5-Dimensional BIM and the Challenges of Adopting Measurement Standards

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Key words: Building Information Modelling, Classification Systems, Measurement Standards, Project cost, Quantity Extraction

Summary

The five-dimensional BIM (5-D BIM) considers a project cost and schedule in addition to spatial design parameters in 3-D, therefore allowing project participants to identify, analyse, and record the impact of changes on project costs and scheduling. However, the Nigerian construction industry still relies on bespoke software tools and there is no common platform to exchange project information among project participants. There is lack of single source that provides integrated project information that can be used for rule-based quantity take-off and estimation in 5 -D BIM. This study identifies the challenges of adopting measurement standards in 5-D BIM in the Construction Industry of developing economy. Online questionnaire survey to practitioners (Architects, Engineers, Quantity Surveyors) that has been previously involved on BIM projects in Nigeria and semi-structured interview to quantity surveyors. The interview was designed to figure out the existence of classification systems used in the industry, the relationship between such classification systems and measurement standards, how quantities are extracted for BIM, the feasibility of using measurement standards for quantity extraction and estimating in BIM models, and suggestions to enable the use of measurement standards in 5-D BIM. The study also investigates how design information are exchanged among project participants. Findings from the study show that, 79% of the participants believed there is no classification systems in the construction industry, 20% have no knowledge of the use of classifications systems, 45% pointed out that there is no relationship in the measurement standard used and industry classification systems, 10% of the participants stated that they have organisation-based classification system used for BIM projects. Findings from the study have allowed conclusion to be drawn that there is no building classification system in the industry that provide basis for information exchange among project team. That there is no synergy between measurement standards used by cost consultants and design information produced by the designers. Therefore, cost information is extracted separately to another software before quantity extraction and estimation could be carried out by cost consultants. This study is important because it contributes to the research on 5-D BIM adoption by cost consultants and addresses the challenges faced in the use of measurement standards.

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1. INTRODUCTION

The traditional approach to quantification, estimation and pricing of BOQ items by Quantity Surveyors (QS) is time consuming, inefficient and susceptible to human errors. Quantity Take-Off (QTO) is generally performed manually or using software packages from 2D or 3D Computer-Aided Design (CAD) drawings. This inefficient and time consuming traditional practice by QS can be replaced by automating the processes through adoption of Building Information Modelling (BIM). BIM is defined by Gu & London (2010) as an IT enabled approach that involves applying and maintaining an integral digital representation of all building information for different phases of the project lifecycle in the form of a data repository. BIM has the capabilities to automate quantity take-off, estimating and production of BoQ Perera et al (2012) but it requires a move away from the traditional sequential workflow, to an environment where all parties share and effectively work with a common information pool (Pittard & Sell, 2016).

Adoption and usage of BIM have the potential of removing the problem of lack of collaboration affecting the construction sector, removing wastage and creating efficiencies both at the design stage and construction stages (Eadie, et al., 2013; Eadie, et al., 2014). BIM is based on information schema which makes the activities in the construction industry readable by machine. This capability enables automation of various design, construction management, quantity surveying and procurement processes while reducing design and construction errors (Fung, et al., 2014). Therefore, BIM offers the potentials for risk reduction, enabling sustainable procurement systems for the industry and encouraging adoption of lean approaches for project delivery. However, for BIM to be routinely used in the construction industry, literature observed that there would be need for adoption of common standard and operational protocol among other issues.

The traditional standard commonly used by the QS is referred to as Standard Method of Measurement (SMM). SMM is the name of the document codifying the uniformity in description and measurement of items of construction works, and the version currently used by Nigerian Quantity Surveyors (NQS) is referred to as Building and Engineering Standard Method of Measurement (BESMM4). BESMM4 was developed according to NIQS (2015) to: Prescribe the method and procedure for determining dimensions, and calculating the quantities of measured items; lay good basis for automated applications in terms of software and systems development thereby allowing users to price tender documents more efficiently and lay good foundation for effective collaboration by quantity surveyors and other project team which is a major requirement for Building Information Modelling (BIM) adoption.

In the current industry practice, the use of paper drawing is reducing, electronic drawings (2D and 3D CAD) is replacing paper drawings and enabling automated quantity extraction through new tools. The user of CAD-based tools has pointed out that automated measurement requires that models, documents, project information and specifications need to be organised to ensure interoperability and allow the external processes such as cost planning to take place. Hence a system needs to be put in place to classify the BIM data. Available systems include Uniclass, NRM 1, 2 and 3, CESMM, SMM, BCIS, NBS BIM Toolkit, MasterFormat (US) and UniFormat (US). However, models are often structured using the classification that is built into the original authoring software which allows the QS/cost manager to map the majority of classification systems across to NRM.

Classification systems constitute the backbone of effective model–based information exchange among construction project participants (Eastman, Teicholz, Sacks, & Liston, 2011). Interoperability issues in the construction industry cannot be easily resolved without a set of rules and principles for classification of information requirements into data exchange specifications (Boon and Prigg 2012; Abdulahi, Abdullahi, & Musa, 2016, Amuda-Yusuf 2016). These classification systems differ greatly from country to country such as MASTERFORMAT and UNIFORMAT (now in Omniclass) in the US and Canada (Dell'lsola, 2002 Goedert and Meadati, 2008); Unified Classification systems for the Construction Industry (Uniclass) in UK (Boon and Prigg, 2012; Gelder, 2013); and Building 2000 in Finland because it supports BIM (Firat, *et al.*, 2010).

Literature Review

Building Information Modelling (BIM) is a methodology for generating, exchanging and managing a constructed facility's data throughout its life cycle. While BIM is solidly rooted in technological advances, partially transferred from other industries, it extends into the realm of social exchanges between organizational actors. As a transformative approach to designing, constructing and operating in the built environment, BIM includes a wide range of concepts, tools and workflows which need to be learned and applied by industry stakeholders (Succar & Sher, 2013). Various models have been espoused by authors to describe maturity models of BIM at industry level. The models are adopted to differentiate adoption and awareness levels by the practitioners. This is further explained in the ensuing sections.

The Bew-Richard presented a model that identifies basic CAD (Computer Aided Draughting) as **Phase 0** which implies "no BIM maturity". this phase is a replacement for traditional drawing board where design information is presented using lines and curves on a 2D plane. The final drawings contain no intelligence such as layering and models. This phase is the use of unmanaged CAD and 2D with hard paper or electronic paper are used as exchange mechanism (BIM Industry Working Group (BIWG) (2011) this phase of maturity can be regarded as infant industry (Jayasena and Weddikkara,(2013). Similarly, Succar (2009) presented a three-stage linear BIM maturity model. The stage one of the model is referred to as the pre-BIM stage which represents the conventional building practices, or the industry before the implementation of BIM. This stage includes both manual and computer-based documents such as
CAD drawings and spreadsheet schedules. Under the pre-BIM stage, even 3D CAD is not considered as stage of maturity of BIM. This implies that, until and unless the modelling is object-based, it will not be considered as a BIM maturity phase. Khosrowshahi & Arayici,

(2012) considered that the pre-BIM stage would be characterized by 2D draughting, document-based linear workflows, one-directional electronic communication, and lack of interoperability

Under the Bew-Richard model, Phase 1 is characterized with the use of intelligence on basic CAD usage as the entry into early BIM maturity level. This embodies the use of a managed CAD with 2D or 3D drawings with the introduction and application of information standards such as those introduced by the UK Construction Project Information Committee (CPIC) and supported standards. The UK Uniclass establishes the methodology for managing the production, distribution and ensuring reliability and improving quality of construction information including that generated by CAD systems, using a well organised system for collaboration and specified naming convention. The standards is used by all parties involved in the preparation and use of such information throughout the design, construction, operation and deconstruction of projects and throughout the entire life cycle of the project. Owen et al. (2010) emphasized on the need to get maximum benefit of innovative technologies by ensuring improvements in terms of people, process and technology for better productivity in the industry. The features of these are collaborative processes, enhanced skills, integrated information and automated systems, and knowledge management. This is the ultimate goal of BIM adoption at industry level. This is referred to as phase 2 and 3 in the BIM maturity models presented by in Bew-Richard and Succar.

While the benefits of BIM adoption cannot be disputed, there are several concerns about its success as well as the strategies to be adapted in it implementations in various developing countries (Olatunji, et al., 2010; Abubakar, et al., 2014). The future adoption of BIM technology in the lifecycle of construction projects in Nigeria construction industry is inevitable, but there is currently lack of clear roadmap for BIM implementation in Nigerian construction industry. The rate of BIM adoption in developed countries is increasing and many countries have released policies to implement mandatory BIM adoption (Eadie, et al., 2013; RICS, 2014; RICS, 2015; Rogers, et al., 2015). The shortage of IT literate personnel as well as an absence of National BIM implementation programs is affecting BIM implementation in the context of developing countries (Kori & Kiviniemi, 2015; Bui, et al., 2016, Amuda-Yusuf 2018). According to Morlhon, et al., (2014) a transition as well as technical mind-set is compulsory to achieve the benefits that BIM offers. He pointed out that, the challenge of seamless data interchange is possibly the major barrier to the widespread adoption of building information modelling.

2. INFORMATION CLASSIFICATION AND MEASUREMENT STANDARDS

The information classification standards created by the Architectural Engineering and Construction Industry (AEC) are called Construction Information Classification Systems (CICS) and often defined as standard representation of construction project information (Carlos & Soibelman, 2003). The classification structure in CICS according to Klang and Paulson (2000) provided a common framework for improving organisation and coordination of information in construction projects. As the CICS codes serves as key fields for transferring information among project teams and facilitates access and management among project organisations. A CICS must consist of both a Work Breakdown Structure (WBS) for classifying information that comes from actual construction phases and an information management system for classifying materials such as construction product literature, procurement documents, and technical standards (Maritz, Klopper, & Sigle 2005)

It is important to note that, the standardised national classification systems started in the 1950s and 60s, in the Scandinavian countries, and some of the national information classification systems used in other countries include; the Swedish Classification System (SfB), the UK Common Arrangement of Work Sections (CAWS) and Unified Classification Systems (Uniclass); the Singapore's Code of Practice for Classification of Construction Cost Information (SS CP80: 1999) and Code of practice for Classification of Construction Resource Information – SS CP 93:2002, The Australian National Specification Systems (NATSPEC) (Winch, 2010). The use of CICS as basis for electronic measurement standards in selected countries is discussed in the next sections.

2.1 The Swedish Building Classification Systems

The Swedish building classification system (SfB) is one of the most important classification systems in use. The system originated from Sweden and had been in use since 1945 and is still the basis for many existing national knowledge classification systems such as CI/SfB used in the UK (Winch, 2010). The committee that was responsible for the establishment of SfB was called Samarbetskommitten for Byggnadsfragor, from which the acronym SfB was formed. The SfB was centrally adopted in Sweden as the national method for organising official and national construction industry specifications, price books and building product sheets (Maritz, *et al.,* 2005). The SfB system set-out information in such a way that it can be easily stored and retrieved for quick reuse.

The weaknesses in CI/SFB as identified by Winch (2010) are: it applies only to building and not civil engineering; it does not contain classifications for process elements; its coding system is inappropriate for computerisation; new facility types have developed which are not included. The limitations associated with this classification system leads to the publication and adoption of globally recognised classification principles known as Unified Classification for the Construction Industry (Uniclass) in the UK published in 1997 (Winch, 2010). UniClass is the UK implementation of BS ISO 12006-2. The new code of practice, BS 1192:2007 referred to as collaborative production of architectural, engineering and construction information, published in January 2008, recommends the use of Uniclass (Gelder, 2010). Uniclass was adopted as basis for the classification of the revised SMM7 in the UK as explained in ensuing sections.

2.2 The UK CAWS, UNICLASS and Measurement Standards

The CAWS first published in UK in 1987 purposely to promote standardization and coordination between Bills of Quantities (BoQ) and specifications. It is the document used to set–out the National Engineering Specification (NES), the National Building Specification (NBS), and the seventh edition of the UK standard method of measurement (SMM7) (Seeley and Winfield, 1998). The CAWS comprise of 24 levels "1" group headings and about 300 work sections divided between building fabric and services; section numbers are kept short and cross reference are made to the specification to facilitate consistencies between various documents used on building project (Finch, 2012). Project specifications often prepared by designers and arranged on the basis of the CAWS; this is similarly applicable to the library of clauses in both the NBS and the NES for services installations (Gelder, 2010; Gelder, 2013). The lists of items in each work section are coded to allow for completion of specifications and advice on specification preparation by reference to British Standards (Co-ordinated Project Information, 1987). The overall aim of this is that, if the descriptions in the BoQ are cross referenced to clause numbers in the specification, then the co–ordination of drawings, specifications and BoQ will be improved and the risk of inconsistent information will be reduced (Seeley 1989; Seeley and Winfield 1998; Ashworth 2004; Brook 2008). The major shortcoming of CAWS is that, it does not easily adaptable to computerised applications. The alphanumeric order in CAWS is not ordered in elemental format; therefore, it is not suitable for object naming in the software models. This constitutes one of the reasons for the development and implementation of Uniclass in the UK.

However, Uniclass is a more current classification system published in UK in 1997 for the UK construction Industry (Finch 2012). The Uniclass was made of a new work section classification which incorporates CAWS in Table J and replaces the conventional CAWS published in 1987. Uniclass also incorporates the Electronic Product Information Co-operation (EPIC) which is a new European standard for structuring product data and product literature. The elemental classification of building products is incorporated in Section G of Uniclass (Gelder, 2010; Gelder, 2013). One of the main reasons for this development is the need for classification systems and specification of designs to accommodate civil engineering and process engineering, as well as architecture and landscape. Another reason for the development of Uniclass is the requirement for the classification of works to include a description of all anticipated works that a contractor may carry out on a project. The CAWS cannot accommodate these requirements. The main function of Uniclass system was to unify all available classification systems developed in UK; Uniclass was based on CI/SfB, CAWS, CESMM3 and EPIC and the tables are arranged to represent the different facet of construction information unified with sub-titles and coding system. This approach according to Gelder (2010) and Finch (2012) laid an efficient basis for computer applications and can be used in: establishing product literature; organise project information; developing technical and cost information; structuring frame of reference for databases; set-up Libraries.

2.3 The Singaporean SS CP80:1999 and SSCP 93:2002

The SS CP80:1999 was developed to serve the key purpose of allowing the exchange of data and information to guarantee effective communication of design, construction and contractual matters relating to cost through a uniform and accepted classification format. The main components of the standard are: an elemental classification; a work-section classification; a mapping dictionary for elements and work sections and a set of guidance notes. The standard was developed in 1999 by reviewing relevant international standards and an adaptation of a few international standards to suit local use (Productivity and Standard Board (PSB), 1999). Users of this standard in Singapore are property developers, architects, mechanical and electrical engineers, civil and structural engineers, quantity surveyors and contractors. The long-term benefits for users include an efficient information exchange between different parties, reduction in duplication of work between the different disciplines, increased familiarity with a uniform standard leading to an overall increase in productivity for the company as well as the industry. In Singapore, the Construction Industry IT Standards Technical Committee (CITC) formed in 1993 and the Construction and Real Estate Network (CORENET) formed in 1998 for ensuring that national standards are aligned with international standards as well as other industry de facto standards; leading to the publication of Singapore standards (Goh & Chu, 2002):

The Singapore Standard Code of Practice for Classification of Construction Cost Information is to ensure that construction cost information is structured and stored in a way that is consistent and reliable within and between the different disciplines to reduce any duplication of work. In addition, the Code of Practice for the Classification of Construction Resources Information will present a uniform system for classifying information relating to construction products, materials, services and machinery. The main purpose of the standard is to develop and provide a standardised format to facilitate procurement activities in the construction industry as construction projects are used for a broad range of products and services, there is a greater need for a classification standard to ensure a consistent and structured way of information exchange and storage (Goh & Chu, 2002). The Singapore industry appears to have made the most progress in agreeing a coding system to facilitate exchanges of information between computers based design models and costing systems. According to Boon & Prigg (2012) the Singapore Standard CP97: Parts 1 & 2 2002 "Code of Practice for Construction electronic standards" is aligned with Singapore Standards CP 93:2002 classification of construction resources information and CP 83: 2000 construction computer-aided design, to ensure a common classification and coding system is adopted across the industry.

2.4 The Australian NATSPEC

The Australian NATSPEC was developed and published by the Construction Information Systems Australia (CISA). CISA established in 1975 with the primary responsibility to develop, produce and maintain the national building specification in Australia. NATSPEC is arranged around work sections that are broken down into subsections, clauses and then sub-clauses (Nani & Adjei-Kumi, 2008). NATSPEC also covers tendering procedures, preliminaries, quality assurance and contract issues. The fifth edition of the Australian Standard Method of Measurement is linked to the structure of NATSPEC. These basic classifications provide a comprehensive classification system for knowledge of the construction process and constructed product which can be used for the storage of both physical media such as catalogues and drawings, and digital media in databases (Winch, 2010). International standards for the layering of CAD models covered by the ISO 13567 series also rely on ISO 12006. Uniclass incorporates the UK classification standards for the construction process CAWS and is, therefore, compatible with both SMM7 and CESMM3 (Eastman & Liston, 2008).

The classification, terms of set–out, terminology and sections of the fifth edition of Australian Standard Method of Measurement (ASMM5) were aligned with the classification systems in NATSPEC. NATSPEC also covers tendering procedures, preliminaries, quality assurance and contract issues. These basic classifications provide a comprehensive classification system for knowledge of the construction process and constructed product which can be used for the storage of both physical media such as catalogues and drawings, and digital media in databases (Winch, 2010). Therefore, BoQ based on ASMM5 are readily aligned with NATSPEC sub–

contract sections. NATSPEC was jointly developed by all key stakeholders in the Australian construction industry. Rationalisation of the rules of measurement in the previous edition (ASMM4) resulted in the deletion of measurement rules for a number of less common items and the introduction of rules of some sections of works that were not contained in the previous editions (Australian Institute of Quantity Surveyors, 1990).

3. CHALLENGES OF AUTOMATION OF QS PRACTICES IN BIM

Proponents of BIM considered that it has the capability for automated quantity extraction and estimating but the rules of measurement would be required to provide the basis for codified framework for cost planning (Matipa, Cunningham, & Naik, 2010). This will enhance the involvement of quantity surveyors in the provision of early cost management services to the project team, resulting to a more reliable and consistent approach in the allocation of cost resources (Arayici, et al., 2012). The RICS research report on "How does BIM support the New Rules of Measurement (NRM1)" pointed out that the main advantage of BIM is its ability to capture manage and deliver information. The report further suggests that BIM delivers a more efficient operational solution for QS to perform cost estimating, with its ability to link the relevant quantities and cost information to the building model and update them simultaneously to design changes. The study identifies that QS encounter difficulties in taking full advantages of BIM due to the substandard quality of BIM models, inconsistent level of design information included, data exchange issues in BIM tools and inconsistent format used for estimating.

However, the structure and term of set-out of BESMM4 is based on RICS New Rules of Measurement (NRM2) without reflecting the philosophy behind implementation of NRM2 in the UK. BESMM4 is not coordinated with any local classification and specification standards used by other built environment professionals. There is a dearth of industry classification and specification standards that links the activities of these professionals for effective information exchange. This is completely different from the practices in other countries where measurement standard is used to organise cost information. For instance, the seventh edition of Standard Method of Measurement (SMM&) was aligned with Uniclass (Cartlidge, 2011; Finch, 2012). While the NRM2 which serves as source document for BESMM4 was align with UK Standard Form of Cost Analysis (SFCA) a document that could also map into Uniclass Gelder (2013). Similarly, the Construction Electronic Measurement Standards (CEMS) in Singapore is aligned with Singapore Standard Code of Practice for Classification of Construction Cost Information (SS CP80:1999) (Boon and Prigg, 2012).

The implication of this is that, it will be difficult for QS to use the document to collaborate with other project team members to exchange electronic information for automated quantity extraction and estimating process on a common ICT platform (Teo & Heng, 2007; RICS, 2014). However, Boon & Prigg (2012), said that there is a significant non- alignment between the object in BIM models and the traditional trade items in standard method of measurement because the objects in BIM 3D model represent components of the finished product whereas the SMM calls for quantification of the work to create that component. A need arises, for QS to consolidate the BIM Schema with the information from the rules of measurement to improve the consistency and efficiency of BIM based measurement and estimating approaches (Matipa et al. 2010; Abdulahi, et al., 2016).

Arguably, IFC's provide a designer-focused product model that explicitly represents components' and openings as an attribute of components (Staub-French, Fischer, Kunz, Paulson, & Ishi, 2002). However, QS have different preferences for describing these different design conditions and the impacts on the construction costs (Towey, 2013). But IFC do not provide a way to filter the component features connections in a way that are defined in the trade-based measurement standard used by Quantity Surveyors (Olatunji, Sher, Gu, & Ogunsemi, 2010; Boon & Prigg, 2012). This is because of the dearth of standard to support systematic data exchange between software applications and BIM models (Sabol, 2008). RICS (2014) considered the need to align BIM-based cost estimating and planning process with measurement standard so as to enhance QS collaboration in BIM environment.

RICS explained that project team must agree on a set of requirements which is defined from the viewpoint of cost estimating and planning to enable the QS use BIM more effectively. This standpoint is based on the supposition that interoperability issues in the construction industry cannot be easily resolved without a set of rules and principles for classification of information requirements into data exchange specifications (Yang and Zhang, 2006; Sabol, 2008; RICS, 2014). The use of classification system as basis for measurement standard development will enable sharing of complex cost information and ensure consistency in a project and from project to project.

4. Methodology

Two approaches were adopted for data collection. The first is online questionnaire based survey involving the various professionals in the building and construction industry in Nigeria was used for data collection. Email address of participants in this survey were obtained through the member list of the various professional bodies such as Nigerian Institute of Quantity Surveyors (NIQS), Nigerian Society of Engineers (NSE), Nigerian Institute of Architects (NIA) and Nigerian Institute of Builders. The data collected was coded and analyzed using SPSS (20). Chi-Square Tests were conducted to examine the level of agreement among industry practitioners on some questions bothering on industry practices. Also analysis of variance (ANOVA) test was used to assess group mean difference. The essence of this is to determine whether or not significance differences exist among the different groups (profession groups, organization size and turnover). The second method used for collecting practitioners' opinion was by interview. The targeted respondents in this were quantity surveyors working in clients, contracting and consulting organizations. The interview was limited to QS because measurement of construction work is primarily the work of QS and other professionals were neither involved nor interviewed. Snowballing sampling approach was adopted to ensure that respondents have sufficient experience in the use of measurement standard. A number of questions were asked by email and face-to-face interview regarding the structure, development process and the classifications systems used in developing measurement standards. A total of 27 interviews were conducted.

5. RESULTS AND DISCUSSIONS

4.1 Industry Practices

The results in Table 1 show that all the builders (100%) agree that architects develop building design with CAD and pass on to other project team members. However, 82 .1% and 68.3% of Quantity surveyors and Engineers respectively stated that architects design with CAD and pass on to other project team members. About 31.7% of Engineers and 17.9 % of Quantity Surveyors stated that design input is sought from other project team members by architect before design completion. The Chi-Square Tests show that at .05 level of significance, differences exist in the responses obtained from respondents with respect to their professional background (X^2 = 6.695s[a], $p<0.05$). Based on professional background, respondents varied in their response on current design information exchange format being used in the industry, what this suggest therefore is that, the traditional design-bid-build is still the most popular practice among the construction industry practitioners.

Table 1 Cross –Tabulation (Profession and Design Information Exchange Format)

		Information exchange format		Total
		Architect develop building design with CAD and pass on to other project team members	Design input is sought from other project team members by architect before design completion	
Profession	Architect	20	3	23
		87.0%	13.0%	100.0%
	Engineer	28	13	41
		68.3%	31.7%	100.0%
	Quantity	64	14	78
	Surveyor	82.1%	17.9%	100.0%
	Builders	9	0	9

In terms of CAD data exchange format used by the organizations where these professionals work, results (Table 2) show that all the Architects and Builders (100%) stated that their organizations use Drawing Exchange format (DXF) while 87.8% and 67.9% of Engineers and Quantity Surveyors stated same. Other formats used by organizations where the Quantity Surveyors work as shown by results in Table 3 include: Standard for the Technical Exchange of Product Data (STEP) (12.8%), Industry Foundation Class and Initial Graphics Exchange Specification (IGES) 6.4% respectively. Only 12.2% of Engineers agree that their organization use Initial Graphics Exchange Specification (IGES). Chi-Square tests equally show that respondents differ in their opinion on the medium which their company used in receiving/providing design information ($X^{2} =$ 26.087[a], $p<0.05$).

Table 2 Cross –Tabulation (Profession and Use of CAD data exchange format by organization)

	CAD data format used					Total
Profession	Drawing Exchange format (DXF)	Industry Foundation Class	Initial Graphics Exchange Specification (IGES)	Standard for the Technical Exchange of Product Data (STEP))	Others	
Architect	23	0	0	0	0	23
	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Engineer	36	0	5	0	0	41

	87.8%	0.0%	12.2%	0.0%	0.0%	100.0%
Quantity	53	5	5	10	5	78
Surveyor	67.9%	6.4%	6.4%	12.8%	6.4%	100.0%
Builders	9	0	0	0	0	9
	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Total	121	5	10	10	5	151
	80.1%	3.3%	6.6%	6.6%	3.3%	100.0%
Chi-Square (X^2 = 26.087[a]) Sig = .000						

The next question that was asked respondents to capture current industry practice was whether they have been involved in a project that utilizes BIM. The results in Table 3 reveal that more than half (50%) of the respondents aside engineers (61%) have not been engaged in project that utilizes BIM. Looking at the breakdown of the results, only 13% of Architects agree that they have been involved in a project that utilizes BIM, while 32% and 44.4% of Quantity Surveyors and Builders respectively said the same. The Chi-Square tests equally show that significant differences exist in the level of BIM utilization for projects among the professional groups (X^2 =16.636 [a], $p<0.05$).

Table 3 Cross –Tabulation (Profession and BIM Utilization)

		Involvement in a project that utilize BIM		Total
		Yes	No	
Profession	Architect	3	20	23
		13.0%	87.0%	100.0%
	Engineer	25	16	41
		61.0%	39.0%	100.0%
	Quantity Surveyor	25	53	78
		32.1%	67.9%	100.0%
	Builders	4	5	9
		44.4%	55.6%	100.0%
Total		57	94	151
		37.7%	62.3%	100.0%
Chi-Square (X^2 =16.636 [a]) Sig = .001				

Having examined in the previous section how professional groups in building and construction industry utilized information exchange format and CAD data exchange in their projects, the ensuing section looks at alignment of measurement standards and information classification systems.

4.2 Aligning Measurement Standards with Information Classification Systems by NQS

On whether it is possible for QS to align measurement standard with information classification systems in Nigeria, predictably, all the responses were qualified and about 52% of the interviewees fell into the “Yes with comments” while the remaining 48% fell into the “No with comments” categories. The views of the “YES” categories of respondents were that it is possible and that the use of computer applications in measurement is not new by the NQS. The reservations here were mostly about the lack of generally accepted classification system adopted by all professionals as is the case in more developed countries. It was felt that, if developed, the traditional ways of working by Architects, Engineers, Quantity Surveyors and other project team members must be reflected before it can support a seamless information exchange among project participants. One of the respondents felt that the development should be by QS with other experts from the construction industry and implementation should include software companies. Three (3) of the "No" categories of respondents believe that useful standards do not exist and any new development should start from a common local industry practices. About 75% of the respondents agreed that major changes were necessary to make the current BESMM4 match the local industry practices. The need for integration of design, specification and costing as basis for collaborative working was also proposed to the industry.

4.3 Development of information classification systems

On how information classification systems should be developed, respondents to this question all believed on the need for Construction Industry Classification Standards to be the basis for measurement standard that could aid electronic transfer of information. However, they differed on what should be classified or to adopt classification approaches from other countries. For wide recognition, some felt that such classification should be formalised to follow international standard such as ISO which has been used as basis for classifying products information. Another opinion was on the need to use a classification standard developed locally and possibly align with other international standards because classification systems in Europe may be different from that of US. The main issue highlighted by one of the respondents in the "No." category is whether the industry professionals supported the development of such classification standard. The respondent further stressed that, since the importance of such classification systems is not well known, it may not be supported. Another important observation was the issue of adaptability of such measurement standard for BIM model quantity extraction in line with QS practices. This may need consideration to ensure that it is useable in BIM environment to perform the traditional QS roles. Another point raised during the interview was that useful classification standards that can directly meet local requirements do not exist and any new development should start from industry practice and ideas. More classification and data definition work is required locally for such measurement standard to facilitate collaboration among practitioners. These findings also corroborate the work of Gelder (2013) that standard is required to promote efficient collaboration among project participants, and suggested that a single all-embracing national classification system with one structure and philosophy is needed and such classification systems must be able to serve the whole project timeline, all disciplines and all sectors.

6. CONCLUSION

This study has examined the need to align the measurement standards with construction industry information classification system to facilitate QS collaboration and automation of quantity extraction and estimating process in Building Information Modelling. The nature of the construction industry classification systems used in some selected countries were identified and the relationships between their measurement standards highlighted. There is need for a collaborative synergy between all the construction industry professionals and they must take a lead in defining the structure of the classification standard before QS processes could be effectively automated at industry level. This effort must also involve software vendors to give direction with respect to integration with ICT tools, while Government should provide a policy framework that will facilitate standard development and adoption by the professionals in the industry.

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