EFFECT OF BUILDING INFORMATION MODELING (BIM) INNOVATION ON QUANTITY SURVEYING

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Abstract
Quantity surveyors (QS) have various roles in the construction industry. One of their main roles is preparing bills of quantities that mainly entails taking measurements and pricing of construction work. They also develop schedule of project work, engage in construction project management, arbitration and dispute resolutions. Quantity take-off was their original role during 1820s when the profession was conceived. Critical observations brought criticisms alluding to the inability of the profession to survive if a tool could be developed that substituted QS roles in construction. Contingent to that criticism has seen the emergence of Building Information Modeling (BIM) that has specific attributes where the BIM technology can be used to quantity building works and produce schedule of works in 5D model interface. Thus far, has the BIM technological innovation posed threats to the QS roles and/or to the profession? The aim of this research was to investigate the effect of BIM innovation in the construction industry and to evaluate its effect on the quantity surveying profession. Is it a bane or boon to the QS profession? Specific objectives were to determine the extent of BIM usage by QS, the magnitude of relationship between the current BIM usage and the future of QS considering BIM growth in the construction field. Strength, Weakness, Opportunity and Threat (SWOT) analysis was conducted about BIM usage. Survey questionnaire was administered to investigate the effect of BIM, current usage and future standing in construction. The results showed that BIM was an opportunity that added to the progress of QS. It was concluded that QS needed to embrace BIM technology more with integration of digital twins for full benefit in the construction industry.

Keywords: building information modeling (BIM), construction industry, estimating, project management, quantity surveying.

1. Introduction

The profession of quantity surveying is important in the construction industry as it is involved in project cost estimates, cost control and overall project management. Quantity surveyor (QS) is the construction professional charged with these roles in the construction industry and they are from design phase, construction to maintenance and operation phase of a project; even to the demolition or deconstruction stage in the life cycle of a project. In some cases, they can be owner’s representative in projects. Alhasan et al. (2019) stated that the quantity surveyor is one who on behalf of the employer is professionally trained, qualified and experienced in dealing with issues of construction costs, construction management and communication issues. The QS has different names in different regions globally. They are called cost engineers in the USA, building economists in some parts of Africa, Asia and UK, and their roles in projects have been developing over the years (Wao and Flood, 2016).

QS is found to have evolved overtime since its inception in 1820s where their main roles were taking measurements of work (Wao, 2015). This used to be manual and relied on 2D drawings to calculate quantities of work and to prepare bills of quantities (BOQ) as part of contract documents. At some point in the continuum, it was thought that any tool that would arise to better calculate and measure work would be a threat to the QS profession and render it obsolete in the construction industry (Wao, 2015).

With the increasing demands of project owners and position in the construction industry, QS has taken many roles such as cost planning, measurement and quantifying construction work, cost control throughout the project life cycle, financial advice and management, offering procurement advice to clients, etc., (Gilchrist et al., 2021). As noted by Fung et al. (2014), these services can be tedious,
erroneous and inefficient especially if they involve a lot of information especially in large projects. Thus, QS had to find ways to keep up with the developments and maintain relevance in the industry.

The information technology (IT) and effective communication have provided opportunities for the QS. Their role of representing project owners and also acting as point of contact in projects as well as managing critical areas of project required them to improve. Areas such as Value Engineering (VE), Lean Management, Sustainable Construction, Building Information Modelling (BIM), Internet of Things (IoT), Digital Twins (DT), Artificial Intelligence (AI) and ChatGPT have been prevalent lately in various fields. These new areas have potential applications in the construction industry and QS can possibly use them as opportunities to improve and in marketing themselves. For example, research on BIM has shown that BIM has presented challenges and opportunities for the QS especially in the design stage of construction (Gilchrist 2021). Also, research showed that BIM is not a threat but rather an opportunity for QS to provide better value services and improved efficiency to project owners (Smith, 2014).

In spite of the viewpoints in favour of BIM use in construction, the implementation has been slow with some QS preferring to work with traditional methods to execute project work. Some have not embraced BIM as high cost of its implementation is hindering them from using it (Gilchrist et al., 2021).

Therefore, this research investigated the effect of BIM innovation in the current construction industry and to find if its effect was a bane or boon to the QS. There is research in this area but the IT area is ever fast changing and this can significantly affect the field in less time, and so this research informed prior research by assessing the QS field taking into consideration the current IT uses mainly BIM and DT. Literature review section assessed the QS profession in relation to integrating BIM and DT.

2. Literature review

2.1. Quantity surveyor in construction project

Quantity surveyor has key role of project execution in the construction industry. They oversee every aspect of the project right from preconstruction, construction to closeout, and also during operation, maintenance to deconstruction. The duties include quantity take-off, preparing bills of materials, scheduling of work, dispute resolution, project waste management, preparing bidding or tender documents as well as client/owner’s representative in projects (Wao and Flood, 2016). The profession is popular in the UK, Africa, Asia and Australia where they have more responsibilities in projects beyond cost estimating as in the USA where they may be referred to as cost engineers, project estimators, cost manager or construction project accountant. Noteworthy, the Royal Institution of Chartered Surveyors (RICS) has popularized the QS profession with its chapters in the international arena through professional certifications and memberships (Wao and Flood, 2016; RICS, 2023).

The QS has had various challenges in providing their duties. These may include; other construction professionals competing with them for jobs in terms of services offered and fees, project owners increasing demands mounting pressure on them, perception that QS lack awareness for project value addition, and the current trends in construction such as sustainable construction and rapid technological advances which threaten to reduce QS roles (Gilchrist et al, 2021). Research on the challenges and avenues for QS to improve on project deliveries to remain relevant has shown that BIM is top in the opportunities (Alhasan, 2019; Wao, 2015). Professional organizations such as RICS have put competency requirements to improve on the value addition of QS in projects. RICS (2023) provide basic competencies which QS must meet such as having good understanding of professional practice and procedure, information and business skills, measurements and law. Core competencies such as quantifying and costing of building works by preparing BOQ, contracting and construction economics and preparing financial accounts for better project budget, are competences specific to improving QS. Optional competencies such as VE, risk management, BIM, research methods, arbitration and dispute resolution are areas of specialty and provide avenues for future career development and opportunities.

The influx of IT in construction has seen BIM as an area for continuous professional development (CPD) for QS. This has provided opportunities and strength in their value addition services (Wao, 2015).
2.2. Quantity surveying and building information modeling (BIM)

QS provides information about the project whether on procurement, cost, time, safety, or sustainability. These require providing information quickly for project success. This success depends on the QS in meeting the project goals efficiently. As noted by Alhasan (2019), the success criteria could be linked to time, cost, or quality which are key parameters for measuring project success over its life cycle.

The use of BIM by QS has been investigated as potential avenue to improve the productivity and efficiency of service delivery of QS. Wao (2015) study on predicting the future of QS in the construction industry noted that BIM had potential for being used largely by QS.

BIM is a collaborating process among construction teams where they exchange digital data of a project. That is, BIM is a technology and a set of processes to create, communicate and analyse building models in a way that is replicating what is to be constructed (Eastman et al., 2012). Those involved could be QS, engineers, architects, contractors, project owner, etc. BIM provides them with 3D modelling of the project and they could input cost in the model, hence called 4D, which is a cost loaded BIM 3D model. When time component is added, hence schedule, it becomes BIM 5D. Others from 6D to 9D could incorporate sustainability, facility management, lean management (for waste management), and safety. These can be integrated in 3D BIM. BIM can therefore greatly improve project quality by providing an overview of a project in a way that project data interchange is effectively communicated among teams.

With the IT BIM skills, the QS skills is expected to be improved in areas such as cost estimation, team communication, project management, etc. In this case, BIM usage by QS has been investigated especially in areas of estimation, quantity take off and planning where it has been stated that it can be a good value addition to provide accurate cost information through application of most effective quantity take off tools over the life cycle of a project (Alhasan et al., 2019). Even though this is an opportunity, BIM presents challenges especially early in the design stage. It has been noted that many QS are still behind in understanding BIM usage in projects and they are encouraged to embrace the technology if they want to reap the benefits. As noted by Alhasan et al. (2019), it is important that the project designs be detailed to replicate the actual project. It is obvious that BIM would not get accepted if the designers do not provide detailed digital information that is useful to the team over the project life cycle. As noted by Fung et al. (2014), there are several benefits of using BIM from preconstruction to post-construction during operation and maintenance periods, and these include speedy preparation of cost information at conceptual stage, providing initial cost data by extracting quantities from BIM models, generating cost information for different design alternatives, reducing design errors and cost revisions through clash detections, better 3D project visualization for improved design understanding, removing manual measurements and quantity take-offs, acting as project information management ,etc. These benefits can be avenues to market the QS with other professionals who maybe in competition with them (Wao and Flood, 2016). Noteworthy, BIM is a multi-dimensional construction tool that is promising to the QS since it can provide value addition to project owners. This promise is still farfetched because of lack of skilled personnel that understand BIM workflow, high cost of implementing BIM considering the high cost of hardware/software and related training and most importantly, lack of higher management or leadership support who are usually reluctant to embrace the technology (Gilchrist et al., 2021).

2.3. Building information modeling (BIM) and digital twins (DT)

Another area of IT that has been on the rise recently is the Digital Twins (DT) technology. BIM has been playing a key role in the design and construction stage of projects while DT which can be applied in the operation and maintenance phase of a project has the potential to shape a DT-enhanced BIM framework to fully enable whole life cycle digital/virtual construction (Honghong et al., 2023).

Digital twins refer to replication or digital mirror of the actual project which can mimic all aspects of the physical processes under the integration of the physical project details, virtual details as well as connection data between the physical and virtual project (Pan and Zhang, 2021). As stated by Pan and Zhang (2021), DT can combine BIM, Internet of Things (IoT) and data mining techniques whereby IoT
connects the physical world and the internet/cyber world to capture real time data or information for building modelling and related analysis, and data mining methods incorporated in virtual building model is focused on discovering hidden knowledge in the collected data or information. This process can be done in the whole building life cycle, and so BIM based digital twins is a possible inclusion in the operation and maintenance of the construction world because it would be useful to see how the building operates in a virtual world and the construction team is able to identify errors and correct them before damages occur. This is why DT (initially proposed in 2003) was used by National Aeronautics and Space Administration (NASA) to simulate, forecast and evaluate spacecraft state with the aim of stopping potential dilapidation or failure of aircrafts. Just like lean management, VE and sustainable development, the concept of digital twins can be integrated in the construction industry to improve processes.

Pan and Zhang (2021) researched about building a data driven DT framework with BIM for advanced project management. Honghong et al. (2023) discovered that the adoption of DT in bridge engineering caused confusion which hindered the DT fusion to achieve its full capability and so their study focused on a DT enhanced BIM framework to shape full life cycle digital transformation for bridge engineering. And there could be other various ways by which BIM can be integrated with IoT and Artificial intelligence (AI); even with the current ChatGPT based on bot. Noteworthy, these studies show the value in integrated BIM-DT in projects but there is still lack of relationship between them. BIM has operational standards but not DT. This is an area for QS to venture into for full use of BIM-DT enhanced interface for improved project operations and maintenance. Therefore, this research focused on assessing BIM innovations and its effect to the QS profession. The following was the research methodology employed.

3. Research Methodology

This research set to investigate the effect of BIM innovation in the construction industry and to evaluate its effect to the QS profession. Is it a bane or boon to the QS profession? The specific objectives were to determine the extent of BIM usage by QS, the relationship between the current BIM usage and the future of QS considering the growth of BIM in the construction industry. Strength, Weakness, Opportunity and Threat (SWOT) analysis were conducted about BIM through literature reviews. Survey questionnaire was administered to explore the current BIM usage and future standing in the industry.

3.1. Survey questionnaire

Survey questionnaire was used to gather the views of the respondents about QS involvement in the construction industry and their ideas about BIM and DT. Emphasis was placed on their knowledge and use of these technologies in projects. The questionnaire consisted of multiple-choice and open-ended questions. A section of the questionnaire focused on demographic information such as work title, number of years in the field, being a project owner representative, role in projects, knowledge about BIM and DT and possible uses of these tools in projects, and their level of utilization in projects in terms of project budget. The other part required the respondents to rate their current level of satisfaction with using BIM in their projects/company on a five (5) point Likert scale (1 = not rewarding, 2 = neutral, 3 = somewhat rewarding, 4 = rewarding, 5 = very rewarding). In addition, they were asked their opinion about the overall growth in the usage of BIM in the next 10-15 years on a similar scale (1 = not improve, 2 = neutral, 3 = somewhat improve, 4 = improve, 5 = improve highly). Finally, they were to give reasons for the growth (or not).

3.2 Sample size and Data Synthesis

The study utilized 33 quantity surveyors who completed the survey. This sample size (n = 33) was considered adequate for statistical analyses and tests for adequate statistical power. SAS on Demand was used for quantitative data analysis which was mainly descriptive statistics. The descriptive statistical analysis results utilized the measures of central tendency that mainly comprised of mean/average values. The main purpose of the analysis was to determine the level of satisfaction with the current state
of BIM use and to provide ideas for growth in future. Qualitative data were gleaned and assessed by content analysis.

4. Results and Discussion

Majority of the respondents were directors, senior quantity surveyors, senior cost managers, or professors. This shows that the sample was from a population that held leadership and managerial roles in construction. Out of the sample, 93% were males, 3% were females and 3% preferred not to say their gender. This outcome leads to a deduction that the QS field is male dominated and so it is important to encourage other genders to get into QS. The results also showed that about 90% of the respondents had over 10 years of experience, 72% had over 15 years of experience with about 23% having over 30 years of experience and so it was prudent to conclude that they would provide invaluable ideas in regard to the BIM and construction industry. They were mainly involved in commercial construction projects (31%) and residential construction projects (26%) with industrial and heavy civil projects accounting for 19% and 11% respectively. About 62% had been project owner’s representatives. Their roles included cost planning and control; contract administration; construction management; project management and integrative delivery partnerships; and consultancy. These roles aligned with those in the study by Wao and Flood (2016). About 97% of the respondents were registered with professional organizations and they mentioned that the benefits tied to those registrations and memberships were for idea/information sharing and networking, CPD, and being recognized as professionals by peers and institutions.

With regard to knowledge and familiarity with BIM, about 80% of respondents stated that they were familiar with the term with about 45% having first heard of BIM from reading while about 30% got to know BIM first from taking a course with about 15% hearing it first from job training. It can be concluded that avenues such as CPD and academics need to be used more to propagate BIM knowledge. Noteworthy, this familiarity and knowledge was not for long term use in projects. About 44% of the respondents had used BIM in their construction projects and from those who had used it in their projects, 70% of them had used BIM for about 2-5 years with about 18% having used it for 6-10 years and the rest (12%) having used it for less than 1 year. This states that BIM usage by QS was still in its infancy and needed to be embraced. For those who had used BIM in projects, about 53% had used it in 2-5 projects, 26% for 6-10 projects while 7% had it in over 20 projects. Again, this shows that a few embraced BIM.

Of those who had used BIM in projects, about 40% had used it in the design phase, 32% in the construction phase, 15% in facilities management and 4% in the deconstruction phase. Others (10%) used it in university training course. This implied that a few got involved with BIM training in the academia. Noteworthy, it was used in the facilities management and deconstruction phase which is an opportunity to integrate DT with BIM since DT is used more in the operation and maintenance phase.

When asked about the aspect of the project they used BIM in, about 24% had used it in quantity take-off, 18% in estimating, 14% for 3D building simulation and clash detection respectively, 12% for scheduling, 6% for project presentation and 4% for waste management. The other (8%) had used it in sustainability. This shows that majority use BIM4D for QTO and estimating but also for the other extended versions like 5D, 6D to 9D which opens various applications and opportunities for QS. Also, about 26% of them used BIM in projects worth $2millions-10 millions, 12% in $51-100 millions worth of projects with about 10% in projects over $100 million. In these projects, 89% of the respondents mentioned benefiting from using BIM. However, some experienced some difficulties in using BIM. They stated that BIM software were expensive with deep learning curve. This aligns with the literature review which stated that some of the hindrances to the BIM adoption by QS. Also, some cited getting ‘buy in’ from all the supply chain, information overload for some of the parties and too many revisions to drawings as some of the problems in BIM usage which also aligned with other viewpoints from the literature review. Also, some stated that there are few BIM operators which calls for more training of BIM professionals in the industry. A notable one stated that some design consultants fell behind with regular uploads of their developing models making them not able to be clash managed prior to tendering and this resulted in change management and additional costs post contract. This posed serious problems which should be addressed.
On the topic of digital twins, only 27% were familiar with DT. Of those familiar with it, 30% had heard about it from taking a course and from reading respectively while 10% from colleagues and from job training. When asked if they had used it in their projects, only 10% had used it. When asked if DT and BIM could be related, about 60% thought they were related. This provided opportunity for training on BIM and DT integration in construction. Majority of QS practitioners were not familiar with it, and so training and CPD, possibly by RICS, may have these put in the core or optional competencies for QS.

When asked about rating the current use of BIM in their companies, about 62% of the respondents thought that it was rewarding with about 27% being neutral and about 6% on the somewhat rewarding range while about 5% stated that it is not rewarding. Average score of 4 meant it was rewarding on a 5-point Likert scale. The same percent scores were seen when asked for the level of satisfaction with the current use of BIM in their companies with a mean score of 4 implying satisfied on a 5-point Likert scale.

For the growth in usage of BIM in projects in the next 10-15 years, 70% believed that it would greatly improve, 10% were neutral while 20% thought it would somewhat improve. So about 90% of the respondents believed that BIM would be better in future and this could provide a great opportunity for QS. This aligned with Wao (2015) that also noted BIM for greater use in future. Some viewpoints of the respondents for future of BIM alluded to BIM evolving with great potential for improvement, more contracts requiring BIM uses and the fact that BIM was increasingly getting adopted in projects with more innovations and applications expected in years to come.

5. Conclusion

This research has used survey questionnaire to investigate the effect of BIM on QS profession and to determine the breadth of its current usage and future standing in construction. Strength, Weakness, Opportunity and Threat (SWOT) analysis was conducted on BIM. It was found that BIM had not been fully embraced within the QS field and the few who had embraced it had not employed full potential of BIM in projects. DT as integrated with BIM was also not popular in the QS field and was not applied fully in projects. As such, the QS field needed to integrate full use of these technologies to enhance their value addition in projects and also to develop professionally.

This research added into the body of knowledge that focused on the application of IT in the construction industry with special emphasis on BIM and DT. The use of BIM had shown that it was rewarding to the QS, and BIM was expected to improve in the next 10-15 years. Future research could focus on DT and its application in the construction industry especially in the operation, maintenance and deconstruction stage which focuses on closed loop system or circular economy and sustainable construction.

Reference