Building Information Modelling (BIM) – its applicability in Architectural firms in Uganda

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Abstract

Utilization of Building Information Modelling BIM during design stages is extremely important in the pursuit to achieve efficiency, early clash detections, adequate project evaluation and more importantly, the ease in collaboration and information exchange during the design stages. Currently, BIM utilization at design stage is not fully realized in Ugandan architectural firms. This study has explored how to bridge the existing gap by establishing the potential and existing limitations to BIM's applicability in Uganda's Architectural firms. It has been widely acknowledged that BIM is an emerging technological and procedural shift within the Architecture, Engineering and Construction (AEC) industry. BIM represents a methodology to manage the building design and project data in digital format throughout a building's lifecycle. The aim of the paper was to establish the potential of BIM and possible implementation of BIM operations as well as the existing limitations to its applicability in Ugandan architectural firms. The esearch was conducted through a series of interviews with 12 leading Architecture firms, where for each firm, a senior architect was interviewed as well as some software technicians employed in some of the firms. The findings highlighted the current state of application of BIM tools in architectural firms and several issues related to the general understanding of the BIM concept and lack of adequate training by the software technicians. This research also revealed a lack of awareness of certain factors like operational processes, operational efficiency and the importance of BIM operations as a whole. The focus on the BIM concept in architectural practice was found to be a new area of research, therefore, this study, adopted a random sampling method on architectural firms with in Kampala to establish the potential of BIM on architectural practices in Uganda. This study concludes by recommending a holistic integration of designers, processes, appropriate BIM tools and other third-party BIM stakeholders (Engineers, Quantity surveyors and contractors) in order to reach the optimum utilization of BIM during design.

Keywords: Building Information Modelling (BIM), Architectural firms, Uganda.

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1. Introduction

BIM is defined as "a set of interacting policies, processes and technologies that generate a methodology to manage the building design and project data in digital format throughout the building's life cycle" (Succar et al., 2012). Furthermore, BIM is considered as a "system" innovation (Murphy, 2014; Succar & Kassem, 2015) due to it being a set of interacting policies, processes and technologies that work in tandem throughout a built facility. According to Slaughter (1998), "system innovations are identified through their integration of multiple independent innovations that must work together to perform new functions or improve the facility performance as a whole". The Architecture, Engineering and Construction (AEC) industry is constantly in pursuit of techniques to improve quality, increase productivity, decrease cost of construction projects. One of the most notable examples is the development of Building Information Modeling (BIM). BIM is a fundamental tool or system the ACE industry, in that it could facilitate efficient collaboration of these project stakeholders (Architects, Quantity Surveyors, Engineers, contractors and clients) during project delivery. This process cannot be efficiently coordinated if it is not properly organized from the start of the project, that is from the design stage. It was therefore the purpose of this research to study the relevancy and potential of BIM at design stage of a project for a case on architectural practices in Uganda. It is undoubtedly important in construction management, but needs to be fully implemented to reap its benefits. Despite the various benefits of BIM, the rate of adoption appears to be lower than expected and much more so in Uganda where its adoption considerations have not yet taken off.

BIM implementation is defined as " a set of activities undertaken by an organisational unit to prepare for, deploy or improve its BIM deliverables (products) and their related workflows (processes)" (Succar and Kassem, 2015). Accordingly, BIM implementation enablers refer to a set of tools, techniques and strategies to facilitate the BIM readiness, capability and maturity phases (Abbasnejad et al., 2018). To gauge a comprehensive evaluation of the key organizational BIM implementation enablers, different organizational levels such as individuals, groups (different organizational working divisions/functions), as well as the entire organization itself should be taken into account. At the individual level, key aspects comprise individual characteristics, individual competencies including their skills, abilities, and experiences as well as user learning and training. At the group level, key aspects comprise communication, coordination, collaboration and cross-functional/group training. At the organizational level, key aspects include organizational culture and structure, leadership, top management support, communication and collaboration (Peansupap & Walker, 2005).

2. Literature review

BIM is the act of making an electronic model of a facility for the reason of imagining, analysis of conflict, checking of code criteria, engineering analysis, cost engineering, as-built product, planning and other reasons (Kreider and Messner, 2013). It is described as offering a better way by which outcomes of a project can be predicted, enhance communication among team members throughout the entire project life-cycle, lessen rework, manage risk, and better the operation and routine maintenance of a facility (Sanchez et al, 2014). Blackwell (2015) considers BIM as a collaborative way of working, underpinned by the digital technologies which unlock more efficient methods of designing, creating and maintaining construction facilities. According to American Institute of Architects, BIM is defined as a digital, three-dimensional model which is found to be associated with a database providing all aspects of project information. It is also promoted that BIM can blend with other criteria denoting construction project success, including design of construction, availability of information fabrication, instructions related to construction, and logistics related to project management in a single database. It encourages the blending of project goals throughout the project's design and construction. AIA (2007).

According to Kymmel (2008), the use of software and hardware related to computer application in order to identify a virtual representation of a building in a manner which promotes identification of physical characteristics of the project is the basis of a Building Information Model. This model conveys all the information which is contained or attached to the components of the model. Such a model provides information of all or any of the following features including 2D image, 3D image, and time scheduling using 4D, cost information identification related to 5D or nD related to other aspects like sustainability, energy, and management of available facilities. With few other variations Lee et al. (2006) identified Building Information Modeling as the process of making and/or utilizing a Building Information Model. According to this definition, Building Information Modeling is to be promoted as an essential tool that plays a major role in attaining the objectives associated with the construction project during design stage as this research will identify how a BIM model can be built and utilized during the design process of a building project.

Eastman et al. (2011) made a contradictory statement that BIM is not solely a software package, but also a process. According to them, BIM can be identified as a modeling technology with well-organized procedures to create, interact and examine building models. Building Information Modeling is a word utilized for the description of tools, processes and technologies that are associated with digital, machine-readable documentation. This documentation is about a building, its functioning, its planning, its construction as well as its operation. Hence, BIM is said to depict an activity and not any type of entity or substance. As BIM has quite often been mistaken for a certain drafting and modeling software, this definition clearly explains that BIM is a whole software package, process and technologies, which is in agreement with the definition provided in Hardin (2009), which defines it as a set tools and processes involving the use of software to achieve the goals of construction project management throughout the entire life-cycle of a project.

The National Building Information Modeling Standards (NBIMS) committee of USA defines BIM as a digital representation of physical and functional characteristics of a facility. And further explains that, BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle; (as existing from earliest conception to demolition). It also explains BIM as collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder (NBIMS, 2010). Furthermore Ashcroft (2008) identified BIM to be the outcome of a modeling function which can be further described as a digital, machine-readable record of a construction, the related performance, the degree of planning and the delay in construction.

They further present the view that a number of project stakeholders proceed with a false conception that the purchase of BIM software will automatically promote integration of BIM benefits successfully in their operations.

Heesom and Mahdjoubi (2004) supported this view by indicating that there is lack of awareness with regards to the perceived use of BIM. They further mention that Building Information Modeling not only comprises usage of three-dimensional modeling software, but also requires expertise and innovation on the part of the user. National Institute of Building Science (NIBS), also focuses on the 'The process view' with one of the three categories of the process identified as: Intelligent representation of data – authoring tools, Collaboration process and a facility lifecycle management (National Institute of Building Science (NIBS), 2007). Furthermore in support of BIM usage for project delivery, Howard and Bjork (2008) proffered that the moment a company begins to implement BIM technology it will begin to experience a change in its processes. They also emphasize that; other procedures that have been suitable for CAD-type technology are not as good as BIM. BIM is capable of adapting to changes in any stage of construction and therefore is the ideal software tool which can be used by a construction organization.

BIM offers numerous benefits (Azhar et al, 2008, Eastman et al, 2011). Azhar et al, (2008) explains that the model increases profitability, accelerates and promote collaboration among project teams, reduces costs, provides improved time organisation and develops client/customer associations. Hergunsel (2011) adds that BIM ensures effective management and dissemination of information. Technical benefits include three-dimensional (3D) coordination, prefabrication, cost estimation, and as-built model (Yan and Demian, 2008). Throughout the bidding stage, the project manager can offer renderings, walkthroughs, and sequencing of the model to better show the BIM concept in 3D. Also, virtual replicas like laboratories can be given to the owner and the designer. The virtual replicas aid to connect and work together among the project members (Hergunsel, 2011). If the architect is only providing 2D drawings, then the construction manager should convert the 2D drawings to 3D intelligent models (Hergunsel, 2011). If mechanical, electrical, plumbing (MEP) contractors and steel fabricators are involved, they need to coordinate their work. Just after the model is produced, 3D coordination can begin to make sure that any same space interference (hard clash) or clearance clash (soft clash) disagreements are resolved (Wang et al, 2016).

Prefabrication needs field and design accuracy. Building information models shall give this level of accuracy by including the specifications, sequence, finishes, and the 3D visual for each component (Eastman et al, 2011). BIM can be used to construct prefabricated walls, rooms and houses with roughed MEP components. Final MEP connections can be made once the prefabricated components are assembled onsite. BIM can be removed to an excel file or a cost database. The cost estimator is required to examine the material constituents and ways they are installed (Sattineni and Bradford, 2011). The cost estimator might need additional breakdown of the component for more precise pricing if the value for any particular activity is not captured in the database (Forgues et al, 2012). A record Building Information Model can be provided by construction managers to the owner at the end a project (Teicholz, 2013). Also, each object property in the model can comprise links to submittals, operations and maintenance, and warranty information. Record model can be used to manage security and safety information such as emergency lighting, emergency power, egress, fire extinguishers, fire alarm, smoke detector and sprinkler systems (Liu, 2010).

2.1 BIM as tool and a Process.

BIM is not just the latest release of CAD software; it is an entirely a new way of looking at the design and construction of a building. During the designing of a facility, you can not only select and place the materials that will make up the finished structure—including concrete slabs, rebar, steel structure, wall and ceiling components, HVAC, plumbing and electrical—but you can also test all such parts for conflicts (clash detection) to ensure everything will come together seamlessly. And all this while you can still use an "eraser," rather than having to rework later in the field. You can also use this 3-D building model to analyze the designed building's energy efficiency by running "what if" scenarios to determine the best of several potential solutions. In addition, depending on the detail of the model, you can automatically take off all items contained in the model and that way produce an impressively precise estimate. The software and database management technology exists today to accomplish exactly this. What has yet to be realized and bought in to by a large majority of our industry, however, is the degree of collaboration and coordination between the various construction disciplines that BIM calls for.(Words & Images, 2009).

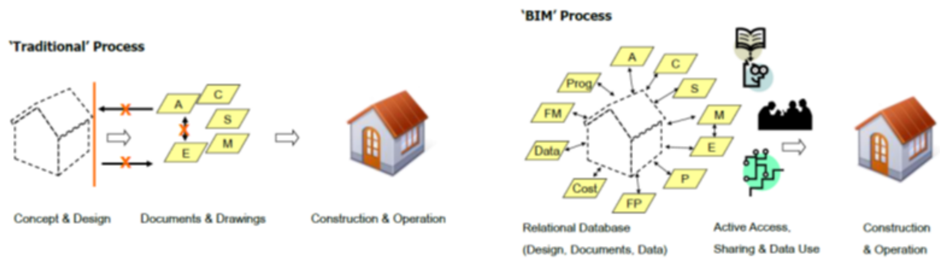

Figure 1: A Comparison between "Traditional" and "BIM" Process (Azhar, S et al. (2012); Holder Construction, Atlanta, Georgia, USA)

Kymmel (2008) identified several nature of information within Building Information Model. This pertains to all information that is part of, or connected to, the components as well as the physical information inherent in the model itself such as size, location, etc. The nature of information can be summarized as follows: Component Information. Component information is the most basic information, contained in the 3D model file. It is primarily visual information and resides in the nature of the model part itself. Components in a 3D model also have specific locations in relation to an origin and to one another. Example of component information is a wall with material information or quantitative information such as area, volume and etc. Parametric Information is editable information contained in the parametric object. This is not an external source of information—it is embedded in the object, and therefore the model. Some of this information will be visual, while much of it can also be intellectual, such as part numbers, or material-related qualities, such as density (providing weight based on the geometry of the object), R value, etc.

Linked Information refers to information that is actually not part of the model, but is connected to the model through visible or invisible links. Visible links can be ―flags that will open a window or file when clicked to display that file, invisible links could be, connections to a database with cost information. When two files are linked, changes in one will result in adaptations in the other linked file, and vice versa. External Information refers to information that is generated separate from the BIM, such as a construction schedule, manufacturers' specifications of products, etc. External information may be linked to the model or remain autonomous. It is possible to provide a reference to a catalog without creating a link to an electronic file. Since not all information will be available in a compatible format, it may necessary to keep it accessible in printed form, as an external reference.

2.2 3D information Coordination and collaboration with in a design team

The degree of coordination and collaboration between different team members of the project is most important. Jung and Joo (2011) identified that, in order to avoid huge design errors and for the better understanding of the project, collaboration between the construction manager and specialty contractors must take place in advance. This will provide space and time for the contractors and construction managers to understand each other and promote 3D coordination.

2.3 Interoperability of BIM

BIM is clearly a vital subset; however, the main ingredient that makes BIM crucial is its "interoperability", which is nothing but its ability to coordinate and interact as a consistent representation of the same building for all of the purpose built models. According to Howell and Batcheler (2012), the success of BIM depends upon the sharing of information among the various BIM models. Synchronization issues, project management, partial model exchange and software interfaces all require high interoperability and would definitely appreciate further research." BIM is constantly evolving and as it keeps evolving more tools are being introduced, and once again interoperability becomes an important matter.

The technological interface between the construction and the design industries is an area where a lot of the issues crop up on BIM models. The file formats and the various programs have to be compatible if a virtual model is to be created. These programs and files should be capable of being opened by different software that is being used by the different companies. In cases where some of the files cannot be opened up, or they require additional software, then the implementation of BIM is said to have failed (Furneaux and Kivits, 2008).

2.4 Benefits of BIM to an architect.

According to Azhar, S. (2011), BIM creates an overall better project management by improving productivity issues, such as reducing rework and errors. Architects have achieved benefits related directly to time saving and cost reduction. Other benefits: more efficiency and enhanced design collaboration; risk management – early identification of issues that might arise; more successful project delivery – reduction of conflicts and changes during construction Valuable data within the model can improve cost estimating and building maintenance.

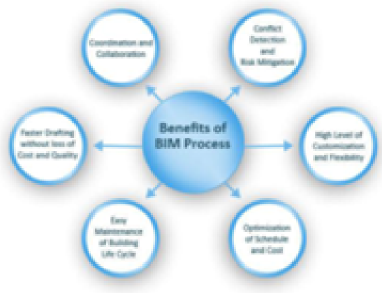

Figure 2: Benefits of BIM process at architectural design stage. Azhar, S. (2011)

Building Information Modeling is distinct in its qualities when it comes to exhibiting its abilities. It renders architects, engineers, and construction managers the required interoperable program in order to fulfill their entire operations. It is declared to be completely limitation free during utilization depending on the competency of the users. The advantages achieved while using the BIM are: conflict identification and resolution; adjusts costs as changes occur; speeds up design/construction process; construction sequencing as well as scheduling; life cycle evaluations – solar energy and other nonrenewable sources of energy use in building can be evaluated; operational simulations; interoperability of BIM tools.

2.5 BIM Software Package Categories.

Building Estimating Software (added)- TBD, Analysis Software - complete engineering analyses (examples include: Risa 3D, RAM, STAAD, and ETABS); Design Software - produce coordinated construction drawings (examples include: Autodesk's Revit and Architectural Desktop, and Bentley's MicroStation or V8); Coordination Software - host and/or merge Design and Detailing Models (examples include: Navisworks, Tekla Structure, and Graphisoft); Detailing Software - produce shop drawings and control fabrication processes (examples include: Xsteel, SDS/2, QuickPen, and CADPIPE); Rendering Software—provide a three-dimensional interactive rendering of the project (examples include: "Sketchup" and MS PowerPoint); Facilities Management Software (added) – TBD

2.6 BIM Implementation

BIM implementation should be considered as an organizational innovation (Succar & Kassem, 2015). Organizational innovation is defined as "the adoption of an idea or behavior that is new to the organization" and is subject to influences in individual, organizational, and environmental components (Hage, 1999). In addition, it is widely discussed that BIM implementation is more than a mere software implementation (Saka and Chan, 2019). It requires changes in the existing business processes of adopting firms (Abbasnejad et al., 2016). Hence, the theoretical framework of Business Process Change Management (Kettinger & Grover, 1995) is used to categorize the key enablers of the BIM implementation process. According to this theory "any significant business process change requires a strategic initiative where top managers and leaders define and communicate a vision of change. The organizational environment with a ready culture, a willingness to share knowledge, balanced network relationships, and a capacity to learn, should facilitate the implementation of prescribed process management and change management practices" (Kettinger and Grover, 1995). In the following section, key enablers of BIM implementation are explained in further detail and the role each enabler plays in the BIM implementation process is clearly delineated.

A clear vision, strategy, and an implementation plan are prerequisites for successful BIM implementation (Chunduri et al., 2013; Lindblad, 2019; Mason & Knott, 2016; Succar et al., 2013). BIM vision herein refers to the understanding of the role that BIM should play in the organization as a whole. BIM vision can be regarded as either a "generalized technological promise", "guiding vision" or a "promotional metaphor" to transform the organization (Miettinen & Paavola, 2014). These visions guide BIM initiatives in AEC firms. Understanding the possible impact of BIM on a particular stakeholders' interest can aid managers in overseeing BIM implementation more effectively and efficiently (Arayici et al., 2011a; Husain et al., 2018). Moreover, the BIMenabled business process is reliant on what is considered to be BIM (Ayyaz et al., 2012). Different actors' resort to different meanings of 'BIM' which can obscure the unique characteristics and real benefits of BIM amongst BIM and non-construction parties (Barlish & Sullivan, 2012; Mehran, 2016). Most organizations treat BIM as a tool that completes their conventional methods of creating, storing, viewing and exchanging information (Ayyaz et al., 2012). Defining the BIM in practice and clarifying its scope during the implementation planning can help to eliminate this obscurity.

3. Methodology

Literature review was used to define BIM, its processes during project design phase and its benefits and limitations as well as possible root implementation strategies. Articles relating to BIM were selected for a comprehensive state in the literature review. Research defined and compared BIM software operations from professional architects in their respective firms. The objective was to establish the particular BIM software employed by different architecture firms in their project designs and the extent to which the respective software were utilized as far as BIM operations are concerned particularly at design stage.

In order to accurately address the type of inquiries regarding this research, a qualitative research approach has been adopted. Morgan and Smircich (1980) suggest that, the choice of the method should be based upon the nature of the research problem. According to Dawson (2007) qualitative studies attempt to explore an in-depth opinion from the respondent about their attitude, behavior, experience and perspectives in a particular set of issues. Qualitative method is built on the facts which are socially constructed based on people's experience (Noor, 2008).

Therefore, this method was adopted primarily to explore a multidimensional understanding and experiences within Architectural design stages towards potential areas, and information needed where BIM could provide an appropriate intervention in enhancing their operations. In this research the main themes that guided the interview were the same to all the architects that were approached in their respective firms. The main reason to make the themes similar was to explore and compare the architects' views, opinions, and experience regarding processes, and application of developing BIM at design stage of a project.

The main themes were divided into four main categories of the research objectives. Firstly, was to explore the understanding of processes and application of BIM at design stage. Secondly; was to establish the current level of utilization of BIM software in Ugandan architectural practices. Third, was to explore areas where BIM can provide value to architects during design. Lastly, was to reveal the challenges/limitations encountered in taking on the full utilization of the BIM processes at design stage in Ugandan architectural firms.

To thoroughly address the above mentioned themes, semi-structured interview method was selected where interviews were carried out in order to determine whether the architecture firms employ any BIM software and to understand the extent to which they employ these software in their projects as far as BIM operations are concerned at design stage and also establish the reason behind their adoption of such software including the benefits that accrued the firm as a result of applying the respective software as well as the challenges. 12 firms were approached for the interviews and for each firm, a senior architect was interviewed to obtain the relevant information that was further analyzed.

The target population for this research was architecture firms operating within Kampala city. The sampling frame included well established firms in Kampala city. Research participants were selected using convenience sampling. In total, 12 firms were approached and their respective architects interviewed though there was some form of snowball, where some interviews were conducted with the software personnel in the respective firms as referred by some architects. For the purpose of confidentiality, the names of these firms are withheld to maintain their anonymity. In this research, a qualitative data analysis was conducted.

4. Discussion of findings

The findings are hereby presented in four main aspects; designers' understanding of processes and application of the BIM concept, current level of utilization of BIM software in Ugandan architectural practices, areas where BIM can provide value to architects during design and the challenges/limitations encountered in taking on the full utilization of the BIM processes at design stage in Ugandan architectural firms. Different respondents from architectural firms were interviewed to explore the above objectives. Opinions from the respondents were discussed.

The majority of the firms that were visited had been operating for at least more than six years where by 7 firms were above 10 years, 3 firms were 6-10 years and 2 firms were 1-3years and 100% of the firms agreed that they were handling projects ranging from simple to complex structures, this therefore would probably explain why they would need a proper and systematic process technology that would ease their operations during execution of their designs. However, it was also noted that all the sampled architecture firms were employing BIM software in executing their project designs and these were; Graphisoft Archicad, Autodesk Revit and AutoCAD by Autodesk and most of these were being used as pirated software in most of the sampled firms.

With respect to the awareness of BIM, 41.7% of the respondents reported that they were unaware of the technology, 58.3% of the respondents reported that they were actually aware of the BIM technology, however, all the firms indicated that they were using BIM software, implying that BIM was being used as a tool and not as a whole process in their operations. With respect to the adoption prospects, it was noticed that most firms indicated a lot of reluctance towards BIM adoption plans. Further analysis revealed various reasons as to why these firms were very reluctant towards BIM adoption plans and the top three most cited reasons were: the existing system can already fulfil their needs; BIM is expensive to operate and maintain; and thirdly the projects they undertook did not require the use of BIM because they could be well offset by their current systems.

All the sampled firms apart from one, reported that they sometimes had a team working on a single project depending on the size of a given project and the expected time of delivery. They reported that, it normally happens when there is a very big and relatively more complex project that needs to be delivered within a short time than an individual can perform. Firms majorly use printed two dimensional drawings to share project information and reviews and sometimes use flash disks and other memory disks to share copies of the project information. This poses a risk of loss of information in process of converting different file formats to suit users of different software. With this information, the research was able to establish how these firms achieve effective collaboration during project design as a design team. Several firms also reported that they receive quit a substantial amount of error queries more especially during construction and further reported that the biggest nature of these queries are to do with missing information in details and specifications noting one example as missing material specifications notes, though they mentioned that they sometimes receive some queries arising from misunderstanding of the drawings and that such queries that need retouching the model are redone, including the process of printing and the delivering them to the concerned parties.

Apart from three firms the rest of the sampled firms reported that during preparation of construction drawings they detached the two-dimensional drawings from the system data base as they reported that they later work on them independent of the project model as just line components. When the drawing is still attached to the to the project data base, the software clearly identifies the components with their physical characteristics and displays the specifications of the sampled component therefore detaching it from the data base breaks all the flow of project information and the drawing no longer contains the relevant information of the project. The two drawings (attached and detached) still look the same however, in this case the software interprets the elements in the detached drawing as only line components. This means that the drawing loses its original project information and can no longer synchronize with the rest of the project information.

These firms acknowledged certain benefits of using their respective BIM software in their operations. With respect to using the BIM tools for visualization, they reported that they gained benefits in terms of: Cost estimates - All the sampled firms reported that at design stage, cost estimates made for the clients are estimated according to experience and manual calculation and computation from the schedules. This shows that the software ability to easily produce the schedules and cost estimates is not utilized as the information is extracted manually from the drawings and computed differently. Improved project presentations to clients; as the software provides 3D visualization and one firm also reported that they sometimes present walkthroughs to their clients to help them make better and well informed decisions and choices. Facilitation of examination and verification of architectural designs; as it is possible to assess the components of the project as they can be viewed in 3D models that are automatically generated by the programs as well as section perspectives that help to assess particular project components better. Reduced production time; as most firms reported that some of the required drawings are automatically generated by the software for example; sections, elevations, details and perspectives though some of them needed to be cleaned up to the required detail. Increased quality of the output and efficiency; most firms also reported that they had achieved a good level of efficiency in their operations, especially those firms that worked on their drawings when still attached to the project data base as they explained that any changes made during the process of producing construction drawings are automatically and instantly updated in the rest of the drawings in the entire project.

It was found out that the software restricted/limited creativity during designing and one of the architects explained that it is on rare cases where for example they produced custom made stairs because the software provides already made stair case libraries which are also not adequately stocked and the tend to be limited to that. As for some firms the interviews were extended to particular software technicians and it was found out that 2 firms were encountering a problem of lack of strong computers to handle optimum software performance especially for considerably big projects and so they explained that they sometimes prefer to employ 2D CAD software in order to work with lighter project data that their computers could easily handle. Lack of adequate knowledge about the full abilities of the software as some users mentioned that they sometimes run into problem whereby they find it hard to perform certain tusks as may be required in a particular project design and they also find it difficult sometimes to do custom components that they would need to incorporate in their designs because the libraries are inadequate. The same problem was also identified in Gu and London (2010) who highlighted the lack of awareness and training are the main barriers associated with BIM adoption.

Most architects responded that they had intentions of increasing productivity in their operations. On an attempt to find out what methods they would employ to adopt BIM processes in their operations as an option, most of the results were identical and they involved efforts to improve the skills of their employed software technicians and upgrading their machinery to meet the considerations for proper BIM operations. However some participants mentioned that they would not be ready because they see no great need for taking on the technology besides the difficulties and costly BIM implementation plans.

Results from all respondents showed that all firms employed at least one BIM software alongside other CAD software much as some firms were using more than one BIM software and this was thought to be a good platform for any future prospective BIM implementation plans. It was cited in (Cheng, 2006); the steps that should be taken to implement BIM in an architectural practice include first creating a BIM adoption or implementation plan that covers all aspects of its content and delivery and measures its impact both internally and externally. Many firms were found to be extracting and detaching the 2D drawings (plans, sections, elevations and details) from the project data base. Here, the drawings are not attached to the project model anymore therefore any information added to them is never interpreted right in rest of the project information because there is loss of sync between the two. An update made in the original project model does not reflect in the detached drawings and this becomes a big problem especially when working with relatively big and/or complex projects and may compromise the consistence in the drawings because the drawings then have to be manually updated of which this is also a tedious process.

Most respondents mentioned that they often had teams working on a single project at a time, this in one way or another poses the need for collaboration to ease the process of sharing information among the design team. In further mention, the methodology they employed to achieve collaboration in such situations included use of 2D printed drawings or copies and shared using flash disks and other memory disks. However this would expose them to the risk of loss of information as the files may get corrupted in the process and also during conversion to different file formats to suit the different software used by different technicians. This could otherwise be alleviated in the BIM process operation as the large and/or more distributed teams are able to easily and quickly share project information and work securely each with their part of the design regardless of where they are physically located.

The majority of the firms were found to have the potential to handle construction projects ranging from simple structures to complex structures, this therefore presented a basis for need of full BIM operations in order to efficiently handle especially complex projects as it can offer a series of interoperability and collaboration as well as easy project information management options.

Major benefits of BIM for early design stages mostly reported by researchers are the ability of BIM to correct errors from early design stage, accurate scheduled construction, construction sequencing, clash detection, design alternative and easy solutions for complex projects (Kubba, 2012, Azhar, et al, 2011). As it was also found that all the sampled firms in the process of providing cost estimates for the clients, they normally use estimation from experience and manual calculation and computation from the schedules that are also manually generated from the design drawings. This may result in double counting or under counting errors in the process of manually obtaining the schedules from the drawings. However, with adequate knowledge about the BIM software such schedules and cost estimates can be easily obtained automatically from the projects data base as shown in the figures below

Most firms benefited from their respective BIM software in a way of 3D visualization enhancement and efficiency during design. These benefits are consistent with what was cited in Linderoth (2010) listing the benefits associated with the use of BIM at an early stage of projects including: rapid visualization, increased communication across the total project development team, and clear improvement in the design quality in terms of error free drawings. However, it was also found out that the rate at which they received queries about the drawings especially during construction was high and some of the queries that were mentioned were; missing information in the details and specifications, inconsistence in the drawings and also due to misinterpretation of the drawings. In relation to the benefits of using BIM tools like clash detections, as earlier seen in the previous chapters, BIM provides benefits in reducing costly errors by integrating models to analyze, detection and resolve some future issues as early as during design stages in order to reduce on the would be incurred cost on rectification of errors during the process of construction. This is in consistence with Azhar, S. (2011), who identifies that, BIM creates an overall better project management by improving productivity issues, such as reducing rework and errors. Architects have achieved benefits related directly to time saving and cost reduction.

This study identified three main interlinking areas that need to be addressed accurately in a holistic way in order to achieve a-well thought functioning BIM process. The interlinking areas are BIM, processes, and BIM stakeholders. The application of BIM for architectural design stages may be successful if all three interlinking factors are considered seriously and well-coordinated. Stakeholders (Architects, Engineers, Contractors and project managers); this aspect takes into considerations the need for architects to develop competency on proper application of BIM from early design stage for operations in the future. The results indicated a lot of reluctance to adoption of BIM and lack of BIM adequate knowledge among other limitations. Processes; Results indicated that, due to fragmented nature of the construction industry, it was difficult to have a holistic processes that carries holistic views from all parties regarding efficient design stage as it was found out that most firms were not multidisciplinary in their operations. To achieve this, closer collaboration of all stakeholders to bring in accurate information to be put in a BIM model is necessary. This is very important later on during construction and operation so that the asset information is accurate.

Several respondents highlighted the fragmented culture of the industry as well as cost of adopting such technology as well as inadequately trained technicians as the main barriers to the employment of new technologies like BIM operations. This was because all the stakeholders (Architects, Engineers and Quantity surveyors) work on their phases independently, whereby architects do their designs until they finish and then hand them over to the other professionals like quantity surveyors and engineers who have to use the information provided in the drawing to do their part. This was also explained in (Bernstein and Pittman 2004), the fragmented nature still appears to be the main factor that would hinder the industry from coming up with practical strategies for the effective collaborative exchange of information.

In addition, due to the fact that most of the firms were medium sized firms, limited resources available for expenditure on such technology in terms of machinery and personnel/technicians was cited as another main barrier. This was also cited in (Coates, et al, 2010) who proffers that; BIM is considered to enhance collaboration, but in reality, most of the architectural firms are not multidisciplinary in nature, and BIM utilization and decision are made internally within firms with respect to their processes, and perceived benefits within the firm.

Results indicated that, despite the growing awareness of potential benefits provided by applying BIM, it is still not crystal clear on how BIM can be applied practically at design stage. Architects have little knowledge on how BIM can be effectively assimilated in their systems and how to practically use BIM in the process in a simplistic way. This calls for inevitable knowledge need on practical projects associating architects. Control difficulties: Difficulty to track changes made by stakeholders or owners during operations/construction. A control difficulty was also other concern that was raised by architect respondents as they further identified that; it requires a strong coordination from design stage to keep the right information at the right place. It was also revealed that owners make several changes during operation and sometimes there is no feedback of what has been changed. This has to be clearly stated on contractual bases on duties and obligations of each stakeholder in order to maintain value during operations and can be done with proper organization of the BIM processes at design stage and a proper coordination with other stakeholders.

5.0 Conclusion

The findings from this research revealed that among the 12 sampled firms, the 58.3% were aware of the BIM technology however these also had inadequate knowledge about BIM as process in terms of how it operates especially at design stage. 41.7% had no idea about the technology though all the firms identified that they were using BIM software implying that BIM was being used as a tool and not as process or a system much as it was found that the software was being underutilized as some of the operations like schedules were being manually obtained from the drawings. Many firms showed a lot of reluctance towards BIM adoption plans due to reasons like; the existing system can already fulfil their needs, BIM is expensive to operate and maintain and the projects they undertook did not require the use of BIM because they could be well offset by their current systems.

For the purpose of assisting integrated design processes in the architectural firms, Building Information Modelling could provide a good platform whether it is taken as a tool or as a process and concept. The nature of the technology which has the ability to link to or receive, broadcast or export sets of attributes, to other application and models should attract many efforts to extend the use of it. To gain the benefits of the technology, however, requires changes to some or perhaps the overall process in current practice and it is really important for the architectural firms to be aware and ready to accommodate the change.

The results of this study indicated a lack of awareness of operational processes, operational efficiency and the importance of BIM operations as a whole. The focus on the BIM concept in the construction industry in Uganda was found to be a new area of research, therefore, this study adopted a random sampling method on architectural firms operating with in Kampala to establish the potential BIM has on Ugandan architectural practices. Therefore the study did not target BIM adoption for the entire construction industry. Future research can focus on this area and identify its potential and possible adoption plans in the entire construction industry of Uganda.

Future research needs to be done on interoperability with the various programs that are essential to the designers to see how well BIM can be integrated with rest of the CAD software being used in the firms without phasing them out due to the fact that most technicians have already developed great skills in producing fine drawings with these software. This would also substantially reduce on the cost of obtaining totally new software, which was one of the challenges mentioned by some of the respondents. Surveys should be conducted to determine how well BIM can be possibly integrated in the architectural curricular of the architecture schools in Uganda. This will help in acquiring formal training in BIM operations and provide a better understanding of BIM processes at early stages before one joins the field.

A number of barriers to the applicability of BIM in Uganda's Architectural firms. The need should addressed mainly at the industry level, including: cost of system setup; resistance to change; lack of BIM understanding; fragmented industry; lack of visions; and inadequate training and education. It is thus recommended that if the government decided to enforce the use of full BIM in the delivery of public projects, they should address the above issues to ensure that the industry has adequate level of preparedness to ensure successful adoption of BIM.

6.0 References

Ahmad A. M; Demian P and Price A.D.F (2012) BIM implementation plans: A comparative analysis In: Smith, S.D (Ed) Procs 28th Annual ARCOM Conference, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 33-42.

Azhar, S et al. (2012) 'Building information modeling (BIM): now and beyond', Australasian Journal of Construction Economics and Building, 12(4) 15-28

Azhar, S. (2011) 'Building Information Modeling (BIM): Trends, Benefits, Risks and Challenges for the AEC Industry', ASCE Journal of Leadership and Management in Engineering, 11 (3), 241-252

BIMing the Architectural Curricula – Integrating Building Information Modeling (BIM) in Architectural Education, University of Lincoln repository.

Britani Harris1 and Thais da C. L. Alves2, 4d building information modeling and field operations: an exploratory study.

Building Information Modeling (BIM) Benefits, Risks and Challenges Salman Azhar, Michael Hein and Blake SketoMcWhorter School of Building Science Auburn University Auburn, Alabama

Building Information Modeling: Understanding and Operating in a New Paradigm, Prepared for the Foundation of Wall and Ceiling Industry by Words & Images, Published by Foundation of the Wall and Ceiling Industry 513 West Broad Street, Suite 210 Falls Church, VA 22046-3257 (703) 538-1600 July 2009

CRC Construction Innovation. (2007). Adopting BIM for Facilities Management: Solutions for Managing the Sydney Opera House, Cooperative Research Center for Construction Innovation, Brisbane, Australia.

Eastman, C, Teicholz, P., Sacks, R. and Liston, K. (2011) BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, 2nd ed., NY: John Wiley and Sons

Farin, Gerald; Hoschek, Josef and Kim, Myung-Soo (2002). Handbook of computer aided geometric design [electronic resource]

Goedert JD and Meadati P (2008). Integrating construction process documentation into building information modelling.

Gu N and London K (2010). Understanding and facilitating BIM adoption in the AEC industry. Automation in

Holzer, D. (2007). Are You Talking to Me? Why BIM Alone is Not the Answer. Available at: http://epress.lib.uts.edu.au/research/handle/2100/476.

Howell I and Batcheler B (2005). Building information modelling: two years later- huge potential, some success and several limitations. The Laiserin Letter. Available at: http://www.laiserin.com/features/bim/newforma_bim.pdf.

Innovation, 4(3), pp. 155-171.

International Journal of Architecture (IJA), Volume 1, Issue 1, January – December (2013), © IAEME

Journal of Construction Engineering and Management. 134 (7), pp. 509-516

Linderoth HCJ (2010). Understanding adoption and use of BIM as the creation of actor networks. Automation in Construction. 19(1), pp. 66-72.

Line in the United Kingdom, France and German. Olatunji OA, Sher WD, Gu N and Ogunsemi DR. (2010). Building information modelling processes: benefits for construction industry. Proceedings of the 18th CIB World Building Congress, Salford, UK. pp. 137-151.

McGraw-Hill (2009). The Business Value of BIM - Getting Building Information Modeling to the Bottom Line.

McGraw-Hill (2010). The Business Value of BIM in Europe - Getting Building Information Modeling to the Bottom

McGraw-Hill Construction (2008) Building Information Modeling: Transforming Design and Construction to Achieve Greater Industry Productivity, McGraw-Hill Construction, New York

NBIMS (2010) National Building Information Modeling Standard, online at http://www.wbdg.org/pdfs/NBIMSv1_p1.pdf

Royal Institute of British Architects, 2012, Published by RIBA Publishing, 15 Bonhill Street, London EC2P 2EA, ISBN: 978 1 85946 467 0

Stewart RA, Mohamed S and Marosszeky M. (2004). An empirical investigation into the link between information technology implementation barriers and coping strategies in Australian construction industry. Construction

Succar B (2009). Building information modelling framework: a research and delivery foundation for industry stakeholders. Automation in Construction. 18(3), pp. 357-375.

Yan H and Damian P (2008). Benefits and barriers of building information modelling. Proceedings of 12th International