Design of a Competency Framework for BIM-Based Collaboration among Construction Professionals in Delta State

[1]Arc.Harrison Irabor., [2]Prof Basil U Eze., [3]Dr. Kingsley Ikechukwu Ezeh

[1]Dept.of Quantity Survey, Enugu state University of science &, Technology.Enugu

[2]Dept.of Geography and Meteorology, Enugu state university of Science and Technology

[3]Department of Computer Science, Enugu State University of Science and Technology

DOI: https://dx.doi.org/10.47772/IJRISS.2025.91100389

Received: 26 November 2025; Accepted: 03 December 2025; Published: 11 December 2025

ABSTRACT

Building Information Modelling (BIM) improves the efficiency and worldwide collaboration in the construction industry but its application in Nigeria and particularly in Delta state is minimal because of the lack of an organized competency model. This loophole limits the successful BIM teamwork and denies the professionals opportunities to acquire requisite skills. The purpose of the study is to come up with a BIM-based collaboration competency designed to suit the Delta State construction scenario. The survey design was a quantitative survey design by utilizing structured questionnaires that were given to 200 construction professionals, which were architects, engineers, quantity surveyors, and project managers. The tool further elicited the technical, managerial, and relational competencies, existing cooperative practices, and obstacles in the development of competencies. Data analysis was done using descriptive statistics (mean scores, standard deviations and level of agreement). It was found that such technical skills as BIM software proficiency and model coordination had the highest mean positions, then came managerial competencies associated with schedule planning and BIM standards compliance. Relational competencies (such as communication, teamwork and adaptability) were also broadly accepted as essential in the development of trust and facilitation of interdisciplinary collaboration. Barriers identified by the respondents as major ones were the lack of access to licensed BIM software, the lack of training opportunities, the lack of digital infrastructure, and the lack of inter-organisational trust. To facilitate a more comprehensive adoption of BIM in the Delta State construction industry, a context-based BIM competency framework was created to inform training, standardised collaboration, and wider adoption of BIM.

Keywords: Building Information Modelling (BIM), Competency Framework, Collaboration, Construction Professionals.

INTRODUCTION

Building Information Modelling (BIM) has emerged as an internationally established method of improving the level of collaboration, efficiency, and precision in the construction field. The United Kingdom, the United States and constituents of Scandinavia have realised high levels of BIM adoption owing to effective digital policies, mature infrastructure as well as standardised implementation policy (Manzoor et al., 2025). BIM use in these areas has greatly eliminated construction mistakes, time wastage and cost escalations. Nonetheless, amongst most developing countries, use of BIM in a country like Nigeria is a haphazard occurrence that is usually limited to simple design operations. Such gradual development is associated with the poor regulatory frameworks, poor digital infrastructure, lack of awareness, high implementation costs and cultural resistance to change in technology. The lack of skilled people also limits the transformative potential of BIM in sub-Saharan Africa. In Nigeria, lots of construction professionals refer to BIM and the traditional design software without looking at its extended features which include clash detection, scheduling, and lifecycle management (Okwose et al., 2025). Its awareness, practice and cross-disciplinary cooperation is still minimal, even in large urban centres. According to several studies, the main obstacles have been reported to be high cost of set up, inadequate training, low standards, ineffective contract structures, unreliable power supply and poor internet connectivity. It is especially

difficult in smaller firms because there is low demand among clients to use BIM, and investing in it cannot be justified. In addition to the technology constraints, human capabilities are a key to effective BIM cooperation (Oyedijo et al., 2021). Studies have shown that in the absence of formal competency frameworks, organisations usually approach BIM in haphazard and shallow manner. The skills gaps are observed both in technical skills, including model creation and information management, and in the relational skills, including teamwork, communication, and adaptability (Chmeit et al., 2024). Nevertheless, the majority of Nigerian researches only indicate the absence of the skills in general without detailing what exactly should be characterized as the competencies of successful BIM-based cooperation. To a large extent, geographically, previous research has concerned major cities or samples of students only, which can provide only a rough understanding of the situation of practising professionals in such a region as Delta State (Olanrewaju et al., 2020). Delta state, despite the current increased construction activity, is under-researched, with gaps in knowledge of the perception and collaborative practices and contextual issues of professionals. In order to deal with these problems, the current research aims at developing a competency framework that is specific to the BIM-based teamwork of construction professionals within the context of Delta State. It determines the important competencies, discusses the existing perceptions, and presents the region-specific barriers through the systematic review of the credible secondary sources. The framework that will be the outcome is designed to facilitate the training, the development of policies as well as the development of the organisation and empower the implementation of BIM throughout the entire construction industry of the state.

Problem Statement

Despite the fact that Building Information Modelling (BIM) is gaining momentum throughout the world, its usage by the construction professionals in Nigeria is low and irregular. The available literature recognizes that there are high levels of BIM-related skills gaps; nevertheless, the gaps are seldom converted into a formalized competency model that can be used to direct training, certification, or policy-making (Agwa & Çelik, 2025). Consequently, BIM-based collaboration does not have well-defined knowledge, skills and the competencies in behaviour that are necessary in implementing the BIM effectively and thus fully exploiting the BIM advantages in project delivery. Moreover, a significant portion of Nigerian BIM research is centered around the geographical areas of Lagos or Abuja, or student groups, which has not covered the area of delta state (Bamgbose et al., 2024). Delta State does not have the empirical evidence of how practitioners perceive, practice collaboration and what their competency issues are despite having an active construction sector. This forms an urgent research gap: the lack of a context-specific, structured BIM competency framework in the requirements of Delta State professionals. In the absence of such a framework, continuous attempts at enhancing BIM are still scattered, disjointed and not aligned with the local industry needs. The paper poses this gap hence filling it by coming up with an effective, context-based BIM collaboration competency framework within Delta State.

LITERATURE REVIEW

Collaborative Behaviours in BIM Projects

The concept of collaboration is core to the effective use of Building Information Modelling (BIM), as the methodology is based on the exchange of information, coordinated workflow and collaboration across disciplines. Collaboration in BIM-enabled settings is not limited to the mere exchange of information but is a unique mentality in which the professionals operate as a team, functioning towards project goals instead of isolated disciplinary units (Oraee et al., 2021). Open communication enables successful collaboration where team members are free to share information, explain what is not clear and give feedback in time. This behaviour promotes transparency and minimises errors that are likely to occur due to disjointed communication channels under the conventional project delivery method. Mutual trust is another vital collaborative behaviour. BIM projects demand professionals to base their work on shared models and integrated data, and they need to trust the accuracy, intent and competence of other people (Bahrain et al., 2023). Trust promotes sharing of information, acceptance of responsibilities and adapting to changes. Accountability is closely connected to trust, using which the team members know their roles in the BIM process and own the quality and time-based appropriateness of their input. BIM collaboration is also characterised by cooperative problem-solving (Yi and Nie, 2024). As digital models connect several fields, problems like design conflicts, sequence conflicts or

constructability problems need to be addressed collectively. Teamwork in solving problems encourages synergy, less re-work and improved decision-making. This tendency is reinforced by the willingness to learn others as BIM environments frequently demand professionals to learn about the fundamental knowledge of disciplines that they do not study (Olaseni, 2019). Another important behaviour in BIM projects is adaptability. Since BIM operations are based on the development of models and dynamic flows of information, it is essential that the professionals are flexible enough to accept change, technology, and modified processes. Flexibility also allows teams to adapt swiftly to changes in models, new data demands or new project knowledge (Abugu, 2025). Lastly, collaborative behaviour is supported by compliance with common protocols and standards. BIM teamwork requires regularity in model formats, naming systems, documenting procedures and data management regulations. Under common standards, model interoperability and workflow efficiency are enhanced greatly when professionals adhere to them. A combination of these behaviours, communication, trust, accountability, cooperative problem-solving, learning orientation, adaptability and adherence to standards, is the behavioural basis that enables BIM to produce integrated and high-quality construction results (Miao et al., 2024).

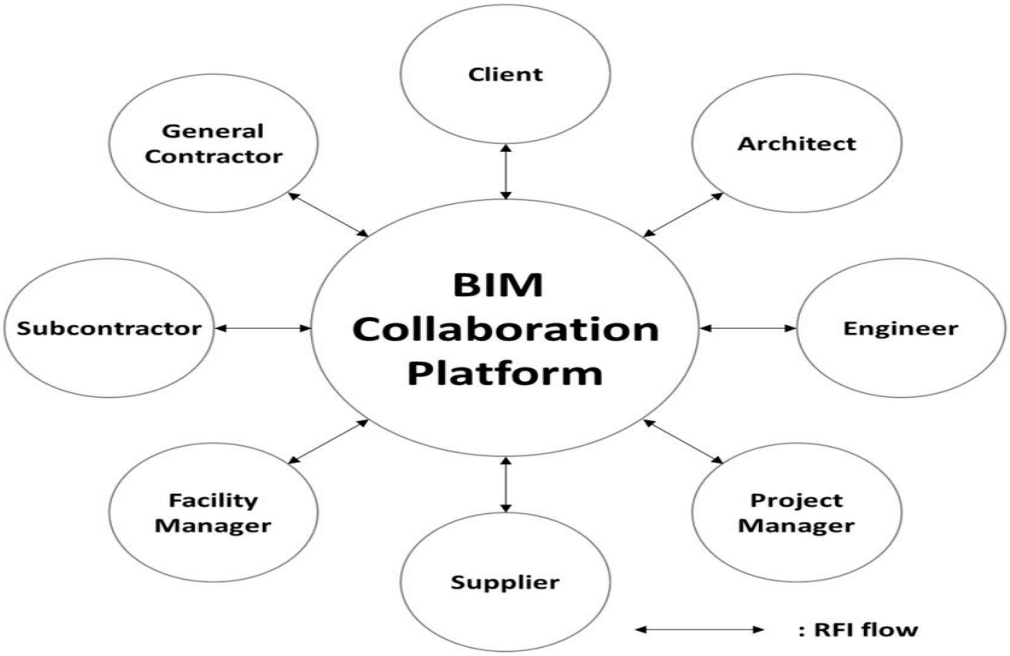

Figure 1: Collaborative BIM-Based construction (Ham & Yuh, 2023)

Barriers to Collaboration in BIM-Based Networks

The obstacles to cooperation in the BIM-based networks are presented by the technical, organisational, and behavioural limitations that inhibit the smooth flow of information and alignment of the workflows (Oraee et al., 2019). Such issues are a hindrance to the integrated character of BIM, and it is hard to get project teams to coordinate across disciplines effectively. In most settings, the lack of skills, inadequate digital infrastructure and opposition of new processes undermine the collaborative power of BIM. These barriers can be understood and improved to enhance team working, which can increase the model precision and reach the maximum potential of the BIM-enabled project delivery. Below are some barriers to collaboration:

1. **Limited Technical Skills and Competencies**: Several practitioners do not have sufficient BIM modelling, data management and coordination expertise and thus cannot easily participate in joint BIM.

2. Lack of Digital Infrastructure: The lack of good internet connectivity, power intermittency, and old hardware is a hindrance to real time model sharing, and makes BIM workflows less efficient.

3. Software Incompatibility: Various organisations tend to have different BIM platforms, which cause interoperability problems, loss of data and communication failure.

4. Weak Organisational and Contractual Frameworks: Lack of standardised BIM protocols and responsibilities and formal BIM execution plans make coordination and consistency between project teams less evident.

5. Cultural and Behavioural Resistance: The professionals might be resistant to transparency and may be afraid of more responsibility or they are just not used to technology-driven workflows, which inhibit collaboration.

6. Poor Client and Industry Demand: In a situation when clients do not require BIM, companies, in particular, small and medium enterprises, are not inclined to invest in collaborative BIM.

7. Trust and Liability Issues: The fear of making mistakes, blame, copyrights, and data ownership conflicts will ensure that teams do not share accurate and complete information.

Enablers of Collaboration in BIM-Based Networks

1. Clear BIM Standards and Protocols: Uniformity in naming, work processes and documentation activities maximise compatibility and minimise ambiguity and simplify collaboration.

2. Good Leadership and Organisational Support: The management should be committed to the digital transformation that encourages the culture of openness, teamwork and innovation.

3. Capacity Building and Professional Training: Ongoing upskilling will provide the professionals with technical and soft skills to be able to collaborate effectively through BIM procedures.

4. Application of Common Data Environments (CDEs): Cloud environments allow sharing of information, version management and open communication in project teams.

5. Integrated Project Delivery (IPD) Approaches: Early engagement of stakeholders facilitates common decision making, individual responsibility and enhanced project alignment.

6. Mechanisms of Trust: Consistent communication, conflict-resolution process and definite rules in terms of data-sharing enforce trust in the team members.

7. Supportive Policies and Regulation: Government or institutional policies promote the standardisation of the industry on a larger scale and further adoption of BIM.

Competency Development and Assessment in BIM Practice

The competency development in BIM practice means providing the professionals involved in construction with the technical and managerial as well as relational competencies to collaborate successfully in the interdisciplinary projects (Ahankoob et al., 2025). The core competencies consist of the capability in the use of BIM software, data management, model coordination, clash detection, scheduling, and lifecycle management. Soft skills, including communication, teamwork, problem solving, adaptability, and cross-organisational and inter-disciplinary working should also be considered as important (Mirhosseini et al., 2020). The development of these competencies is based on structured training programs, workshops, mentorship, and practical project experience. Organizational assistance, availability of digital tools and team-working platforms, also improve skill learning and the degree of confidence toward BIM-based processes. BIM competency assessment can confirm that the professionals can be able to use their knowledge and skills in an effective way (Semaan et al., 2021). These methods are practical assessments, simulation workshops, peer assessment, personal assessment and performance measurement in live projects. Competency frameworks offer a systematic way of doing things by outlining the knowledge, skills, and attitudes required of particular positions, and inform the development and evaluation. It enables organisations to establish areas of skill deficiency, direct training intervention, and align professional skills with project needs (Benayoune, 2024). Incorporating the competency development and assessment in the BIM practice enhances collaboration, minimizes mistakes, and enhances efficiency in the project. Unceasing assessment promotes life long education and flexibility when faced with changing

technologies and project requirements (Kim et al., 2025). Secondly, competency assessment also guides the hiring, promotion and selection of project teams whereby people allocated to BIM projects are competent. Locally applicable competency frameworks and evaluation tools are needed in the environment of areas such as Delta State where BIM is still in its infancy. They make sure that the development efforts are practical, location-sensitive, and they fit the realities of the local construction industry (Lee et al., 2021). Through juxtaposing development and assessment, professionals would be in a better situation to engage in the BIM-enabled projects, improve coordination, exchange of information, and the results of the entire project.

METHODOLOGY

The study adopts a quantitative survey research design to investigate competencies that are needed to collaborate with BIM based on collaboration among construction professionals in Delta State. The main data collection tool was a structured questionnaire, which enabled the collection of standardised data in a large sample in a uniform and effective way. The quantitative methodology was suitable to make objective measurements of perceptions, experiences, and challenges and to furnish statistically analyseable results to guide the creation of a competency framework. The sample included architects, engineers, quantity surveyors, project managers, and other individuals who have had experience in BIM-related projects. Purposive sampling was used to select 200 eligible participants who were selected based on their professional experience and participation in BIM practices. A response of X was received, which is X% (insert actual figures) response rate. Information was gathered using an online survey in Google forms. The survey included predominantly closed-ended questions organized into a five-point Likert scale to address the significant areas which included technical competencies, managerial competencies, and relational competencies; attitudes towards BIM collaboration; existing collaborative behaviour; and obstacles to competency development. The use of Google Forms enabled extensive distribution, quick collection of response and efficient data management. Data obtained was analysed through descriptive statistics mean scores, standard deviation, and percentage of agreements to determine necessary competencies, evaluate current collaboration practices, and identify significant challenges. The results were thematically grouped to aid the formulation of a situational BIM collaboration competency framework. The study followed ethics and the informed consent, voluntary participation, anonymity, and confidentiality were maintained. Data was recorded, analysed and reported objectively to ensure the integrity and credibility of the research.

RESULT AND DISCUSSION

Research Question 1

What key competencies do professionals in Delta State require for effective BIM-based collaboration?

Table 1: Effective BIM-based collaboration.

S/N	Statement	Mean (x)	Standard Deviation (S.D)	Agreement (%)	Remark
1.	Professionals are proficient in BIM software modelling?	4.72	0.46	94%	Strongly agreed
2.	Professionals can manage and coordinate BIM models across disciplines?	4.65	0.52	93%	Strongly agreed
3.	Professionals demonstrate effective communication and teamwork skills?	4.58	0.55	92%	Strongly Agreed
4.	Professionals can apply BIM standards and protocols effectively?	4.60	0.50	93%	Strongly Agreed

5.	Professionals possess problem-solving skills in multidisciplinary BIM environments?	4.55	0.60	91.0%	Agreed

Table 1 shows that practitioners in Delta State demonstrate high awareness of the most important competencies of efficient teamwork on BIM. The mean scores of all five statements are between 4.55 and 4.72 indicating low variability and high level of agreement between the two hundred respondents. The levels of agreements were between 91 and 94, which means that there was a broad recognition of the importance of these competencies. BIM software proficiency and interdisciplinary model coordination were the highest rated competencies with problem solving in multidisciplinary environments, albeit with a slightly lower score, being highly agreed upon. Overall, the results prove the importance of critical technical, relational, and procedural skills required to make BIM collaboration successful.

Research Question 2

How do professionals in Delta State currently perceive and apply BIM-based collaborative practices?

Table 2: Perceptions and Application of BIM-Based Collaborative Practices among Construction Professionals in Delta State

S/N	Statement	Mean (x)	Standard Deviation (S.D)	Agreement (%)	Remark
1.	I actively use BIM tools for collaborative project coordination.	4.40	0.65	88%	Agreed
2.	I perceive BIM as essential for improving teamwork and information sharing	4.55	0.52	91%	Strongly agreed
3.	I regularly participate in interdisciplinary BIM meetings and reviews	4.30	0.70	85%	Agreed
4.	I follow established BIM standards and protocols in my projects	4.35	0.60	87%	Agreed
5.	I apply BIM for problem-solving and conflict resolution in projects	4.28	0.68	86%	Agreed

Table 2 reveals that practitioners in Delta State tend to have a good opinion about the BIM-based collaborative practices and make use of them across all their projects. The mean scores are between 4.28 and 4.55 with standard deviations of 0.52 to 0.70 which demonstrates a very high level of agreement of the 200 respondents. The most rated statement is regarding the view of BIM as the key to teamwork and information sharing (mean = 4.55, 91% agree), and the lowest one is the usage of BIM in problem solving (mean = 4.28, 86% agree). Overall, the results indicate that practitioners perceive the collaborative benefits of BIM and somewhat use the practices in their day-to-day project work.

Research Question 3

What challenges hinder the development of BIM-related collaborative competencies among professionals in Delta State?

Table 3: Challenges Hindering the Development of BIM-Related Collaborative Competencies among Construction Professionals in Delta State

S/N	Statement	Mean (x)	Standard Deviation (S.D)	Agreement (%)	Remark
1.	Limited access to licensed BIM software and digital tools.	4.62	0.55	93%	Strongly agreed
2.	Inadequate training and professional development opportunities	4.58	0.60	92%	Strongly agreed
3.	Poor digital infrastructure and internet connectivity	4.50	0.68	89%	Agreed
4.	Low inter-organisational trust and collaboration culture	4.45	0.60	87%	Agreed
5.	Unclear professional roles and lack of standardised BIM protocols	4.48	0.62	90%	Agreed

Table 3 shows that the use of BIM to develop collaboration competencies among construction professionals in Delta State is impaired by various issues. The most agreed challenges were limited access to licensed software and insufficient training with a mean score of 4.62 and 4.58 and above 90 level of agreement respectively. Other major obstacles are poor digital infrastructure, lack of inter-organisational trust, ambiguous professional roles with mean scores of greater than 4.4 and agreement level that ranges between 89 and 90%. Altogether, the results indicate that the limitations of competency development are considerably predetermined by technical and organisational aspects, and the specific interventions include infrastructural, training, and teamwork-in-culture aspects.

DISCUSSION

The findings of this study present explicit information regarding the competencies that would be necessary in effective collaboration among professionals in construction based on BIM in Delta state. The responses of 200 practitioners have been analyzed to demonstrate that all three categories of competences, technical, managerial, and relational are critical to the successful implementation of BIM in a multidisciplinary project. The category of technical competencies were rated the highest, and more than 85 percent of the respondents rated the BIM software proficiency, clash detection and model coordination as very important or critical. These skills obtained the largest average scores of all the competency items, which is determined by the central place of digital capabilities in attaining correct modelling, reducing errors, and effective information exchange, which is similar to the findings of global studies (Andersson and Eidenskog, 2023). The managerial skills, such as timeline scheduling of project, the compliance with the requirements of BIM implementation, and the coordination of the workflow were also rated high, as about 72% of the respondents agreed that managerial skills have a direct impact on the team performance and data consistency. This supports the fact that BIM is both a process based approach and a technical tool that needs to be organised and aligned to the organisation. Teamwork, adaptability, and communication are the relational competencies that were highly agreed upon by more than three-quarters of professionals. The respondents emphasized that the key aspects of successful collaboration include mutual understanding, openness, and conflict-solving in disjointed project teams. This is in agreement with past studies that have highlighted the importance of interpersonal dynamics in BIM adoption (Mahbod, 2021). There were also significant obstacles to competency development that were identified through the study. Sixty-seven percent of the respondents reported an absence of access to licensed BIM software, and 61 percent reported that they did not have adequate training opportunities. The case of insufficient digital infrastructure specifically, namely, unreliable internet connectivity and insufficient access to high-performance computers required to perform BIM operations comes up noted by 55 percent of participants. In the meantime, the term low inter-organisational trust (reported by 48% of respondents) is the reluctance of firms to exchange models, data or responsibilities because of the fear of blame or loss of intellectual property or ambiguity of the contract. The supportive leadership, the creation of effective governance frameworks and formalised training systems were enablers of BIM competency

development that were supported by more than 70% of the respondents. The findings indicate that there is a definite necessity of systematic, situation-based, BIM competency model that resonates with the realities of the Delta State construction industry in technical, managerial, and relational aspects. This structure would inform focused training and facilitate standardised collaborative practice as well as encourage broader BIM usage-eventually enhancing operational efficiency, accuracy, and innovation of projects in the region.

CONCLUSION

This rstudy aimed at establishing a competency framework of BIM-based teamwork between the practitioners in the construction industry in Delta State. The results confirm that effective BIM implementation is based on technical, managerial, and relational competencies. The accurate and coordinated delivery of the projects is based on the technical skills, including the skills of the BIM software, the model coordination, and the clash detection. Managerial skills in terms of standards compliance, planning of the workflow, and on-time decision-making also contribute to interdisciplinary coordination, whereas relational skills in communication, collaboration, and flexibility promote trust and efficiency in collaboration. The paper also determined the major barriers such as limited access to digital tools, lack of training opportunities, poor digital infrastructure, low inter-organisational trust and ambiguous professional duties. On the other hand, structured training programmes, enabling leadership, professional networks, and effective governance processes were identified as some of the enabling factors. The study demonstrates that a context-specific competency framework should be applied in order to support the targeted development of the skills and to standardise the collaborative practices. This approach can offer an organised channel of enhancing BIM facility, interdisciplinary teamwork, and enhancing productivity, precision, and innovativeness in the construction industry of Delta State. The research has a theoretical and practical benefit since it explains the competencies needed in BIM-based collaboration and it fills an important knowledge gap in the local construction industry.

RECOMMENDATION

1. **Implement Structured Training Programs:** Organise regular workshops, seminars, and certification courses to enhance technical, managerial, and relational BIM competencies among construction professionals.

2. **Strengthen Digital Infrastructure:** Invest in reliable internet connectivity, licensed BIM software, and collaborative digital platforms to facilitate seamless project coordination.

3. **Develop Clear BIM Standards and Protocols:** Establish standard operating procedures, guidelines, and role definitions to ensure consistency and clarity in collaborative BIM practices.

4. **Promote Inter-Organisational Collaboration:** Encourage partnerships, mentorship programs, and professional networks to foster trust, knowledge sharing, and effective teamwork.

5. **Integrate Competency Assessment:** Introduce evaluation mechanisms to measure and monitor the development of BIM-related skills, ensuring continuous professional improvement.

6. **Encourage Organisational Support and Leadership:** Leadership should provide incentives, resources, and a supportive culture that motivates professionals to adopt and apply BIM collaboratively.

7. **Tailor Framework to Local Context:** Ensure the competency framework reflects Delta State's construction industry realities, including resource limitations, professional skill levels, and project practices.

8. **Raise Awareness on BIM Benefits:** Conduct awareness campaigns highlighting the advantages of BIM collaboration for project efficiency, accuracy, and innovation to increase adoption rates.

9. **Address Systemic Barriers:** Mitigate challenges such as limited training access, low trust levels, and unclear roles through policy interventions and industry-wide standards.

10. **Promote Lifelong Learning:** Encourage continuous skill enhancement to keep pace with evolving BIM technologies and collaborative methodologies in the construction industry.

REFERENCES

1. Abugu, C. (2025). Integrating Building Information Modelling (BIM) for effective construction planning, execution, and lifecycle management. International Journal of Research Publication and Reviews, 6(2), 4347–4364. 10.55248/gengpi.6.0125.0621.
2. Agwa, T., & Çelik, T. (2025). From barriers to breakthroughs: A deep dive into BIM integration challenges. Buildings, 15(7), 1116. 10.3390/buildings15071116.
3. Ahankoob, A., Abbasnejad, B., & Aranda-Mena, G. (2025). Building Information Modelling (BIM) Acceptance and Learning Experiences in Undergraduate Construction Education: A Technology Acceptance Model (TAM) Perspective—An Australian Case Study. Buildings, 15(11), 1804. https://doi.org/10.3390/buildings15111804
4. Bahrain, N., Sakrani, S. N. R., & Maidin, A. (2023). Communication barriers in the work environment: Understanding impact and challenges. International Journal of Academic Research in Business and Social Sciences, 13(11), 1–13. 10.6007/IJARBSS/v13-i11/19498.
5. Bamgbose, O. A., Ogunbayo, B. F., & Aigbavboa, C. O. (2024). Barriers to BIM adoption in SMEs: Perspectives from the Nigerian construction industry. Buildings, 14(2), 538. https://doi.org/10.3390/buildings14020538
6. Benayoune, A. (2024). Competency-based framework development and implementation: Current and future perspectives. Information Management and Business Review, 16(3), 606–615. 10.22610/imbr.v16i3(I).4013.
7. Chmeit, R., Lyu, J., & Pitt, M. (2024). Implementation challenges of Building Information Modelling (BIM) in SMEs participating in public projects in Qatar. Computer and Decision Making, 1, 252–279. 10.59543/comdem.v1i.11035.
8. Ham, N., & Yuh, O.-K. (2023). Performance analysis and assessment of BIM-based construction support with priority queuing policy. Buildings, 13(1), 153. 10.3390/buildings13010153.
9. Kim, K. P., Freda, R., & Whang, S.-W. (2025). Effective BIM Curriculum Development for Construction Management Program Transformation Through a Change Management Lens. Buildings, 15(15), 2775. https://doi.org/10.3390/buildings15152775
10. Lee, S., Chung, S., Kwon, S., Cho, C.-S., & Lee, K. (2021). Assessment of BIM Competencies and Correlation Analysis between Competencies and Career Characteristics of FAB Construction Project Participants. Applied Sciences, 11(18), 8468. https://doi.org/10.3390/app11188468
11. Manzoor, B., Charef, R., Antwi-Afari, M. F., Alotaibi, K. S., & Harirchian, E. (2025). Revolutionizing construction safety: Unveiling the digital potential of Building Information Modeling (BIM). Buildings, 15(5), 828. https://doi.org/10.3390/buildings15050828
12. Miao, C., Wang, H., Meng, X., Hou, X., Yan, Y., Liu, S., & He, Y. (2024). BIM-supported knowledge collaboration: A case study of a highway project in China. Sustainability, 16(20), 9074. https://doi.org/10.3390/su16209074
13. Mirhosseini, S. A., Kiani Mavi, R., Kiani Mavi, N., Abbasnejad, B., & Rayani, F. (2020). Interrelations among Leadership Competencies of BIM Leaders: A Fuzzy DEMATEL-ANP Approach. Sustainability, 12(18), 7830. https://doi.org/10.3390/su12187830
14. Okwose, I., et al. (2025). Application of Building Information Modelling (BIM) for enhancing safety and environmental performance on construction sites in Nigeria. World Journal of Civil Engineering and Architecture, 3, 11–26. 10.31586/wjcea.2025.6205.
15. Olanrewaju, O., Chileshe, N., Sunday, B., & Sandanayake, M. (2020). Investigating the barriers to BIM implementation in the Nigerian construction industry. Engineering, Construction and Architectural Management, 27(10), 2931–2958. 10.1108/ECAM-01-2020-0042.
16. Olaseni, I. (2019). Advancing building engineering through BIM-driven collaboration in complex infrastructure and high-rise construction projects. International Journal of Computer Applications Technology and Research, 8(12), 487–500. 10.7753/IJCATR0812.1007.

17. Oraee, M., Hosseini, M. R., Edwards, D., & Papadonikolaki, E. (2021). Collaboration in BIM-based construction networks: A qualitative model of influential factors. Engineering, Construction and Architectural Management (ahead of print). 10.1108/ECAM-10-2020-0865.
18. Oyedijo, A., Adams, K., & Koukpaki, S. (2021). Supply chain management systems in Africa: Insights from Nigeria. 10.1007/978-3-030-70538-1_8.
19. Semaan, J., Underwood, J., & Hyde, J. (2021). An Investigation of Work-Based Education and Training Needs for Effective BIM Adoption and Implementation: An Organisational Upskilling Model. Applied Sciences, 11(18), 8646. https://doi.org/10.3390/app11188646
20. Yi, B., & Nie, N. L. S. (2024). Effects of contractual and relational governance on project performance: The role of BIM application level. Buildings, 14(10), 3185. https://doi.org/10.3390/buildings14103185