A Review: Application of Building Information Modelling (BIM) over Building Life Cycles

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Abstract: Building information modelling (BIM) in the last two decades has been one of the most positive inventions in the fields of architecture, engineering and construction (AEC) industry. The BIM software gives a digital representation of how the building will be after construction. The digital model can be used at preliminary stage for planning and design, at construction stage for construction and at pre-completion stage for the building operation and maintenance. This model, helps the engineers, constructors and architects identify the likely problems that may occur through the generated model of the intended facility in a virtual environment. A total of “108” conference papers, referred journal articles and other academic sources were analysed based on their relevance and research focus. This article gives a review on the implementation of Building information modelling (BIM) over building life cycles with a view of addressing the challenges and future research prospects. The paper concludes by stating that most of the BIM research focuses mainly at the preliminary and construction stages.

Keywords: Architecture, engineering, and construction (AEC); Virtual design and construction (VDC); Building Information Modelling (BIM); Project planning and management; Work activities scheduling; Project cost estimating; Building life cycles; Facility management; Construction safety; Building operation and maintenance; Building demolition.

1. Introduction
The world is entering into a new epoch where individuals play an active role in the economy due to precipitous advancement in technology, business, demographics and the world at large. In order to survive the fierce competition is to either “collaborate or perish” [1]. This new rule is applicable to all people and industries including architecture, engineering, construction and facilities management (AEC&FM) industry. An industrial survey was conducted on the Canadian construction IT industry [2], and found out that “The most frequently identified issue is related to collaboration (including communications, document management, and interoperability)” which is considered to be the most important “opportunity for improvement to the Canadian construction industry”. According to survey on the same question related to “the trends in information technology that will be important for the construction industry over the next 10 years”, the strongest response was “Web-based collaboration and project management systems” (67%) followed by “integration of software tools across the project lifecycle” (43%). Surveys conducted in other countries showed similar results [3, 4, 5, 6, 7]. In view of the complex nature of the construction industry, the participation of different professionals
(architects, consultants, engineers, contractors, sub-contractors, suppliers including clients), the
different stages involve in the project lifecycle, the use of different hardware and software tools
which requires system integration as a major necessity to realize effective and efficient
collaboration. Furthermore, software/system integration mainly pertains interoperability. And in
the context of this review, interoperability is the ability of different software and hardware to
operate and transmit automated product and project information efficiently. The problems of
software interoperability in most buildings emanates from the discorded data available which are
complicated in nature due to high number of small companies that are yet to catch up with the
advancement in information technologies [8]. In the last 30 years, the use of computer software
(computer aided design (CAD)) and other software’s such as building information modelling
(BIM) have transformed the conventional method of design and communication mode in the
AEC industry [9]. BIM is defined as the digital illustration of a building in a 3D format through
the use of project data to ease interoperability and exchange of data with similar software’s. The
BIM software supports digital modelling for spatial visualization and simulation of buildings
behaviour for effective project management. BIM is unequivocally a collaborative tool. If the
scope BIM usage is widen from design and planning stage to facility management and
maintenance stage, different stages of interoperability and collaboration can be attained [10].
Several researchers have done reviews in related areas of the current BIM research and its
possible applications throughout the entire life cycle of the building [11, 12, 13, 14, 26].

2. Literature Review

2.1 BIM Impact and Outcome

According to, BIM industry working group [15] which shows that there are great organisational
impacts through the implementation of BIM at all the stages of construction process. Arayici et
al. [16] also shows that the collaboration of relevant stakeholder widens the organisational
boundaries thereby improving the general performance of the organization right from design
stage to construction stage as added by [17,18]. Nevertheless, Howard and Björk [19] further
highlighted the impacts that needs to be addressed in the implementation of BIM, which is
capable of changing business processes with simple advanced technology. BIM during
implementation should not be treated separately as an ordinary software tool because of the
impact it has on all the construction processes construction industry. In other words, BIM should
be seen as a linked process instead of a simple technology that requires to be managed as a
whole. Holzer [20] deduces that BIM is a more precise working tool. Due to change in process
and through improved design, BIM is capable of reducing material waste, resource wastage and
cost control during construction [21]. Nawari [22] relates that one of the key successes of BIM
invention is to create a more sustainable construction environment. BIM hub [23] and Bentley
[24] identifies 3D visualisation during design and construction as a key aspect for improved
accuracy. Therefore, for effective implementation of BIM, all the key stakeholders in the
construction team needs to assured of the confidentiality of their data both internally and
externally in the BIM model. Other legal issues might arise if the BIM model is part of an
extranet [25,26] which needs to be dealt with in the contract document in order to minimize
considerable risk [27,28,29].
The major barriers in the implementation of BIM are the resources needed for the
implementation and the cost of training personnel’s [30,31,32,33,34,35,36]. Notwithstanding the
high cost involve in the implementation, BIM at the end of the day is been piloted by clients [32]. Therefore, it has become imperative for the government to subsidize the cost of training to facilitate the implementation of BIM as a major requirement for its adoption [37]. The significant factors to consider in the implementation of BIM is the size of the organisations because will be easier to manage between small medium enterprises (SMEs) and clients. On the other hand, it may be costly for some SMEs to acquire [37].

2.2 BIM Application across the Project lifecycle
The research examined the use of BIM at various stages of the project lifecycle after analysing the magnitude of its impacts in BIM application. In the context of this research, project life cycle is described as all the activities involve in a project from inception, planning, feasibility, design, construction, completion, handover, usage, facility management, maintenance and demolition. The key text defines the different stages of using BIM as feasibility [38,39,40], design [38,40,41], preconstruction stage (detail design and tender) [33,38,39,41,42], construction stage [35,41,43,44,45,] and post constructions stage (operation, maintenance, facility management and demolition) [43,45]. The benefits of BIM at this stage is being cited as useful but, missing in the literature is the rate of use by companies at various stages of the project lifecycle. This research try’s to find an empirical proof from the agreed parties on this subject. The main concern in the construction industry is ensure efficiency in the industry and to increase productivity, and BIM can be seen as the medium here. Other benefits of using BIM as highlighted are: to reduce design errors and ensure quality of design, to aid in the management of construction activities during construction, to strengthen communication and collaboration between construction team members, and to ensure good collaboration between contractors and clients. There are other several benefits of using BIM as stated in the influential BIM handbook [46], as it relates to preconstruction stage, construction stage and post construction stage [46]. The AEC industry has already devise new techniques that are capable of reducing cost, fostering productivity and quality and reduction of time overrun. BIM proffers the possibility to attain these objectives [47].

BIM model gives the digital representation the intended project in a virtual environment. The BIM software is a software design to give a precise digital model of how a facility is digitally constructed which is known as building information model (BIM). The BIM model when generated gives an accurate dimension and a detail data that will be required in the design, procurement, and material fabrication, and construction activities for the realization of the building into reality [48]. At the post construction stage the model can be utilised for operational management and maintenance of the facility. Figure 1 shows the real applications of BIM at various stages throughout the project lifecycle. The BIM illustrates the geometrical details, geographic data, spatial correlations, cost schedules, material estimates, quantities and details of building components together project schedule. The BIM model can be employed to display the complete details of building from inception to completion [49]. Consequently, quantities and related material properties can be easily obtained. The scope of work can be simply separated and outlined. The sequence, assemblies and systems can be illustrated in a virtual scale in the entire facility. Contract documents which contains the drawings, procurement and tender documents, and other construction details can be clearly connected [50].
BIM can be seen as a simulated process that incorporates all areas, specialties, and approach to a single facility within a digital model, by giving access to all professionals to work together professionally and correctly than using old fashioned processes. When the model is generated, the model is subjected to constant review and adjustment to suite the drawing specification and model modifications to ensure accuracy as imaginable as possible before the implementation of the project [51]. It is worthy to note that is not just an ordinary software, it is a method and software. The BIM is not just using 3D model tools but also a means for making considerable modifications in the project delivery processes [52]. BIM represents a new concept in AEC industry that promotes collaboration of relevant stakeholders on a project. The BIM as a process, has the ability to encourage better efficiency and coordination among the project team members who see themselves as adversaries in the past [53]. BIM is a novel project delivery process that integrates systems, people and business practices in a collaborative manner to minimize waste and maximize efficiency throughout the project lifecycle [54]. A project lifecycle can be define as the process that involves different phases of work from inception to completion. The processes involve the extraction of raw materials, manufacture building materials, assembling of materials on-site, usage of facility, facility management, maintenance and repair, demolition and disposal and recycling of the materials [55,56,57]. BIM is considered as a multidimensional interrelatedness of social and technical aspect which merges artificial technology and social aspect and establish the significance of its implementation in the organisation [58].

Figure 1: Different components of a building information model: MEP = mechanical, electrical, and plumbing (Courtesy of Holder Construction Company, Atlanta, GA) [49]
The most essential technical aspect of the BIM software is that it enables data management and 3D modelling [58]. The BIM software is specifically manufactured and designed by vendors to work within the BIM framework, and gives room for modification for long term purposes and for maintenance purposes into the model. Among the commercially available BIM software in the market is the Autodesk Revit which allows the operator to design a facility, structure together with its other components in 3D or 4D model form. The BIM software uses the latest digital technology in creating a model. In a nutshell, a model in BIM is a digital illustration of an object or a concept ordinarily with a precise degree of abstraction [17].

2.3 The Financial Benefits of BIM to the Stakeholders

Other financial benefits can be realised through the adoption of BIM as suggested in the previous research. Jardim-Goncalves and Grilo [37] stated that savings can be analyse by company size. There is positive return on investment by two-third of BIM users as reported by [59] on the overall investment in BIM. Financial savings can also be attained in all phases of the project lifecycle as indicated by the BIM Industry Working group [15]. Maintenance and operation of the facility and the responsibilities of facilities managers amounts to 60% of the total cost of the project [60]. It was further suggested that the main financial benefits can be achieved by focusing on the above mentioned aspect of the project. According to a research carried out in Australia by Furneaux and Kivvits [61] which shows that a significant amount can be saved through the improved interoperability of the BIM software by users, clients, occupants and operators by a cutback of $15.8 billion per year of the total amount spent in Australia. Consultants can also save a substantial amount through the use of BIM if they are able to produce a full working drawing at “half time at half cost” [35]. A saving of 1%–2% of Electrical, Mechanical and Plumbing Engineering systems can be achieved by specialist contractors on a big health care project [62]. Additional specifications and accurate costing creates more benefit and opportunities to the suppliers [63]. The benefits of using the BIM software does not just pertains the construction industry but also have a substantial return on investment to the software vendors through the implementation of the BIM software [64]. Nevertheless, the research does not show which of the speciality benefits most or categorize the cost advantages by discipline because the literature was specific only on the cost benefit of implementing BIM.

2.4 Project Execution Plan Use for BIM Projects

Execution Plan (PEP) has specified the implementation of BIM throughout the project life [65]. The greatest benefits of using BIM is at the design, planning, construction, operation and maintenance stage of a project. The construction teams are already familiar with the tasks related to BIM implementation in the working drawing by ensuring that this plan specifies the whole program. When the plan is established, the growth against this plan can be observed to reap the maximum benefit of using BIM. It is a key success factor in the implementation of BIM to produce an advanced level of project performance.

2.5 BIM Information Supplied at the End of the Project

In the United Kingdom, the Construction, Design and Management (CDM) guidelines specifies clearly that built drawings will be required at the completion of the contract because most of the drawings are as as-designed data rather than as-built data [66]. This information is conventionally given in 2D format only [67]. The development of 3D BIM model as-built model consumes more time than the conventional 2D as-built model [67]. Other Multi-Disciplinary
BIM Model (MDM) can be utilized as as-built model as demonstrated by Tang et al. [68]. Individual disciplinary BIM models at stage 2 of BIM can be provided separately within each discipline at completion and handover [10]. The Cobie system gives the basis for maintaining the efficiencies attained through the Facilities Management (FM) Dataset at the completion of the project [25].

2.6 BIM Key Performance Indicators (KPIs) Measurement

The need to measure the full benefit of BIM over the project life cycle is very essential so as to ensure continuous improvement. The key factor to attain this efficiency as identified by Luu et al. [69], is through performance measurement by the use of mostly Key Performance Indicators (KPIs) as also identified by Kagioglou et al. [70]. Hence, through the use of similar KPIs systems, they can be used to benchmark and classify standards related to national performance in the construction industry and detect areas for improvement [70]. However, it is important to define what KPIs are; ‘they are the union of different measures’. But these BIM measures remain unknown and specific modifications can only be carried out if the implementation of BIM projects are clearly measured. KPIs can accelerate system performance improvement which can be enumerated in the list of Constructing Excellence for the construction industry [71]:

Table 1: KPIs base on constructing excellence

| S/No. | Client Satisfaction | Defect (Predictability) | Safety (Construction) | Others |
|-------|---------------------|-------------------------|-----------------------|--------|
| 1.    | Product             | Cost                    | Cost                  | Profitability |
| 2.    | Service             | Time                    | Time                  | Productivity |

All of the above mentioned KPIs applied to BIM even though they are general. Nevertheless, it is important to note that prior to the headline KPIs, the industry was using performance measure as identified by this research. Yuan et al. [72] mentioned that KPIs usually allows assessment between the real and projected performance on the basis of three factors; quality, efficiency and effectiveness. This work detects what is currently being used for the assessment of performance in the industry and suggest further research area on categorising a particular set of BIM related issues.

3. Research methodology

A broad literature search was carried out based on the title, abstract and keyword. The search was first carried out based on journal publications search engine i.e. Google Scholar, Scopus, and SCI. A more in-depth search was carried out with the aid of Google search engine. And the keywords were used successfully. The keywords utilized in the literature search included ‘Architecture, Engineering and Construction (AEC)’, ‘Building Information Modelling (BIM)’, ‘Virtual Design and Construction (VDC)’, ‘Project Planning and Management’, ‘Work Activities Scheduling’, ‘Project Costing Estimating’, ‘Building Lifecycle’, ‘Facility Management’, ‘Construction Safety’, ‘Building Operation and Maintenance’. Articles from journals, conference proceedings, published case studies, press releases, online articles, professional presentation and review papers were used. Other sources included are book reviews, editorials, and letters to editors, discussion and comments. All the above stated sources were published and publicised within the last two decades hence, signifying the use of most recent data with the respect to the topic reviewed.
A total of “108” papers were studied during the process and “73” papers on planning and management related to BIM were identified and included in the analysis. Most of the top journals used in this review search are journals of engineering and construction: ‘Engineering, Construction and Architectural Management (ECAM)’, ‘Automation in Construction (AIC)’, ‘Journal of Construction Engineering and Management (JCEM)’, ‘Journal of Management in Engineering (JME)’, ‘Construction Management and Economics (CME)’, ‘International Journal of Project Management (IJCM)’, ‘Building Research and Information (BRI)’, ‘Building and Environment (B&E)’, and ‘Building Simulation (BS)’. But the most cited journal was Automation in Construction. The reviewed paper were further classified according to the five main stages of project lifecycle. They are; Building planning and design, construction, repair and maintenance, operation and demolition. It is important to note that although the findings are explained at each stage of the building life cycle. The literature review was carried to analyze the current trend of BIM over building lifecycle. The details of the findings are discussed in the next section.

4. Research Findings

4.1 Virtual Design and Construction (VDC)

Researchers are yet to agree on a consensus definition of Virtual Design and Construction (VDC). VDC is a concept that is intermittently developing. VDC as defined by Fischer and Kunz (2004) is “the use of multi-disciplinary performance models of design-construction projects, including the Product (i.e. facilities), Work Processes and Organisation of the design–construction–operation team in order to support business objectives” [73]. Fischer (2006) [74] has classified VDC development into three main phases:

I. Phase 1 (Visualization).
II. Phase 2 (Integration).
III. Phase 3 (Automation).

In the first phase, designs were carried out in the past using the 2D approach. The construction activities were guided by different methods i.e. critical path method and bar chats. Visualization aims to represent design and review construction activities through pictorial model, 3D models and virtual reality. At phase two, different professionals and various construction processes are integrated in a project. And finally, at phase three, construction activities and some design tasks are automated. Presently, design and construction planning are innovative work carried out solely by humans; the VDC platform only provides the platform for this work. Originally, VDC was used for visualization but gradually integration of construction work is being included [74].

A web-based survey package (Limesurvey™) analysis was performed by Robert Eadie, et al., (2013) using a questionnaire to collect data from respondents on the application of BIM through project lifecycle. The survey shows that BIM is the most frequently used software for design with (54.88%) and (51.90%) of projects at preconstruction stage (Table 2) [75].

| Use at construction project stages | Often No | Often% | Occasionally No. | Occasionally% | Never No. | Never% |
|----------------------------------|----------|--------|------------------|---------------|-----------|--------|
| Feasibility                      | 21       | 26.92% | 41               | 52.56%        | 16        | 20.51% |
| Design                           | 45       | 54.88% | 35               | 42.68%        | 2         | 2.44%  |
| Preconstruction                   | 41       | 51.90% | 31               | 39.24%        | 7         | 8.86%  |
| Construction                      | 26       | 34.67% | 39               | 52.00%        | 10        | 13.33% |
| Operation and Management          | 6        | 8.82%  | 31               | 45.59%        | 31        | 45.59% |
Fischer [93] produced a Construction Knowledge Expert (COKE) guide that shapes designers thoughts or perception on designing structures that can be easy to construct [76]. Some researchers Patty et al. [77] invented a new program as a computer tool which provides the designer with ability to access constructability at any point of design. A new methodology was introduced by Kupernas et al. [78] which uses a computer aided drafting (CAD) 3D model to review design layout of a project and to identify design conflicts for constructability purpose at preconstruction stage. Walid Thabet (2000), suggests a model for design/construction integration using virtual construction.

As shown in figure 2, a developed design model through virtual construction was developed based on design review process. The design review process can be put into operation on incomplete and completed designs based on the dimensions and intricacy of the facility under discussion [79].

As depicted in figure 3, the generated model will make use of user-interactive terms that will grant the user/designer/builder to virtually generate a 3D models of the building with the aid of construction CAD components or assemblies. The computer generated model will be managed by the facility’s 3D model created during design development. At preconstruction stage, the virtual construction process allows the user to undertake rehearsals of the construction activities by criticizing and analysing the designs. The construction option module and resource module that are knowledge base can aid the user in making decision. The construction module will also help in examining the potentials of using the chosen construction option and the selected resources in the most preferred order of construction. The design review module will give the user access to modify or re-design the building [79].
Succar (2009) has carefully analyse and identified the maturity stages of BIM by categorizing them into components for easy understanding as in figure 4 [80]. As shown in figure 2 there are three main stages in the implementation of BIM:

1. Stage 1 (object-based modelling).
2. Stage 2 (model-based collaboration).
3. Stage 3 (network-based integration).

Stage 1 denotes the migration from 2D to 3D with object based modelling and documentation. While stage 2 shows the evolvement from modelling to collaboration and interoperability. And at stage 3, there is transition from collaboration to integration which indicates the fundamental philosophy of BIM. And finally at this stage, the project life cycle phases disintegrate and team members relate in real time to create actual benefits from virtual workflows. And finally at this stage, the model product goes beyond the meaning of objects properties but also includes the whole building lifecycle costings, business intelligence, lean construction and green policies.
Figure 4: BIM maturity stages in BIM implementation [80]

The maturity stages provide an efficient framework for categorization of the BIM implementation. These maturity stages are used as benchmarking tools for appraising data from the UK questionnaire based survey and Finnish interview carried out by Farzad and Yusuf (2012) [81].

4.2 Virtual prototyping (VP) planning process

Project planning in construction is regarded as the most important process in project lifecycle because it signifies the effective implementation of project delivery. At this stage, construction strategies are developed by project planners so as to determine construction path and assembly sequence, in order to organise construction resources and techniques that are needed for the effective execution of the project. This will allow the planners to give workers daily working guide for all the site workers [82,83,84]. Virtual prototyping allows 3D static product models to be built as the first step in the application process in order to assist the project team members in analysing and communicating design data. Errors can easily be detected using the 3D product models. The 3D product model allows the modelling of site environment so as to review the design and to study the site layout [85].
4.3 Virtual Design and Construction (VDC) technology

In the rapid evolving world of information and communication technologies, software and applications such as BIM [86], VDC alongside Geographic Information Systems (GIS) etc. have become recognized tools in the AEC industry. The issue of congestions of construction activities and detection of spatial conflict have been addressed in the 4D visualizations [87]. Project parts such as roof, north façade, walls etc. can be selected using spatial selection in 2D or 3D since all the necessary data are available in the construction site and at production unit which forms the basis for automated tracking of material flows using software’s like RFID. Other construction issues such as construction safety have also been addressed by creation of design-for-safety-process (DFEP) through the adoption of Virtual Reality (VR) [88]. The VR-built DFEP tool assist in identifying safety hazards based on manual selection at the design stage. Other software developed to address various construction issues include Patterns Executions and Critical Analysis of Site Space Organization (PECASO) [89], integrated system for construction and safety based 4D CAD model [90], the rule based algorithms (Hazard Explorer and Safety Measure Advisor), 5D CAD based risk visualisation system for construction risk degree visualization [91] and design for safety tool for safety suggestions [92]. Bansal [93] also developed a GIS based navigable 3D animation tool for predicting likely places and areas with high potentials for accidents. The software links the data between the CPM schedule and safety database. Safety manual using BIM technology was also developed by Finland for safety planning, management and communication [94]. Automated safety rule checker for BIM was also developed by The Georgia Institute of Technology in 2010 [95]. The review indicates that the issue safety hazards has been addressed with the introduction of virtual safety controls in the BIM model. The potentials of using VDC at different construction stages is to assist the architects, engineers and contractors to identify, envisage and prevent probable problems and risks prior to their occurrence in the project.

Figure 5: Underpinning the construction planning with VP [85]
5. Discussion and Future Research

5.1 Successes of BIM implementation

The data obtained in this study suggests that BIM is a valuable tool in enhancing specific key areas of project delivery. Cost have the most positive effect in the implementation of BIM, then time, communication, coordination improvement and quality [96]. Based on this comprehensive reviews, it can be deduced that financial gains can be achieved through the adoption of BIM. Moreover, the significance of BIM adoption is rapidly rising and becoming recognised in the AEC industry. Software like Vicosoft is designed to support full lifecycle services more than other competitive products.

5.2 Challenging Research Issues and Barriers on the use of BIM on Projects

The most notable barriers and challenges in the AEC industry are; low productivity, inefficiency, poor quality and other sustainable issues. But based on the papers reviewed, the barriers hindering the adoption of BIM in many companies can be summarized below.

| Barriers                                                                 | Reference          |
|-------------------------------------------------------------------------|--------------------|
| 1. Lack of expertise within the project team                             | [96,97]            |
| 2. Lack of expertise within the organization                             | [96,97,98]         |
| 3. Lack of demand                                                        | [99,100]           |
| 4. Cultural Resistance                                                  | [100,101]          |
| 5. Investment cost                                                       | [33,102]           |
| 6. Lack of additional project finance to support BIM                    | [103]              |
| 7. Resistance at operational level                                       | [104]              |
| 8. Lack of collaboration between team members                            | [105]              |
| 9. Lack of immediate benefit from projects delivered to date            | [106]              |
| 10. Legal issues pertaining ownership, IP & PI insurance                 | [28,107,108].      |

From the table 3, it can be seen that the negative challenges of implementing BIM are comparatively few and majority of them are focussed on lack of expertise within the project team and external organisation. These barriers and challenges are associated with change management task in relation to BIM adoption and could be mitigated through advance training of all relevant stakeholders involve in the construction activities in order to adapt to the new working tools.

5.3 Future Research Opportunities

BIM is a key change management task that is associated with different risk areas. The precondition is to identify the problems and impediments of this change process. This in-depth literature review tries to ascertain the BIM maturing concept which creates an avenue for analysis through quantitative and qualitative methods. It also creates a strong base for companies to make a knowledgeable decision in the implementation of BIM within the entire company structure. The original value of this research also creates a future research opportunities on broader application of BIM and creates the bases for developing a good BIM strategy guide. Future research area should focus on exploring the full potential benefits of implementing BIM in facility management, building maintenance and operation, and deconstruction and demolition.
6. Conclusion

Results from this study shows the implementation of BIM throughout the project life cycle. It was also observed that BIM implementation in the AEC industry is still premature, but is receiving rapid attention. Nonetheless, “the formal standards on BIM, such as the Industry Foundation Class (IFC) are complex and have not had the resources for rapid development and promotion that their potential deserved [19]”, as such has a long way to go. BIM is emerging as an advanced way of designing and managing projects digitally. The full potential benefits of BIM can be seen at every construction stage. As the adoption rate of BIM increases, teamwork among team members should increase thereby leading to reduction in project cost, time saving, customer satisfaction and improved performance. BIM presents a new concept in the in the AEC industry, that enhances collaboration between stakeholders of a project. This collaboration is capable of enhancing efficiency and unity among stakeholders who most of the time see themselves as rivals within the AEC industry.

The reviewed journal publications and general statement from professionals within the AEC industry suggest the emergence of BIM as the most recognized performance analysis tool in building concept, planning, and design. The literature findings also suggests that lack of expertise within the project team and external organisations are the major barriers hindering the implementation of BIM, which could be the reason why the advantages of BIM and 3D modelling have not been attained in the AEC industry in a related manner seen in other industries like machinery design and car manufacturing industry. It is envisaged that the AEC industry through continued professional training and increased awareness, that the maximum financial gains of BIM will be achieved. The future of BIM is both bright and stimulating because the full benefits of BIM implementation is gradually been seen in the AEC industry.

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