CONSTRUCTION PROJECT MANAGEMENT

Assessing the Concept and Benefits of Building Information Modelling in Large-Scale Infrastructure Projects in Lagos State, Nigeria

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Abstract

Building Information Modelling (BIM) is becoming widely recognised as an information management approach that can improve coordination, visualisation and decision making. In large scale infrastructure projects the benefits of BIM are often highlighted due to the multi-disciplinary nature of the project, the complexity of interfaces and the large amount of information to be managed. This paper discusses the concept of BIM and associated benefits for large scale infrastructure projects. This was the first objective of a larger study looking at BIM implementation strategies within Nigeria. Data was gathered using a quantitative descriptive survey approach. A structured questionnaire was provided to construction professionals with a total of 100 valid responses. This data was analysed using weighted mean scores and ranking. The responses demonstrate that the top benefit identified was improved design coordination between project members (Mean=4.02), followed by improved visualisation prior to construction (Mean=3.91), improved design accuracy and reducing errors (Mean=3.90), improved decision making (Mean=3.83), improved communication with all stakeholders (Mean=3.77), increased productivity (Mean=3.70) and improved schedule (Mean=3.64). Some lower ranking benefits included reduced re-work (Mean=3.44), quality control (Mean=3.37) and reduced cost over-runs (Mean=3.32). All ten benefits were found to be above the decision point of 3.00, showing that overall construction professionals do see BIM as an important tool. The main benefits identified by respondents were those related to information quality and coordination. Cost and quality related benefits may however be dependent on how maturely BIM is implemented. To gain maximum benefit from BIM project teams should see it as a collaborative project management tool. This can be done by providing links between BIM information and planning, scheduling, costing and monitoring.

Keywords: BIM; infrastructure projects; construction project management; design coordination; project visualisation; Nigeria

1 Introduction

Large scale infrastructure projects are vital for economic growth, urban connectivity and providing essential services to the public. These typically require large amounts of funding, have long time scales and involve many different professionals and institutions. Due to the complexity of these projects having reliable information, good design coordination and control over the project scope, time, cost and quality is required. However, large scale construction projects often struggle with coordination issues, delays, re-work and cost pressures due to the disjointed information throughout the project (Flyvbjerg, 2017; Olatunji, 2022).

Traditional methods of construction documentation often involve multiple 2D drawings, schedules, specification and manual recording. This can cause issues for project members to understand the

design intent and project status. The lack of coordination in multi disciplinary projects can cause issues with design conflict in the later stages of the projects. Having a centralised information source is an important consideration when managing construction projects (Eastman et al., 2011; Azhar, 2011).

Building Information Modelling (BIM) is a method of generating, managing and sharing structured information about a built asset. BIM provides a way of working collaboratively using geometric and non-geometric information. BIM is not a simple 3D modelling tool but a process that includes people, technologies, information standards and coordinated processes (Succar, 2009; National Institute of Building Sciences, 2015). BIM can be used in many forms from basic 3D visualisation through to time based construction sequences, cost information and asset management.

The potential benefits of BIM are particularly important in large scale infrastructure projects. Large scale infrastructure projects often require design coordination between multiple different disciplines e.g. civil, structural, architectural, mechanical, electrical and specialists. BIM can help improve the visibility of interfaces between disciplines by providing a central information source. Previous research has shown that BIM can help improve project coordination, communication and outcomes (Bryde et al., 2013; Azhar, 2011).

However, the benefits of BIM rely on the project team using reliable information, agreeing responsibilities, ensuring quality models and integrating BIM into project management processes. In developing construction markets there may be a lack of BIM skills, varying levels of BIM readiness across organisations, high costs and lack of institutional support (Bamgbose et al., 2024; Kineber et al., 2023). Understanding how construction professionals view BIM in terms of concept and importance is important.

This paper looks at the first objective of the larger research and focuses on the ten BIM benefits identified in the questionnaire. This provides an insight into how important construction professionals see the different BIM benefits.

1.1 Research problem

Large scale infrastructure projects require timely, accurate and coordinated information. If the information is not centrally available in the form of drawings, it can cause confusion for stakeholders and cause misunderstanding of design requirements. This can lead to re-work, delays, inefficient use of resources and disputes. Whilst BIM is widely talked about as a way of improving information integration, the benefits may not be seen equally amongst construction professionals.

The construction industry in Nigeria still faces many challenges. Whilst BIM has been identified as a way of improving coordination, visualisation and project outcomes in existing literature, it is important to understand which benefits are seen as most important to practitioners. If organisations do not understand which areas of project management BIM will add value to they may invest in BIM without having a clear understanding. This paper looks at how BIM is seen in terms of concept and benefits for large scale infrastructure projects.

2 Conceptual and theoretical review

2.1 Concept of Building Information Modelling

Building Information Modelling is a process of generating and managing information about the physical and functional characteristics of an asset. This can include geometric information, properties of components, specifications and other structured information that will be needed by different project members. This provides a single source of information for the project to be developed and used during design, construction and running the asset (Eastman et al., 2011; National Institute of Building Sciences, 2015).

There is often confusion between BIM and traditional computer aided design. Traditional design drawings are used to convey design information. BIM brings together model elements with information. This enables changes to be made in a coordinated manner. BIM is a framework that includes technology, processes and policies (Succar, 2009).

BIM is often discussed in terms of dimensions. 3D BIM can be used for geometric modelling. 4D BIM can be used to relate model elements to construction times. 5D BIM can be used to relate model information to cost information. There can be further additions to look at sustainability and facilities or asset management. The terminology can vary depending on how it is used, however the core principle is that information is being integrated to help make decisions throughout the asset life cycle (Eastman et al., 2011; Azhar, 2011).

2.2 BIM and construction project management

Project management is the process of planning, coordinating, executing, monitoring and closing projects to meet requirements. Project managers must ensure all aspects of the project are coordinated. This includes scope, time, cost, quality, resources, risk and stakeholder expectations. In infrastructure projects this can be complex due to the size of the project, complexity of interfaces, geographical spread and number of organisations involved (Kerzner, 2022; PMI, 2021). Having reliable information is key to project management.

BIM can help project management by providing a central information source for design information, coordination and communication. During planning stages visualisation can help project members understand what the asset will look like and help to understand different design options. During design development BIM can help with identifying spatial and technical conflicts using federated models and clash detection. During construction BIM can help with sequencing, resource planning and cost control by using schedules and cost information. During asset running BIM can help with maintenance and facilities management by having structured information (Azhar, 2011; Bryde et al., 2013).

However, BIM will not just provide a model. It is important to define information requirements, agree responsibilities, ensure versions and interoperability. Stakeholders must be able to use the model output. ISO 19650 is an international standard that defines how information should be managed throughout the life cycle of built assets using BIM (ISO, 2018).

2.3 Benefits of BIM in infrastructure projects

Improved design coordination: Large infrastructure projects often involve many interfaces. BIM can help provide a coordinated information source for different disciplines. This can help identify any inconsistencies and improve communication of design intent. Identifying conflicts early can help

reduce the chance of issues being discovered during work. BIM can help improve communication, coordination and project outcomes (Bryde et al., 2013).

Improved project visualisation: Using 3D models can help stakeholders understand how the infrastructure will look, where it will go and the spatial relationships. This can help improve design reviews, client communication and can help explain complex technical proposals. BIM can help improve visualisation and communication which are key benefits (Azhar, 2011).

Improved design accuracy and fewer errors: Having a coordinated model can help identify any inconsistencies between design elements. Clash detection and reviewing using BIM can help identify potential conflicts earlier. This benefit depends on how complete, accurate and well-coordinated the model is (Eastman et al., 2011; Volk et al., 2014).

Improved decision-making during planning: BIM can help project teams understand the design options better. If the model information is linked to schedules and cost information then project managers can understand what resources are needed for different sequences. Ayman et al. (2022) show how integrated digital modelling and 4D BIM can be used as a decision-making tool.

Improved communication with stakeholders: Having a central information source can help ensure the information is consistent between architects, engineers, contractors, clients and other stakeholders. This can help provide a common source when reviewing designs. Having consistent information is key (Volk et al., 2014).

Improved productivity and schedule: Using BIM for planning can help teams understand how the work will flow, identify spatial issues and improve coordination. 4D BIM can help relate construction activities to model elements. This can help identify potential clashes with different work packages. This can help improve resource deployment and schedule management. However this will depend on the quality of the planning information and how BIM is implemented (Ayman et al., 2022; El Mounla et al., 2023).

Reduced re-work, quality and cost management: BIM can help reduce re-work by helping teams identify inconsistencies in design. It can help improve quality by linking model elements to specifications. 5D BIM can help improve estimating and budget reviews by linking quantities and cost information. However, the cost and quality benefits will depend on when information is available, procurement and how much BIM outputs are used by project teams (Bryde et al., 2013; Azhar, 2011).

2.4 Evidence from research

Overall, the literature supports the idea that BIM can help improve project coordination, communication, visualisation and information. Azhar (2011) looks at trends, benefits, risks and challenges of BIM in the architecture, engineering and construction industry. Bryde et al. (2013) looks at the benefits of BIM at project level. Eastman et al. (2011) gives a detailed overview of BIM concepts, tools and processes. This shows there is a strong concept behind BIM and the importance of benefits.

However, research has shown that BIM outcomes depend on the organisation and institution. Kineber et al. (2023) identify challenges with BIM. Bamgbose et al. (2024) discuss barriers to BIM in the Nigerian construction industry. This indicates that whilst BIM can provide value it depends on how well it can be implemented. This paper does not look at the barriers but uses the literature to understand why some benefits may be seen more immediately.

The focus of this objective is on how important the benefits are seen to be. The ten BIM benefit statements were included in the questionnaire. This was analysed using weighted mean scores and ranking.

3 Research methodology

3.1 Research design and population

The larger study used a quantitative approach and descriptive survey. The population targeted were construction professionals involved in delivering infrastructure projects. This would include architects, civil engineers, quantity surveyors, project managers and if available BIM specialists. The population would be professionals working in construction companies, consultancy organisations and government related infrastructure agencies.

3.2 Sample

A total of 115 questionnaires were issued and 100 were returned giving a response rate of 87.0%. The data collected came from the returned questionnaires. A structured questionnaire was used to gather opinions from the respondents. A five-point Likert scale was used to gather responses with weights. Strongly Agree had a weight of 5 and Strongly Disagree had a weight of 1.

Stratified random sampling was used and then simple random sampling within the strata. This ensured that there was representation from all different professional groups. The data used for this paper came from the 100 returned questionnaires.

3.3 Measurement

The Objective was measured by ten statements relating to the concept and importance of BIM in infrastructure projects. This was analysed using weighted mean scores and ranking. The equation used was:

$$\overline{X} = \frac{\sum fx}{N} \quad (1)$$

where f = frequency of responses, x = Likert scale weight and N = total number of respondents. The decision point used was 3.00 meaning if the mean score was above this it was seen as an agreement/importance. If the mean score was exactly 3.00 it was seen as neutral. If the mean score was below 3.00 it was seen as disagreement/not important.

Table 1 shows the mean scores and ranking for Objective 1. There is no information on the frequency of responses or standard deviation for each item. This information has therefore been repeated as presented. No inferential testing has been carried out for this objective.

4 Results and discussion

4.1 Response rate and profile

A total of 115 questionnaires were issued and 100 were completed. This gave a response rate of 87.0%. 15 questionnaires were not returned (13.0%). From the demographic information it can be seen that 71% of respondents were builders, 13% were architects, 8% civil/structural engineers and 8% were project managers. 60% had HND/B.Sc. qualifications and 40% had M.Sc. qualifications. Most

respondents had between 5-10 years of professional experience (60%). 49% of organisations were contracting firms. This shows that the responses came from construction professionals with relevant experience. However, a high proportion of the respondents were builders.

4.2 Perceived concept and benefits of BIM

Table 1 presents the ten benefits assessed under Objective 1, together with the weighted mean scores and rankings reported in the larger study.

Table 1. Mean scores and ranking of the concept and importance of BIM in infrastructure projects.

No.	Benefit statement	Mean	Rank
1	BIM improves design coordination among project participants	4.02	1
2	BIM enhances visualisation of infrastructure projects before construction	3.91	2
3	BIM improves design accuracy and reduces errors	3.90	3
4	BIM facilitates better decision-making during project planning	3.83	4
5	BIM improves stakeholder communication and collaboration	3.77	5
6	BIM reduces project cost overruns	3.32	10
7	BIM improves project schedule performance	3.64	7
8	BIM minimises rework during construction	3.44	8
9	BIM improves construction productivity	3.70	6
10	BIM improves quality control in infrastructure projects	3.37	9

Note: Research survey, as reported in the larger study (2026).

All ten mean scores exceeded the decision point of 3.00. This indicates that respondents generally considered each of the listed benefits important. However, the differences in mean scores reveal a clear hierarchy: coordination, visualisation, accuracy and planning-related decision-making received the strongest ratings, while cost-overrun reduction and quality control received comparatively lower ratings.

4.3 Design coordination as the highest-rated benefit

Improved design co-ordination (Score = 4.02) received the highest average score and was seen as the most important benefit. This is in line with the main purpose of BIM as an integrated information management process. Large scale infrastructure projects require multiple disciplines to be involved, so having a well coordinated set of models can create a central source of information. This allows issues to be identified, interfaces to be reviewed and conflicts resolved.

The high score suggests that BIM is seen as a tangible and visible benefit. Where multiple consultants and specialist teams will be developing design information, poor co-ordination can cause incompatibilities, design changes at late stages and queries at site. Using BIM can help by making relationships between model elements more visible and providing a controlled environment for multi-disciplinary review of the model (Eastman et al., 2011; Azhar, 2011).

This is also in line with the findings of Bryde et al (2013) who identified this as one of the benefits of BIM. From a project management perspective, co-ordination is an important factor to consider when developing procurement strategies, planning construction stages, allocating resources and managing

changes. Overall this shows that construction professionals see BIM as the most important benefit due to its ability to integrate information within the project.

4.4 Visualisation and improved design

Improved visualisation of the infrastructure project (Score = 3.91) received the second highest score. This highlights that BIM can be seen as a valuable tool to aid understanding of the project by having a 3D digital model. This can help with technical reviews, allowing all stakeholders to understand the design intention. It can also allow spatial limitations to be identified.

Improving design accuracy and reducing errors (Score = 3.90) received the third highest score. As the scores are very similar, this suggests that professionals see these as highly related. Having a clear model can help with reviewing designs and having a well coordinated model can help identify any discrepancies between disciplines. However, the accuracy of BIM is dependent on the accuracy of the data input, modelling standards, co-ordination and review. This is in line with the literature which has identified BIM as a process that requires reliable information and good collaboration (Eastman et al., 2011; Volk et al., 2014).

4.5 Better decision making and improved stakeholder interaction

Improved decision making (Score = 3.83) was seen as the fourth most important benefit. As project managers will need to plan the project, having information from BIM can help with this. Having a single source of information can help the project team understand the design options, identify limitations and communicate the implications. If model information can be linked to schedules and cost information then this may be used to help with scenarios (Ayman et al., 2022).

Improved collaboration and communication between stakeholders (Score = 3.77) was seen as the fifth most important benefit. This shows that BIM can be seen as a good collaboration tool. Infrastructure projects rely heavily on good information flow between all stakeholders. Having a single source of information can reduce fragmentation issues and provide more consistency in the information provided. Having consistent information and managing information throughout the project life cycle is important (Volk et al., 2014). ISO 19650 provides a structured approach to managing information (ISO, 2018).

The scores suggest that BIM is seen as more than just a design visualisation tool. Instead it is viewed as a way to manage information and interactions between stakeholders. This is important for project managers as the true value of using digital models cannot be realised unless they are being used to make decisions.

4.6 Increased productivity and improved project scheduling

Increased productivity during construction (Score = 3.70) and improved project scheduling (Score = 3.64) were seen as the sixth and seventh most important. Both of these scored above the decision score, showing that overall they are seen as important benefits of BIM. Having well coordinated models and visualisations can help with productivity. The uncertainties can be reduced, requirements can be clearly understood and teams can plan how to construct.

However, it was seen to be less important than design co-ordination and visualisation. This is because project scheduling depends on more than just the BIM model itself. Having accurate schedule information, up to date information, well co-ordinated information between contractors and good project controls can help. Whilst BIM can be used to help with these, it cannot directly help with

delays caused by other factors such as financial constraints, procurement issues, land access etc. Therefore this should be seen as a perceived benefit. (Ayman et al., 2022; El Mounla et al., 2023).

4.7 Reduced rework, improved quality and reduced cost overrun

Reducing rework during construction (Score = 3.44) was seen as the eighth most important benefit. Improving quality control (Score = 3.37) was seen as the ninth most important. Reducing cost overruns during the project (Score = 3.32) received the lowest score. All of these scored above the decision score and were seen as important. However the scores were lower than other benefits.

The low score for reducing cost overruns was interesting. Whilst BIM is often seen as improving quantity information, estimating costs and managing changes, there are many variables involved in how it relates to the final cost of the project. Changes to the scope, market conditions, contract management, procurement, inflation and project management can all have an impact. Respondents may realise the potential of BIM but may not be sure that it will prevent cost overruns. This is in line with the literature which has identified benefits of BIM but also highlighted the impact of how it is implemented. (Azhar, 2011; Bryde et al., 2013).

Reduced rework and improved quality control would require models to be consistently used, good communication on site and model information being used during inspections. If BIM is only being used during the design development then it may not have much impact on quality and rework on site. This could be why the scores are lower.

4.8 Interpretation

Overall there is a clear trend. The highest scores were for benefits related to improving the quality, co-ordination and communication of information. The lower scores were for benefits that are more directly linked to cost, rework and quality. This suggests that BIM is seen as a tool to improve information management aspects immediately. However respondents still recognised it as having the potential to impact the final performance of the project.

This should not be read as evidence that BIM does not reduce rework or cost overruns; the mean scores show only how important respondents perceived each benefit to be. The study did not look into whether cost savings were actually occurring, projects were being completed quicker, defects were fewer or productivity was increasing. There is a difference between perceived benefits, actual implementation and measurable outcomes.

The result is in line with BIM being seen as a socio-technical process. Many factors need to come together to realise the potential benefits (Succar, 2009). To realise the benefits of BIM project teams are more likely to use BIM if they know what information is required, the models are well co-ordinated, there are clear roles and the model information is being used in planning. The results give empirical evidence for why BIM is seen as a valuable tool by construction professionals. However, there is an indication that to realize the benefits further integration would need to occur.

5 Implications for construction project management

There are a few implications for construction project management:

1. **BIM should be implemented with the aim to improve co-ordination.** As design co-ordination received the highest average score, project managers should ensure that models are well

co-ordinated across multiple disciplines. This should include clear roles for the models, when to review and ensure that design interfaces are reviewed before packages are issued for construction.

2. **Models should be used for communication and decision making.** Project managers can use model reviews to communicate design intentions, spatial relationships and help stakeholders understand. This is important if the project involves public agencies, clients and technical stakeholders.

3. **BIM should be integrated into planning.** Positive scores were achieved for decision making, project scheduling and increased productivity. This shows that model information can be used outside of design. Project teams should aim to integrate BIM models with programme and cost information. This should be done depending on what information is available and how accurate it is. This can help improve the connection between design decisions and construction management.

4. **Project teams should not automatically assume that using BIM software will improve cost and quality.** Lower relative scores were achieved for reducing cost overruns, rework and quality control. This highlights that BIM should be integrated into monitoring, change management, inspections and cost control. Having clear roles and up to date information will help ensure that model information is useful.

5. **Clients and public sector procurement authorities can help with the value of BIM by specifying information requirements and encouraging information collaboration.** Using recognised information standards such as ISO 19650 can help with defining roles and managing information.

6 Conclusion and recommendations

6.1 Conclusion

This paper has looked at the concept and benefits of Building Information Modelling in large scale infrastructure projects. This was part one of a larger study looking into BIM implementation strategies. The results show that generally construction professionals see the identified benefits of BIM as important. All ten questions had an average score above the decision score of 3.00.

Improved design co-ordination (Score = 4.02) was seen as the most important benefit. This was followed by improved visualisation, improved design accuracy and reduced errors, improved decision making and improved stakeholder interaction. Construction productivity and project scheduling had positive scores. Reducing rework, improving quality and reducing cost overrun had lower scores but were still above the decision score.

Overall this shows that BIM is seen as a way to improve co-ordination and information management. Whilst it is seen as important to improve cost, quality and construction outcomes, it may depend on how much model information is integrated into planning, implementation and control. This study has reinforced the need to see BIM as a collaborative project management process rather than just a software tool for creating 3D models.

6.2 Recommendations

1. Construction organisations should prioritise multidisciplinary design coordination when adopting BIM, including clear model responsibilities, coordination reviews and agreed information-exchange procedures.

2. Project managers should make structured use of BIM visualisation during feasibility, design review and stakeholder consultation to improve understanding of project requirements and design decisions.
3. BIM should be progressively integrated with project planning, scheduling and cost-management processes so that model information supports decisions throughout the project lifecycle.
4. Project teams should extend BIM use beyond design development by incorporating model information into construction monitoring, quality assurance, inspection and change-control processes.
5. Clients and public-sector procuring authorities should define project information requirements and encourage consistent information-management practices, drawing on relevant standards such as ISO 19650.
6. Organisations should evaluate BIM benefits using project-level performance indicators, including coordination issues, design changes, rework, schedule performance, cost variance and quality outcomes. This would help distinguish perceived benefits from measured project results.

6.3 Limitations and further research

This paper is based on the first research objective and the descriptive results reported in the larger study. The weighted mean and ranking data for this objective are shown in Table 1. However, the response frequencies and standard deviations were not calculated and therefore cannot be reproduced. This research was focused on perception of professionals. The respondents were also weighted towards builders.

Further research could be carried out to identify differences in perception between different professions, whether having BIM experience affects how the benefits are rated and if there is a relationship between BIM usage and objective outcomes. Case studies could be carried out on large infrastructure projects to show how coordination, visualisation and modelling are being used to create measurable improvements to rework, scheduling, cost and quality.

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