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BUILDING COLLABORATION AMONG CONSTRUCTION PROFESSIONALS ON BUILDING INFORMATION MODELLING (BIM) IMPLEMENTATION IN ABUJA, NIGERIA

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ABSTRACT

BIM (Building Information Modelling) is one of the most important technical developments in the building design and construction industry to date. BIM adoption has risen dramatically over the last decade, as project participants recognize that awareness and information sharing is one of the most important aspects of a successful contractual partnership among stakeholders in the construction industry, due to a lack of collaboration among the parties, the project was delayed, materials were wasted, rework was done, and the work was of poor quality. This research aims to create a guiding principle for active participation among professionals in order to improve BIM implementation proficiency. A total of 115 questionnaires were distributed to Architects, Quantity surveyors, Structural engineers, and Builders. Eighty-five (85) questionnaires were returned and analyzed, accounting for 73.9 percent of the total. The data obtained was analyzed using descriptive analysis (chart, table, relative important index and mean item score). The study resulted in a "reduction and avoidance of project failure, as well as team building," according to the researchers, who went on to discuss the advantages and drawbacks of building. Finally, the factors that enhance BIM cooperation and how stakeholder success can be assessed were investigated, who went on to discuss the advantages and drawbacks of building. Finally, the factors that enhance BIM cooperation and how stakeholder success can be assessed were investigated finally, the factors that enhance BIM cooperation and how stakeholder success can be assessed were investigated, with the conclusion that professional engagement can minimize project delays and improve project delivery time and quality. If efficiency, project completion on time, quality, and cost remain the organization's priorities for successful and productive *productivity, it was recommended that deliberate technique be instituted during the construction process to effectively develop and assess the binding relationship and performance among all parties in the construction sector.*

Keywords; *Collaboration; Stakeholders; BIM Implementation; Construction stage*

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INTRODUCTION

Companies, joint ventures, public and private enterprises, and tactical deals are all becoming more relevant in the construction industry (Akintoye and Main, 2007). According to the study by AbdullRahaman *et al.*, (2013), in the early 1990s, the assertion for cooperation between businesses in the construction industry was very strong, The call for cooperation has shifted from profit motives to increased competition, increased demand for innovation and technological growth, and increased demand for industry internationalization (Akintoye and Main, 2007).International demand, rivalry, risk, and uncertainty within the business setting are all factors that induce collaboration around the world, according to AbdullRahaman *et al.*, (2013), while the construction industry is realizing the need to collaborate in order to subsist (Bocerik-Gerber *et al.*, 2010).

Building information modelling (BIM) is a strong collaborative environment that has been attracting the responsiveness of Architectural Engineers and Construction (AEC) Industry. Building design and construction industry (BDCI) is one of the industry's most talented technological innovations (BDCI) (Himmati, 2017). The evolution of ArchiCAD software was regarded as the true foundation of BIM, and the use of Revit software saw a move toward BIM implementation (Hartmann, 2012). After a comprehensive literature analysis, BIM has a variety of ability to assist operatives, organization and cooperation of various disciplines in "Architects, Engineers, Contractors, Sub-contractors, Facility Management" (Conway, 2010).

BIM is a 3D-object data base that can be easily visualized and contains rich and organized information which can also be applied to building results, sustainability, schedule, and costing analyses (Edirisinghe, 2015). However, BIM was originally applied to the construction stage of building projects, but it has since expanded to include the service and maintenance phases, as well as mega infrastructures. It has developed a range of marching technologies, as well as a method for representing buildings and infrastructures over their entire life cycle (Ahn and Kim, 2016). This research aims to find out how BIM technology-assisted collaboration improves the activities of construction projects.

BIM has reinvented the construction industry over the past two decades, BIM has progressed from 3 dimensioning to 4 dimensioning, 5 dimensioning and even n dimensioning modelling programme, linked to the building process and integrating cost data. It is generally assumed that the model play an important part in incorporating the different stages in the entire construction project lifecycle (Tabassi *et al*., 2012).

Over the last two decades, BIM has reinvented the construction industry. Building design and construction industry (BDCI) is one of the industry's most talented technological innovations (BDCI) (Hinmati, 2017). Nonetheless, proper research on BIM adoption and implementation in the construction stage in terms of benefits and barriers has been completed (Hinmati, 2017). As a result, it is thought worthwhile to investigate the social aspects of management and organization, as they seem to be understudied in comparison to the technical aspects and processes that can play a key role in BIM implementation (Hardin, 2009). As a result, the emphasis of this study will be on improving cooperation among organization participants and how the organization's philosophy evolves in response to the trend shift to BIM implementation in the building stage of construction projects.

CONSTRUCTION PROJECT

Agreeing to the National Centre for Construction Education and Research (NCCER), project development in the construction industry is separated into three steps: pre-construction step, construction step, and post-construction step (Davis and Soger, 2008). These three steps are referred to as a Project Life Cycle, and they include a variety of tasks and participants. Construction projects are fraught with issues; incorporating BIM will help the construction industry evolve by promoting modern construction, increasing efficiency, and adding value to a variety of stakeholders (Rogers et al., 2015). The enormous quantities of information and digital technology needed to realize the significant benefits from data and numerical technology are parts of the building aspects required

(Davies and Harty, 2013). Issues such as organizational, legal, and economic problems have decelerated the design and development stages of projects. Though, studies have shown that buildings can be built more speedily and efficiently through computerised gathering and enhanced processes which significantly reduce construction accident and dispute and improve construction efficiency (Lee *et al.,* 2012). Bringing the right knowledge to the right location is one of the problems of organizational fragmentation in building projects (Davies and Harty, 2013).

Over the last two decades, BIM has revolutionized the building industry. From 3D modelling to 4D programming linked to the construction process, 5D modelling with cost data, and even nD modelling, the idea of BIM has evolved. BIM is commonly thought to play an important role in incorporating the different phases of growth across a construction project's entire lifecycle (Ahn and Kim, 2016). As a result of introducing and integrating emerging technologies such as BIM into building projects, benefits such as lower business costs and reduced errors can be realized (Cabinet Office, 2011).

Construction projects are fraught with challenges. Implementing BIM will help the construction industry grow by allowing for more modern construction, growing efficiency, and adding value across multiple departments (Rogers *et al*., 2015). Massive quantities of data are one of the construction features that are desirable to realize the major benefits from information and numerical technology (Davies and Harty, 2013).

MEASURE OF COLLABORATION IN CONSTRUCTION PROJECTS

Collaboration is needed in BIM. Various parties share their expertise and skills in a single model. BIM promotes streamlined project execution by providing a platform and tools for collaborative design and project management (Hinmati, 2017). To ensure coordination, mechanisms for cooperation must be in place. For construction management, a number of key performance indicators (KPIs) have been developed. Team performance, coordination, stakeholder management, and human resource management are among them, as are price, time, and productivity (Ku, 2013). Ku (2013) outlined the behaviors that can contribute to good teamwork. Just a few examples include: ingenuity, productivity, co-location, commitment, multidisciplinary work, decision authority, supportive environment, planning, openness, consensus leader selection, aligned people and organization, and aligned process and practices. Hamid and Pardis (2014) developed a framework for determining teamwork that takes into account personal and team attributes, as well as planning, human-human interactions, human–computer interactions, communication networks, and team members' physical locations.

When assessing collaboration, take into account the effect of BIM on construction performance. "Based on a case study, Kassim *et al*. (2015) identified some KPIs focused on the business impact of BIM, such as speed of development, improvement in skills and knowledge, cost reduction, travel, printing, document shipping, and better architecture and deliverables."

The effects of BIM on the construction life cycle in Nigeria, according to the researcher, should be investigated. The impact on production speed, performance, time and completion, change reduction, and cost reduction are just a few of them.

BIM IMPLEMENTATION AND ITS BENEFITS

In the construction sector, BIM assists in the preservation of graphical features and delivers a data processing situation (Lee *et al.*, 2013). Both quantity and consistency elements are linked to the BIM. For instance, BIM has inclined quantity aspects such as schedule, cost and material inventory, all of which add to speedy decision-making, while quality aspects involve evaluating data. For example, all UK government contracts awarded since 2014 onwards necessitate the input of complete collaborative 3D model into construction projects, according to a report (Cabinet Office, 2011). The use of BIM in project management can be useful because it reduces the time it takes to complete documentation tasks and increases communication between participants (Bryde *et al.*, 2013).

The ability of BIM to simplify knowledge sharing and contribute to reuse of this information over the project life is one of the main drivers of its growing popularity among industries (Lee *et al.*, 2013). Building knowledge modelling can help the construction industry become more efficient by improving teamwork among project participants, reducing disputes, and reducing the amount of time spent on variation and correction (Migilinskas *et al.*, 2013). While BIM has many benefits for large-scale projects like the London 2012 Olympic Stadium, it can also be used for individual components of a smaller job (Bryde *et al.*, 2013). Furthermore, big and medium sized companies should acclimatize to and use automated construction procedures (ACP) as a result of the increased use of BIM to solve various tasks (Migilinskas *et al.*, 2013).

Agreeing to the study by Hooper (2015), project managers can benefit from using BIM as a management tool in organizing schedules and budgets, coordinating with design teams and subcontractors, and increasing owner satisfaction, all of which are linked to BIM tool. A review of previous studies of BIM-enabled building works indicates that the greatest affirmative effects of BIM depend on cost and time, communication, teamwork, and proficiency (Brydee and colleagues, 2013). By incorporating computer modelling and object simulation technology into developed processes, BIM typically leads to better strategies and techniques for building project design, construction, and facility management (Migilinskas *et al.*, 2013). This development opens up the possibility of securing the integrated management of the design and data operation through the concept and implementation of integrated software. BIM implementation aids in integrating individual tasks into teams and individual assignments into processes through distributing tools. It also allows for the management of building life-cycle operations quickly and efficiently (Hooper, 2015).

Table 2.1 Benefits of BIM implementation

Benefit of BIM implementation	Authors
Design Stage	
Creates schematic detailed design	
Refining the demonstration of project to clients for	Azhar,*et al*, (2009), Hardin,(2009)
Easy judgement making	Barlish and Sullivan, (2012)
Perfect considerate nature and scope of effort to be done.	
Specifics analysis of energy , efficiency, cost estimates,	
Sustainability schedule and budget information of the structure.	
Construction Stage	
Schedule and work flow management	Azhar, *et al*, (2012)

Cost estimates, virtual construction logistics of materials on site. The target and scheduling of building scheme Scheduling of construction task Clash detection and reporting Better quality of projects.	Barlish,(2012)
Post construction stage Long range and annual facility planning Facility financial forecasting Work specification installation and space management. Real estate acquisition and disposal Architectural and engineering planning and design New construction and renovation Maintenance and operational management Telecommunication, integration, security and general administrative services	Roger *et al,* (2015) Ahn and Kim, (2016)

Source; field survey 2019

MEASURES OF BIM COLLABORATION IN AEC PROJECTS

Collaboration in BIM is a requirement. Different parties share their knowledge and expertise in a single model. BIM supports integrated project delivery by providing platform and tools for collaborative design and project management (Hamid and Pardis, 2014). For collaboration to be monitored there must be measures for collaboration. In construction management, several key performance indicators (KPI's) have been identified. These include cost, time, and quality, team performance, communication, stake-holder and human resource management. Brewer and Mendelson (2013) identified traits in an effective team that can result in collaboration. These include creativity, productivity, co-location, commitment, multidisciplinary work, decision authority, productive environment, training, accountability, consensus leader selection, aligned people and organization, aligned process and practices. Hamid and Pardis (2014) developed a collaboration assessment tool to monitor collaboration. Factors to be considered in their assessment tool include personal and team characteristics, training, human-human interactions, human–computer interactions, communication channels and physical location of team members.

To measure collaboration in BIM, its effect on productivity in the construction industry must be considered. "Coates *et al.* (2010), developed some KPIs from a case study, focusing on the business impact of BIM, including speed of development, improvement in skills and knowledge, reduction of costs, travel, printing, document shipping, and better architecture and deliverables."

To determine challenges to lack of collaboration amongst professionals and disciplines within the construction industry, measures of collaboration in BIM need to be developed. Measurement of collaboration in BIM will include: personal and team characteristics, human interactions within the BIM model, channels of communication for team members as well as physical locations of team members. We will also examine the impact of BIM in construction life-cycle in Nigeria. These include the impact on the speed of development, quality, time and completion, reduction in changes and reduction in cost

METHODOLOGY

The best suitable methodology for this study was a questionnaire survey which was conducted among professionals in the construction industry. The research was designed focusing mainly on architects, quantity surveyors, Engineers and builders, whom were tagged "stakeholders" in the construction industry within Abuja Nigeria. The stratified sampling technique was adopted in the probability sampling in order to give chances to professionals in the construction industry to participate in the survey. Analysis of data was done using descriptive statistical method; this was carried out to reveal the attributes of the respondents. The summary of factors resulting from collaboration in BIM implementation, and the key performance indicators of collaboration were analysed and ranked using RII, and statistics mean scores formula to determine the significant importance of each variable; in other to make generalization to the entire population of which the samples were drawn.

RESULTS AND DISCUSSION

The Success Factors of Collaboration

It has been considered previously that in order to be significant, a factor should have RII value as 0.8 or above and the weighted statistical mean (average) should score 4.0 or above. The results of the statistical mean score of each factor have been examined for their distribution using the frequencies command on SPSS. The results showed that all factors mean scores has acceptable significant normal distribution. This distribution check strengthened the ranking of significant factors.

After conducting the RII analysis for the responses as seen in Table 4.1, the most significant factor of collaboration is the avoidance of project failure with (RII= 0.939 and mean=4.694) which is also ranked 1st in the overall factor ranking. This result is similar to the study conducted by (Gerard, 2016 and Himmati, 2017).

The 2nd ranked factor is “Encourages team building” with relative important index of (RII=0.929 and mean=4.647). The 3rd and 4rd significant factor enhancing collaboration is “with (RII=0.922 and mean=4.612) and (RII=0.918 and mean=4.588) respectively. Furthermore, the average relative important index has scored a value of RII=0.824 and mean=4.118 making this factors a significant tool of collaboration in BIM implementation.

Table 4.1 **Success Factors of Collaboration.**

Factors of collaboration	Weighted Sum	RII	Mean Ranking	Score
Encouraging team building.				
Information Sharing.	395	0.29	4.647	2nd
Improved quality of Service.	375	0.882	4.412	7th
Facilitate communication among Project members.	376	0.885	4.424	6th
Project completion within time.				
Profitable to organization.				
Friendship and trust.				
Avoidance of project failure.	370	0.871	4.352	8th
Sustainable on large project.				
Reduces bureaucracy.	365	0.59	4.294	10th
Cost reduction in construction.				
Risk management.	390	0.918	4.588	4th
Legal risk liability.	360	0.847	4.235	11th
	399	0.939	4.694	1st
	392	0.922	4.612	3rd
	350	0.824	4.118	13th
	377	0.887	4.435	5th
	369	0.868	4.342	9th
	358	0.842	4.212	12th

Source; Field Survey, 2019

THE KEY PERFORMANCE INDICATORS OF COLLABORATION

Table 4.2 present the key performance indicators (KPIs) showing their level of significant importance as a tool for measuring collaboration in BIM based construction environment. After conducting the analysis, Reduction in changes, alteration or rework was ranked 1st with (RII=0.988 and mean score=4.941), the result was also similar with work of (Miettinen and Paavol, 2014; Olatunji, 2011). The 2nd ranking is document shipping, with (RII=0.935 and Mean score=4.765). However Communication and team performance was ranked 3rd and 4th with the (RII=0.941and Mean score=4.706), and (RII=0.939 and Mean score=4.694) respectively.

However the average relative important index has scored (0.788) and statistical mean score of (3.941), meaning that the speed of development of construction activities in collaboration falls below the level of significant as such it may not have the relative significance in measuring collaboration in the BIM implementation at the construction phase of AEC projects.

Figure 4.2: The Key Performance Indicators of Collaboration

Key Performance Indicators	Weighted Sum	RII	Mean Score	Ranking
Cost, Time & Quality.	373	0.878	4.388	9th
Team performance	399	0.939	4.694	4th
Communication	400	0.941	4.706	3rd
Human Resource Management	375	0.882	4.412	8th
Productivity	385	0.906	4.529	7th
Speed of Development	335	0.788	3.941	10th
Improvement in Skills and Knowledge	395	0.929	4.647	5th
Better Architectures and Deliverables	393	0.925	4.624	6th
Document Shipping	405	0.953	4.765	2nd
Reduction in Changes/Alterations/Rework	420	0.988	4.941	1st

Source; field survey 2019

CONCLUSION

Architects, Quantity Surveyors, Builders, and Structural Engineers are constantly faced with the question of how to promote high technical performance and better collaboration among Architects, Quantity Surveyors, Builders, and Structural Engineers during the implementation of BIM. A layer of uncertainty is added by the fact that, according to this article, the everyday realities of handling construction activities provide the ability to “reduce and prevent project failure, promote team building and engagement, and maximize gains and sustainability on large projects and organizations.” This is especially important during the construction phase of a project to ensure timely completion. As a result, the study's most encouraging finding highlighted the main performance indicator that has a direct relationship with factors unique to achieving good project outcomes through collaborative networks at the construction level, namely "reduction in job changes or alterations during construction, document shipping, team performance, good communication, and productivity". The study discovered that coordination between architects, quantity surveyors, designers, and structural engineers can be strengthened during the implementation of BIM technology during the construction stage of projects to increase project performance and productivity.

RECOMMENDATION

The changing construction industry has shifted its activities to increase efficiency, effectiveness, productivity, and project quality while lowering project costs and timelines, as stated at the outset of this study. Furthermore, the scope of today's building projects necessitates the participation of many specialists at different stages of the project, and this breadth of knowledge is critical for active participation. However, a deliberate technique should be introduced in order to efficiently increase the mandatory collaboration among all professionals in the construction industry.

The following are some of the most important factors to consider in order to improve collaboration among professionals in the construction industry: ‘the management to integrate motivational derivation and help to create an enabling environment for collaboration, transforming management and organization's mind set to accept the new trend of BIM collaboration, prompt updates of resources and software for ease of work, and to encourage cross-sectional information flow to identify and report any clashes.

Finally, an assessment and measurement section should be established, with experts from various disciplines tasked with evaluating professionals' performance in collaborative construction project activities.

Since a lack of technical experts is one of the challenges of BIM collaboration, our universities and other higher learning institutions should introduce BIM technology subjects and courses as soon as possible in order to educate the younger generation on the concept of BIM and enhance collaboration through skills and expertise.

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