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Research Article

Integrating Building Information Modelling With Construction

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Abstract **–** Building Information Modeling (BIM) has revolutionized the construction industry by encouraging communication and improving project performance. The research highlights utilization of BIM in industrial plant fabrics. It investigates procurement issues, challenges, and opportunities for improvement in the areas. Through semi-structured interviews, questionnaires and real time field application of BIM implementation with, the study reveals BIM plays an excellent role when it comes to communication and teamwork as it can give real time data sharing and working. Though these obstacles to BIM adoption, namely, expensive initial costs, organizational resistance, or technical complexity, are still to be solved, the technology has a future in construction. The study indicates that proper BIM introduction in the industrial factory construction includes staged implementation, strong management support, and full-scale training. The project provides recommendations on dealing with cost as well as resistance aspects of technology adoption, underscoring the role of effective communication using personal context. Even though there is a self-limitation in sample size and geographical focus, this research will create a framework for better BIM uptake in the industrial sector. Through this research our observations can be added to the knowledge bodies about the special features of BIM application in industrial facility construction and the road may be open for others who will study applicable fields in industrial construction and long-term impact.

Keywords: Building Information Modeling (BIM), Construction, Project Efficiency, Collaboration, Lifecycle Management, Implementation, Stakeholder.

I. INTRODUCTION

The construction industry is experiencing ongoing changes with the integration of Building Information Modelling (BIM) to enhance collaboration, reduce errors, and improve project efficiency. However, BIM's potential can only be fully realized through alignment with procurement strategies tailored to the specific requirements of industrial facility construction [1]. This dissertation provides an in-depth

examination of the intricate relationship between BIM and procurement processes pertinent to industrial construction projects. The growing demand for industrial facilities underscores the need for improvements in procurement processes. As reported by [2], global demand for industrial spaces in 2021 increased by 19% compared to 2020. This rise is driven by the rapid expansion of sectors including general retail and wholesale, ecommerce, food & beverage, and third-party logistics, where efficient industrial facilities are essential. There is a need to enhance existing procurement procedures and explore how BIM can contribute to improving the construction industry [3]. The collaborative and information-intensive nature of BIM contrasts with traditional procurement mechanisms [4], which hinders the optimal utilization of this transformative technology. This dissertation aims to bridge the gap between current procurement systems and the integration of BIM in industrial construction by evaluating procurement systems and proposing tailored strategies for adopting BIM more seamlessly [5].

This research aims to facilitate positive changes by recognizing and incorporating necessary modifications into procurement strategies. The objective is to promote the adoption of BIM by all stakeholders, leading to improved collaboration, reduced errors, better planning, and increased value. This research has the potential to develop standard procurement strategies that can serve as a model for the broader construction industry, fostering a culture of collaboration among participants and enhancing efficiency in the modern construction environment.

II. METHODS

The research approach adopted for this study is deductive, leveraging established theories and literature related to BIM integration and procurement practices in industrial construction to guide the investigation and analysis of empirical data [6]. The deductive approach involves starting with existing theories and hypotheses derived from the literature review on BIM integration and procurement practices in industrial construction. These theories serve as a framework for developing research questions and hypotheses that will be tested through empirical data collection and analysis. By applying existing theoretical frameworks to real-world contexts, this approach aims to validate or refine theoretical propositions regarding the challenges and opportunities associated with BIM adoption in procurement processes.

Through the deductive approach, this research seeks to test and validate theoretical propositions derived from the literature, such as the benefits of BIM for enhancing collaboration, reducing errors, and improving project efficiency in industrial construction [7]. The research will explore how these theoretical concepts manifest in practice, considering the unique context of industrial facility construction and its specific procurement requirements. By grounding the research in established theories and concepts, the study aims to contribute to the refinement and advancement of theoretical knowledge on the topic. Empirical data collected through interviews and questionnaires will be analyzed to validate or refute the theoretical propositions derived from the literature. This process involves systematically comparing empirical findings with existing theories to draw conclusions about the effectiveness of BIM integration strategies in industrial construction procurement [8].

2.1 Data Collection

The data collection process for this research involves both qualitative and quantitative methods to gather comprehensive insights into the integration of BIM into procurement practices within the industrial construction sector [9].

Semi-structured interviews will be conducted with key stakeholders in the industrial construction industry, including project managers, procurement specialists, architects, engineers, and BIM coordinators. These interviews will be guided by a flexible set of open-ended questions to explore

stakeholders' perspectives, experiences, and challenges related to BIM integration in procurement processes [10]. The qualitative data obtained from interviews will provide in-depth insights into the complexities and nuances of BIM adoption within industrial facility construction projects.
Structured questionnaires will be distributed to a broader sample of industry professionals involved in industrial construction, using convenience sampling methods to reach a diverse cross-section of practitioners. The questionnaires will include closed-ended questions with Likert-scale response options to quantify respondents' attitudes, perceptions, and practices related to BIM integration in procurement.

2.2 Sampling

The sampling strategy for this research will involve purposive sampling for semi structured interviews and convenience sampling for questionnaires, aiming to capture a diverse range of perspectives and experiences related to BIM integration in industrial construction [9].
Purposive sampling will be used to select participants for semi-structured interviews based on their expertise, roles, and involvement in industrial construction projects. This sampling approach ensures that the interview sample represents key stakeholders, including project managers, procurement specialists, architects, engineers, and BIM coordinators, who possess relevant insights into BIM adoption and procurement practices within the industry. Convenience sampling will be employed for the distribution of questionnaires to industry professionals involved in industrial facility construction. This sampling method will leverage accessible and readily available participants within professional networks and industry associations.
Special attention will be given to ensuring diversity and representation within the sampled population, particularly in terms of organizational roles, project types, and geographical location. By strategically selecting interview participants and employing convenience sampling for questionnaires, the research aims to gather comprehensive data that reflects the varied experiences and viewpoints pertinent to BIM integration in industrial construction procurement.

2.3 Data Analysis

The data analysis process for this research will involve a combination of qualitative thematic analysis for interview transcripts and descriptive statistical analysis for questionnaire responses, aimed at uncovering patterns, themes, and trends related to BIM integration in industrial construction procurement. Thematic analysis will be employed to analyze qualitative data obtained from semi-structured interviews with key stakeholders in the industrial construction sector. This approach involves systematically identifying, organizing, and interpreting patterns (themes) within the interview transcripts [11]. Through iterative coding and thematic grouping, themes related to BIM adoption challenges, opportunities, and stakeholder perspectives will be identified, providing a nuanced understanding of the complexities surrounding BIM integration in procurement processes. Descriptive statistical analysis will be used to analyze quantitative data collected through structured questionnaires distributed to industry professionals. This analysis will involve summarizing and presenting numerical information using measures such as frequencies, percentages, means, and standard deviations. The statistical analysis will provide insights into the prevalence of specific attitudes, stakeholders engagement in success perceptions, and practices related to BIM integration within the industrial construction sector [12]. The findings from thematic analysis and descriptive statistical analysis will be integrated to develop a comprehensive understanding of the challenges, opportunities, and implications of BIM integration in industrial construction procurement. Triangulation of qualitative and quantitative data will enable a robust interpretation of research outcomes,

facilitating the identification of key recommendations for enhancing BIM adoption practices within the industry.

2.4 Validation

Validation of research findings in this study will involve several strategies to ensure credibility and trustworthiness of the results [13]. Methodological triangulation will be employed by combining qualitative and quantitative data collection methods (interviews and questionnaires) to provide complementary insights into BIM integration in industrial construction procurement. Triangulation enhances the validity of findings by corroborating results obtained through different approaches. Member checking will be conducted by sharing preliminary findings with participants to verify the accuracy and interpretation of their contributions [13]. This process allows participants to confirm or challenge the researcher's interpretations, enhancing the credibility of the study outcomes. Peer review will be sought by presenting the research findings to colleagues or experts in the field for critical evaluation and feedback (Silverman, 2016). Peer review provides an external validation of the study's methods and conclusions, ensuring rigor and credibility. Reflexivity will be practiced by maintaining awareness of the researcher's biases, assumptions, and perspectives throughout the research process (Finlay & Gough, 2003).

III. RESULTS

This research paper explores the inclusion of Building Information Modeling (BIM) in industrial construction procurement. A primary concern is the level of adoption, realizing the current trends and assessing the associated challenges and opportunities. Data was collected using observation and target questioning, which yielded a deep understanding of how BIM is facilitating a solution-oriented construction process.

3.1 Data Collection Overview:

Flowcharts were used to illustrate the study process, in a way that shows all the stages, as data collected from both semi-structured interviews and questionnaires. An illustration of a flowchart outlining the general framework for data collection is provided below:

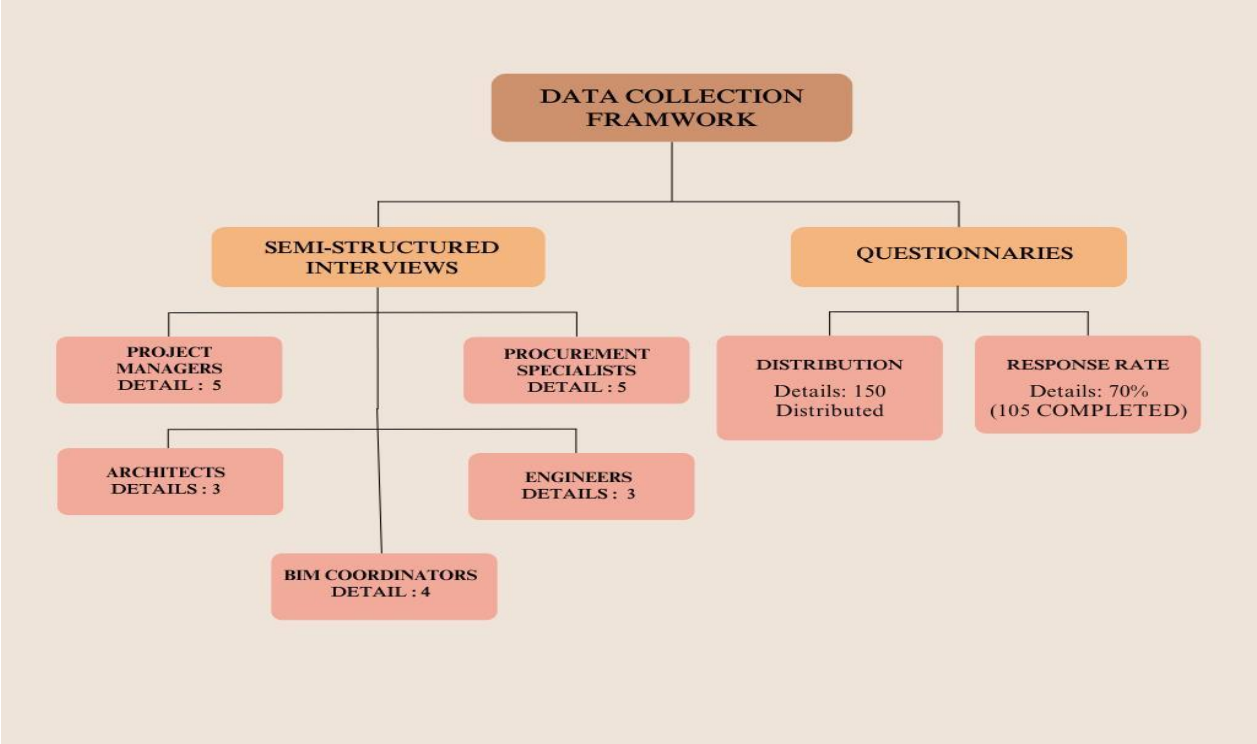

Figure 1: Data Collection Overview

3.2 Semi-Structured Interviews

In total 20 semi-structured interviews were held with representatives of the industrial construction sector as key actors. Such stakeholders were selected as they were directly engaged in procurement process and have the experience in BIM-related activities. The interview participants consisted of a diverse group of professionals: There are 5 participants who are given the responsibility to help in the construction projects and make sure that deadlines, budgets, and quality are accomplished.5 members dedicated to finding and procurement of materials, equipment, and services for construction projects.3 participants, developed a construction plan and its design.3 participants engaged in the process of construction projects at the level of structural, mechanical, and electrical engineering.4 participants, in charge of managing and applying the BIM processes to the projects. Using the semi-structured interview approach, the survey makes a detailed dive into the issues handled by each participant during the BIM integration, which allows us to know the depths of experiences with the procurement process.

3.3 Questionnaires

Along with the interviews, a total of 150 questionnaires were distributed to industry professionals across the country who were working in large-scale constructions. The list of respondents included project managers, architects, engineers, as well as other stakeholders of procurement processes. A 70% response rate was achieved, 105 complete responses recorded, and therein provided abundant numerical data for analysis. The questionnaire included some close-ended questions, like Likert-Scale, to understand how the people were thinking about and perceive BIM. These inquiries addressed a variety of subjects, such as:

• **Experience with BIM:** Evaluating the knowledge and expertise in BIM technology.

• **Perceived Benefits:** Determining the perceived BIM procurement benefits by considering such factors as improved collaboration, fewer mistakes and better-run projects.

• **Challenges and Barriers:** Awareness and investigation of the obstacles and challenges encountered during the BIM implementation. A quantitative view of the integration of BIM in procurement of industrial construction was seen through the data gathered from the questionnaires thereby providing a wider context to the interviews.

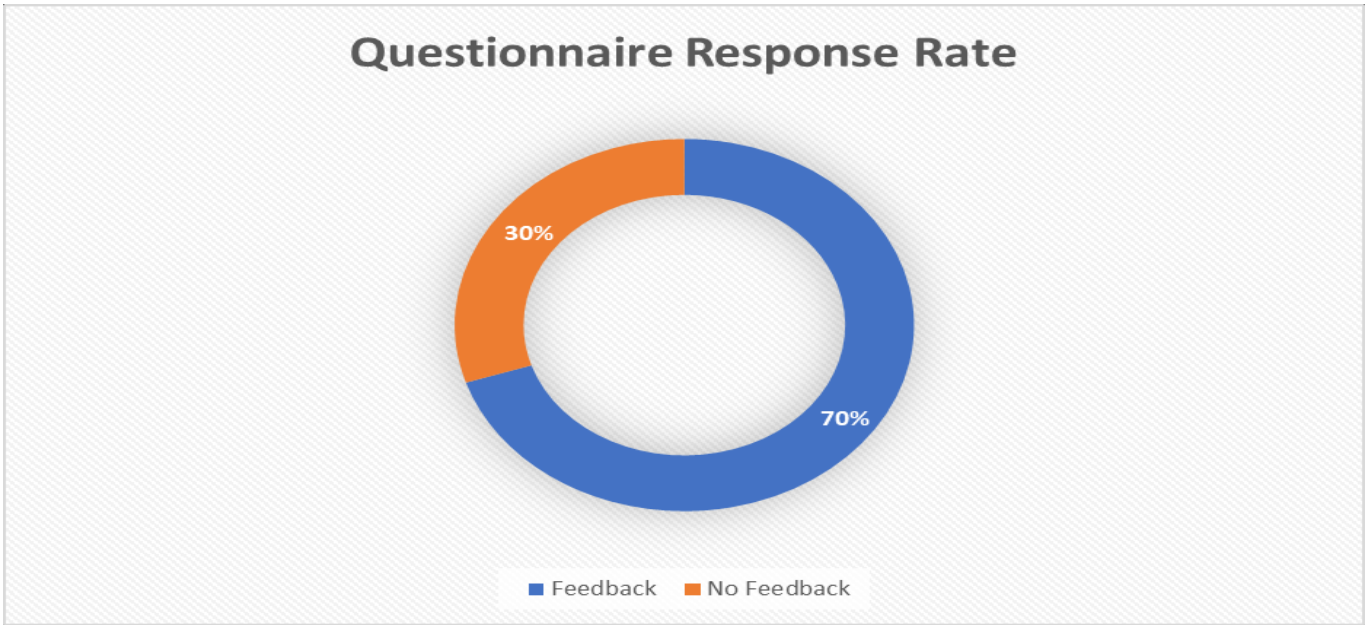

Figure 2: Questionnaire Response Rate

3.3 Demographics of Interview Participants

This study examined the opinions of numerous industry players from the industrial construction sector using a semi-structured interviewing technique. The following provides a thorough overview of the interviewees' demographics:

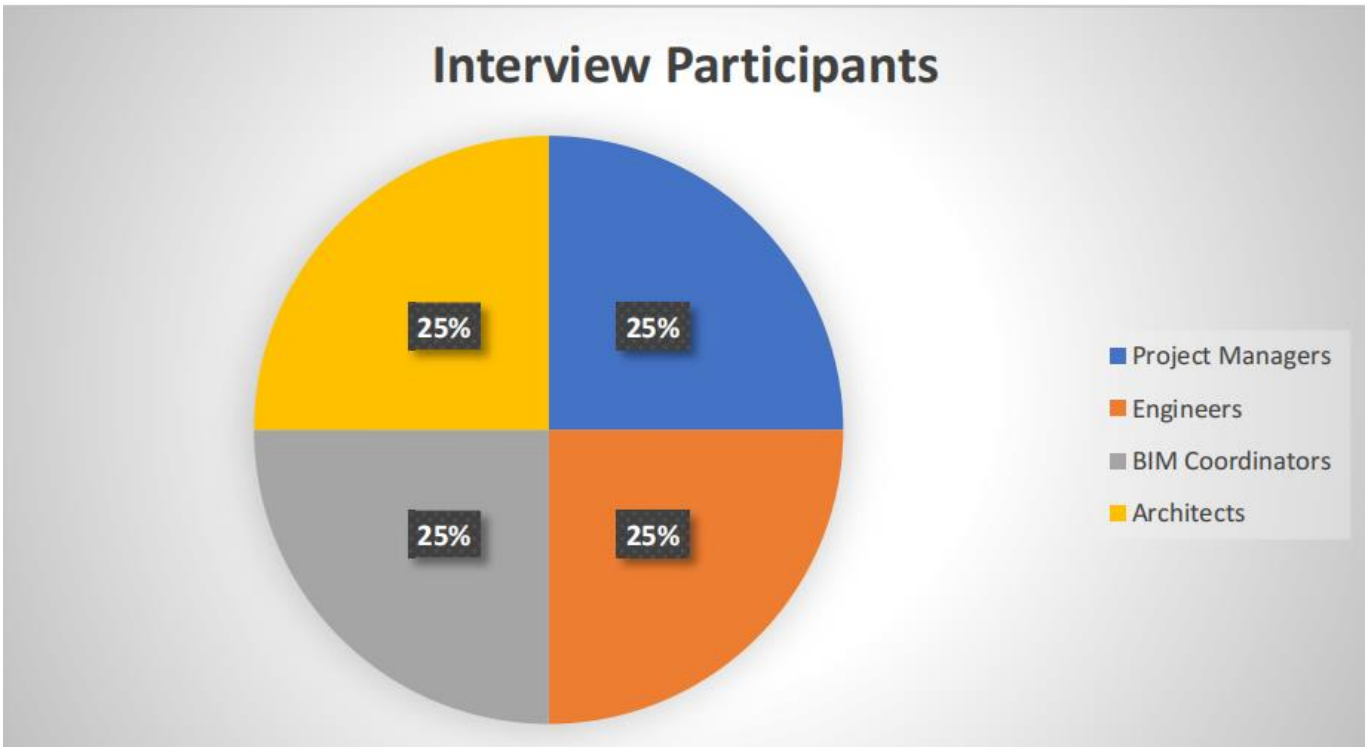

Figure 3: Demographics of Interview Participants

Roles: The interviewees revealed they came from different positions within the industrial construction process. The sample was comprised of five Project Managers, five Architects, or Engineers, and five BIM Coordinators. This fair distribution is giving information from the many important fields, that leads to a general perception of the usage of BIM integration in industrial contract procuring. Each of these roles involves a distinct approach with Project Managers handling overall project coordination, Architects designing, Engineers tackling technical aspects, and BIM Coordinators focused on technology and data management.

3.4 Demographics of Questionnaire Respondents

In order create a wide and dense demographic, questionnaire in the study was distributed in the industrial areas, among many other construction industries. The composition of the questionnaire respondents offered a quite broad perspective on Building Information Modeling (BIM) integration in industrial construction tendering, involving various steams, skill levels, and geographic locations. Respondents took roles in all aspects from project management, procurement, architecture, engineering, and BIM coordination.

The respondents lacked uniformity of experience with the least having 4 years and the most 20 years in the industry. This open range gave us a glimpse into how BIM integration sits with industry veterans and novices differently. A broad representation will keep the analysis factual that clearly address all industrial construction fields, thus making a viable yet strong evaluation of the concerns and opportunities as BIM implementation plans commence. The report intends to accomplish this coverage to get results that are both reliable and applicable to a larger sector.

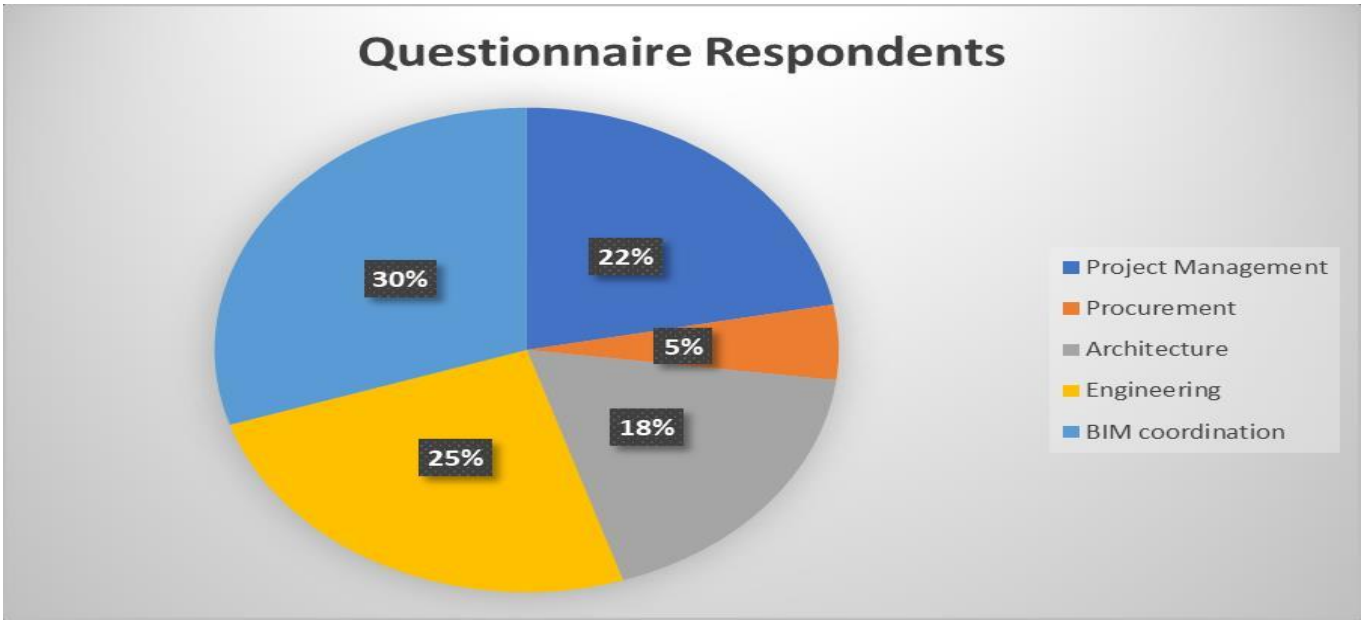

Figure 4: Demographics of Questionnaire Respondents

3.5 Analysis of Semi-Structured Interviews

This section contains a detailed explanation of the semi-structured interviews. We employed thematic analysis to identify the central themes from the interview transcripts. Three key themes emerged from this analysis: standpoints of Building Information Modeling (BIM) integration, procurement practices, and organizational culture and BIM adoption.

IV. DISCUSSION

4.1 Benefits of BIM

The following is a summary of the advantages that the interviewees mentioned for BIM integration:

• **Collaboration**: BIM enhances communication among the stakeholders, and, consequently, it improves teamwork. As a result, it serves as a one-stop place for information and thus leads to fewer misconceptions but more efficient project management [14].

• **Error Reduction**: The BIM solution provides elimination of design faults and contractor revision mostly by identifying the problems early in the design and planning steps. It will cause more precise construction processes and certainly result in a reduction of costly delay [15].

• **Enhanced Tracking**: BIM can be used for more efficient use of and tracking of project resources. This competence enables project managers to be under control in terms of material utilization an allocation during the entire project period [16].

• **Project Efficiency**: BIM helps make projects faster. Better coordination and planning contribute to efficiency rising, thus resulting in timely (or even early) completion of tasks [4].

***4.2** Challenges of BIM*

Even though BIM has many advantages, there are still several obstacles that may prevent it from being implemented successfully:

• **Resistance to Change**: Other stakeholders oppose technology substitution, particularly those used to behaviors enforce through these new procedures to traditional methods. This resistance is usually caused by the lack of knowledge or job-concern [17]
• **Cost Implications**: The application of BIM implies an initial cost of tools and training. This cost is a burden on small businesses or those with limited budgets [18].
• **Skill Development**: BIM requires special training to be utilized completely. Organizations should have continual education courses to keep the workforce updated with the BIM features [19].
The following flowchart shows the major elements of perception of BIM integration.

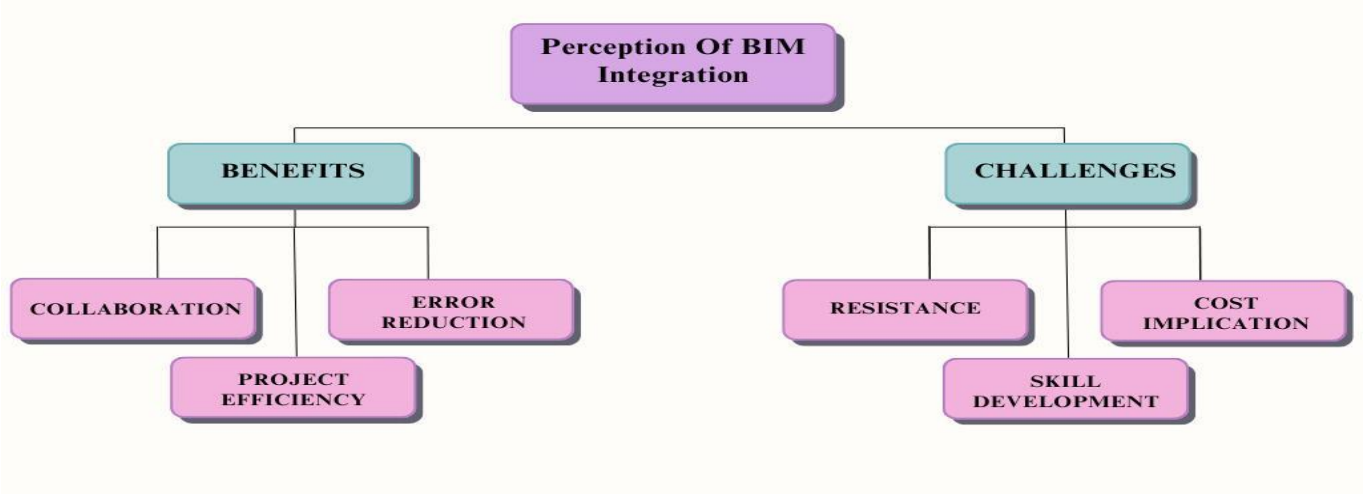

Figure 5: Perceptions of BIM Integration

• Lessons from Early Adopters: Organizations which transitioned to BIM early had their mistakes and best practices as a lesson for others to learn. The lessons were repeatedly based on the significance of training, leadership and cultivating an environment that promotes teamwork [20].

V. CONCLUSION

1. Diverse Professional Roles: Even percentages of 25% in each role of Project Manager, Engineer, BIM Coordinator, Architect are indicative of the fact that BIM's integration touches on all facets of industrial construction.
2. Broad Representation: Large number of respondents (30% BIM Coordination,22% Project Management from the research) suggests that BIM is applicable not only to the people directly involved with the technology, but also for dicesion makers involved in project management, procurement and architecture.
3. Varied Experience: As the research shows respondents span the spectrum from 4 to 20 years industry experience which indicates that experienced and newcomers have experienced BIM. This means that the acceptance in BIM is flexible and people at different professional level are embracing this technology.
4. Benefits and Challenges: While BIM provides more data to indicate that it has positive impacts on project outcomes on communication and efficiency, However, during BIM implementation challenges such as technical barriers, training and even resistance to change still exist.
5. Key Insights: The research indicates that BIM is a technical tool at the surface but the three key themes BIM integration, procurement practices, and organizational culture indicate it is deeply about organizational factors. BIM provides support to evolving procurement practices and

embracing technological change within the organization's culture will be needed for BIM to be used throughout the entire construction process.

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