BUILDING INFORMATION MODELLING AND FUTURE QUANTITY SURVEYOR'S PRACTICE IN SRI LANKAN CONSTRUCTION INDUSTRY

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ABSTRACT

Sustainability has been an often mentioned goal of businesses, non-profit organizations and governments in the past decade, yet measuring the degree to which an organization is being sustainable or pursuing sustainable growth can be difficult. Building Information Modelling (BIM) is a new paradigm in the thriving Sustainable construction industry, from which the triple bottom line of the Sustainability can be greatly achieved. As the significance of BIM has become increasingly appreciated, most of the activities in the building industry have focused on BIM with sustainable design strategies. BIM has a great potential for integration into construction projects life cycle which will lead to pave the way towards becoming the industry standards for construction projects. Hence BIM would be a key tool in the project procurement in the future. However, BIM is not yet implemented in Sri Lankan construction industry where incorporation of BIM into construction projects life cycle would create differentiation in traditional procurement systems. Consequently, the role of Quantity Surveyors whose building procurement is based on BIM would be revolutionized drastically from the existing role where BIM permits to analyse the building, the structure, materials and performance in real time as it is being designed. Hence, a research is conducted with broader aim of exploring the potential expansions of QS roles, changing key roles and responsibilities of future Quantity Surveyors in a sustainable BIM based project delivery in Sri Lanka, which will lend a hand in training Quantity Surveyors to face future challenges. This paper contains the preliminary findings of a literature review conducted on the current key roles and responsibilities of Quantity Surveyors in local building procurement and future expectations in a BIM based project delivery.

Keywords: *Building Information Modelling; Quantity Surveying; Sri Lanka; Sustainability.*

1. INTRODUCTION

Building Information Modelling (BIM) is a new paradigm in the thriving Sustainable construction industry. BIM has a great potential for integration into construction projects life cycle which will lead to pave the way towards becoming the industry standards for construction projects and hence would be a key tool in the project procurement in the future. As a result, key roles of Quantity Surveyors (QS) in building procurement which is based on BIM would be quite different from today's roles. There are fears that adoption of BIM could threaten and challenge the existence of Quantity Surveying profession. There is a necessity to understand its potential expansions of QS roles in BIM based project delivery. Under this context, the work presented in this paper is a part of an on-going research which is conducted with broader aim of exploring the changing key roles and responsibilities of future Quantity Surveyors in a BIM based project delivery. While the ultimate findings of such a study will be helpful in training Quantity Surveyors to face future challenges, this paper presents literature synthesis of the same identifying the appropriate next steps to further the knowledge.

2. BACKGROUND

The construction industry is on the precipice of significant shift in the way that projects are executed. This shift promises to greatly improve the overall design and construction process. BIM and sustainable design construction are two important primary trends that are driving these changes in the industry (Johnson and Gunderson, 2009). Sustainable design is based on a number of factors, primary

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of which are climate, culture, place, building type and resources consumption. With the rising cost of energy and growing environmental concerns, the demand for sustainable buildings is growing day by day. Both public and private organizations are increasingly requiring architects and contractors to design and construct buildings with minimal environmental impact (Azhar and Brown, 2009). The most valuable decisions related to the sustainable design of a building can be made in the planning and design phases. As the significance of BIM has become increasingly appreciated, more activity in the building industry has focused on BIM and sustainable design strategies (Smith, 2007). Furthermore, Wong and Fan (2013) stated that it is believed that BIM is a critical element in reducing industry waste including wasted energy, adding value to industry products and decreasing environmental damage. According to Gleeson (2008) the combination of sustainable design strategies and BIM technology has the potential to change the traditional design practices, and produce a high-performance facility design. Therefore, there is a need for QS to get accustom to BIM based project delivery. This will pave the way towards the current Quantity Surveyors to become equipped with the necessary skills and competencies to ride the next global wave of sustainable development in order to remain in the forefront of the industry. The review follows first identifies the significant features of BIM and identifies their impact on QS roles.

3. BUILDING INFORMATION MODELLING

BIM is a new paradigm with the result of tremendous change for every professionals involved in the construction industry (Harris, 2011). BIM is not just software; it is both a technology and a process. The technology component of BIM helps project stakeholders to visualize what is to be built in a simulated environment to identify any potential design, construction or operational issues. The process component enables close collaboration and encourages integration of the roles of all stakeholders on a project (Azhar *et al*., 2012).

Several researchers have found that BIM is the process of creating a digital parametric model which represents the physical and functional characteristic of a building in full detail and further shared knowledge pool which can be used to form reliable decisions during the design, construction phases and throughout the life cycle of the facility (Eastman *et al.,* 2011; Suranga and Weddikkara, 2012). To create relationship between objects with in a virtual building model BIM uses parametric object modelling technology. These relationships include physical and functional characteristics as well as project life cycle information (Azhar *et al*., 2008). According to Wong and Fan (2013), BIM consists of information representing the entire building and the complete set of design documents stored in an integrated database. Hence it is clear that all the information is parametric and thereby interconnected. If any changes to an object within the model automatically it will affect the related assemblies and constructions. Furthermore, Jayasena and Weddikkara (2012) added that, BIM is not a software application. Instead it is an IT solution for integration of software applications and IT tools to design a building in a common platform, a platform which is independent of the software we use. Therefore BIM can be clearly differentiated from traditional Computer Aided Design (CAD).

3.1. CONVENTIONAL CAD AND NEW BIM APPROACH

BIM is a successor to the computer-aided drafting (CAD) was initially based on two dimensional drawings and lately on 3D views. However, these drawings lacked the interactivity and the change in one view was not automatically reflected in other views. With the advent of BIM, this practice has gradually started changing since the beginning of the 21^{st} century. BIM based architectural software have allowed the automatic updating of views once the change is made in one view by the production of intelligent 3D/4D models. Besides the form (geometry), BIM is further meant for modelling the functions and behaviour of building systems and components (Sacks *et al.,* 2004).

BIM is gradually replacing the 2D or 3D CAD technology in many parts of the world. Although, most of these drawings can be prepared using conventional CAD software, BIM software produces these drawings more efficiently as part of the BIM and have the added advantage of parametric change technology, which coordinates changes and maintains consistency at all times (Azhar *et al*., 2010) The principal difference between BIM and 2D CAD is that the latter describes a building by 2D drawings such as plans, sections, and elevations. Editing one of these views requires that all other views must be checked and updated, an error-prone process that is one of the major causes of poor documentation today. In addition, the data in these 2D drawings are graphical entities only such as lines, arcs and circles, in contrast to the intelligent contextual semantic of BIM models, elements and systems such as spaces, walls, beams and piles (Ballesty, 2007).

3.2. BIM BASED PROJECT DELIVERY

BIM based project delivery can be known as the project which is based on BIM applications spans over the entire life cycle of a facility such as; project programming, design, preconstruction and post-construction phases. According to Autodesk (2013), the traditional 2D CAD-based design approaches focused on increasing the productivity of the construction document phase, a BIM-based design workflow changes the process in a more fundamental way by enabling the sharing and incremental enhancement of design information through all project phases. Following figures illustrate the development process traditional Design-Bid-Build Delivery System and BIM based delivery system.

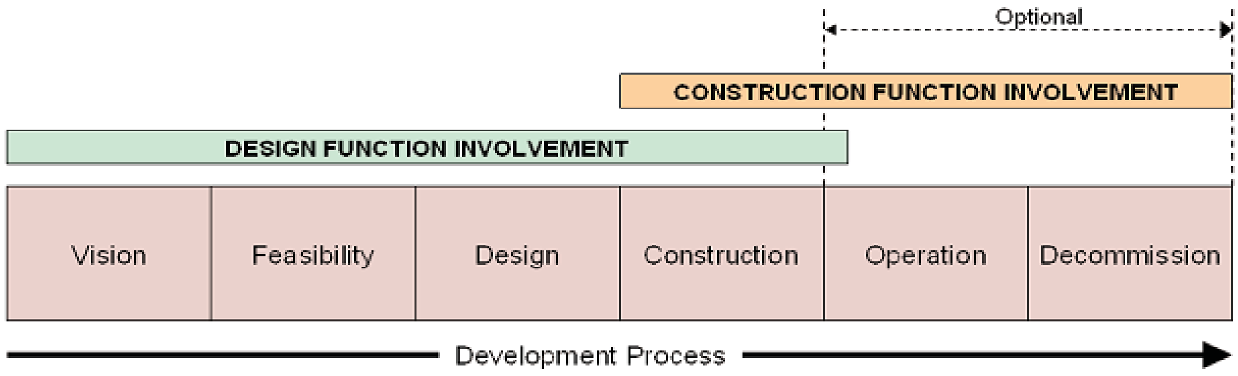

Figure 1: Design-Bid-Build Delivery System

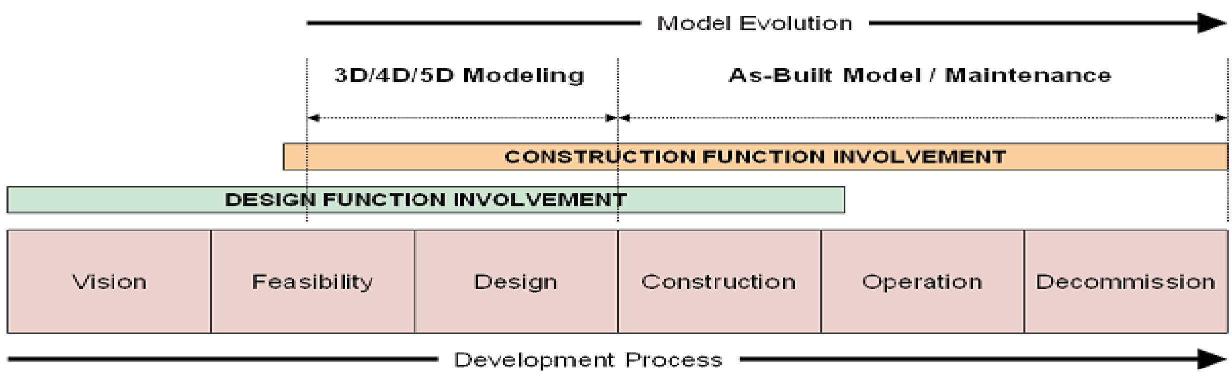

Figure 2: BIM Based Delivery System

The contrast of timeline interactions between design and construction functions in various project delivery systems are displayed in Figures 1 and 2. Figure 2 displays the involvement of the construction function stakeholder as early as the feasibility stage in BIM based project delivery which contains lot of benefits that identified by Ballesty, (2007) are listed below.

- Faster and more effective processes – information is more easily shared and can be value added and reused.
- Better design – building proposals can be rigorously analysed, simulations can be performed quickly and performance benchmarked, enabling improved and innovative solutions.
- Controlled whole life costs and environmental data – environmental performance is more predictable; lifecycle costs are understood.
- Better production quality – documentation output is flexible and exploits automation.
- Automated assembly – digital product data can be exploited in downstream processes and manufacturing. Better customer service – proposals are understood through accurate visualization.
- Lifecycle data – requirements, design, construction and operational information can be used for, for example, facilities management.
- Integration of planning and implementation processes – government, industry, and manufacturers have a common data protocol.
- Ultimately, a more effective and competitive industry and long-term sustainable regeneration projects.

Understanding about the BIM is compulsory for Quantity surveyor. Incorporation of BIM into the QS profession, leads Quantity Surveyor to perform their practices in a sustainable manner. The below sections are described how the BIM can be helped to perform cost management roles of quantity surveyor.

4. KEY ROLES OF QUANTITY SURVEYORS IN THE CONSTRUCTION INDUSTRY

Quantity surveyors are ubiquitous in the construction industry (Poon, 2003). According to a report published by RICS in 1971, the quantity surveyor's roll is "to ensure that the resources of the construction industry are utilized to the best advantage of society by providingthe financial management for projects and a cost consultancy service to the client and designer during the whole construction process". As we discussed earlier in introduction part, there are several roles which perform by the traditional QS. The key roles of a Quantity Surveyor are to perform financial control, cost and contractual administration of a project at every stage, from inception to completion. Table 4.1 most important Cost management roles of QS in the construction projects.

Table 4.1: Cost Management Roles of QS in the Construction Projects

Pre - Contract	**Post - Contract**
Preliminary cost estimating	Interim valuation and Payment
Procurement Advice	Final account preparation
Cost planning	Settlement of contractual disputes
Measurement of Quantities	Cost control during construction
Preparing Bills of Quantities	Analysis of Financial Risks
Bidding Process	Insurance Valuations

Source: (Willis *et al.,* 1994)

Quantity surveying is an essential part of the construction process, from project inception to building completion. It is a profession that necessitates both a high degree of knowledge and finely honed deployment skills. It entails accurate interpretation of designs and numerical representation of component quantities. Traditionally it is a manual process and such, is prone to errors as well as being very time consuming. However, time issues can be addressed and errors eradicated by automating the process BIM. Some cost management function of Quantity Surveyors are identified above table 4.1 briefly explained as follows.

Preliminary Cost Estimating

A process in which a BIM model can offer a reasonable accurate quantity take-off and cost estimate early in the design process and provide cost effects of additions and modifications with potential to save time and money and avoid budget overruns. This process allow designers to see the cost effects of their changes in a timely manner which can help curb excessive budget overruns due to project modifications. If the BIM model is shared with contractor, time for detail estimate can decrease dramatically and precision can go up (Colleen, 2009).

Procurement Advice

According to Boon (2009), for the potential of BIM to be realized, additional work early in the design process is necessary to set up the model and develop and analyses alternative design solutions. Adjustments to fees and timing of payments may be necessary to facilitate this. Similarly it is necessary to involve the contractor in virtual prototyping exercises for them to be meaningful. A procurement method that allows early contractor involvement is therefore necessary to realize this potential. Further, the use of BIM models that integrate the work of the architects, engineers in their many forms, contractor, subcontractors and suppliers creates new legal issues. Thompson and Miner (2006) identify the following:

- Who owns the BIM model and the intellectual property contained in it?
- Who controls the entry of data and who is responsible for inaccuracies?
- Who is responsible for the integration process and checking for dimensional coordination and clashes?

For quantity surveyors involved in providing procurement advice to clients these are issues they need to take account of and deal with in an arena where practice is rapidly evolving.

5D Cost Planning

Cost planning services that deliver cost certainty through realistic and precise cost estimates from inception to construction and at any point throughout all levels of development (Mitchell Brandtman, 2013). The broad objectives of cost planning are to ensure that the client receives an economical and efficient project in accordance with the agreed brief and budget, make the design process more efficient thus reducing the time needed to produce a successful design and, ensure that all work arising from the client's brief to the design team is included in the cost planning process. Specifically, cost planning is conducted to predict the contract sum by allocating cost targets to different parts of the building. It is also conducted to avoid abortive design work and provide a basis for cost control (Hua, 2010). Therefore, BIM provides facilities to quantity Surveyor to do cost plan automatically throughout the building elements.

Cost Estimating

Automated quantities generation provides a faster, more accurate tool to analyse data and provide better advice. This enables real-time options modelling and facilitates scenario testing to explore ways to improve building design, efficiency, performance and cost (Shaw, 2010). Quantity take-offs from a BIM model enable project teams to quickly generate cost estimates to assist in decision-making and provide cost information about alternatives to owners early in the design phase and throughout the project lifecycle. The BIM model is integrated with cost information from an estimating database, and this approach has proven to be quicker and reduces the possibility for errors and omissions. It can also reduce quantity take-off time and allow estimators to focus on higher value activities, such as identifying construction assemblies, generating pricing, and factoring risks (Autodesk, 2013).

Preparing Bills of Quantities

BIM is now liable for executing many traditional QS functions automatically with its 4D modelling capabilities. A BIM system can computerize the measurement of quantities from construction drawings. This will facilitate quantity surveyor to have design documents which include exact quantities and specified materials in electronic format. With the utilization of a correctly configured Building Information Model, a BOQ can be generated automatically. The BOQ is then applied to create reports in the essential format. This is performed with any phase of the QS dispatch ranging from estimating, tendering and construction control (BIM Outsourcing, 2013).

Bidding Process

Competitive tendering and bidding with BIM models can reduce the risky gap that exists between project members due to the transparency and accessibility to project information and documentation (Graham, 2010). In the Bidding stage, traditional tender process can be used for procurement. The BIM provided substantially higher quality construction information than conventional working drawings and provide a 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, further enabling more accurate bids. The bidders could fully understand the building and their associated risk, which reduces the tender return prices (American Institute of Architect [AIA], 2008)

Cost Control

With the development of 3D building information modeling (BIM) combined withquantity information management, quantity and cost progress can be monitored and controlled in real-time, with accuracy and with transparency. Discrepancies, cost overflows and problems are seen earlier and steps can be taken to rectify them or at least minimize the consequences. The key issue is that quantity and cost information is monitored on as-it-happens basis and as-built quantity surveying is done in line with progress on site. Accurate quantity control can provide numerous benefits to the project as it is the basis for cost management, schedule management, procurement, logistics and resourcing. The more accuracy used and more importance given to it, the better the results: a better managed project (Gren, 2008).

4.1. NEED OF A QS TO GET ACCUSTOM TO BIM BASED PROJECT DELIVERY

Over budget, delays, rework, standing time, material waste, poor communication and conflict are the typical issues that have been faced by the today construction industry. With added pressures from the current global economic difficulties, the need to address and resolve these problems has never been greater. Key to tackling such widespread and internationally recognised woes could be through optimising building design information exchange efficiency and accuracy with a view to creating great certainty in delivery of construction projects. Therefore, the intelligent BIM may offer a solution to above deficiencies (Hooper, 2012).

Furthermore, Owners are often faced with cost overruns or unexpected costs that force them to either "value engineer or Quantity Surveyor" go over budget, or cancel the project. To mitigate the risk of overruns and unreliable estimates, owners and service providers add contingencies to estimates or a budget set aside to cope with uncertainties during construction (Touran, 2003).Unreliable estimates expose owners to significant risk and artificially increase all project costs. The reliability of cost estimates is impacted by a number of factors, including market conditions that change over time, the time between estimate and execution, design changes, and quality issues (Jackson, 2002).The accurate and computable nature of BIM provides a more reliable source for owners to perform quantity take-off and estimating provides faster cost feedback on design changes. This important because of the ability to influence cost is highest early in the process at the conceptual and preliminary phase (Eastman, *et al.,* 2008). Furthermore, quantity surveyors cite insufficient time, poor documentation and communication breakdowns between projects participants, especially between client and QS, as the primary causes of poor estimates (Akintoye and Fitzgerald, 2000).

Several researchers evaluated that reasons for adoption of BIM in to the Quantity Surveying profession are as follows (Thomas, 2010);

- 30% of projects do not meet original programme or budget
- 92% of clients said that designer's drawings are typically not sufficient for construction
- 37% of materials used in construction become waste
- 10% of the cost of a project is typically due to change orders
- 38% of carbon emissions are from buildings not cars

This brings forth the argument that as BIM reduces the resources needed for a construction project and costs are saved on the reduction of resource, professional fees needs to be adjusted downward (Gee, 2010). Today, use of BIM is typically limited to the late phase of design and engineering or early phases of construction. Use of BIM earlier in the design process will have greater influence on cost. Improving overall cost reliability is a key motivator for employing BIM based cost estimating methods (Eastman *et al.,* 2008).

Considering the current academic research, in professional development and industrial market, BIM is being considered highly significant to the future development of construction information technologies and to the construction industry (Azhar and Brown, 2009). Further, BIM has emerged as an innovative way to manage projects. BIM accelerates collaboration within project teams, which will lead to improved profitability, reduced costs, better time management and improved customer/client relationships (Azhar *et al*., 2010). Therefore, there should be the needs for QS to get accustom to BIM based project delivery.

4.2. CHALLENGES OF BIM

A major challenge is that most design firms are hesitant to practice on real projects. Therefore, they often set up a BIM group and let BIM guys work in parallel with the project's teams. As a result, the project will have a BIM model but the project's team will have had very limited exposure to BIM. Worse yet, this practice will often bring more costs to the project, since the BIM teams' efforts will add extra cost and may not contribute much savings (Wang, 2012). Some problems with BIM highlighted by Howell and Batcheler (2004) include:

- BIM systems create big and complex files hence the scalability and manageability of a fully loaded central BIM project database becomes a major challenge.
- Sharing BIM information as drawing files. Users are defaulting back to exchanging documents (drawing files created as views of a building model) rather than sharing intelligent objects from the model.
- The need for increasingly sophisticated data management at the building objects level. Pioneering model server technology is only now being developed to help address issues which surface when multi-disciplinary design teams try to adopt a single BIM such as object versioning, object-level locking and real-time, multiuser access.
- A contradiction in work process when using a single detailed BIM to try to represent a number of the alternative design schemes under consideration. While parametrically defined building objects can quickly be recreated based on the input of selected dimensions and properties, the need to maintain separate BIM models for different design alternatives is prohibitive
- Every company on the project team cannot adopt one BIM system. Each company normally has its own preferred and trusted software applications for design and analysis. It is very rare that a single technology is being used on any one building project between different companies and across all phases of the project lifecycle rather than being dependent on a single building model, project team members typically rely on a number of purpose-built models.

4.3. Influence of BIM and Effect Towards QS Roles

Traditionally quantity surveyors fulfilled the role of measuring and valuing construction works. With the deterioration of this role, quantity surveyors have been evolving and adapting their services that have led them to become professional experts on the contractual and financial aspects of construction developments and the management there of (Ballesty, 2007). The changing role of the quantity surveyor lies in the ability to remain key advisors on the financial and contractual decisions on construction developments. Quantity surveyors need to keep reinventing themselves and continually add value and enhance their professional services (Ashworth and Hogg, 2007; Sutrisna *et al*., (2005) specified that, Conventional construction estimating practices have been criticized as there is hardly an estimate without its own peculiarities and current estimating processes are seen by some as too rigid. BIM remains a nascent ideal whose realization is probably many years off. However, the rewards are high as the time taken to measure buildings will be markedly reduced, leaving more time for estimating calculations (Olatunji *et al*., 2010). Masidah and Rashid, (2005) argued that, measurement and pricing of construction works are important functions provided by Quantity Surveyors. This is central to the contention that BIM's potential to automate quantity measurement might threaten clients' requirements for quantity surveying services. BIM is a major challenge to the services conventionally provided by quantity surveyors and other construction disciplines. The adoption of BIM may redefine traditional professional boundaries in construction (Olatunji *et al*., 2010). Following are some of the barriers and risks identified for the QS profession with incorporation of BIM.

4.3.1. Software and Computer Systems

Regardless of the many limitations of the collaborative capabilities of software supporting the traditional methods for developing construction products, most professionals prefer such system due to the traditional approach to 'software implementation' enables the systems to be user-friendly. Further, they offer a gradual change to using automated systems and most systems present data in traditional paper format such as take-off paper (Matipa, 2008). However, Current systems seem to be working well, yet they severely impact on the pace at which the quantity surveyor performs his responsibilities at the design stage of the construction project (Matipa, 2008). Cost estimates are prone to contain various inaccuracies as they are usually based on limited information and prepared within a limited time frame (Aibinu and Pasco, 2008). In an ideal BIM environment, first step would be the design of a 3D model of the client's proposal and the second will be to automatically generate resource demands, cost calculations or estimates, list of product specifications and bills of quantities (Popov *et al*., 2009). This requires the extraction of all dimensions and information on building components from the 3D model and then combining it with databases containing unit costs and other data (Bazjanac, 2010).

4.3.2. Adjusting Services and Responsibilities

Traditionally, when the design of the proposed project is at a point where it can almost be frozen, the Quantity Surveyor starts to prepare bills of quantities and other documentation that can support the procurement process. Estimating in the design phase is usually conceptual and is based on limited project information, with the consequence that Quantity Surveyors are more involved in the latter part of the design appraisal process (Matipa, 2008).

The automation of bills of quantities reduces error and misunderstanding and evolves in step with the design changes (Ashcraft, 2007). It removes some of the tedium and speeds up the process (Ashworth and Hogg, 2007). This leaves more time for analysis, interpretation and organization of data into a logical, consistent and cognizant format, and shifts the traditional role of costing a design to designing to a cost (Matipa, 2008). Designing to a cost satisfies the demand for 'value for money' and therefore fulfils one of the cardinal responsibilities of the quantity surveyor (Petric and Maver, 2003). However, prevention of inaccuracies of data re-entry and ensure consistency between models creates the need for an individual to manage the data exchanged between consultants.

4.3.3. *TRAINING AND EXPENSES*

The development of new technology and the implementation of new methods and tools usually go hand in hand with multiple expenses and a lack of knowledge and skill relating to the technology. The transition phase from traditional methods to new generation, BIM technology will not come without the necessary challenges. The lack of knowledge and skill relating to sophisticated software and techniques are usually easily over come through training programs, seminars workshops and software tutorials (Rundell, 2010).

4.3.4. *PREREQUISITES FOR QUANTITY SURVEYORS*

New skills will be required by project team in order to use BIM with significant outcomes and fee scales will need to be adjusted in order to commensurate with professional responsibilities (Olatunji and Sher, 2010). RICS (1971) emphasized that the distinctive competencies or skills of the Quantity Surveyor are associated with measurement and valuation which provide the basis for the proper cost management of the construction project in the context of forecasting, analysing, planning, controlling and accounting.

5. CONCLUSIONS

BIM is a major challenge to the services conventionally provided by Quantity Surveyors and other construction disciplines. BIM is a development aimed at integrating working systems and adding value to building economics and project delivery (Matipa, 2008). It offers to remove routine and drudgery from many activities and produce high standard results (Ashworth and Hogg, 2007). Quantity surveyors are still relaying on the production of bills of quantities to feature as their main line of business, this is reducing substantially due to the automation of this task (Matipa, 2008). The changing role of the quantity surveyor lies in the ability to remain key advisors on the financial and contractual decisions on construction developments (Ashworth and Hogg, 2007). Quantity surveyors that are able to overcome these challenges will secure their future in the technologically developing industry. Therefore they need to focus on enhancing the learning experience on BIM technology and collaboration techniques, updating industry methods and techniques and development of QS specific skills such as visualisation (3d viewing), quantification, and data scheduling and pricing and finally multi-disciplinary work based projects. In order to understand the future role of QS into further detail, a thorough study on what specific information will be made available for him from BIM at different stage of the project and what information the QS has to contribute at each stage is required. This is identified as the way forward for the current study.

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