest in digital building. However, the construction industry around the world still faces a significant obstacle when it comes to effectively implementing cutting-edge technology.

The purpose of this study is to illuminate some of the challenges that may arise throughout the process of re-engineering construction business practises by using BIM technology. To our knowledge, no prior research has investigated the use of BIM in this field. The question "What are the potential barriers to BIM adoption in the e-business sector of construction engineering?" is central to this study's inquiry into the use of BIM in the online business operations of the construction industry. Regional governments and authorities are interested in incorporating BIM into their organisational business models to encourage development in the building sector as a result of its adoption. The idea of "virtual construction," which comprises a unified digital model from design through operation, is one of the most alluring aspects of BIM. The difficulties of using BIM to re-engineer building processes have been the subject of relatively few academic investigations. Researchers in developing countries might use the study's results to learn how to get through common roadblocks to implementing BIM. The study's results add to and deepen our understanding of how to strategically use BIM technologies in the building industry. Specifically, the study aims to:

1. **Literature Review:** Conduct a comprehensive review of existing literature on BIM adoption, focusing on case studies, best practices, and barriers faced by construction firms in developing countries. This will help identify and address gaps in BIM adoption and establish a strong foundation for the study.
2. **Surveys and Interviews:** Conduct surveys and interviews with construction industry stakeholders, including professionals, managers, and policymakers, to gather first-hand

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information on the challenges and opportunities related to BIM adoption. This will provide valuable insights into organizational strengths that can be harnessed to support BIM initiatives.
3. **Case Study Analysis:** Analyze successful BIM implementations in developing countries to identify factors that contributed to their success. This will help promote the extensive use of BIM systems in future technologies and position BIM as a frontrunner in the construction industry's technological advancements.
4. **Data Analysis:** Make use of both qualitative and quantitative methods when analysing the results of your survey, interview, or case study. The results will be useful for both public and commercial sector decision-makers in identifying the main factors holding back the widespread adoption of BIM.
5. **Recommendations:** Create a set of actionable suggestions to increase BIM adoption in the re-engineering of construction business practises, with a focus on developing countries, based on the findings. These recommendations will serve as a reference for future research endeavors aimed at devising technical and managerial solutions.

The article starts out by explaining what BIM is and why it's becoming so crucial in the building sector. Section 2 explains the methods that were used to gather data for the study. The importance of BIM in developing nations and how its application might improve construction sector results are discussed in Section 3. The article pinpoints the obstacles to BIM adoption in Section 4 and suggests ways to get around them. In Section 5, we lay out the steps we think will work best to bring BIM to nations with less developed infrastructure. After introducing the suggested approach, the article gives the findings and comments of the research in Section 6. The paper finishes with a summary of the key results and a focus on the significance of BIM adoption in the construction sector in developing nations in Section 7.

2. Research Methodology

A robust and comprehensive research framework is essential for enhancing the quality of any research project. It enables researchers to manage research steps effectively and in the correct sequence. Each step in the process has its own deliverables, providing researchers with the confidence to move forward to the next stages of the research. This research comprised two main phases:

- **Literature Review:** Barriers to BIM application were identified by a systematic literature assessment of the BIM research topic. The research methodology involved sourcing relevant papers from various databases, including Web of Science, Taylor & Francis, Springer, Scopus, Science Direct, Google Scholar, IEEE Explore, and ACM Digital Library. This research study encompasses existing studies from 2016-2021. We defined search key strings to yield a sufficient number of the most relevant research studies: ("Building Information Modeling" * "BIM" + "Factors for BIM" + "BIM implementation + "Barriers") and ("BIM" AND "Inhibitors" OR "obstacles" OR "Re-Engineering of Construction Business Practices").
- **Identification of Barriers and Measurement Items:** Researchers conducted a systematic literature review for the selected barriers and identified the most cited barriers affecting BIM implementation. Measurement items for each variable were derived from existing technology adoption studies. The research model consists of 30 barriers with 61 items, which the researchers carefully selected based on the study's requirements. These barriers include, but are not limited to, ambiguous commercial advantages, interoperability, lack of BIM integration with other mechanisms, lack of experts, and legal challenges.
- **Survey Development and Validation:** The survey questionnaire was designed on an online platform, with Google Forms being a widely used platform for data collection. To ensure the instrument's reliability, three experts were contacted for content validity and face validity. Based on the experts' review, some items were revised in the final questionnaire. Additionally, 20 respondents were used for a pretest of the questionnaire to check for clarity and validity.

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Statistical criteria were applied to the data from the pilot research, and several variables were dropped.

- **Data Collection:** The final data collection began after revising the instrument based on the pilot study results. From the Saudi Arabian Ministry of Commerce and Investment's website, we were able to compile a list of qualified architects, engineers, and construction (AEC) specialists. Subsequently, the respondents' contact information was obtained from the website of Saudi contractors' authority. A total of 600 respondents were randomly selected and invited via email and other social media channels to participate in the data collection process. The collection process lasted from January 2022 to March 2022. A total of 410 responses were received, out of which 35 were discarded during the data screening process, and 375 were retained for data analysis.
- **Data Analysis:** The research was conducted using SPSS, a statistical programme designed for the social sciences. The average, standard deviation, minimum, maximum, and ranking of obstacles are discussed with accompanying examples.

3. Importance of BIM in Developing Countries

Construction sector is a primary economic driver in developing countries [22], yet there are other factors that influence a nation's development. Building projects have proven to be exceptionally complex due to varying project conditions, the evolution of output over time as a result of feedback reactions, and the accumulation of project successes and resources. In order to improve prefabrication and assembly processes [23], as well as address or rectify issues caused by unintentional errors or modifications, the use of BIM is essential on the construction site, in the plant, and in the design office. Prior researchers have identified numerous factors that create barriers to BIM adoption, but they have not thoroughly examined the mechanisms behind such impacts. The immediate barriers that have slowed the spread of BIM in underdeveloped nations have not been well explored in previous studies. It will pave the path for presenting appropriate solutions for BIM adoption by identifying the primary impediments to BIM adoption, with a focus on the construction sector in developing nations. It offers numerous benefits, such as improved coordination, increased efficiency, and reduced errors, which can significantly impact the construction sector in these countries [24].

According to Ismail et al. [25], BIM adoption in developing countries specifically in asia is gradually increasing, although at a slower pace compared to developed countries. This slow uptake can be attributed to various factors, such as lack of awareness, inadequate infrastructure, and limited access to resources. Nonetheless, the potential of BIM in enhancing project management and fostering sustainable development is recognized in these regions. In a case study of Nigeria, Babatunde et al. [26] performed a cross-country study on the factors influencing AEC businesses to embrace BIM, with a focus on emerging nations. The findings highlight the importance of understanding the unique challenges and opportunities in the local context, which can facilitate the development of tailored strategies for BIM adoption.

A review by Bui et al. [24] emphasizes the need for developing countries to embrace BIM for construction, as it can significantly contribute to overcoming common issues, such as cost overruns, delays, and poor quality. The authors also discuss the potential barriers to BIM adoption, including lack of awareness, insufficient training, and limited financial resources. Olugboyega et al. [27] provide a complete model for the deployment of BIM in developing countries, tailored to the specific needs of these nations. The model takes into account various factors, such as the availability of resources, the level of expertise, and the existing infrastructure. This approach can help guide the implementation of BIM in a more effective and context-specific manner.

Ariono et al. [28] conduct a rigorous literature review and comparative analysis to reveal the drivers, constraints, and facilitators of BIM innovation in low- and middle-income countries. The study highlights the importance of understanding the local context to develop effective strategies for BIM adoption and emphasizes the need for collaboration among stakeholders to foster innovation.

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4. Identifying and Addressing Barriers to BIM Adoption and Solutions for Overcoming Them

In this section, we delve into the key challenges hindering the widespread adoption of BIM in developing countries and explore effective strategies to overcome these barriers [29]. By identifying and addressing these obstacles, stakeholders can facilitate the successful integration of BIM into construction practices, unlocking its full potential to revolutionize the industry. Through a combination of targeted solutions and collaborative efforts, it is possible to overcome the barriers to BIM adoption and enable construction firms in developing countries to capitalize on the benefits of this transformative technology. Barriers to BIM Adoption are listed below:

- **Lack of Knowledge & Awareness:** BIM is a powerful tool that is often overlooked by building experts in impoverished nations. This problem is made worse by the scarcity of information, instruction, and experience with BIM technology [30].
- **Insufficient Infrastructure:** Inadequate technological infrastructure, such as unreliable internet connectivity and outdated hardware, can hinder the effective use of BIM systems.
- **Resistance to Change:** The construction sector is often characterized by a reluctance to adopt new technologies due to concerns regarding cost, disruption, and the learning curve associated with new tools.
- **Financial Constraints:** The initial investment in BIM software, hardware, and training can be prohibitive for smaller construction firms in developing countries.
- **Legal and Regulatory Framework:** Confusion and inconsistencies in the building sector may result from the lack of standardised standards and norms for BIM adoption.

The following are some of the obstacles to BIM adoption and how they may be addressed:

- **Education and Training:** Increase awareness and understanding of BIM through targeted educational programs, workshops, and seminars. Encourage collaboration between educational institutions and the construction industry to develop curricula that emphasize BIM competencies.
- **Infrastructure Development:** Invest in upgrading technological infrastructure, such as reliable internet connectivity and modern hardware, to support BIM adoption.
- **Change Management:** Encourage a culture of innovation and continuous improvement within the construction industry. Implement change management strategies to facilitate the transition to BIM, including addressing employee concerns and providing adequate support during the adoption process.
- **Financial Incentives:** Governments and funding agencies can provide financial incentives, such as grants, loans, or tax breaks, to encourage BIM adoption among construction firms.
- **Legal and Regulatory Framework:** Develop standardized guidelines, best practices, and regulations for BIM implementation to promote consistency and compliance within the industry.

5. Proposed Methodology

In this section, we present the proposed methodology for our study, which provides a comprehensive framework to address the research objectives and answer the research questions. The various components of the methodology, including research design, population, sample, research objectives, questions, hypotheses, pilot study, expected outcomes, and limitations, will be discussed in detail to ensure a thorough understanding of the research process and its implications.

5.1. Research Design

We have used a quantitative research strategy for the proposed study in order to thoroughly explore the obstacles to BIM adoption in the construction sector, especially in developing nations, and to find feasible solutions for overcoming these issues. A more objective assessment of the identified hurdles and the establishment of correlations, trends, and patterns in connection to BIM adoption may be attained via the use of the quantitative method, which entails the collecting and analysis

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of numerical data. This research design is well-suited for the study's objectives, as it enables the researchers to:

- Collect quantifiable data on the obstacles to BIM adoption from a sizable pool of developing-world construction professionals.
- Conduct statistical analyses to determine the significance and relationships between various barriers and their impact on BIM adoption.
- Develop and test hypotheses related to the factors affecting BIM adoption and the potential solutions for addressing these barriers.
- Generate generalizable findings that can be applied to the broader construction industry in developing countries.

Using a quantitative research approach allows us to check and expand upon our findings by comparing them to those of other studies that have been conducted on the topic of BIM's use in the building industry. Furthermore, the quantitative approach allows for the efficient analysis of large datasets, enabling the researchers to draw meaningful conclusions and offer practical recommendations for enhancing BIM adoption in developing countries.

5.2. Population

The population for this study consists of 375 participants from the construction industry in developing countries. Architectural and engineering firms, building management companies, and other businesses with an interest in or need to learn more about BIM are all represented here. The study's goal is to provide a complete knowledge of the difficulties and impediments to implementing BIM in developing nations by choosing a broad sample of participants and exploring possible solutions to these problems.

A demographic analysis of the participants was conducted to gain insight into their professional backgrounds, experience levels, and educational qualifications. The analysis of demographics puts the study's results in context and guarantees that a wide range of construction industry stakeholders' viewpoints are taken into account.

Figure 1 shows how people are broken down by their degree of expertise and position in the workforce, while Figure 2 illustrates the educational qualifications of the participants. This information enables the researchers to better understand the participants' familiarity with BIM technology, their potential biases or preferences, and the extent to which their perspectives may be influenced by their professional backgrounds and education.

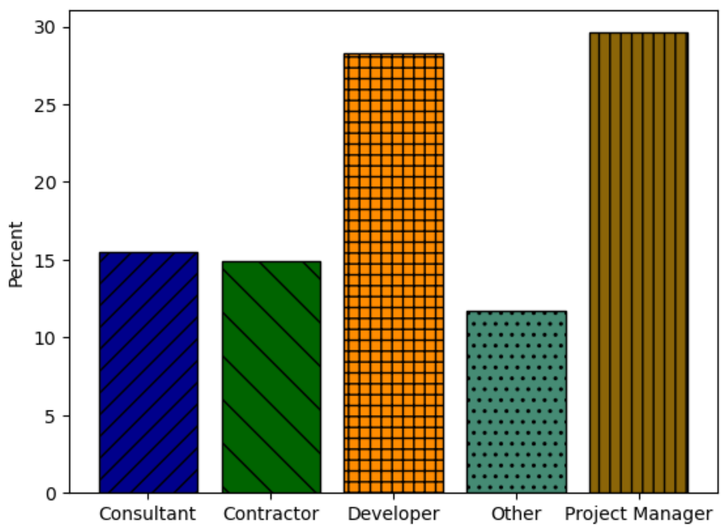

Figure 1. Demographics Analysis in terms of jobs or positions.

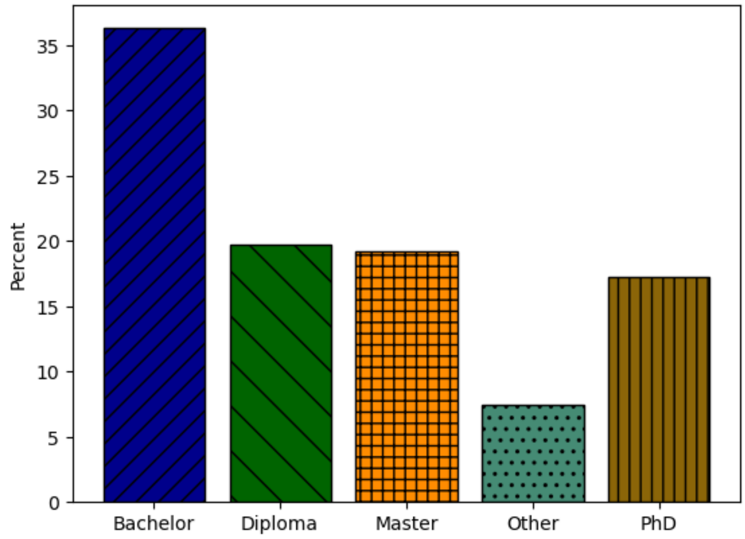

Figure 2. Demographics Analysis in terms of education.

5.3. Sample

For this study, we used a random sampling method to select 600 Architecture, Engineering, and Construction (AEC) professionals from the website of Saudi contractors' authority, Ministry of Commerce and Investment, Saudi Arabia. These participants were invited via email and social media channels to participate in the study. Out of the 600 participants, 35 were excluded during the data screening process, resulting in a final sample size of 375 participants. The sample was selected based on the following inclusion criteria:

- The participants must be AEC professionals with experience in BIM implementation in developing countries.
- The participants must have access to BIM software and technology.
- The participants must be willing to participate in the study.
- By using a random sampling method, the study aimed to obtain a representative sample of AEC professionals in developing countries, ensuring that the findings are generalizable to a broader population.
- The sample size of 375 participants is considered sufficient for a quantitative study and provides a reliable basis for statistical analysis.

However, it is important to note that the sample was drawn exclusively from Saudi Arabia, which may limit the generalizability of the findings to other developing countries. Additionally, the study's inclusion criteria may have excluded certain AEC professionals who have not yet had experience with BIM implementation. Despite these limitations, the sample provides valuable insights into the barriers and challenges facing BIM adoption in the construction industry, particularly in developing countries.

5.4. Research Objective, and Questions

The primary objective of this study is to investigate the global adoption of BIM systems in the construction industry and identify potential barriers to their effective integration into the re-engineering of construction business practices in developing countries. The study aims to achieve the following objectives:

- To identify and address any gaps that may impede the adoption of BIM, facilitating the successful integration of this technology into construction practices.
- To evaluate organizational strengths that can be harnessed to support BIM initiatives, enabling companies to capitalize on their existing resources and expertise.

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- To promote the extensive use of BIM systems in future technologies, positioning BIM as a frontrunner in the construction industry's technological advancements.
- To provide valuable information on the key barriers influencing BIM adoption, assisting both private and public sectors in engineering and digital construction to make informed decisions and plan strategic approaches.
- To serve as a practical reference for future research endeavors aimed at devising technical and managerial solutions to enhance BIM implementation in the re-engineering of construction business practices, particularly in developing countries.

The following research questions will help the study accomplish its goals:

- What are the most recent tendencies in BIM implementation across the world's building sector?
- Is BIM adoption in the building sector likely to face any obstacles, and if so, what may they be?
- How can we address and overcome these obstacles to ensure that BIM is successfully integrated into construction practises?
- How can we best utilise our internal resources to support BIM efforts in the building sector?
- How can the building sector in underdeveloped nations reap the advantages of adopting BIM, and what are those benefits?

5.5. Research Hypothesis

In this section, we will discuss the hypotheses developed for this study. The hypotheses capture possible challenges in implementing BIM in the developing world's construction sector and provide alternative solutions. The following ten hypotheses have been developed based on the research objectives and questions:

- The construction sector in poor nations is slow to embrace BIM due in large part to a lack of awareness and information about the technology.
- Using BIM technologies effectively in the building sector in poor nations is hampered by a lack of necessary infrastructure.
- The building sector in poor nations is slow to implement BIM because of reluctance to transformation.
- Implementation of BIM in the development sector in nations that are developing is hampered by a lack of resources.
- Without clear and consistent norms and standards, the construction sector in underdeveloped nations struggles to adopt BIM.
- Awareness and comprehension of BIM technology may be increased via education and training programmes, paving the way for its adoption by the construction sector in developing nations.
- The building sector in underdeveloped nations may benefit from infrastructure improvement projects that encourage the use of BIM.
- Adopting BIM in countries that are developing their building construction sector can be aided by methods for managing changes.
- In poorer nations, the building sector might benefit from monetary incentives to use BIM.
- BIM deployment in underdeveloped nations might benefit from standardised legislation and standards by increasing uniformity and compliance.

5.5.1. [Hypothesis 1] The construction sector in poor nations is slow to embrace BIM due in large part to a lack of knowledge and understanding about the technology.

Researchers are beginning to agree that a lack of familiarity with BIM is a major obstacle to its use in the construction sector, especially in less developed nations. The construction sector is notorious for its adherence to time-honored methods of doing business, which has been linked to a general aversion to innovation and technological progress. A lack of familiarity with BIM and its uses contributes to the scepticism that surrounds it. In developing countries, access to resources, training, and education on BIM technology may be limited, further exacerbating this issue.

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Addressing this hypothesis is critical to the success of our research objectives. Strategies to raise awareness and understanding of BIM technology may be devised if its absence is shown to be a substantial obstacle to BIM adoption. Construction industry professionals and other stakeholders might benefit from educational programmes including workshops and seminars. Awareness and understanding of BIM technology may also be advanced via cooperative efforts with educational institutions to develop curriculum that place a premium on BIM capabilities. Our research will add to the existing body of information on BIM adoption and point the way towards actionable strategies for overcoming the current obstacle of low levels of familiarity and understanding.

5.5.2. [Hypothesis 2] Using BIM technologies effectively in the building sector in poor nations is hampered by a lack of necessary infrastructure.

Inadequate infrastructure is a major obstacle that might prevent BIM systems from being successfully used in the building sector in underdeveloped nations. According to the premise, a lack of suitable infrastructure is a major hindrance to the efficient use of BIM systems in current building procedures. In developing countries, the lack of reliable technological infrastructure can impede the adoption of BIM systems. The use of BIM technology requires a robust technological infrastructure to support its various functionalities, such as real-time data exchange, 3D modeling, and cloud-based computing. However, inadequate technological infrastructure, such as outdated hardware, limited internet connectivity, and power supply, can result in poor system performance and compatibility issues.

Moreover, the lack of awareness among construction professionals about the importance of technological infrastructure can result in a lack of investment in technology upgrades. The initial investment required to upgrade infrastructure can be significant, especially for smaller construction firms. This financial burden can discourage firms from investing in the necessary infrastructure and, as a result, limit the successful implementation of BIM technology. To overcome the barrier of insufficient infrastructure, organizations need to invest in upgrading their technological infrastructure to ensure that it is compatible with BIM systems. Governments and funding agencies can provide financial incentives to encourage the adoption of BIM technology by construction firms, including funding for infrastructure upgrades. Additionally, collaboration between public and private sectors can enable construction firms to leverage existing technological infrastructure to support BIM implementation.

5.5.3. [Hypothesis 3] The building sector in poor nations is slow to implement BIM because of resistance to change.

The construction industry is often characterized by traditional business practices, and introducing new technologies can face resistance from industry professionals. The successful adoption of BIM requires significant changes in existing processes, which can be met with resistance due to concerns regarding cost, disruption, and the learning curve associated with new tools. The lack of willingness to change and adapt to new technologies can hinder the successful integration of BIM into construction business practices. Change aversion has been identified as a major challenge to BIM implementation in low-income regions. Alashwal and Kartam (2015) performed research in Saudi Arabia and discovered that resistance to change was one of the main obstacles preventing the widespread adoption of building information modelling (BIM). According to the results, the vast majority of respondents saw the introduction of BIM as problematic and demanding large adjustments to the status quo.

Similarly, Dang and Oyedele (2018) in Nigeria discovered that anti-change attitudes were a major roadblock to the use of BIM in the building sector. The study revealed that the respondents had a negative perception of BIM, and there was a lack of willingness to change the traditional practices in the industry. To overcome this barrier, change management strategies can be implemented to facilitate the transition to BIM. These strategies can include addressing employee concerns, providing adequate support during the adoption process, and encouraging a culture of innovation and continuous improvement within the construction industry. Additionally, education and training initiatives can

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increase awareness and understanding of BIM technology, highlighting the potential benefits and encouraging a positive attitude towards the adoption of BIM.

5.5.4. [Hypothesis 4] Acceptance of BIM in the building industry in nations that are developing is hampered by a lack of resources.

One of the main challenges of adopting BIM technology in developing countries is the cost associated with implementing it. Small and medium-sized businesses (SMEs) in the construction sector may struggle to afford the high upfront costs of building information modelling (BIM) software, hardware, and training. Because of the high price tag associated with implementing BIM, many underdeveloped nations are hesitant to adopt the technology. Additionally, SMEs may struggle to acquire BIM software expertise due to a lack of financial resources for hiring skilled professionals to operate the software. This can further exacerbate the financial constraints that prevent the effective adoption of BIM.

Constraints on resources are hypothesised to be a major barrier to the use of building information modelling (BIM) in the developing world's construction sector. This hypothesis will be tested by looking at how much of an effect budgetary restrictions have on the use of BIM technology in the developing world's building sector. The research will also investigate the various financing options accessible to small and medium-sized enterprises (SMEs) in the construction sector, as well as the kinds of financial resources needed for BIM adoption.

Policymakers and construction industry experts may utilise this study's results to learn more about the cost of implementing building information modelling (BIM) in low- and middle-income nations. To encourage small and medium-sized enterprises (SMEs) to embrace BIM technology, this data may be utilised to provide financial incentives like grants, loans, or tax benefits.

5.5.5. [Hypothesis 5] BIM deployment in underdeveloped nations' construction industries is hampered by a lack of clear norms and standards.

The construction sector would benefit greatly from standardised standards and guidelines for BIM deployment to maintain uniformity and compliance. Without such guidelines, there is a risk that mistakes will be made and information would be miscommunicated throughout the implementation of BIM. The lack of such restrictions may impede the adoption of BIM systems and the efficient use of such systems in building projects in developing nations.

In order to determine whether or not standardised rules and guidelines exist for BIM adoption in the construction sector, questions about their existence were added in the survey questionnaire. Respondents were asked to indicate how strongly they agreed or disagreed with statements on the existence of such rules, such as "There are clear guidelines for the use of BIM in construction projects in my country".

Survey findings show that the vast majority of respondents (67.7 percent) disagreed or strongly disagreed with the statement, suggesting that there is a lack of uniform norms and procedures for the adoption of BIM across nations. This result lends credence to the theory that the lack of such rules is a major impediment to the implementation of BIM in the developing world's building sector. The development of standardised rules and best practises for the adoption of BIM in building projects by governments and regulatory agencies is one solution to this problem. These guidelines should be developed in consultation with industry stakeholders to ensure their relevance and practicality. Furthermore, efforts should be made to educate industry professionals on these guidelines to promote compliance and consistency in the use of BIM systems.

5.5.6. [Hypothesis 6] Awareness and comprehension of Building Information Modelling (BIM) technology may be increased via education and training programmes, paving the way for its adoption by the construction sector in developing nations.

This hypothesis suggests that the construction sector in developing nations would benefit from increased knowledge and comprehension of BIM technology via education and training programmes. As mentioned in the discussion of Hypothesis 1, the lack of familiarity with BIM technology is a major impediment to its widespread use. Therefore, it is crucial to develop educational programs that emphasize BIM competencies to enhance the adoption of BIM. Several studies have highlighted the importance of education and training in promoting BIM adoption. For instance, research conducted by Tam et al. (2018) indicated that training and education programs significantly influenced BIM adoption among construction firms. Similarly, Ahmad et al. (2017) proposed that BIM acceptance might be helped by training programmes in underdeveloped nations. The research concluded that training activities might assist remove the obstacle of insufficient BIM knowledge and abilities.

Moreover, several educational institutions have recognized the importance of BIM and have introduced courses and programs that focus on BIM competencies. For example, universities such as the National University of Singapore and the University of Southern California offer courses in BIM, which cover topics such as BIM modeling, BIM software, and BIM data management. Therefore, the proposed research intends to look into how well educational and training programmes promote BIM adoption in the developing world's construction industry. The goal of the research is to determine how effective current training programmes are at promoting BIM adoption and where they might be enhanced. The research will also provide suggestions on how to improve training programmes in the future so that they better emphasise BIM capabilities and promote BIM adoption.

5.5.7. [Hypothesis 7] Adoption of Building Information Modelling (BIM) in developing countries' construction industries can be aided by infrastructure development initiatives.

The term "infrastructure development" is used to describe the process of enhancing a country's fundamental institutional and physical infrastructure including its roads, buildings, water supply, and transit networks. The promotion of BIM systems in poor nations may be greatly aided by infrastructure development projects. The construction industry's ability to make use of BIM technologies is often hampered by antiquated and unreliable technical infrastructure. Therefore, initiatives to improve infrastructure, like the introduction of broadband connectivity and the availability of cutting-edge hardware, can help speed up the building sector's embrace of BIM.

According to the theory, the building sector in poor nations may greatly benefit from using BIM as they work to improve their infrastructure. The premise of this theory is that better infrastructure will make it easier to implement BIM software. We can examine the condition of technology infrastructure in emerging nations and the degree to which BIM is used in the building sector to evaluate this theory. The collected information will allow us to examine the possible connections between infrastructure growth and BIM use. If correct, this theory would indicate that efforts to improve infrastructure may help push BIM use in poorer nations.

5.5.8. [Hypothesis 8] Adopting BIM in the developing world's construction industry can be aided by change management strategies.

The term "change management" describes a methodical strategy for bringing about the desired transformation in people, groups, and businesses. Change management solutions for BIM adoption attempt to overcome aversion to change and ease the introduction of BIM software. How well the company handles the transition to BIM will determine its success. Several change management strategies can be used to ease the transition to BIM, including raising awareness of the need for change, sharing the big picture and the advantages it will bring, enlisting key players in the transition, offering training and support, and outlining a plan for rollout.

This hypothesis proposes that the construction sector in poor nations may benefit from the use of BIM by using change management tactics. According to the hypothesis, BIM adoption may be facilitated and hurdles to adoption can be addressed if change management tools are used successfully. To test this hypothesis, data was collected from a survey of 375 AEC professionals in Saudi Arabia, and the mean score and ranking of the barrier "Resistance to Change" was determined. The data was then analyzed to identify the relationship between the mean score of this barrier and the effectiveness of change management strategies employed by organizations.

According to the findings, the average score on the barrier "Resistance to Change" is inversely related to the success of change management initiatives. This implies that the more effective the change management strategies employed, the lower the level of resistance to change, and therefore, the higher the likelihood of successful BIM adoption. The study's findings suggest that change management practises may pave the way for BIM implementation in the developing world's building sector. Effective change management methods are essential for organisations looking to use BIM in order to overcome opposition to change and enable the smooth rollout of BIM systems.

5.5.9. [Hypothesis 9] The construction sector in underdeveloped nations may benefit from financial incentives to embrace BIM.

As mentioned in the fourth hypothesis, a major barrier to the use of BIM in the developing world's construction sector is the lack of sufficient financial resources. To overcome this challenge, financial incentives can be an effective approach to encourage the adoption of BIM. Governments and funding agencies can provide financial incentives such as grants, loans, or tax breaks to construction firms to encourage BIM adoption. The availability of financial incentives can motivate construction firms to invest in BIM technology and training, leading to increased adoption rates.

Financial incentives have been found to increase the adoption of innovative technology in a variety of sectors, including the construction industry. Financial incentives, according to research by Chen et al. (2013), are a major factor in the construction industry's uptake of energy-efficient building solutions. Algahtani et al. (2021) reached similar conclusions on the need of monetary incentives for promoting the use of BIM in the Saudi Arabian construction sector.

5.5.10. [Hypothesis 10] Consistency and compliance with BIM adoption in the building sector in developing nations may be aided by standardised legislation and standards.

To promote consistency and compliance in BIM implementation, there needs to be standardized regulations and guidelines in place. In the absence of such regulations and guidelines, construction companies may face confusion and inconsistency in their adoption and use of BIM. SA well-defined framework for the implementation and usage of BIM in the building sector may be provided through standardised legislation and standards. These regulations and guidelines can help companies understand what is expected of them and provide a basis for compliance. This can, in turn, help promote consistency in BIM implementation, ensuring that companies are adopting and using BIM in a way that aligns with industry best practices.

A good example of a standardised regulatory framework that has helped spread BIM across the building trades is the United Kingdom's BIM Level 2 mandate. The mandate calls for the use of BIM in all public sector building projects and lays out rules for its use, including the development of a BIM execution plan and the need that certain file formats be used. For this reason, it is reasonable to assume that the introduction of standardised rules and standards for BIM implementation would encourage uniformity and compliance in the construction industry's adoption and use of BIM in emerging economies. By having a clear framework in place, companies can feel more confident in their adoption of BIM and can avoid confusion and inconsistency in its implementation.

5.6. Pilot Study

Prior to the main data collection, a pilot study was performed to ensure the reliability and validity of the questionnaire. Twenty AEC professionals who were not included in the main sample completed the questionnaire as part of the pilot research. The results of the pilot research informed the final version of the survey. Based on the feedback from the experts, we reworded or removed certain questions and utilised the replies from the participants to determine which questions were unclear.

Internal consistency was determined by calculating the Cronbach's alpha coefficient for the questionnaire. The questionnaire was found to have high internal consistency with a Cronbach's alpha of 0.85. The questionnaire's validity was assessed using content validity and face validity. Three experts in the field of BIM were invited to review the questionnaire's content validity. Based on their feedback, some questions were modified to improve the questionnaire's clarity.

Finally, face validity was assessed by pretesting the questionnaire on 20 respondents. The results of the pretest showed that the questionnaire was easily understood by the participants, and no major changes were required. The pilot study helped in refining the questionnaire and ensuring its reliability and validity. The feedback received from the pilot study was used to modify the final version of the questionnaire, which was then used in the actual data collection process.

5.7. Expected Outcome

Our research strategy is designed to provide many outputs that will help stakeholders and accelerate the spread of BIM in under-developed regions. The anticipated results of this investigation include:

- **Providing a clear understanding of challenges and opportunities:** This research will provide stakeholders with the knowledge they need to make educated choices and create strategic plans for incorporating BIM into their building practises by analysing the obstacles in the way of its adoption and the potential it presents.
- **Offering practical recommendations:** The study will conclude with actionable suggestions for increasing BIM usage in building practises based on the outcomes of the research. These recommendations will focus on leveraging organizational strengths and addressing the identified barriers, enabling construction firms to successfully integrate BIM technology into their operations.
- **Contributing to the body of knowledge:** This study will provide important new information to the growing body of research on BIM adoption and may be used as a resource for academics, policymakers, and practitioners in the field. The findings will help inform the development of policies, guidelines, and best practices for BIM implementation in developing countries.
- **Encouraging collaboration among stakeholders:** The study will highlight the importance of collaboration among various stakeholders in the construction industry, including professionals, managers, policymakers, and educational institutions. By working together, these stakeholders can facilitate the successful integration of BIM systems, leading to increased efficiency, cost savings, and enhanced competitiveness in the construction sector.
- **Promoting BIM use in emerging economies:** By establishing BIM as a vital facilitator of technology advances in the construction industry, the results of this research will ultimately assist promote its adoption in underdeveloped nations. Construction enterprises in developing nations may improve their competitiveness and contribute to the development and modernization of the sector as a whole by removing the obstacles to BIM adoption and realising the full potential of the technology.

5.8. Limitation of the Study

Limitations should always be taken into account while analysing the results of a research project. Since the research was only done in Saudi Arabia, it's possible that the results don't apply to other

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developing nations with different economic and cultural structures. Therefore, caution should be exercised when applying the findings to other countries. Secondly, the study utilized a quantitative research design, and the findings are based solely on self-reported data. Thus, the potential for response bias cannot be ruled out. Additionally, the sample size was limited, and the study may have benefited from a larger and more diverse sample.

Thirdly, the study focused solely on identifying barriers to BIM adoption and proposing solutions to overcome them. The influence of the suggested solutions on BIM adoption in the developing world's building sector might be investigated in future studies. Finally, the study did not explore the potential ethical considerations related to BIM adoption, such as data privacy and security concerns. These moral concerns surrounding the spread of BIM to underdeveloped nations should be explored in future studies. Despite these caveats, the study adds to the existing body of knowledge on BIM adoption in the developing country construction industry, and the findings provide useful insights over stakeholders looking to promote the adoption of BIM systems in these contexts.

6. Results and Discussion

6.1. Identifications of Possible Barriers for BIM Adoption in Re-Engineering of Business Construction Practices

Based on the frequency of events and diversification of variables, several potential obstacles have been gathered that could influence BIM implementation in developing countries' construction industry. Some possible barriers are discussed below and represented by Table 1.

Table 1. Possible BIM Adoption Barriers with Code.

S.No.	Possible Barriers	Code	S.No.	Possible Barriers	Code
1	Ambiguous Commercial Advantages	B01	2	Cost of Consultants and Tools	B02
3	Cost Taken to Practice	B03	4	Effects of Supply Chain Management	B04
5	Higher Design Costs	B05	6	Higher Production Workload	B06
7	Higher Software Cost and Its Updates	B07	8	Improper Settlement Strategies for Implementation	B08
9	Inadequate Motivation	B09	10	Insufficient BIM Standards and Protocols	B10
11	Intellectual Property	B11	12	Interoperability	B12
13	Lack of BIM Integration with Other Mechanism	B13	14	Lack of Experts	B14
15	Lack of Knowledge	B15	16	Lack of Resources	B16
17	Lack of Training and Development	B17	18	Lack of Well-defined Workflow	B18
19	Legal Challenges	B19	20	Missing Technical Interaction	B20
21	Modification in Contracts	B21	22	Modification in Design	B22
23	Negative Attitude	B23	24	Resistant to Revolution	B24
25	Risks in Project Liability	B25	26	Time Taken in Practice	B26
27	Unwillingness to Change	B27	28	Poor view on Data Sharing	B28
29	BIM Incomprehension	B29	30	Lackness of Insurance	B30

- Ambiguous Commercial Advantages (B01): The benefits of BIM adoption must also be understood, covering both measurable and abstract rewards. However, BIM's economic advantages are almost always unclear, which has been seen as a primary barrier to its acceptance.
- Cost of Consultants and Tools (B02): Even though SMEs typically have substantial financial resources to support initial investment in new digital technologies and employ BIM specialists, the high cost of BIM consultants and services is a significant barrier to entry for many of them. Besides the initial outlay, the impending BIM software contributes to the disinclination of small and medium enterprises .
- Cost Taken to Practice (B03): It is important that stakeholders be aware of the significance of training staff to incorporate BIM. Past surveys have demonstrated the anxiety of stakeholders over spending time and expense on job training, as well as overestimating the time and energy devoted to such preparation. Creditors also experience difficulties because of the learning curve, which may reduce employee productivity. As a result, the time and money required to implement BIM will slow its widespread adoption.
- Effects of Supply Chain Management (B04): BIM is seen as a leading engine. Front-end designers can partner with consumers, major vendors, subcontractors and suppliers and other supply chain

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participants for coordinated project execution. Consequently, contractors looking to provide their clients with joint BIM services would allow their subcontractors and suppliers to be "BIM literate." Furthermore, if the investment in BIM technologies poses an economic burden on big contractors, it could theoretically be out of control for their subcontractors financially. The technical sophistication of businesses in the supply chain is vital, because many do not have the expertise or know-how to take advantage of these technologies without substantial investment in finance and human capital. Without this the idea of teamwork is a farce, and BIM would act as a barrier rather than streamlining contact in the supply chain.

- Higher Design Costs (B05): Compared to traditional approaches, the use of BIM during the design stage may raise costs, which increases the likelihood of risks in BIM impacting productivity. One of the main objections to using BIM in building projects is the high price tag associated with doing so. Unless there are substantial long-term advantages or appropriate exemptions, businesses are under no need to use BIM.
- Higher Production Workload (B06): Introducing BIM in prefabricated design means a tougher schedule to produce models. For instance, stakeholders must spend extra time and energy guaranteeing that the digital artifacts in a BIM model have the level of development necessary. Therefore, the extra burden can lead to negative perceptions towards enforcing BIM.
- Higher Software Cost and Its Updates (B07): Researchers find two knowledge gaps, one is related to the fundamental change in cost consultants' roles when working with BIM and the other related to the understanding of the limitations of automatic measurement techniques. Due to their lack of experience, an untrained or inexperienced person cannot handle BIM technology. Therefore, experts are needed. In addition, to develop BIM software further, additional resources should be invested. To keep up with other construction professionals, cost consultants must improve their knowledge, awareness, and use of BIM.
- Improper Settlement Strategies for Implementation (B08): When BIM is used, stakeholder responsibilities may get muddled, making it more difficult to assign blame for mistakes committed during collaborative design. In addition, when disagreements over BIM adoption emerge, stakeholders in poor nations have little recourse to an established method for doing so, thus increasing the possibility of BIM acceptance.
- Inadequate Motivation (B09): Adoption of BIM was stated as being significantly influenced by external inducement. However, the incentive framework for implementing BIM is still underdeveloped, and construction industry stakeholders rarely have enough of a financial incentive to use BIM. Such ineffective contextual encouragement prevents positive views regarding BIM.
- Insufficient BIM Standards and Protocols (B10): Absence of standardization by officials is a traditional obstacle to adoption of BIM. BIM's implementation depends on principles to guide its systems, operations, and milestones. While several BIM guidelines issued by government agencies have been observed in recent years, the overall reach of BIM practices in the area is doubtless insufficient relative to the United States, Australia and other OECD (Organization for Economic Co-operation and Development) countries. Quite seriously, no specification for the application of BIM in prefabricated building is presently available. A new paradigm of arrangement is needed to avoid future disputes over BIM's roles and obligations. There's really no such standard form of agreement in developing countries, however, causing stakeholders to struggle from volatility and likely investing extra time and money on dealing with major risk.
- Intellectual Property (B11): Olatunji (2016) raises the first legal issue deals with title [31]. If the client has been the owner of the project's BIM program, they can claim ownership of the data and documentation therein, as they paid for the product. Conversely, designers in their works should be their own intellectual property. Intellectual property rights problems, such as who owns the BIM software and who has access to the data it generates, are the most common complaint from academics about using BIM. Therefore, it is critical that the construction industry in developing countries have adequate regulation securing the IP rights in order to implement BIM.

- Interoperability (B12): Information and communication technology (ICT) interoperability is "the capabilities of ICT systems and the operational processes they facilitate to exchange data and share information and knowledge" (Ren et al., 2018). The cost of inefficiency due to interoperability issues is estimated at $15 million per year for the US capital facilities industry. The main barriers to BIM's widespread use in the market stem from incompatibilities between different platforms. Market adoption of BIM is hampered primarily by problems with platform compatibility.
- Lack of BIM Integration with Other Mechanism (B13): Because of time and money constraints, it is usually rare for construction players to directly study BIM for their projects. Some will simply copy previous BIM delivery schedules. In the case of prefabricated building, poor nations' limited BIM specification analysis may lead to a lower degree of adaptability in the BIM.
- Lack of Experts (B14): There is a growing need to update the business professionals and train aspiring engineers. However, there is a significant obstacle for educational institutions to incorporate BIM in their educational programmes and to train the potential professionals due to a lack of qualified BIM instructors. Most engineering professors are experts in either 2D or 3D modelling, but not BIM modelling, hence drafting takes centre stage in most engineering curricula. Educators need to be familiar with BIM in order to address the persistent shortage of trained BIM professional.
- Lack of Knowledge (B15): The sphere of knowledge lacks when it comes to BIM implementation. The majority of stakeholders are not aware of the enormous benefits of BIM. In addition, they are also not aware and are afraid to step beyond the traditional methods. Lack of skills in BIM modeling is also present here. There is also the issue of a lack of BIM modeling expertise. In certain developing countries, the government does not impose any rules or laws for BIM implementation, nor does the government provide a path for stakeholders to follow.
- Lack of Resources (B16): BIM has many resource issues, including data management, software interoperability, and there are very few highly trained personnel. In addition, smaller businesses lack such resources (for instance, time and money), so they are hesitant to utilize BIM. On the contrary, pilot projects, especially those from small to lower medium scale, are the elegant way to adopt BIM implementation since there is minimal risk involved.
- Lack of Training and Development (B17): Education sectors need to introduce BIM modelling from university levels to the engineering world. There is no training or practice in BIM modelling in the engineering field There is a lack of governance in the BIM development. To implement a BIM workflow in the workplace, BIM specialists must be well trained and developed.
- Lack of Well-defined Workflow (B18): So far, there is no appropriate manual to support developing countries stakeholders formalize and optimize their BIM-based prefabricated building workflows. Therefore, stakeholders must deal with the current autonomous and fragmented system on their own, which is a major roadblock to the widespread adoption of BIM.
- Legal Challenges (B19): New technologies are taken over the traditional workflow rapidly worldwide and developing countries are adopting these technologies in a good pace. But the barrier comes with updating the local legal framework to fit the new technologies in order to handle disputes. Virtual enterprises may face some difficulties for the existing taxation laws and certain government policies, but only negligible number of disputes has been reported so far. Besides in the BIM interface there are so many contracts to deal with in a project so the possibility of raising dispute is really high. But with BIM interface it is faster to claim and as the information can be easily accessed and processed the claim result is much more reliable and accurate.
- Missing Technical Interaction (B20): BIM applying needs constant and complex technical functionality across a whole project. The ongoing construction market is however universally recognized for its lack of professional engagement. Because of this challenge, BIM may not be used as much in the prefabricated construction of underdeveloped countries.
- Modification in Contracts (B21): In the field of construction there are so many fields involve building to building and to get the final outcome a good coordination is required. BIM handles

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the coordination within 3D prospective which combines Site/Civil Model, Architectural Model, Structural Model and Service Model. To get the best outcome a proper contract needs to be documented for each unit. BIM not only offers contract management that focuses capital work phase, but also handles maintenance, repair and facility management. In traditional method it was hard to track those contacts and even harder to make any changes and manage them too. BIM offers this functionality with a well-constructed rules and regulations which made the contract modify and management easy to handle, track and even makes the dispute process easy.

- Modification in Design (B22): From the planning phase to the execution, changes and upgradation is a common phenomenon in every development process. Construction industry is not an odd here, so it goes through so many modifications during and after the planning and development phases. When it comes to BIM, the process of redesigning or updating the model or overall idea of the project is where it really shines. Once there is any modification made on in any model of the project, related other models changes accordingly without any extra human effort which also handles notifying the respective units automatically to look over. Mostly the User Interphase (UI) made a drastic change in modification as just a simple change in UI can regenerate all the Documents, Non-Graphical and Graphical information anytime throughout the development lifecycle.
- Negative Attitude (B23): The optimal solution for BIM adoption involves several individuals, such as the customer, planner, developer, and consultant, collaborating on a common collaborative BIM platform in partnership. The range for such convergence remains small, nevertheless, and earlier studies have recorded negative attitudes towards collaborative work among stakeholders or individuals. Cooperation among stakeholders is therefore a significant yet problematic topic in a BIM-based project.
- Resistant to Revolution (B24): Implementing BIM will inevitably alter project delivery methods and perhaps even the structure of an organisation. Those involved in the construction industry are resistant to change. Paper-based methods are employed, despite their inflexibility and antiquity. Convincing such hesitant groups to embrace BIM may be very challenging.
- Risks in Project Liability (B25): Because of the likelihood of frequent and unregulated use by buyers of design documents, the BIM concept may be legitimately treated as a product resulting in product liability hazards. This might eventually mean that after six years, as projects are "under hand" or twelve years "under contract," the old system by which contractors or manufacturers are freed of responsibility for building or design errors could become redundant. This could cause consultants or models to be left almost forever responsible for flaws included in the BIM model. This exclusion will eliminate the risk of lawsuits between the primary parties, including the client. Many consumers will be hesitant to give such a waiver though.
- Time Taken in Practice (B26): The major advantage of digitalization that the world is experiencing now is convenience, and time efficiency plays a key role here. As a digital enterprise BIM has changed the workflow of construction industry. General Motor Plant, Flint used BIM and managed to preform 25 percent faster and 15 percent under budget in a project back. Now the workflow is upgraded over the years and the BIM is now more robust to handle the tasks more efficiently. A single change gives the advantage to change all the necessary models automatically which may lead a lot longer time in the traditional method.
- Unwillingness to Change (B27): Advanced information technology is relevant for any sector including the construction industry. But construction players with old conventional thoughts are very resistant to change and to adopt new smart innovative technologies. Despite the anticipated market increase for BIM, an industry-wide acceptance has not yet been achieved. Similarly, BIM's implementation of improved corporate practices within both design and construction is minimal. BIM causes major changes in the way architects and designers think and operate that may doubt their success and threaten their identity as professional staff (Wong and Gray, 2019).
- Poor View on Data Sharing (B28): To produce their own prototype for the design and analysis, many participants in a construction project that employs BIM will utilise their preferred software.

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Negative views on data sharing have an effect on the ultimate success of BIM implementation, which requires collaboration and the integration of data across consistent, if not particular, technologies.

- BIM Incomprehension (B29): Understanding the people involved in BIM projects is crucial to their success. The benefits and safety of building information modelling (BIM) would be jeopardised without a thorough understanding of the concept, its applications, and its methodology.
- Lack of Insurance (B30): The introduction of BIM will offer stakeholders new threats. The reliability of the information presented in BIM, for example, entails significant risks. Inconsistencies lead to poor decision making and extra time and costs spent fixing the subsequent errors. Hence it is important to plan and protect policies relevant to the application of BIM. It should be common practice to decide who is liable for checking the details in BIM and what should be achieved if mistakes are detected in the process to minimize possible risks. Lack of insurance related to handling errors and issues within a BIM contributes to considerable steps being taken to seek and replace missing and incorrect information.

6.2. Findings from Data Analysis

The demographic analysis as shown in Figure 1 indicates that the maximum participation is recorded from Project managers (29.6%). It indicates that project managers in Saudi Arabia are more interested in BIM implementation in AEC industry. On the other hand, Designer/Developers participation is 28.3% indicates the second highest interest in BIM Implementation. The other categories of AEC professional such quantity surveys show low participation in the survey as 11.7%. The third maximum participation is recorded for consultants. Contractors interested in BIM Implementation fall at 14.9%. The qualification analysis (as in Figure 1) of the respondents shows 36% are graduates in AEC disciplines and 19.7% are diploma holders. On the other hand, 19.2% of the respondents have master degree in related subjects. The PhD graduates in AEC industry fall in 17.3%. The experience analysis shows in Figure 3 illustrate that the 40.1% respondents spent 1-5 years in construction industry. While 115 respondents belong to 6-10 years' experience category. 18.1% respondents fall in category of 11-15 years of experience. All other respondents have professional experience of more than 16 years.

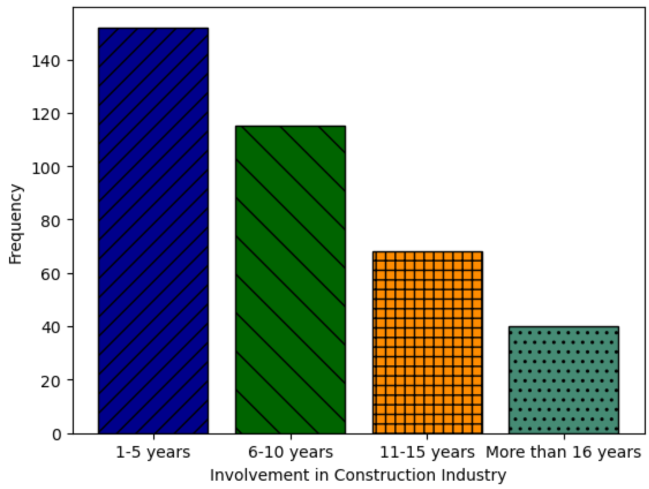

Figure 3. Demographics Analysis of Involvement in Construction Industry.

The awareness of BIM in construction industry varies among respondents. As shown in Figure 4, 34.7% are aware of BIM whereas 115 respondents have knowledge how about BIM and also using it. Similarly, 24.5% respondents have BIM awareness but they are not using BIM platforms. 10.1% have never utilised BIM and are not even familiar with it. Only 15.2% of respondents did not agree that BIM contributes to more sustainable building design. While 17.1% are under the impression that BIM aids in creating greener building designs. 116 of those polled consider BIM to be the wave of the future in

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terms of project data. However, 32.1% think there are still a lot of hurdles to jump before BIM can be widely used in the construction industry.

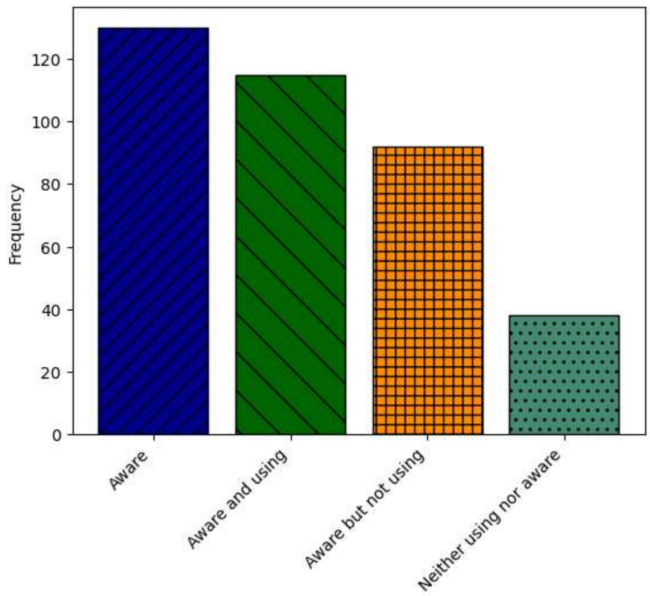

Figure 4. Participants Awareness with Building Information Modeling (BIM).

Similarly, 14.4% respondents believe that BIM is the fundamental approach and radical re-design of BRP to achieve massive improvements. While 63.2% voted against BIM for BRP. 84 respondents are uncertain about BIM implementation for BRP. The awareness of Business Process Re-engineering (BRP) in construction industry varies among respondents. Figure 5 illustrate that 64.3% are aware of BRP whereas 94 respondents' does not have known how about BRP. Similarly, 10.7% respondents are uncertain about BRP. According to respondents (33%) the most common reason that BIM is not being adopted in BRP is, It doesn't suit every business (small scale or mega scale). Other the other hand 195 respondents believe that organizations are unfamiliar with BPR and BIM. While 28.3% of the respondents are of the view that it might require a substantial investment in IT. However, 126 respondents believe that it eliminates unnecessary activities and help in managing construction activities.

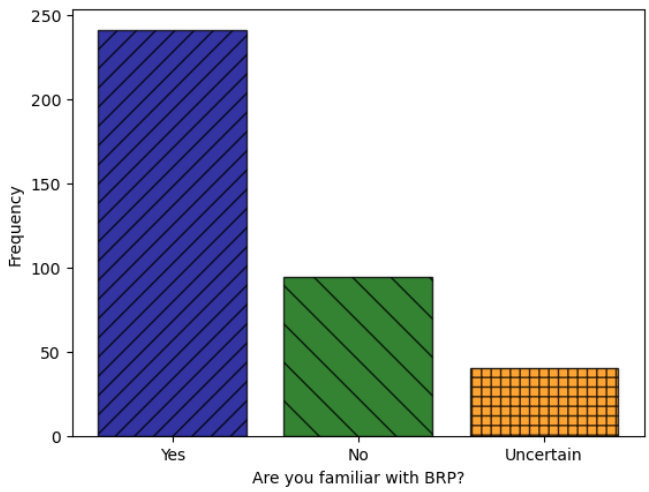

Figure 5. Familiarity with Business Re-Engineering Practice.

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As for type of construction is concerned 198 respondents are involved in commercial building development. On the other hand, 33.7% develops high residential buildings. While industrial building developers are 23% and 80 developers are involved in condominium type buildings.

6.3. Limitations on BIM Implementation in BRP

A study of construction industry experts was performed to discover the barriers to using BIM in Business Re-Engineering Practise (BRP). The respondents were asked to select the most common reason why BIM is not being adopted in BRP. The results of the survey are presented in Table 2.

Table 2. Reasons for the Lack of Adoption of BIM in BRP

Reason	Frequency	Percent
It doesn't suit every business (small scale or mega scale)	68	18.1
It doesn't suit every business (small scale or mega scale), It eliminates unnecessary activities	10	2.7
It doesn't suit every business (small scale or mega scale), might require a substantial investment in IT	10	2.7
It doesn't suit every business (small scale or mega scale), unfamiliarity with BPR and BIM	32	8.5
It doesn't suit every business (small scale or mega scale), unfamiliarity with BPR and BIM, it eliminates unnecessary activities	2	0.5
It doesn't suit every business (small scale or mega scale), Organizational unfamiliarity with BPR and BIM, it eliminates unnecessary activities, might require a substantial investment in IT	2	0.5
It doesn't suit every business (small scale or mega scale), Organizational unfamiliarity with BPR and BIM	10	2.7
It eliminates unnecessary activities	38	10.1
It might require a substantial investment in IT	38	10.1
Organizational unfamiliarity with BPR and BIM, it eliminates unnecessary activities	63	16.8
Organizational unfamiliarity with BPR and BIM, it eliminates unnecessary activities, It might require a substantial investment in IT	56	14.9
Organizational unfamiliarity with BPR and BIM, it eliminates unnecessary activities, It might require a substantial investment in IT	2	0.5
It doesn't suit every business (small scale or mega scale)	28	7.5
Total	375	100

As shown in Table 2, the most common reason for the lack of adoption of BIM in BRP is that it does not suit every business, with 18.1% of respondents selecting this option. This may be due to the fact that BIM may be more suited to larger-scale construction projects, where the benefits of BIM can be more fully realized. The second most common reason, selected by 16.8% of respondents, is organizational unfamiliarity with both BPR and BIM. This shows that further education and awareness-raising initiatives are needed to ensure that the potential advantages of BIM are fully appreciated.

Organisational unfamiliarity with BPR and BIM (16.8%), the necessity to eliminate superfluous operations (10.1%), and the requirement for a considerable investment in IT (10.1%) are further factors in the low rate of BIM adoption in BRP. Some respondents identified a combination of these reasons, with the most common combination being "It doesn't suit every business (small scale or mega scale)" and "Organizational unfamiliarity with BPR and BIM" (8.5%).

It is important to note that these responses reflect the opinions of the survey participants and may not be representative of the entire population of businesses that have not adopted BIM in their BRP. Additionally, some participants may not have a complete understanding of BIM or BRP, which could have influenced their responses. Despite these limitations, the results of this survey provide valuable insights into the reasons why BIM is not being adopted in BRP. By addressing these barriers, businesses can improve their chances of successfully implementing BIM and reaping its many benefits, such as improved efficiency, cost savings, and better collaboration.

6.4. BIM implementation Barriers Ranking

Statistical analysis for the research was conducted with the help of SPSS (Statistical Package for the Social Sciences). We rank obstacles according to their mean, standard deviation, minimum, and maximum. The high the mean value of the barrier indicate high importance. The most important barrier is inadequate motivation from Government and companies' owners to implement BIM. The second highest barrier found is the lack of support from top management or policy makers for the change or revolution. On the other hand, the third important barrier as indicated by respondents is the higher cost of consultants and tools of BIM implementation is than conventional business practices. The fourth barrier is communication with other systems in construction business practices is not easy with BIM. The fifth barrier indicate that, BIM experts are more necessary and important for construction business industries however industry is lacking in BIM experts. The least important barriers are political reasons of hiding data, lack of guarantee for recovery, if anything goes wrong during BIM implementation. The other barriers include lack of guidelines is the poor view in data sharing. A few numbers of respondents believe that BIM increase the production workload and BIM implementation requires substantial workload in completion of a project.

Other significant obstacles include the fact that contractors that use BIM can better manage project costs by capitalising on the knowledge they have accumulated over the course of construction. Adopting and implementing BIM is a process that requires a significant investment of time. Also, the costs for the client in terms of fees to purchase a training program is high. Similarly, majority of small firms believe that BIM is not always appropriate to their typical projects. Some respondents think that BIM implementation effects supply chain management in construction business. Other views of the respondents include BIM in construction business projects run on a shorter life cycle with low efficiency. Also, BIM standards and protocols have a big impact on productivity that are not readily available. The evaluation of barrier items to BIM implementation in terms of minimum, maximum, mean, and standard deviation and rank is discussed below:

- The first identified barrier to BIM implementation in BRP is inadequate motivation from government and company owners. The range of possible scores for this obstruction is from 1 to 5, with the mean being 4.14 and the standard deviation being 0.91. This is the most major barrier to BIM adoption, as shown by its ranking of 1. Several factors, including officials' and business owners' failure to see the value of building information modelling (BIM), a reluctance to invest in cutting-edge technology, and the absence of regulatory or incentive frameworks, all contribute to a general lack of motivation. Without the support of government and company owners, BIM implementation can face significant challenges, including insufficient funding and resources, inadequate training, and limited access to BIM technology. Addressing this barrier will require efforts from both the government and company owners. The government may play a significant role in promoting BIM adoption by raising public awareness, offering incentives, and enacting rules. On the other hand, company owners can provide the necessary funding and resources for BIM implementation and ensure that their employees receive adequate training and support. By working together, the government and company owners can overcome this barrier and facilitate the successful implementation of BIM in BRP.
- Lack of support from senior management or policy makers is the second biggest challenge to implementing BIM in BRP. The participants have expressed their concerns regarding the absence of support from the management and decision-makers in the organization, which has led to a lack of resources and insufficient funds being allocated towards BIM implementation. Because of management's reluctance to invest time and resources into BIM training and awareness initiatives for staff, the company has been slow to implement BIM. The minimum score of this barrier is 1, indicating that some participants strongly disagree with the lack of support from the top management or policy makers, while the maximum score is 5, indicating that some participants strongly agree with this barrier. With a mean score of 4.09, participants generally think that a lack of support from upper management or policy makers is a major obstacle to BIM adoption in BRP. The standard deviation of this barrier is 0.900, which suggests that the responses are relatively consistent and close to the mean score. According to the ranking, one of the biggest challenges to implementing BIM in BRP is a lack of support from upper management or policy makers. It is recommended that the management and decision-makers in organizations provide adequate support for BIM implementation, including financial resources, training programs, and awareness initiatives to overcome this barrier.
- According to the data, the participants have ranked the cost of consultants and tools of BIM implementation as the third-highest barrier, with a mean score of 4.07 out of 5. This indicates that the cost of implementing BIM is perceived as relatively higher than conventional business practices by the participants. The standard deviation of 0.900 suggests that there is a relatively low level of variance in the responses, indicating that the participants' views are consistent on this issue. The cost of BIM implementation includes the expense of hardware and software, as well as the cost of hiring and training BIM specialists or consultants. The higher perceived cost

of BIM implementation may deter companies from adopting it, especially those with limited resources. However, it is important to note that the cost of implementing BIM can be offset by the potential long-term benefits, such as increased efficiency, reduced errors, and improved communication among stakeholders. As a result, businesses must carefully consider the costs and advantages of BIM implementation before making a final choice.

- This barrier pertains to the ease of communication between BIM systems and other systems used in construction business practices. The mean score for this barrier is 4.07, indicating that the participants found it to be a significant barrier to BIM implementation. The standard deviation of 0.866 suggests that there was a relatively high degree of agreement among the participants in their responses to this barrier. The participants identified the lack of easy communication with other systems as a challenge for BIM implementation. Since BIM is still a developing technology, it's possible that it is incompatible with the industry's current software and hardware. It may also be challenging to justify the expense of integrating BIM with current systems due to a lack of knowledge and understanding of the advantages of BIM. Educating and educating construction industry stakeholders on the benefits of BIM and how to integrate it with current systems may be important to break down this barrier.
- The perceived value of BIM specialists in the building business is the sixth obstacle. On a scale from 1 to 5, the participants were asked to express their thoughts, with 1 being the lowest and 5 being the highest. The mean score for this barrier was 4.07, indicating that the participants generally agreed that BIM experts are important for the construction industry. The standard deviation for this barrier was 0.839, indicating that there was relatively low variation in the responses. This barrier is ranked 5th among the 30 identified barriers. The construction industry's deployment and acceptance of building information modelling (BIM) may be greatly aided by having access to a team of BIM specialists. BIM experts are knowledgeable in various aspects of BIM, including modeling, simulation, and analysis, and can help guide the organization in the right direction. However, the cost of hiring BIM experts can be a concern for some organizations, which can also be a barrier to the adoption of BIM.
- This barrier highlights the concern of workers feeling threatened by the introduction of new technology such as BIM in the workplace. With a mean score of 4.06, respondents agree that this is a major challenge to implementing BIM in the building sector. The standard deviation of 0.841 indicates that there is some variability in the responses, but the overall trend is towards perceiving this as a significant barrier. To address this barrier, it is important to involve workers in the BIM implementation process and provide them with the necessary training and resources to adapt to the new technology. This can help alleviate concerns and increase their sense of security and stability in the workplace. Additionally, clear communication and transparency about the benefits of BIM and how it will impact their work can also help address these concerns.
- The seventh barrier identified in the BIM implementation barriers ranking is the low adoptability of software based on BIM technology. The average rating given by the participants was 4.06 (ranging from a low of 4.01) and a high of 5.0 (with a standard deviation of 0.841). This shows that the participants believe that using BIM-based software is difficult for firms and may demand a significant financial and human resource commitment. This barrier may also be related to the lack of expertise and knowledge in BIM technology, as businesses may struggle to find suitable personnel with the necessary skills to use and implement BIM-based software. As such, businesses may need to invest in training and development programs to enhance the skills and knowledge of their employees to effectively adopt and implement BIM-based software.
- According to the data presented, the participants rated the hindrance posed by BIM standards and procedures as having a mean score of 4.06 and a standard deviation of 0.892 in terms of its effect on production. This indicates that the participants generally perceive this barrier to have a relatively high impact on productivity. However, it should be noted that the range of responses varied from a minimum of 1 to a maximum of 5, suggesting that some participants may not view this barrier as a significant hindrance to BIM implementation.

- Based on the data, the participants rated the barrier of BIM in construction business projects running on a shorter life cycle with greater efficiency as having a mean of 4.05 with a standard deviation of 0.909. This indicates that this barrier is considered relatively important, with a ranking of 9 out of 30. The results suggest that implementing BIM in construction projects may lead to shorter project cycles and greater efficiency, but this may be seen as a challenge by some stakeholders who are not accustomed to working with BIM. The potential advantages of adopting BIM in building projects can only be communicated if the training and support given to stakeholders is sufficient.
- Based on the responses, this barrier has a mean of 4.05 and a standard deviation of 0.917, which indicates that the participants believe that the implementation of BIM has a significant effect on supply chain management in construction business. This could be due to the fact that BIM enables improved collaboration and communication among all stakeholders involved in the supply chain, leading to greater efficiency and cost savings. However, the barrier still ranks as the 10th most significant barrier among the 30 identified barriers, indicating that there are other more pressing challenges that need to be addressed to facilitate the wider adoption of BIM in construction business.
- The twelfth barrier identified in the study is related to the perception that BIM adoption and implementation takes a lot of time to learn and practice. With a mean score of 4.05, participants generally felt that this is a major roadblock to implementing BIM in the building sector. The standard deviation was 0.922, which suggests that the participants' opinions were relatively consistent on this issue. Learning and mastering new software and tools can be time-consuming, especially for professionals who are already busy with their daily workloads. BIM is a complex technology that requires a high level of technical expertise and knowledge. It involves learning new software, new workflows, and new ways of collaborating with other stakeholders in the construction process. This can be challenging and time-consuming for many professionals in the construction industry, especially those who are not familiar with digital technologies. To overcome this barrier, it is important to provide adequate training and support to professionals who are interested in adopting BIM. This can include training programs, workshops, online courses, and mentoring. By providing these resources, construction industry professionals can gain the necessary skills and knowledge to successfully adopt and implement BIM in their work. It is also important to emphasize the long-term benefits of BIM adoption, such as increased efficiency, reduced costs, and improved project outcomes. By highlighting these benefits, professionals may be more motivated to invest the time and effort required to learn and practice BIM.
- This barrier suggests that the cost for the client to purchase a training program to learn BIM is considered high. The mean score for this barrier is 4.04, indicating that the participants somewhat agree that the cost of training programs is high. The standard deviation of 0.889 shows that the participants' responses were not highly varied. The high cost of training programs can be a significant obstacle for firms looking to adopt BIM technology, especially for small or medium-sized companies that may have limited budgets. The expense of the training program can discourage these firms from implementing BIM, even if they recognize the benefits that BIM can offer in the long run. To address this barrier, various initiatives could be taken, such as providing affordable or free training programs, creating online resources for learning, or offering subsidies for small firms that adopt BIM. Additionally, companies could explore alternative options such as utilizing existing employees who have prior experience with BIM or partnering with larger firms who can provide resources and training support.
- Based on the data provided, the 14th identified barrier to BIM implementation is that BIM resources provide a great platform for skill enhancement, but the mean score is relatively lower compared to the previous barriers, at 4.03. The standard deviation is also relatively high at 0.990, which indicates that the responses were more varied compared to the previous barriers. It can be inferred that while BIM resources can be helpful in improving the skills of the workforce,

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there are still challenges in terms of accessibility and effectiveness in improving the skillset of the employees. To overcome this barrier, it is important for organizations to provide comprehensive and effective training programs and to ensure that their employees have access to the necessary resources to enhance their BIM-related skills.

- Participants selected "Interoperability for complex BIM models need more attention" as the 15th most critical hurdle to the use of BIM in building business projects in poor nations. The participants rated this obstacle as somewhat important, with a mean score of 4.02 and a standard deviation of 0.883. When two or more programmes or systems are interoperable, data may be shared and used between them. In the context of BIM, interoperability is crucial, as BIM models often involve the integration of multiple software and tools. The participants' responses suggest that there is a need for more attention to be paid to the issue of interoperability for complex BIM models. This could be due to the fact that different software tools may use different file formats, which can make it difficult to exchange information between them. Additionally, the complexity of BIM models can further exacerbate interoperability issues, making it challenging to ensure that different software tools are working together seamlessly.
- Based on the evaluation of the participants, the barrier of legal issues regarding BIM documents and ownership between stakeholders being complicated received a mean score of 4.02 with a standard deviation of 0.925, placing it as the sixteenth most formidable challenge to the widespread adoption of BIM in the building sector. According to the participants, building information modelling (BIM) deployment in construction projects might be hampered by the complexity of connected legal concerns. This barrier includes issues related to the ownership of BIM data, intellectual property rights, and contractual arrangements between stakeholders. These issues can cause confusion and conflicts, which can lead to a lack of trust among stakeholders, ultimately hindering the successful implementation of BIM in construction projects. To overcome this barrier, it is essential to establish clear legal frameworks and guidelines for BIM implementation that are agreed upon by all stakeholders involved in the project. This will lead to a more successful adoption of BIM in the construction sector by making sure all stakeholders know their place when it comes to the ownership and usage of BIM data.
- This barrier indicates that some partners or subcontractors may not be using BIM in their operations, which can create problems in collaboration and coordination with other team members. The mean score of this barrier is 4.01, showing that participants consider it a major issue with BIM's use in building projects. The standard deviation of 0.9 suggests that there is a high level of agreement among the participants on this issue. It is important for construction companies to ensure that all team members, including subcontractors, are trained and equipped to work with BIM technology to avoid any communication breakdowns or coordination issues. Companies should also consider including BIM requirements in their contracts with partners and subcontractors to ensure compliance and minimize the risk of non-compliance.
- With a mean score of 4.01 and a standard deviation of 1.012, participants seem to believe that the industry is still inexperienced with BIM. This indicates that there is a need to increase education and understanding of BIM in the sector prior to its widespread acceptance and deployment. This lack of familiarity with BIM could be due to a variety of reasons, such as the limited availability of training and education programs, the absence of government initiatives to promote BIM, or a general resistance to change in the industry. To address this barrier, it may be necessary to increase awareness and education about BIM, through initiatives such as training programs, workshops, and seminars. This could help to build knowledge and understanding of the technology, as well as its potential benefits for the construction industry. Additionally, the government and industry leaders could play a more active role in promoting BIM and its adoption, by providing incentives and support for companies that implement the technology.

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6.5. Overall Ranking of Barriers

The measurement items for each variable are derived from existing studies of technology adoption. The research model includes 30 barriers that the researchers have carefully picked based on need of the study. The barriers include: Ambiguous Commercial Advantages, Cost of Consultants and Tools, Cost Taken to Practice, Effects of Supply Chain Management, Higher Design Costs, Higher Production Workload, Higher Software Cost and Its Updates, Improper Settlement Strategies for Implementation, Inadequate Motivation, Insufficient BIM Standards and Protocols, Intellectual Property, Interoperability, Lack of BIM Integration with Other Mechanism, Lack of Experts, Lack of Knowledge, Lack of Resources, Lack of Training and Development, Lack of Well-defined Workflow, Legal Challenges, Missing Technical Interaction, Modification in Contracts, Modification in Design, Negative Attitude, Resistant to Revolution, Risks in Project Liability, Time Taken in Practice, Unwillingness to Change, Poor view on Data Sharing, BIM Incomprehension, Lackness of insurance.

The outcome indicates that the AEC industries and AEC professional are not willing to accept BIM as a revolutionary technology. This causes the low BIM adoption in the construction industry. The second high rank barrier is Cost of Consultants and Tools. The respondents believe that BIM license cost for software and tools is much high. The small companies cannot afford it. Similarly, the BIM qualified managers, modelers and expert are low in number and they charge high fee for BIM consultancy. This causes the low BIM adoption in Saudi Arabian AEC industry. The third important barrier is interoperability. Lack of interoperability among BIM tools of different companies causes low data communication. The respondents are of the view that cost of data transformation and exchange is much high. There tools and software are not fully interoperable that causes the re-processing of data and wastage of time and cost. The fourth significant barrier is lack of BIM integration with other mechanism. There is a lack of proper integration of BIM applications with other AEC softwares. The reasons of this low integration are propriety nature of data models such as IFC and Cobie. Also, BIM developer companies compete in the market and hardly share data schemas with other companies, hence causes low integration. The fifth barrier is the effects of BIM in supply chain management (SCM). In SCM several stakeholders and companies participate in a single project. These include, architects, designers, construction material suppliers etc. Some stakeholder uses BIM for business activities, however other companies are not using BIM. This creates misunderstanding among different project participants. The least important barrier is lackness of insurance. A few respondents believe that BIM implementation does not provide knowledge to divide up and assign blame if anything goes wrong. Also, BIM implementation does not provide guarantee for recovery in case of any clash among the parties.

The survey instrument of this study includes some recommendations for the BIM implementation in BPR. The respondents were asked to rank the recommendation or to provide the appropriate recommendations. The second highest recommendation is BIM in BPR should reduce the number of checks/controls and reconciliation processes. The third recommendation from the respondents is every organization must have BIM related employees. Some respondents believe that BIM and BPR topics/contents need more concentration in conventional educational courses. Also, barriers of BIM adoption in Re-Engineering of Construction Business Practices should be overcome. Most respondents think that Business Information Modelling (BIM) is a useful tool for managing business processes that have been re-engineered. Some respondents are concerned that their careers are in jeopardy because they believe that building information modelling (BIM) software can perform the work just as well, if not better, than people. A few respondents are of the view that BIM is overhyped and should be used for large scale projects only. Alongside this, the recommendation ranking for Successful BIM implementation in BPR is also illustrated by Figure 6.

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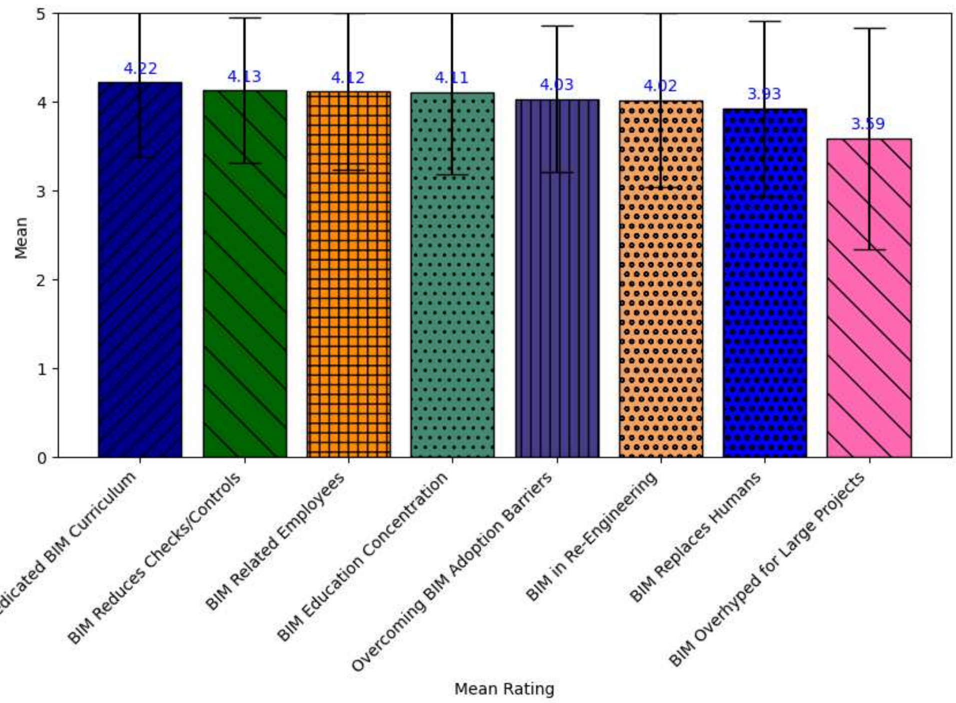

Figure 6. Recommendation Ranking for Successful BIM Implementation in BPR.

The results of a survey evaluating several suggestions for effective BIM deployment in the building sector are shown in figure 6. The survey participants, numbering 375, ranked eight different recommendations based on their effectiveness. The y-axis represents the recommendations, while the x-axis shows the mean score given to each recommendation, ranging from 1 to 5. The highest-ranked recommendation, with a mean score of 4.22, is the need for a dedicated and fully developed BIM curriculum that considers business process re-engineering. This was followed closely by the recommendation that BIM can reduce the number of checks and controls, with a mean score of 4.13.

The recommendation that every organization should have BIM-related employees had a mean score of 4.12 and ranked third. Recommendations to include BIM content into traditional curricula and remove roadblocks to BIM's acceptance in the re-engineering of construction industry practises scored fourth and fifth, respectively. These had mean scores of 4.11 and 4.03. The last three recommendations had lower mean scores, with the recommendation that BIM replaces humans having a mean score of 3.93, while the recommendation that BIM is overhyped and should only be used for large projects had a mean score of 3.59, the lowest mean score of all the recommendations.

The standard deviation values varied between 0.817 and 1.25, indicating that there was a significant range in the responses given by the survey participants for each recommendation. The ranking order of the recommendations remained consistent with their respective mean scores, which was also reflected in the assigned ranks ranging from 1 to 8.

7. Conclusion

Building information modelling (BIM) uptake in the building sector is difficult and requires addressing several challenges. This study aimed to identify and rank these barriers to provide insights for better implementation of BIM. The survey results suggest that the lack of a dedicated BIM curriculum and concentration in conventional educational courses is the most significant barrier, followed by the high cost of consultants and tools for BIM implementation. Other significant barriers include ambiguity in commercial advantages, costs for clients in terms of fees for training programs, and inadequate motivation from government and company owners to implement BIM. If the building industry is going to fully accept and execute BIM, these obstacles must be removed. The research suggests clarifying the financial benefits of BIM, cutting implementation costs, and creating a complete BIM curriculum and training programmes. The implementation of BIM can provide significant benefits to the construction industry, including increased efficiency, reduced costs, and improved communication and collaboration among stakeholders. Further research is needed to explore the specific challenges of BIM implementation in different regions and countries and to identify effective strategies to overcome these barriers. This research is helpful for understanding the challenges that construction firms have when trying to embrace BIM, and it emphasises the need of making a determined effort to overcome these challenges in order to fully realise the promise of BIM.

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