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Practical Application of Building Information Modeling for Quantity Surveying Profession in Tanzania

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Abstract *- Building Information Modeling (BIM) is an innovative new approach to building design, construction and management. During the construction phase of the building lifecycle, BIM makes available concurrent information on building quality, schedule, and cost. Completing a construction project within these three important parameters, i.e. time, cost and quality are the criteria of success for a project. BIM plays an important role in the performance improvement of quantity surveying practice. However; the concept of BIM in Tanzania is not well understood and not really familiar to quantity surveying professionals. As such, the low awareness and knowledge of BIM leads to slow adoption of BIM. This research aimed to investigate on how BIM can practically be applicable to quantity surveying professionals in Tanzania. The research data were collected from forty one (41) Quantity surveying professionals. The analysis done by using Statistical Package for the Social Science (SPSS) shows that, the majority of quantity surveying professional are far behind as far as the BIM knowledge is concerned and hence, this hinders the application of BIM for the profession. Finally, the paper concludes various and relevant issues of concern and suggests appropriate measures towards enabling practical application of BIM to the quantity surveying profession in Tanzania.*

Keywords *- Building Information Modeling (BIM), Quantity Surveying Profession, Tanzania.*

I. INTRODUCTION

In connection with recent technological advancements over the decades especially in Information Technology (IT), the 'Building Information Modeling' (BIM) is one of those advancements that have attracted significant attentions in the construction industry worldwide [1]. BIM is indeed a revolutionary technology and process that has transformed the way buildings are designed, analyzed, constructed, and managed [2].

The National Building Information Modeling Standards (NBIMS) committee in the United States defines BIM as follows; "BIM is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is 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 [3]."

BIM has taken the construction industry into a new era where most processes have been faster. The benefits are not just time and cost savings, but also reduction of risks and uncertainty in construction process. BIM has the potential to automate measurement and facilitate the preparation of accurate estimates. Building Information Modeling has the capability to automate a quantity take-off, which can reduce the time and costs required to estimate a project.

II. REVIEWED APPLICATION OF BIM IN DIFFERENT AREAS

A. BIM In Construction Management

The BIM concept contemplates virtual construction of a facility prior to its actual physical construction, in order to reduce uncertainty, improve safety, work out problems, and simulate and analyze potential impacts [4]. Sub-contractors from every business trade can make an input of critical information into the model before beginning construction, with opportunities to pre-fabricate or pre-assemble some systems off-site. Waste generated on-site can be minimized and products delivered on a 'just-in- time' basis rather than being stock-piled on-site [4].

Quantities and shared properties of materials can be extracted easily. At the same time 'Scope of work' can be separated and defined. Systems, assemblies and sequences can be shown in a relative scale with the entire facility or group of facilities. Besides, BIM prevents errors by enabling conflict or 'clash detection' whereby the computer model visually highlights to the team where parts of the building (e.g.: structural frame and building services pipes or ducts) may be in a wrong intersection.

B. Impact of BIM to Quantity Surveying Profession

Ashworth and Hogg [5] emphasize that the Quantity Surveying profession just like other professions, is an evolving profession that needs to continue to change in order to meet the ever changing conditions in the building industry. The history of Quantity Surveying and the way Quantity Surveying tasks were performed provides enough substantial evidence to show how Information Technology has changed the way Quantity Surveyors perform their duties and the speed and efficiency of the professional services of the Quantity Surveyors.

BIM has the potential to influence every characteristic of the construction industry together with construction

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professionals. BIM consists of 3-dimensional design functions (3D), programming and scheduling functions (4D) and cost estimating functions (5D). Olatunji *et al*., [6] explains that, BIM is a major challenge to the services conventionally provided by QSs and other construction disciplines. BIM has the potential to automate measurement and facilitate the preparation of accurate estimates. In addition, BIM has the capability to automate a quantity take-off, which will reduce the time and costs required to estimate a project; however, the industry is not using BIM for estimating. BIM software is compatible with estimating software, such as Innovaya Composer, which converts BIM files, making them compatible with Timberline's estimate and quantity data [7]. According to Gee [8] BIM's capabilities of automating the production of bills of quantities, which is one of the quantity surveyors fundamental tasks, have both positive and negative effects on the quantity surveying industry.

Hergunsel [9] reported that two main elements of a cost estimate are quantity take-off and pricing. Quantities from a Building Information Model can be extracted to a cost database or an excel file. However, pricing cannot be attained from the model. Cost estimating requires the expertise of the cost estimator to analyze the components of a material and how they get installed. If the pricing for a certain activity is not available in the database, cost estimator may need a further breakdown of the element for a more accurate pricing.

Furthermore, Nigam *at el*., [10] mentions that BIM software can help assist the Quantity Surveyor in various tasks rather than quantification. BIM can aid program certainty at tender stage, contractors can link their program to the model upon tender submission, and this should reduce the amount of variations required during the construction phase.

As a summary it can be concluded that there is a considerable impact of BIM to the Quantity Surveying profession.

C. Application of BIM as a Quantity Surveying Tool

The use of BIM in the construction industry is increasing. It is widely acknowledged that adoption and use of BIM would cause a notable shift in business processes within the construction industry and related fields [7]. The manual process requires more time for revising the BOQ to accommodate design changes. Hence, the BOQ is often out-of-date.

Ashworth [5] notes that the speed of response and the ability to reduce manual errors have led to the wide spread use of software applications for performing QTO and estimating. The 5D model created by BIM has the potential to perform an automatic analysis of all materials and components and to derive their quantities directly from the model [11]. Eastman *et al*. [4], considers BIM as a useful input regarding value for money throughout the design period.

D. Significance of Applying BIM in Quantity Surveying Practices

The quantity surveying profession has become a rapid developing profession over the past few decades. Building works become more complex, and employers become dissatisfied with the methods which are used for controlling and settling the cost of the work. This has led to an urgent need for an independent quantity surveyor.

Quantity surveying is vital in the construction process, from the project initiation phases to project closeout. The quantity surveyor today can be defined as professional consultants that "add value primarily to the financial and contractual management of construction projects at the pre-construction, construction and post-construction stages".

Quantity surveying is a profession that demands adequate knowledge, correct and skillful use and interpretation of this knowledge. It also requires correct interpretation and understanding of designs and the numerical representation of these designs [12]. Cost estimation, feasibility studies, tendering, cost planning, value management, and dispute resolution are some of the activities employed by the quantity surveyor. Raphael and Priyanka [13] explain four cost management functions of quantity surveyors in the following sub-sections;

Bills of Quantities

A Bill of quantities (BOQ) is one of the main tools used in the cost management of construction projects. The automatic production of bills of quantities is one of the functions that BIM technology developers are proud of as the fifth dimension of BIM. The automation of bills of quantities is one of the functions that enhance BIM technology to be both collaborative and integrative. The automation of the production of bills of quantities eliminates the tedious traditional take-off methods, and at the same time reduces human errors.

Cost Estimates

BIM technology can extract accurate quantities and spaces that can be used for cost estimating at any period of the design of a project. It also allows estimators to identify and communicate the relationships between quantities, costs and locations, and distinguish how areas and components of the building are contributing to the total cost of the project.

The realization and understanding of cost-determinants enrich the competence of cost estimators and along with the accuracy of the quantity takeoff produced by the BIM enables the estimator to produce reliable and accurate cost estimates in the early stages of the design phase.

Rapid Updating of Costs

By integrating cost estimation with a BIM design tool, it allows Architects, Engineers, Quantity Surveyors and clients/users to carry out value management throughout the design phase. As design changes are made to the BIM, the cost estimate can be automatically updated with quantities extracted from the modified model, without the estimator needing to take-off quantities.

Bidding Process

Competitive tendering and bidding with BIM models can reduce the risk gap that exists between project members

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due to the transparency and accessibility to project information and documentation. The BIM provides substantially higher quality construction information than conventional working drawings and provide more accurate bill-of-quantities. In addition, potential constructors can receive training in quantity extraction and measurement from the BIM. During tender, bidders can identify and correct errors in the model, hence, enabling more accurate bids.

E. The Influence of BIM to Quantity Surveying Profession

Quantity surveyors are mainly involved with the measurement of works, tendering process and cost control. There are many potential uses of BIM, including automated quantity take-off and BOQ preparation, which have a great impact to the quantity surveying profession. This has raised concern about the viability of quantity surveyors in construction projects and whether or not they are still required [4].

The impact of BIM application to the quantity surveying profession is anticipated to bring more benefits rather than disadvantages. However, the common argument is that, other professions will be able to undertake the quantity surveyor's job as BIM could potentially produce BOQ in a short time. This can be judged as an invalid argument as BIM software does not generate cost estimates automatically; it merely assists the cost estimating process. Cost estimating with BIM still requires basic and measuring skills.

Architects might also not want to take the responsibility of costing the project, as their scope of work does not normally extend to quantity takeoff or cost information. The architects also wouldn't want to be liable if the building cost was inaccurate. At this point, it would be more preferable to leave the responsibility of costing with the quantity surveyors.

The BIM software also allows quantity surveyors, to extract useful data for quantity take-off at any stage of the project. When the manual quantity take-off is no longer required, the generation schedules and cost estimates can be produced more quickly, and the potential for human error is reduced. Quantity surveyors can bring so much more expertise and experience to the project rather than simply counting or quantifying. The use of BIM means that the traditional tedious task of quantifying can be automated, which provides quantity surveyors with extra time that can be used to focus on other tasks that can provide higher value for the project. This includes identifying construction assemblies, risk management, life cycle costing, price generation and others.

Implementing the application of BIM into quantity surveying firm will enable quantity surveyors to do their work more accurately and efficiently, giving them a competitive advantage. The successful application of BIM will however, not happen without affecting the quantity surveying profession in some way or another. The cost management functions of BIM will change the process of cost management of construction projects, which will then shift the responsibilities of the professionals involved, forcing quantity surveyors, to focus on different parts of the cost management process, and create new responsibilities and opportunities for themselves and rearrange the structure that they work in (Eastman *et al*. 2008).

III. METHODOLOGY

This research involved literature review on the subject basing on descriptive and conceptual design. Further, questionnaires and limited interviews were adopted through engaging the quantity surveying professionals. Research data were collected from forty one (41) respondents in Dar es Salaam Tanzania. The questions were processed by using Census and Survey Processing System (CSPro). This software which uses data dictionaries to provide a common description of each data file, tools to view data and export the data to SPSS for analysis in order to obtain a comprehensive and accurate analysis in both the descriptive and statistics.

IV. FIELD DATA

In the present study, the population was quantity surveying professionals who are registered as quantity surveyors and quantity surveying firms within the United Republic of Tanzania. According to the Architects and Quantity surveyors Registration Board (AQRB) [14]), the total number of registered QS professionals was 309 and 109 QS firms as shown in the table I.

TABLE I. Quantity surveying professionals and firms in Tanzania.

S. No	Professionals/Firms	Total
1	Quantity Surveyors	309
2	Quantity Surveying Firms	109

(Source: [14], 2015)

For the purposes of conducting this research, and based on the method used to distribute the questionnaires, i.e. through company's email addresses, cluster sampling was selected, forming two groups. Group one, is those firms registered their company emails with AQRB and the other group with no email address.

Data collection was basically obtained from the following methods;

(i) Primary Data Collection;

In this research, data has been collected through unstructured interview and questionnaires from registered quantity surveyors who are working in quantity surveying firms.

(ii) Interview;

For this research, interview was made to the Registrar of AQRB for the purpose to find if the AQRB has already had any plan regarding adoption and application of BIM for the quantity surveying professions in Tanzania.

(iii) Questionnaire;

For the purpose of this research the questionnaire consisted of five sub-sections;

- Quantity surveying profession profile
- Awareness, knowledge and readiness
- Firms' capabilities toward BIM implementation
- Barriers that hinder BIM implementation, and
- Measures to bring about BIM implementations.

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(i) Quantity surveying profession's profile;

This part, which comprised six (6) questions was aiming to validate the responses as whether the right person was completing the survey or not, therefore the respondents were asked to present themselves and their firm profile, included level of education, company's year of experiences, a sector which the firm does seek the construction works and firm's annual volume range.

(ii) BIM awareness, knowledge and readiness;

This part aimed to evaluate the extent of awareness, knowledge of BIM to the quantity surveying profession and their readiness toward BIM application and implementation. It was designed to capture information related to awareness and knowledge of BIM as well as the readiness of quantity surveying firms to adopt and implement BIM. It consisted of five (5) questions which were not very detailed and only knowledge of the quantity surveyors was targeted.

(iii) Firms' capabilities for BIM implementation;

In order to evaluate the readiness and preparation of firms towards BIM implementation, it was necessary to understand the extent to which firms are preparing themselves to this implementation. The five (5) questions were grouped and the respondents were asked to agree, moderate or disagree with the given strategies.

(iv) Barriers that hinder BIM implementation;

This section consisted of eight (8) questions which were grouped and asked the respondents to agree if those given factor will hinder the BIM implementation or not if BIM is fully implemented. The questions were designed in such a way that the quantity had to evaluate themselves and overview the industry and predict the challenges that may be will hinder the BIM implementation for quantity surveying professions in Tanzania.

(v) Measures to bring about BIM implementation;

This part intended to seek for solutions to the main problem of unawareness and implementation of BIM, so this part which comprised of three (3) questions, in which the respondents were asked to rate.

Table II shows a total of 56 responses were received whereby 12 responses were incomplete and skipped some parts and 3 were filled by unregistered quantity surveyors which were excluded from analysis. Therefore 41 responses were validated for use in the analysis.

TABLE II. Questionnaires distributed and returned.

Total Questionnaire Distributed	Total Questionnaire Returned	Incomplete Returned Questionnaire	Invalid Returned Questionnaire	Valid Returned Questionnaire
79	56	12	3	41

V. Results and Discussion

A. Analysis Regarding Quantity Surveying Profession's Survival Upon BIM Application

The study shows that more firms intend to use BIM as 72% said yes (N=41) and intend to use it, although some of them, 21% were not sure if they will survive in the industry or not. Respondents who said are not going to adopt BIM in the future is 7% (refer figure 1). Figure 2 shows that, 61% firms assume that they will struggle to survive if BIM is fully implemented for use, and only 7% will give up.

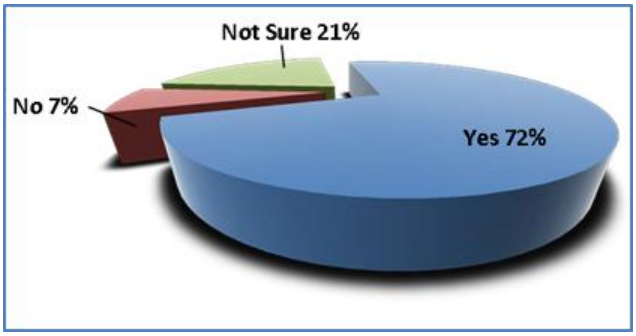

Fig. 1. Perception on BIM application.

The majority, 72% of the firms will be ready to adopt and implement BIM application in the future (Fig. 1), and 61% (N=35) are certain that they will survive if BIM application is fully implemented (Fig. 2). It is evident therefore that, BIM will eventually not replace the quantity surveying profession as many people tend to think.

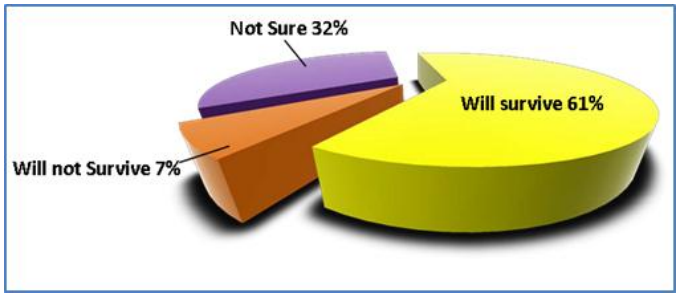

Fig. 2. BIM Application vs quantity surveying position.

B. Analysis Regarding Awareness, Knowledge and Readiness

Figure 3 shows that, the level of awareness of quantity surveying professions in understanding BIM is low, only 24% are aware and about 75% have no idea about it. The challenge is more typical to undergraduate quantity surveyors as only 21% among them were aware of it, as compared to another level of education e.g. masters and PhD holders, which are 50% and 100% respectively (Fig. 4).

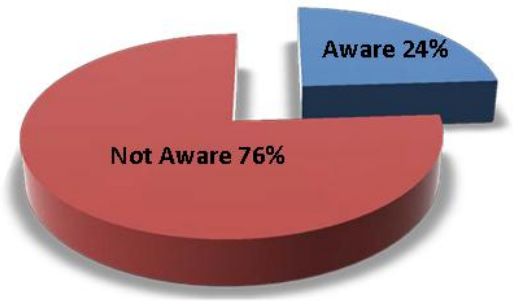

Fig. 3. Understanding of BIM.

Also, many firms are not aware of BIM and the problem is worse to the firms with low years of staff experiences whereby, only 20% among them were aware (Fig. 4).

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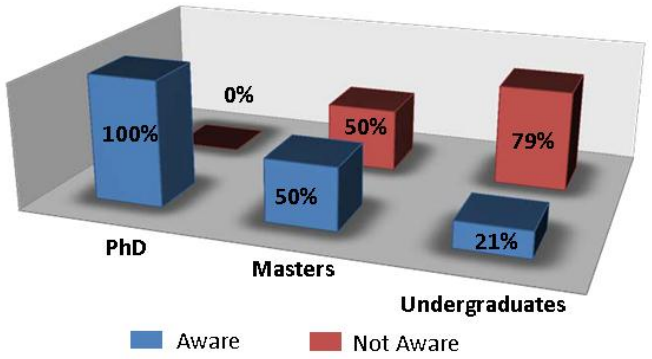

Fig. 4 BIM awareness based on education level

BIM Tools or software is a problem to the quantity surveying profession as only 5% have knowledge about them (Fig.5).

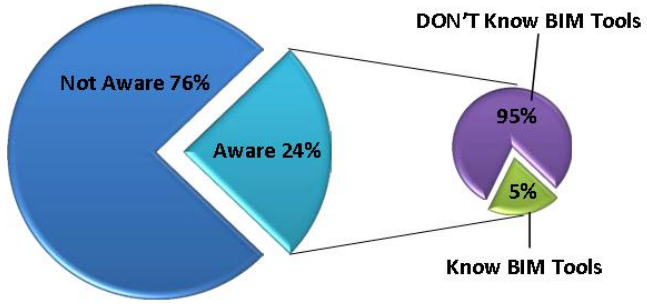

Fig. 5 BIM tools knowledge

Figure 6 shows the range of years in experience and the corresponding BIM awareness. Above five (5) years were most informed about the knowledge.

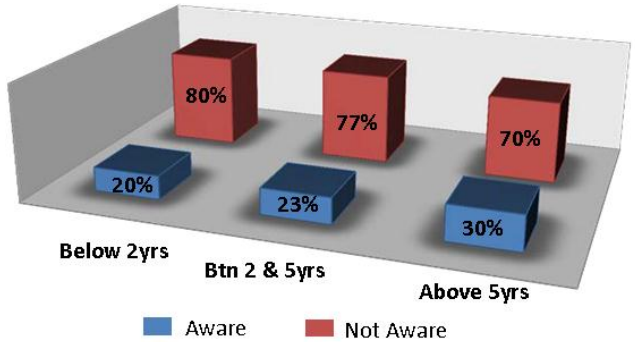

Fig. 6 BIM tools knowledge and experience

C. Analysis Summary Regarding Capabilities Towards BIM Application

The study indicate that seventy two (72%) percent are ready to adopt BIM implementation in the future. Towards BIM application, firms seem to be ready to change their mindsets towards the new technology. They will evaluate their capacities towards new technology and planning for adaptation of BIM by doing in house training, attend workshops, seminars and conferences related to BIM. Findings show that most of the firm's with higher income and more experiences were more capable of adopting the technology.

TABLE III. Firms Capabilities towards BIM application

Firms' Capabilities	Min	Max	Mean	Ranking
Firms will use their resources to research, development and training for BIM implementation	2	3	2.6	1
Firms will be conducting in-house training, attend workshops, seminars and conference related to BIM implementation	1	3	2.5	2
Firms will change the mindset towards new technology	1	3	2.4	3
The Firm will evaluate the company capacity and planning for BIM implementation	1	3	2.4	4
Firms will spend additional time to familiarizing themselves with BIM tools	1	3	1.8	5

Key: 1= Disagreed 2=Moderate 3=Agreed

The odd situation in obtaining additional time to spend on familiarization of BIM tools is considered to be a barrier towards BIM implementation if in-house training fails (mean of 1.8 as shown in table III). This is because the involved firms still use the traditional methods in doing their roles, and one of the challenges of tradition method is time consuming, and most of firms still use the traditional method. Thus, they don't have more time as most of their time is used in fulfilling their roles.

Evaluation of firm's capacity to determine the capability of the firms towards adopting and implement of BIM is one of the aspect which was given priority in firms; however, from the findings, it shows that only 17 firms which is equal to 49 percent, agreed to do an evaluation out of 35 firms, and 5 firms disagreed.

D. Analysis on Barriers Towards BIM Application

The Majority of the firms seem to agree on the eight (8) barriers that hinder BIM implementation for quantity surveying profession in Tanzania, whereby an average of 77% agrees to the factors. These include: as Lack of BIM training Unawareness of BIM can bring to QS firms; Cost of training; Lack of skilled personnel; Cost software a new update; Inadequate Government supports; People refusal/reluctance to learn BIM and Culture changes towards new technology.

Most of the firms put emphasize on lack of government support, cost of training, lack of BIM training and lack of skilled personnel were among the extremely barriers towards BIM application as their mean is more than 2.5 as shown in table IV. It has also been revealed that, it is not true that, the majority of the Qs professionals are reluctant to learn BIM and not ready to change to this new technology.

TABLE IV. Barriers that hinder BIM application

Barriers	Min	Max	Mean	Ranking
Lack of BIM training	2	3	2.80	1
Unawareness of BIM can bring to QS firms	2	3	2.68	2
Cost of training	1	3	2.59	3
Lack of skilled personnel	1	3	2.56	4
Cost software a new update	1	3	2.54	5
Inadequate Government support	1	3	2.51	6
People refusal/reluctance to learn BIM	1	3	2.34	7
Culture changes toward new technology	1	3	2.32	8

Key: 1= Not Hindered 2=Least hindered 3=Hindered

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As indicated in the findings, none of the firms disagreed on the unawareness of BIM can bring barrier to BIM application, although 35%, agreed on least hindered and 63% agreed that, unawareness is the barriers toward BIM application but not very seriously as compared to lack of BIM training.

Most of the emphasized factors which were identified as the main problems to the large income firms were; unaware of BIM (9 firms out of 22), lack of skilled personnel that can impart the knowledge to the firms, culture changes towards new technology also was identified as the main challenge to them and inadequate of government support.

Cost of training was identified as a big challenge towards the BIM application by middle income range firms followed by low income range firms. The large volume income range firms agreed on least hindered (44%, 37% and 19% respectively).

Low income range firms identified person's refusal/reluctant to learn BIM, cost of software and lack of BIM training were the major barriers towards BIM implementation for quantity surveying profession in Tanzania, meanwhile for the large volume range firms were not serious for them.

E. Analysis Regarding Influential Factors On BIM Application

Government involvement in this aspect was confined to be the most important factors that can bring about awareness and full implementation of BIM application by quantity surveying profession as more than 34 firms which is equal to 83% agreed on that (Table V).

TABLE V. Measures to facilitate BIM application

S. No	Not important	Less important	Important	Total
Education and Training (Review of the current QS training program to adhere to this new technology)	5	14	22	41
Changing the ways doing business by QS themselves	19	15	7	41
Government intervenes	0	7	34	41

Education and training programs was much emphasized by quantity surveyors at the Masters degree level as 13 respondents out 20 who argued this factor was important in establishing the way forward to BIM application in Tanzania. In this aspect therefore, there is a need to review the training programs and to introduce BIM concept knowledge to students, especially the Masters level so as to increase students' awareness towards to BIM application.

Among the factors given in the questions which asked the respondents to rate those measures that can bring about BIM implementation to the quantity surveying profession, respondents emphasized on; (1) Review the current program and establish programs that can include BIM concept and (2) The Government through its professional agencies should support the BIM implementation.

VI. CONCLUSION AND RECOMMENDATIONS

Conclusion

Awareness, Knowledge and Readiness for BIM Application

Awareness of BIM concept is low, majority of quantity surveying professionals are far behind the concept in general. The knowledge about BIM is also inadequate, but many firms are eager to adopt and implement BIM but the problem is where to acquire the knowledge. There are no institutes, colleges or universities or training centers that offer training regarding the BIM concept

Regarding readiness, many firms are ready to adopt this new innovative and collaborative environment of doing business in a modern way, saving time and cost. It is not true that firms are worried by the introduction of BIM in connection to the productivities of their works. In fact, BIM is coming to increase benefits for quantity surveyors practices rather than reducing their works.

Capabilities of Firms towards BIM Application

Most of firms have indicated their capabilities towards adoption and implementation of BIM. They are ready to prepare resources for doing research, planning and development. Unfortunately, on the other hand, most of the firms are not ready to set aside additional time to familiarize themselves with BIM tools. Probably that is because they use most of their time with the traditional methods, which makes it difficult to set aside additional time for learning BIM tools.

Training should be established to cater for a higher number of professionals who need to learn BIM knowledge. Indeed, BIM concept and more BIM specialists are needed to conduct in-house training within the firms as many firms may venture to take this as optional solution for BIM training. Conferences, seminars and workshops are also needed regarding BIM and its application.

And more important, quantity surveying professionals are required to change their mindsets towards this new technology.

Barriers against BIM Application

Lack of BIM training is one of the typical barriers towards BIM implementation to quantity surveying profession in Tanzania. There is a need for comprehensive training programs that can facilitate and impart knowledge of BIM to the quantity surveying professionals. Besides, unawareness is a problem or barrier towards BIM application to the profession.

Recommendations

Training

There are different approaches for training programs including; training institutes and centers, workshops, seminars, conference and in-house training. These should systematically be established so as to increase awareness to the professionals.

Government Intervention

A government is recognized as an important actor in relation to standardization and many professionals argues that, Government support towards BIM application can be helpful. This has been done by some European Countries including UK, Norway, Sweden, Denmark and France and Asian countries like Malaysia, Singapore, and Japan.

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