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Examining the protocols and platforms adopted for building information modelling processes by Nigerian construction professionals

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Abstract. BIM is a process of integrating and disseminating information around a network of project team members. It facilitates a new way of working and creating designs with intelligent objects and providing the basis for new, more efficient collaborative workflows that give all stakeholders a clearer vision of the project. Building information modelling (BIM) protocols and processes are required to enable the production and integration of discipline-specific information models and to support collaborative working practices among the project team members. BIM protocols set responsibility for actions and deliverables and ensures that there is an obligation on parties to provide defined elements of their services using models. This study examined the collaboration processes, platforms and protocols being employed by construction professionals in construction industry in Lagos State, Nigeria. The study found that full collaboration was not being practiced among the construction professionals and that interoperable BIM standard platform such as IFC or COBie is not being used at all. The study also showed that the construction professionals surveyed were using file naming standards and file version to control the way they model building information. It was concluded that the construction professionals are still not embracing full collaboration, integration of information models, interoperable BIM platform and BIM protocol because they did not understand the collaboration protocol and information sharing requirements of BIM.

Keywords: Building information modelling, Building information modelling protocols, Collaboration process, Collaboration platform.

1. Introduction

Traditionally, lines and symbols have been used to prepare working drawings, construction plan, bill of quantities and engineering drawings in the construction industry. These paper documents have no native intelligence in them and require human interpretation to provide meaning and value. Effective coordination between design and construction process and interpretation of design concepts on construction sites are a constant challenge; but now, Building Information Modelling (BIM) is driving a revolution in the construction industry (BIM Handbook, 2011; Sawhney, 2014). BIM is a process of integrating and disseminating information around a network of project team members. It enables the project team to work simultaneously on a project in real time and to construct a building directly from a digital model (BIM Guide, 2013; Bhargav, 2014). As defined by CPA (2013), Autodesk (2011), CICRP (2012), BIM Handbook (2011), Sebastian (2010) and Azhar, khalfan and Maqsood (2012), BIM is a process for managing the information produced during a construction project, in a common format in order to make the best and most efficient use of that information. BIM is facilitating a new way of working and creating designs with intelligent objects and providing the basis for new, more efficient collaborative workflows that give all stakeholders a clearer vision of the project and increase their ability to make more informed decisions faster through the production of digital models (Autodesk, 2011).

In BIM, project team members would individually develop information models with full collaboration and information using common BIM software packages or platform to exchange their models. The collaboration among the team members means that discipline-specific information models have to co-exist or be integrated to create a model; and the coordinated information models can serve as database for the project (BIM Guide, 2013; RIBA, 2012). Succar (2009), Gayathri, Himal and Ranadewa (2013) and Ede (2014) opined that any process that allows the geometrical modelling, input of information and generate a methodology to manage the essential building design and project data in digital format can be referred to as BIM. In line with this argument, Arcadis (2015) stated that BIM is a set of interacting policies and collaborative processes generating a digital model to manage a building project.

The change occurring in the global economy has presented construction professionals with a window of opportunity to retool their businesses and adopt new tools and workflows that will help them deliver higher quality building and infrastructure projects at a lower cost and thereby help them differentiate themselves in the marketplace and stay competitive in challenging times (Autodesk, 2011). Macdonald (2013) noted that to design realistic projects, it is necessary to assemble the design and construction team at earlier stages in the construction process compared to traditional practice because construction projects of today are dependent on reliable and updated information and this has created a need to break down barriers that construction professionals have carefully and successfully built up over a long period of time (Wilkforss and Lofgren, 2007). A basis of premise of BIM is collaboration by different stakeholders at different phases of the lifecycle of a building to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder (National Building Specification BIM Report [NBSBR], 2014).

The ongoing digital switch-over in the construction and the advancement in Information and Communication Technology (ICT) have provided an ideal vehicle for integrating and disseminating information around a network of participating groups and organizations. It has become a cost-effective, universally accepted and readily available information presentation and delivery system (Scott, Chong and Li, 2005; Wong, 2012). According to Sabol (2008), BIM gives an accurate model of a building and a database for recording the breadth of information developed and associated with building components; beyond drawing and documentation, BIM offers a platform for enhanced interdisciplinary collaboration, the capability to manage change, and the ability to extend information support throughout the building lifecycle. Also, quantities and shared properties of materials can be easily extracted, scope of work can be isolated and defined, and systems, assemblies, and sequences are displayed in a relative scale with the entire component or group of components. Information can be attached to building components during the design process from manufacturer's specifications to maintenance instructions; thus offering the potential for an integrated information base available to building owners and operators at project turnover. BIM covers geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components, project management and post-construction facilities management.

Alarcon and Mardones (1998), Mohamed and Stewart (2003), Wong et al. (2004), Nielsen et al. (2009), Smith (2013) and BIM Guide (2013) opined that about two-thirds of construction problems are blamed on inadequate communication and exchange of information which is as a result of the use of traditional means of communication and exchange of information such as working drawings, specifications, Bill of Quantities and material schedule. Oladapo (2006) concluded that the core competency of a construction professional is the ability to communicate project information effectively and clearly. Oyedele and Tham (2005) and Li et al. (2000) found that effective communication and integration of project information by project team members enhances the effectiveness of decision-making and serves as a key project performance criterion. It was concluded by Lofgren (2007) and Oladapo (2006) that the widespread adoption of collaborative communication and information technologies should be the focal point for the Construction Industry as this can improve the quality of professional services in the Construction Industry. Hence, this study examined the collaboration processes, protocols and platforms being employed among the construction professionals in the construction industry in Lagos State, Nigeria with a view to improving the performance of the Nigerian Construction Industry.

2. Literature Review

The information exchange concepts of BIM deal with the sharing and distribution of information across a broader spectrum of profession for data aggregation (United State National BIM Standard, 2007). The level of information required and exchange concept or interoperability level in BIM depend on the maturity levels of BIM required or selected for a project. The levels of BIM details or maturity can be used to describe the level of maturity of collaboration among project teams and the supporting infrastructure required at each level of maturity with regard to the ability of the construction supply chain to operate and exchange information. In level 0 BIM, information is often sent as Portable Document Format (PDF) Files and printed off on paper; the level of collaboration is low because it is not mandatory for the team members to exchange information among themselves. Each of the team members will have to develop his output information and forward it to the contractor. It is a level of BIM because it can be used as a launch pad for higher level of information creation and exchange (Royal Institute of British Architect, 2012; BIM Guide, 2013; Smith, 2014). Level 1 BIM which is a level higher than Level 0 BIM describes a level of BIM implementation and approach for design and construction where the team members use one-way information exchange level to collaborate and integrate their designs or information models to create a BIM known as 'federated BIM'. The collaboration could be done using 2D or 3D data exchange format tool such as PDF, DXF, and DWG to provide a common data environment for the project team by forwarding the individual specific models to a nominated BIM coordinator who is responsible for coordinating the models and detecting clashes in the models. The exchange of information models in level 1 BIM is done on compatible BIM software platforms, for example; AutoCAD and Revit or AutoCAD and Orion, where the architectural information model developed on AutoCAD can be imported to Revit for further development or imported to Orion for the development of structural information model (Royal Institute of British Architect, 2012; BIM Guide, 2013; Smith, 2014). The exchange format in Level 2 BIM is the common or compatible BIM software platforms such as AutoCAD, Bentley, and Tekla; however, the level describes a level of building information development with full collaboration and information integration using a two-way exchange level where discipline-specific models are exchanged with the BIM coordinator as output information and with other team members requiring the information as input information from the sender. This level of BIM creates a BIM that is known as 'integrated BIM' Although, at this level, it is not compulsory for discipline-specific models forwarded to the BIM coordinator to co-exist in a single master model, but they can serve as information database for the project required for coordination, clash detection and construction (Royal Institute of British Architect, 2012; BIM Guide, 2013). Level 3 BIM as a highly matured level of collaboration and information integration among the project team members requires discipline-specific models to co-exist as a single master model. This master model is also known as 'standard federated BIM' or 'intuitive BIM' created from various information models forwarded to the BIM coordinator, the degree of integration and interoperability demanded by this level of BIM requires an exchange format that supports this high level of interoperability among the project team. The exchange format should be able to provide a platform for collaboration and coordination of the disciple-specific models where the parties can exchange both input and output information and where the BIM coordinator can also exchange information with the parties and store the master model.

Information exchange formats are like translators that define data on one computer application and put that data into the configuration needed by another application, that is, they provide translation for exporting from and importing to computer applications. Exchanging information between software applications and project team members facilitated by exchange formats allows interoperability which enables collaboration and eliminates manual passing and coping of data generated in one computer application to another application (BIM Handbook, 2011). Level 3 BIM uses three-way exchange level and requires an exchange formats that are capable of storing the information digitally, examples of such formats are Construction Operation Building Information Exchange (COBie), Industry Foundation Classes (IFC) and Extensible Markup Language (XML) based schemas. Level 3 BIM utilizes 4D to 5D model combining 3D models developed by architects and engineers with construction sequence and schedule, cost information and project lifecycle management information developed by the contractor, quantity surveyors and facilities managers (Royal Institute of British Architect, 2012; BIM Guide, 2013; Smith, 2014; Computer Integrated Construction Research Program, 2012; Construction Product Association, 2013; East, 2014).

The collaboration and coordination platform for BIM where the parties can share both formal and informal information about their discipline-specific information models would have to be established or selected based on the level of BIM maturity adopted for a project. These exchange platforms include; compatible and common software platforms, COBie, IFC and XML-based schemas (Construction Product Association, 2013; BIM Guide, 2013; Sabol, 2008). A compatible software platform is an information exchange platform that provides a level of coordination and collaboration among project team members through the use of software applications that can exchange data using industrysupported exchange formats. Examples are AutoCAD and Bentley; AutoCAD is compatible with Revit and Orion, while Bentley is compatible with Primavera, MS Office Documents and Tekla(BIM Handbook, 2011) . Common software platforms are software applications for disciple-specific information modelling developed by the same software firms. By using software application systems within one software vendor’s products to develop discipline-specific information models, project team members are able to achieve a level of collaboration and coordination of information (Sabol, 2008). COBie format is a well-structured exchange spreadsheet data format representing the project in terms of its floors, the spaces on the floors, the components with the spaces and the specification of the types of components. Data in any format can easily be imported into the single COBie dataset. It contains digital information about a building in as complete and as useful a form as possible. These are non-geometric set of data with drawings or diagrams, only basic dimensions and description of shape(Sabol, 2008; Hamil, 2012). COBie allows information about buildings to be organized, documented and shared in a standardized way and it can be managed at any level of Information Technology (IT) capability and linked to other systems and software (BIM Handbook, 2011; Mordue, 2013; Royal Institute of British Architect, 2012).

As an exchange format, COBie outlines a standard method for collecting the needed information throughout the design and construction process; provides system-to-system exchange of the space and equipment information without user intervention; offers the possibility to automatically check the equality of electronic handover documents; provides a simple format for real-time information exchange for existing design and construction; provides a framework to store information for later exchange and retrieval; creates both a format and standardized template for information handover to operations and maintenance entities; captures information incrementally throughout the planning, design and construction processes; and provides a framework for robust information organization to simplify the work required to capture, record and disseminate project information. It collects data from designers, as they define the design, and then by contractors as the building is constructed. It categorizes and structures the information in a practical and easy-to-implement manner (BIM Guide, 2013; Construction Product Association, 2013; East, 2014).

IFC is an open, neutral and standardised schema or data format developed to define an extensible set of consistent data representations of BIM for exchange between Architectural, Engineering and Construction (AEC) software application. It uses shared and open software specifications that are not controlled by a single vendor and enables greater interoperability between software platforms. Applications used by the different disciplines can easily and quickly filter and identify the relevant, specific information from the IFC database. IFC stores a real world description of the elements of a design model, and allows these elements interact in a virtual, computer world, exactly as they would in the real world. It consists of a library of object and property definitions that can be used to represent a building project and support use of that building information for a particular purpose (Construction Product Association, 2013; Smith, 2014).

Royal Institute of British Architect (2012) explained that a building information model can be lonely or collaborative; a lonely building information model is a model created when only one party undertakes the BIM process and a collaborative is a model created when all parties undertake BIM together. (Quigley, 2013) classified BIM as Integrated BIM (a model created with common BIM software platforms; Standard Federated BIM (a model created with various interoperable BIM software platforms and integrated on exchange platform such as IFC and COBie; and Modified Federated BIM (a model created by modifying a Standard Federated BIM using a single BIM platform to further integrate the model). A building information model is a master model that contains not only a list of building components and locations but also the relationships that are intended between those objects. It is a digital database for project information that stores project information in a way that it is always easily available and can be presented in context whenever required and allows exploration and changes to the project information at any time (Autodesk, 2002). (Sebastian, 2010) described a building information model as an object-based definition of a proposed building where a wall is not just an assemblage of lines as found in CAD models, but an object that contains a broad array of information on the geometry and properties of the wall. A building information model is rich in information models and consist of potentially multiple data sources and elements which can be shared across all stakeholders and be maintained across the life of a building from inception to recycling (NBS BIM Report, 2014). A building information model is the product of collaboration among project team members and digital or virtual construction of the proposed building using software platforms in a BIM environment. It serves as a model of a proposed project and it is constructed with parametric objects, which are software counterparts of the actual elements or materials to be used to construct the physical building, such as beams, slabs, frames, and windows (Foundation of Wall and Ceiling Industry, 2009). The intelligence of a building information model is contained in the intelligence of parametric objects used to model the various information models contained in a building information model such that a wall object contains studs or columns or windows or doors at indicated dimension and intervals; a concrete slab object contains reinforcement as specified; while a wall object is ‘intelligent’ enough to know that it ends in an adjoining wall, and should the adjoining wall move 1m farther out, the wall will then automatically adjust its length by adding 1m to its length (Sabol, 2008). Although, a building information model appears as a 3D image of a proposed building, but it is defined by more parameters than just width, depth and height, and contains other parameters such as weight, density, connectivity, cost, manufacturer, proportionality and association. Unlike 2D drawings and normal 3D models developed in level 0 and 1 BIM that require multiple manual updates to coordinate them, a building information model requires just one change to adjust all affected objects accordingly and allows the exportation of 2D plans, 3D models, sections and elevations (Autodesk, 2003; BIM Brochure, 2013).

Nevertheless, (United State General Services Administration, 2007) noted that for building elements in a building information model to be well-defined in the exchange platforms such as IFC, the elements must be created using the right BIM tools for the intended object type and that a building element created using the wrong BIM tool or old versions of CAD softwares will only serve the purpose for visualization and not modelling information. For example, a column modelled as short wall may appear correct in the model but will be exported as a short wall and not as a column during coordination on IFC or other exchange platforms and formats.

Building information modelling (BIM) protocols and processes are required to enable the production and integration of discipline-specific information models and to support collaborative working practices among the project team members. BIM protocols identify the building information models that are required to be produced by members of the project team and puts into place specific obligations, liabilities and associated limitations on the use of the models (Construction Industry Council, 2013). According to (Hooper and Ekholm, 2012), BIM protocols set responsibility for actions and deliverables, makes the minimum changes necessary to the pre-existing contractual arrangements on construction projects, ensures that there is an obligation on parties to provide defined elements of their services using models, serves as contractual document which takes precedence over existing agreements, enables the production of building information models at defined stages of a project, provides for the appointment of an ‘information manager’ or ‘BIM manager’, and sets out the intellectual property right provisions required to enable the models to be used as intended and to protect the rights of the project team members against infringement. Other steps to be taken as BIM protocols include; establishing a conflict resolution process (setting up a process of identifying and resolving conflicts between information models), developing a protocol for addressing design questions, developing discipline-specific information models, and integrating discipline-specific information models.

(AEC UK BIM Protocol, 2012) noted that BIM protocols can also be used by clients to require the adoption of particular ways of working such as the adoption of a common naming standard, and that it can also be used to set guidelines and frameworks for BIM as found in BS 1192:2007 (standard for collaboration working process for project collaboration and efficient data sharing), PAS 1192-2 (Publicly Available Specification for information management for the delivery phase of construction projects using BIM), BS 8541-1 and BS 8541-2 (library objects for architecture, engineering and construction). (Construction Industry Council, 2013) identified definition of the delivery structure, project reference points, file naming convention, scope of the information model, version of the information model, contract language, file version control, communication procedures, technology infrastructure, layering convention, colour scheme, start and due dates, model file types, software used to create file, native file type, file exchange type, quality control procedures, as the process of establishing the protocol and conventions for the information models. Other process of BIM as identified by (Hooper and Ekholm, 2012) include; identification of the potential uses of information models, that is, identifying the building information that requires modelling, and identification of the information modelling requirements, that is, who will create information models, when the information models will be created, and how the information models will be created.

3. Method

Primary data required for the study was obtained through the administration of structured questionnaire. The study population composed of construction professionals who have substantial involvement and responsibilities in BIM and who had used BIM for projects in Lagos State, Nigeria. These include the Architects, Quantity Surveyors, Facilities Managers, Civil and Structural Engineers, Building Services Engineers (Mechanical and Electrical) and Builders. At present, the comprehensive lists of these professionals are not available and this justified the adoption of purposive sampling for selection of the respondents for the study. The selection of respondents for the study was done using Respondent Driven Sampling (RDS) technique. RDS is a sampling technique based on the principle of 'six degrees of separation', with the potential to reach any member of a population in six waves and involves a network-based methods that start with a set of driver respondents who refer their peers; these in turn refer their peers up to the sixth wave.

A list of construction professionals who have used BIM at any level in project was compiled using contacts list from social media based on the recommendation of (Kossinets and Watts, 2006). The construction professionals were divided into professional groups and the contacts list for each professional group was taken as the Personal Network Size (PNS) for the group. PNS for this study is the number of known professionals who have used BIM at any level and it is required to determine the target population. The PNS for each of the professional group is as shown in Table 1. The RDS target population required for the study depends on RDS respondents estimate and this was determined by calculating the degree of person (di) and degree of distribution (Pdij) for the PNS using the summation method proposed by (McCarthy et al., 2001). The RDS respondents estimate is presented in Table 1. The potentials of the PNS to name other respondents in six waves were summed to yield an overall estimate. The degree of person (di) was calculated using the formula given by (McCarthy et al., 2001) .

$$di = \sum Pdij$$

Where:

di = the degree of person i;

Pdij = 1 (if person i knows person j); and

$\sum Pdij$ = 6 (for six degrees of separation).

RDS target population was then determined by calculating the minimum target sample size (MTSS) for each of the professional group using the formula given by (Glenn, 2013).

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n = sample size;

N = population size; and

e = level of precision.

RDS target population for the study is as presented in Table 1. MTSS is required to compensate for differences in homophily and PNS across group and also to determine when the RDS should be stopped. The RDS for this study was stopped when the MTSS for each professional group was reached.

Information elicited for the study included steps and rules guiding the process of BIM among construction professionals. Frequency distribution and percentage, mean ranking and Kruskal Wallis test were used to analyse the data. Mean ranking was used to rank the positions of the professional groups based on their responses and where there were identical scores, joint ranking was used. Kruskal Wallis test was conducted on the responses using the formula given by (National Institute of Standards and Technology, 2015):

$$H = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{R_i^2}{ni} - 3(n+1)$$

Where:

ni(i-1,2,…….k) = sample sizes for each of the k groups

Ri = sum of the ranks for group i

Table 1. PNS and RDS Respondents Estimate and Target Population

Professional group	Personal Network Size (PNS)	Estimated number of respondents	Minimum Target Sample Size (MTSS)

Architects	16	96	77
Builders	11	66	57
Building services engineers	9	54	48
Facilities managers	4	24	23
Quantity surveyors	4	24	23
Structural/Civil engineers	8	48	43

4. Results

Collaboration processes employed by construction professionals

The collaboration processes and platforms in use among the construction professionals in the study area were determined using the ratings indicated by respondents on a 5-point Likert scale. On the Likert scale, the value of 5,4,3,2, and 1 represented 'Very often,' 'Often,' 'Seldom,' 'Rarely,' and 'Not at all' respectively. The levels of collaboration process being employed for BIM in projects were categorized as lonely, part and full collaboration. Possible variants of these types of collaboration were outlined for the respondents to indicate the rate of usage of those levels of collaboration process and their variants. Collaboration process being employed for projects by construction professionals was analysed using frequency distribution and percentage and clustered bar chart. Kruskal Wallis test was conducted to examine the differences in the collaboration process employed among construction professionals, while frequency distribution and percentage was used to analyse the BIM platform employed among construction professionals.

Table 2 shows the collaboration process employed for BIM by professionals on projects. 53.9% of the total respondents indicated that they used BIM by Architects only very often, 49.6% indicated that they use BIM by Structural Engineers only very often, 50.4% indicated that they use BIM by Building Services Engineers only very often, 39% indicated that they use BIM by Builders only very often, 50% indicated that they use BIM by Quantity Surveyors only very often and 65.2% indicated that they use BIM by Facilities Managers only very often.

Table 2. Lonely Collaboration Process among Construction Professionals.

s/n	Lonely collaboration (one professional collaboration)	Not at all	Rarely	Seldom	often	Very often	Mean
1	BIM by architect only	22.30%	0.00%	5.30%	18.40%	53.90%	4.13
2	BIM by structural engineer only	19.90%	0.00%	4.30%	26.20%	49.60%	3.93
3	BIM by building services engineer only	19.90%	0.00%	4.30%	25.50%	50.40%	3.98
4	BIM by builder only	4.30%	19.90%	9.20%	27.70%	39.00%	3.56
5	BIM by quantity surveyor only	4.30%	19.90%	0.00%	25.90%	50%	3.46
6	BIM by facilities managers only	0.00%	0.00%	4.30%	30.50%	65.20%	3.34

As shown in Table 3, 35.5% of the total respondents indicated that they use BIM by Architects and Structural Engineers very often, while 52.5% of the total respondents indicated that they often used BIM by Architects and Building Services Engineers only.

Table 3. Part Collaboration (Two professionals) Process among Construction Professionals.

s/n	Part collaboration (two professional collaboration)	Not at all	Rarely	Seldom	Often	Very often	Mean
1	BIM by architects and quantity surveyors only	37.60%	4.30%	19.90%	28.70%	18.00%	2.98

2	BIM by architects and structural engineers	33.30%	7.80%	14.20%	9.20%	35.50%	3.01
3	BIM by architect and building services engineer only	17%	9.20%	17%	52.50%	4.30%	4.01
4	BIM architects and builders only	30.90%	17.70%	9.20%	12.10%	30.10%	3.45
5	BIM by architects and facilities managers only	56%	0.00%	20.60%	18.40%	5.00%	2.07

In part-collaboration where three professionals are involved, Architects, Quantity Surveyors and Builders (23.4%) and Architects, Builders and Structural Engineers (24.1%) collaborate in BIM very often (Table 4). In four-professional part collaboration (Table 5), 24.8% of Architects, Structural Engineers, Builders and Quantity Surveyors collaborate on projects very often, while 20.6% of Architects, Builders, Building Services Engineers and Quantity Surveyors collaborate on projects very often. For other forms of four-professional part collaboration, 19.9% of the total respondents indicated that they often employ collaboration by Architects, Structural Engineers and Quantity Surveyors.

Table 4. Part Collaboration (Three professionals) Process among Construction Professionals.

s/n	**Part collaboration (three professional collaboration)**	**Not at all**	**Rarely**	**Seldom**	**Often**	**Very often**	**Mean**
1	BIM by architect, quantity surveyor and structural engineer only	47.90%	17%	10.90%	5.30%	20.60%	2.99
2	BIM by architect, quantity surveyor and facilities manager	57.40%	24.10%	0.00%	4.30%	14.20%	1.23
3	BIM by architect, quantity surveyor and	28.70%	29.80%	5%	26.60%	9.90%	1.98

	building services engineer						
4	BIM by architect, quantity surveyor and builder	30.50%	11.70%	28.40%	6%	23.40%	3.01
5	BIM by architect, builder and structural engineer	42.60%	5%	8.50%	19.90%	24.10%	3.02
6	BIM by architect, builder and building services engineer	26.20%	34.80%	9.20%	15.60%	14.20%	1.20
7	BIM by architect, builder and facility manager	45.40%	22%	27.70%	5%	0.00%	1.04
8	BIM by architect, structural engineer and facility manager	70.20%	14.20%	9.90%	5.70%	0.00%	1.00
9	BIM by architect, structural engineer and building services engineer	62.40%	12.80%	0.00%	9.90%	14.90%	1.09
10	BIM by building services engineer, builder and quantity surveyor	76.20%	19.10%	0.00%	4.60%	0.00%	1.08
11	BIM by building services engineer, builder and facility manager	75.90%	19.10%	0.00%	4.90%	0.00%	1.06

In five-professional part collaboration (Table 6), collaboration among architects, builders, structural engineers, quantity surveyors and facilities managers is employed very often among the professionals; 28.4% of the total respondents indicated that they employ this form of collaboration process very often. Also, professionals often employ collaboration among architects, builders, building services engineers, quantity surveyors and facilities managers (27.7%) and architects, builders, structural engineers, building services engineers and quantity surveyors (22.7%).

Table 5. Part Collaboration (Four professionals) Process among Construction Professionals.

s/n	Part collaboration (four professionals collaboration)	Not at all	Rarely	Seldom	Often	Very often	Mean
1	BIM by architect, structural engineer, builder and quantity surveyor	51.10%	26.20%	0.70%	12.80%	9.20%	2.11
2	BIM by architect, structural engineer, builder and building services engineer	55.30%	35.50%	0.00%	9.20%	0.00%	1.78
3	BIM by architect, structural engineer, builder and facilities manager	71.60%	9.20%	0.70%	4.30%	0.00%	1.09
4	BIM by architect, structural engineer and quantity surveyor	18.40%	26.20%	10.60%	19.90%	24.80%	2.32
5	BIM by architect, builder, building services engineer and quantity surveyor	27%	24.80%	7.80%	19.90%	20.60%	3.02
6	BIM by architect, builder, structural engineer, quantity	55.30%	14.70%	9.20%	8.50%	12.10%	1.03

	surveyor and facilities manager						
7	BIM by architect, building services engineer, quantity surveyor and facilities manager	55.30%	14.20%	13.50%	5%	12.10%	1.23
8	BIM by architect, builder, quantity surveyor and facilities manager	51.10%	9.20%	22.70%	9.20%	7.80%	1.20
9	BIM by architect, builder, building services engineer and facilities manager	41.10%	5%	35.50%	10.60%	7.80%	2.01
10	BIM by architect, builder, structural engineer and facilities manager	41.10%	21.30%	17.70%	14.20%	5.70%	1.73
11	BIM by architect, builder, structural engineer, quantity surveyor and facilities manager	43.60%	34%	0.00%	15.60%	5.70%	
12	BIM by architect, builder, building services engineer, quantity surveyor and facilities manager	31.90%	47.50%	0.00%	14.90%	5.70%	

Table 6. Part Collaboration (Five professionals) Process among Construction Professionals.

s/n	Part collaboration (five professionals collaboration)	Not at all	Rarely	Seldom	Often	Very often	Mean
1	BIM by architect, builder, structural engineer, quantity surveyor and facilities manager	14.50%	7.40%	17.70%	33.70%	28.40%	3.21
2	BIM by architect, builder, building services engineer, quantity surveyor and facilities manager	31.90%	5%	21.30%	27.70%	14.20%	1.23
3	BIM by architect, builder, structural engineer, building services engineer and quantity surveyor	28.40%	17.70%	17%	22.70%	14.20%	1.56
4	BIM by architect, builder, structural engineer, building services engineer and facilities manager	35.50%	8.50%	31.20%	15.60%	9.20%	2.33
5	BIM by architect, builder, structural engineer, building services engineer, quantity surveyor and facilities manager	31.90%	37.60%	24.80%	1.40%	4.30%	2.45
6	BIM by builder, structural engineer, building services engineer, quantity surveyor and facilities manager	56.70%	24.80%	9.90%	4.30%	4.30%	1.54

Figure 1 shows that professionals rarely employ full collaboration process for projects. 28.4% of the total respondents indicated that they rarely employ full collaboration, while more than 32.6% indicated that they do not employ it at all.

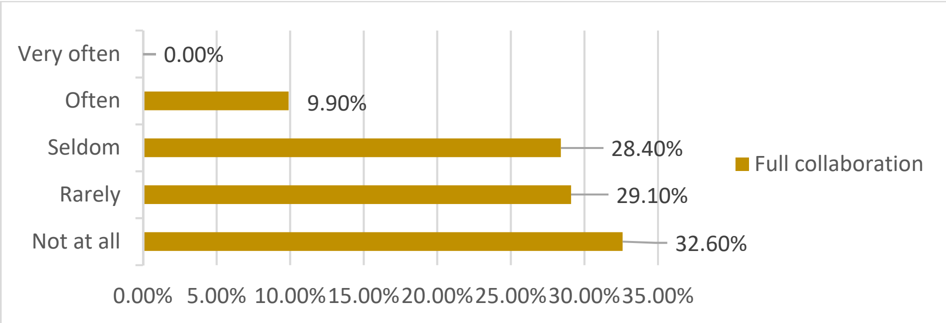

Figure 1. Full Collaboration Process among Construction Professionals.

Difference in the collaboration processes employed by construction professionals

Table 7 shows the result of Kruskal Wallis test conducted to examine the difference in the collaboration process employed among construction professionals. The significant value (p = 0.001) was less than the alpha threshold value (p<0.05) in all categories of collaboration process, indicating that the mean difference is statistically significant. In lonely collaboration process category, Builders ranked first with a mean rank value of 27.864. Architects and Builders ranked first and second with mean rank value of 16.385 and 11.288 in the category of two professional part collaboration. Architects employed part collaboration more than other construction professionals as they ranked first with mean rank value of 34.949 in three professional part collaboration, first with mean rank value of 19.205 in five professional part collaboration, and third with mean rank value of 20.000 in three professional part collaboration. Structural Engineers ranked second with mean rank value of 33.739 and 17.130 in three professional part collaboration and five professional part collaboration respectively. In full collaboration process category, Structural Engineers ranked first with mean rank value of 3.043, followed by Architects with mean rank value of 2.692.

Table 7. Kruskal Wallis Test to Examine the Difference in the Collaboration Process Employed among Construction Professionals.

Collaboration process	Number of respondents	Mean Rank	Rank	Significant value	Remark
ONE PROFESSIONAL PART COLLABORATION					
Architect	78	26.949	4	0.001	Mean
Builder	59	27.864	1		difference is
Building service Engineers	51	12.510	6		statistically
Facilities Manager	24	27.000	3		significant at
Quantity surveyor	24	27.000	3		p=0.05
Structural/Civil Engineer	46	22.174	5		
TWO PROFESSIONAL PART COLLABORATION					
Architect	78	16.385	1	0.001	Mean
Builder	59	11.288	2		difference is
Building service Engineers	51	4.000	6		statistically
Facilities Manager	24	8.000	5		significant at
Quantity surveyor	24	8.000	5		p=0.05
Structural/Civil Engineer	46	11.043	3		
THREE PROFESSIONAL PART COLLABORATION					
Architect	78	34.949	1	0.001	Mean
Builder	59	27.593	3		difference is
Building service Engineers	51	16.353	6		statistically
Facilities Manager	24	24.000	5		significant at
Quantity surveyor	24	27.000	4		p=0.05
Structural/Civil Engineer	46	33.739	2		
FOUR PROFESSIONAL PART COLLABORATION					
Architect	78	20.000	3	0.001	Mean
Builder	59	22.763	2		difference is
Building service Engineers	51	13.706	6		statistically
Facilities Manager	24	14.000	5		significant at
Quantity surveyor	24	16.000	4		p=0.05
Structural/Civil Engineer	46	34.739	1		

FIVE PROFESSIONAL PART COLLABORATION					
Architect	78	19.205	1	0.001	Mean difference is statistically significant at p=0.05
Builder	59	16.712	3		
Building service Engineers	51	10.275	6		
Facilities Manager	24	14.000	4		
Quantity surveyor	24	11.000	5		
Structural/Civil Engineer	46	17.130	2		
FULL COLLABORATION					
Architect	78	2.692	2	0.001	Mean difference is statistically significant at p=0.05
Builder	59	2.254	3		
Building service Engineers	51	1.039	5		
Facilities Manager	24	1.000	6		
Quantity surveyor	24	2.000	4		
Structural/Civil Engineer	46	3.043	1		

As regards BIM platform employed for BIM on projects (Table 8). 51.4% indicated that they employ paper-based platform very often. Compatible software platform is also a predominant BIM platform among the construction professionals, as a significant number of professionals (41.1%) indicated that they employ it very often. 50% of the respondents indicated that they often use common software platform.

Table 8. BIM Platform Employed among Construction Professionals.

s/n	BIM platform	Not at all	Rarely	Seldom	Often	Very often	Mean
1	Paper-based platform	0.00%	24.10%	0.00%	24.50%	51.40%	4.56
2	Compatible software platform	12.10%	5.30%	6.40%	35.10%	41.10%	4.09
3	Common software	9.20%	5.00%	24.10%	50%	10.60%	4.01
4	Interoperable BIM standard platform	45.40%	41.10%	0.70%	2.80%	0.00%	1.34

Protocols and rules guiding BIM processes among construction professionals

The protocols and rules guiding BIM processes were identified from literature and respondents were asked to rate the level of usage of protocols and rules controlling the way they model building information. A five-point Likert scale ranging between 'Not at all' and 'Very often' with weight value of 1-5 respectively was used to describe the ratings to be provided by the respondents. Frequency distribution and percentage, mean ranking and Kruskal Wallis test were used to analyse the data obtained from the respondents. Frequency distribution and percentage was used to determine the percentage of construction professionals using a particular BIM protocol and rule and at what percentage (Table 9 and Table 10). A test of significance was conducted on the responses of the professional groups using Kruskal Wallis test; while the level of usage of BIM protocols and rule by the professional groups using mean ranking.

Table 9 shows the BIM processes employed by respondents, from the Table, 41.1% of the respondents rarely identify the potential uses of building information models; while 24.1% were not identifying the potential uses of building information model at all. Only 14.2% of the respondents often identify the potential uses of building information models. As regard the process of identifying the building information that requires modelling, 49.6% of the respondents reported not at all, 14.9% indicated that they rarely employ the process, 17.0% and 13.5% reported that they were employing the process often and very often.

No more than 51.0% of the respondents were not specifying who will create information models and 52.5% were not specifying when the information models will be created. Only 49.6% of the respondents were not specifying how the information models will be created; 25.5% rarely did and 7.1% indicated that they seldom did. 13.5% and 4.3% professionals who participated in the study reported that they were specifying how the information models would be created very often and often respectively. On whether professionals use to establish rules, conventions and protocols for the information models, 57.4% of the respondents reported that they were not establishing rules and conventions, 20.6% of the respondents rarely do, 0.7% often did; while 13.5% establish rules and conventions for information models very often. No more than 23.4% of the respondents rarely set up a process of identifying and resolving conflicts between information models, 69.5% indicated that they were not setting up the process at all, while only 5% indicated that they often set up the process. 2.1% of the respondents reported that they set up the process of identifying and resolving conflicts between information models very often.

Table 9. BIM Processes adopted by Construction Professionals

s/n	BIM processes	Not at all	Rarely	Seldom	Often	Very often	Mean Score
1	identifying the potential uses of building information models	24.10%	41.10%	15.60%	14.20%	5.00%	2.35
2	Identifying the building information that requires modelling	49.60%	14.90%	5.00%	17.00%	13.50%	2.19
3	specifying who will create information models	51.00%	28.40%	19.90%	0.00%	0.00%	1.68
4	specifying when the information models will be created	52.50%	15.60%	24.10%	7.80%	0.00%	1.87
5	Specifying how the information models will be created	49.60%	25.50%	7.10%	4.30%	13.50%	2.06
6	Establishing rules, conventions and protocol for the information models	57.40%	20.60%	7.80%	0.70%	13.50%	1.92
7	Setting up a process of identifying and	69.50%	23.40%	0.00%	5.00%	2.10%	1.47

	resolving conflicts between information models						
8	Developing a protocol for addressing design questions	70.90%	26.20%	2.10%	0.70%	0.00%	1.33
9	Developing discipline specific information models	8.50%	6.50%	5.00%	13.50%	61.30%	3.98
10	Integrating the information models	35.50%	40.40%	14.20%	9.90%	0.00%	1.99

Similarly, on BIM process of developing a protocol for addressing design questions. Only 70.9% of the total respondents indicated that they were not developing protocol for addressing design questions at all, while 0.7% of the total respondents indicated that they often do.

Only 61.3% of the respondents indicated they develop discipline specific information models very often. 13.5% indicated that they often develop discipline specific information models, while 5% indicated that they seldom do. Only 8.5% indicated that they were not developing discipline specific information models at all.

On the process of integrating the information models, it was found that 35.5% are not integrating the information models at all and 40.4% rarely do. Only 9.9% of the total respondents often integrate information models. The level of usage of the BIM processes among the construction professionals were ranked to know the positions of the BIM processes (Table 9). Using the average mean score (2.09) to determine the predominant BIM processes among construction professionals. With a mean score of 3.96, the development of discipline specific information models ranked first (mean score = 3.98) as the predominant BIM processes among construction professionals in the study area. Other predominant BIM processes were identification of the potential uses of building information models (mean score = 2.33) and identification of building information that requires modelling (mean score = 2.30). The development of protocol for addressing design questions ranked least with mean score of 1.33.

Table 10 shows the BIM rules controlling the way construction professionals model building information. 72.3%, 80.1%, 70.9%, and 65.2% of the respondents were not using BS 1192:2007, PAS 1192-2, BS 8541-1, and BS 8541-2 guidelines at all. 13.5% of the total respondents reported that they were using BS 8541-1 and BS 8541-2 guidelines very often.

Table 10. BIM Rules adopted by Construction Professionals

s/n	BIM rules	Not at all	Rarely	Seldom	Often	Very often	Mean Score
1	BS 1192:2007 guidelines	72.30%	0.70%	6.40%	7.10%	13.50%	1.89
2	PAS 1192-2 guidelines	80.10%	14.20%	0.70%	5.00%	0.00%	1.30
3	BS 8541-1 guidelines	70.90%	4.30%	1.40%	9.90%	13.50%	1.91
4	BS 8541-2 guidelines	65.20%	2.80%	12.10%	6.40%	13.50%	2.00
5	Intellectual property right provisions	73.80%	6.40%	5.70%	14.20%	0.00%	1.60
6	Appointment of an information manager	19.10%	46.10%	28.40%	4.30%	2.10%	2.24
7	Production of BIM at defined stages of a project	33.30%	42.60%	19.10%	2.80%	2.10%	1.99
8	Contractual agreement	7.80%	9.90%	11.30%	19.10%	51.80%	3.97
9	File naming standards and file version control	39.70%	4.30%	2.10%	15.60%	38.30%	3.09
10	Setting of obligations, liabilities and limitations on the use of the models	74.50%	19.10%	2.10%	0.00%	4.30%	1.40
11	Specifying the required BIM to be produced by	57.40%	12.80%	8.50%	19.90%	1.40%	1.95

	members of the project team						
12	Setting responsibilities for action and deliverable	71.90%	23.40%	2.10%	0.70%	2.10%	1.32
13	Definition of the delivery structure	58.90%	32.60%	5.70%	0.70%	2.10%	1.55
14	Establishing project reference point	36.20%	18.40%	22.70%	14.20%	8.50%	2.40
15	Communication procedures	14.90%	48.20%	5.70%	17.70%	13.50%	2.67
16	Layering convention and colour schemes	38.30%	2.80%	14.20%	14.20%	30.50%	3.09

This finding doesn't support the study by [53], which found that majority of professionals in UK use BS 1192:2007 and PAS 1192-2 and that few use BS 8541-1 and BS 8541-2 guidelines. On the provision of intellectual property right for building information, 73.8% were not providing intellectual property right for building information. Only 14.2% of the respondents indicated that they often provide intellectual property right for building information, while 6.4% indicated that they seldom provide intellectual property right for building information.

No more than 19.1% of the total respondents were not appointing information manager and 46.1% rarely do. Only 4.3% of the respondents indicated that they often do.

On the appointment of an information manager, 33.3% of the total respondents were not producing BIM at defined stages of a project, 42.6% rarely produce BIM at defined stages, while 19.1% seldom produce BIM at defined stages of a project. Only 2.8% of the total respondents often produce BIM at defined stages. 54% of the total respondents indicated that they often follow contractual agreement when modelling building information. Few respondents (7.8%) reported that they do not follow contractual agreement when modelling building information. 38.3% of the respondents use names and versions very often to control information files, 15.6% often use names and versions to control information files; while 39.7% indicated that they do not use them.

No more than 74.5% of the total respondents indicated that they were not setting obligations, liabilities and limitations on the use of the models at all. Also, 57.4% of the total respondents reported that they were not specifying the required BIM to be produced by members of the project team at all. Only 71.6% indicated that they are not setting responsibilities for action and deliverable at all; while 58.9% of the respondents indicated that they were not defining the delivery structure for information models. On the other hand, 36.2%, 48.2% and 38.3% of the respondents indicated that they were not establishing project reference point at all, that they rarely use communication procedures and that they were not using layering convention and colour schemes at all.

The mean score of the level of usage of BIM rules in controlling the way that construction professionals model building information is presented in Table 3. Based on the average mean score of 2.14, the following BIM rules were identified as predominant among the construction professionals in the study area: appointment of an information manager (mean score = 2.24), contractual arrangement (mean score = 3.97), file naming standards and file version control (mean score = 3.09), establishing project reference point (mean score = 2.40), communication procedures (mean score = 2.67), and layering convention and colour schemes (mean score = 2.96). PAS 1192-2 guidelines ranked least with a mean score of 1.30.

Variance in the level of usage of BIM rules and protocols

The variance in the level of usage of BIM rule and protocols among respondents was examined and explained in Table 11. The test of difference in the average level of usage of BIM rules in controlling the way construction professionals model building information was statistically significant as the significant value of the level of usage of BIM rules and protocols is 0.01 which is less than 0.05. This means that construction professionals were not using BIM protocols and rules at the same level. The mean scores reveal that the levels of usage of BIM rules in controlling the modelling of building information was significantly higher among Architects (mean score = 0.17), followed by Builders (mean score = 0.15) and Structural Engineers (mean score = 0.14); while the average level of usage was lowest among Facilities Managers. This shows that BIM process was dominated by architects, engineers and builders.

Table 11. Mean Ranking and Kruskal Wallis Test on Levels of Usage of BIM Rules in Controlling the Process of BIM among Construction Professionals

Construction Professionals	**Number of respondents**	**Mean**	**Rank**	**Significant value**
Architect	78	48.087	1	0.001
Builder	59	42.897	2	
Building service Engineers	51	29.000	4	
Facilities Manager	24	26.588	5	
Quantity surveyor	24	29.000	4	
Structural/Civil Engineer	46	39.525	3	
Total	282			

5. Discussion

Collaboration processes and platforms adopted for BIM

The findings on the nature of collaboration processes adopted for BIM among the surveyed construction professionals suggest that professionals often model building information independently in most projects without collaborating with other members of the project team. The findings also show that Architects collaborate with Engineers and Builders on projects more than they collaborate with other professionals. High level of collaboration between Architects and Builders suggests that Architects are beginning to appreciate Builders' input at the design stage. In Hong Kong, Rahman and Alhassan (2012) found that Architects and Engineers model building information together without any input from other team members. The finding of this study is consistent with the previous finding of Rahman and Alhassan (2012); however, the finding in this study showed that the input of Builders in BIM is appreciating.

Although collaboration creates relationship in BIM and gives meaning to the model being generated. The findings of this study show that Architects, Engineers and Builders collaborate on projects more than they collaborate with other construction professionals. This could mean that Builders' input in the design of architectural and engineering models is important for effective coordination and interpretation of design intent on construction site. Construction gives value to design; therefore, the design concept should be clear to the Builder right from the planning stage of the project. Study by (Mom et al., 2011) showed that Architects collaborate with Engineers and Builders on the creation of architectural model. The finding of this study adds to the result reported by Mom et al. (2011).

The concept of BIM is about the usage of CAD with full collaboration, but professionals use CAD to model building information independently without integrating them and without practising full collaboration. This could be as a result of inherent fragmentation in the construction industry and limited adoption of Integrated project Delivery. The findings of this study show that there are various forms of lonely and part collaboration process being employed for BIM on projects. These various forms of lonely and part collaboration can be explained as in-house collaboration, a form of collaboration which can be referred to as convenient collaboration, where professionals collaborate with other professionals in their firms, their associates or where professionals perform the roles of two or more professionals. The findings established that there are Architects who also function as Engineers, Builders or Facilities Managers; and Builders who also function as Architects, Engineers, Quantity Surveyors or Facilities Managers. Also, the availability of full package software technologies such as Autodesk Building Design Suite, which provides a platform for users to develop and integrate all types of building information has also encouraged the practice of in-house or convenient collaboration. This finding is consistent with studies from (National BIM Report, 2013; Sawhney, 2014), which reported that construction professionals in Canada use CAD, develop their models and integrate them in-house, but they do not practice true collaboration and that full collaboration can only be achieved in 6D BIM; also that full collaboration is not currently being practiced in India and that the available forms of collaboration are out-of-sync with the required collaboration in BIM.

It could be inferred from the results that Builders employ lonely collaboration process more than other construction professionals; this could be as a result of their ability to prepare all the building information required for projects and the availability of a total package software technologies such as Autodesk Building Design Suite. This further proves that professionals do not employ collaboration process equally and that Architects and Structural Engineers collaborate more with other professionals. Also, it shows that Structural Engineers and Architects have participated in projects with full collaboration process more than any other professionals.

Paper-based platform was the most predominant BIM platform among the construction professionals. It was found that almost all the construction professionals use paper-based platform on projects. Interoperable BIM standard platform such as IFC or COBie is not being used at all, as only 2.8% indicated that they often use it. This finding shows that construction professionals model building information independently and exchange it physically using paper-based platform or digitally using compatible software platform. Architects, Builders and Engineers often use common software platform, but information is not being exchanged among the construction professionals using COBie or other interoperable BIM standard platform. This finding is consistent with study by National BIM Report (2011), which indicated that few professionals are using interoperable BIM standard platform in UK, Canada and New Zealand.

BIM protocols employed by construction professionals

The findings of this study show that the process of modelling building information was not yet organized and BIM managers were not being appointed among the construction professionals in the study area. This could also mean that architects and quantity surveyors had been representing clients on projects more than other professionals. The unavailability of BIM standards in Nigeria could be responsible for this. The results in this study also show an evidence of information management and establishe a link between the roles of builders in analysing information supplied by other professionals for errors, omissions and discrepancies and the BIM process of identifying and resolving conflicts between information models. It could be inferred from this findings that professionals were not following the stipulated protocol and processes of resolving design conflicts. This finding is consistent with the recent study by Sawhney (2014) in India, which found that BIM protocol and processes been employed in India is out-of-sync with the standard BIM protocol and processes.

It could be inferred that construction professionals in their own capacity as member of a project team or individually have been developing information models to provide information for the team members. The development of discipline specific information models by the team members is a BIM process that precedes the integration of the information models. The various discipline specific models are coordinated and integrated by the appointed BIM manager to develop a building information model which serves as the database for the project. This finding confirms the previous findings that the process of BIM isn't organized among the construction professionals. The professionals develop discipline specific information models but were not appointing information managers or BIM managers to be coordinating and integrating the information models. It could also be inferred that fragmentation in the construction industry could be responsible for non-integration of information models among the construction professionals. Architects and engineers may not want to subject their information models to builders or whoever is appointed as the BIM manager to scrutinize. Construction professionals can collaborate and develop information models in order to fulfil their contractual obligations, but without unity and cooperation on their parts, information may be shared and yet not integrated and this can impede the BIM processes and benefits. When discipline specific information models are not integrated, the problems that may arise in the course of construction won't be identified before the construction stage and this would defeat the objective of BIM.

The findings on BIM processes show that construction professionals usually identify the potential uses of building information models based on clients' requirements and information required by other team members before developing the information models. It could also mean that in the course of collaborating with the other professionals on projects, the construction professionals analyse the request for information to identify the information required and to know the specification on how the information models should be created. Although, there were no protocol guiding the request for information and the process of addressing design questions. This could also mean that the process of BIM wasn't being managed and that each member of a project team determined the content of output information by himself and requested for input information from the concerned parties by himself. As noted by (BIM Guide, 2013), the BIM manager should be nominated to coordinate the exchange and integration of information models. Protocols should be developed to address questions on output information and guide the process of requesting for input information; but this was not the case among the construction professionals in the study area. It could also mean that in the course of collaborating with the other professionals on projects, the construction professionals analysed the request for information to identify the information required and to know the specification on how the information models should be created. Nevertheless, the construction professionals may not be familiar with the process, protocols and terminologies of BIM but they were developing discipline specific information models and forwarding them to the builder either for the purpose of meeting contractual obligations or integrating the information.

The level of provision of intellectual property right for building information among the construction professionals suggested that intellectual property right provision was appreciating among the construction professionals. The findings also show that much importance is not being attached to the appointment of a BIM manager or information manager. This means that the production of BIM lacks structure among the professionals as the stages of a project where particular information is produced were not well defined. It was found that construction professionals abide by contractual agreement when modelling building information and that they control the way they name file folders and versions. It could also be inferred that majority of the construction professionals use file naming standards and file version to control the way they model building information. This suggests that construction professionals do not usually set obligations, liabilities and limitations on the use of the models and responsibilities for action and deliverable. This is consistent with the findings on the appointment of an information manager. It is the BIM manager, where appointed, that specifies the required output information to be produced by members of the project team. The appointment of a BIM manager should always be considered in BIM so as to guide against conflicts and chaos. This further confirms the above findings that professionals are not appointing BIM managers and that BIM as being practiced lacks structure. This was also revealed in the responses to the question on the establishment of project reference point, communication procedures and layering convention and colour schemes. These are rules that are required to be established by BIM managers.

Furthermore, the results show that construction professionals were adhering to contractual arrangement, exchanging input and output information with the appropriate file names, indicating the file version of the input and output information, and arranging the information according to the agreed convention, and using specified colours for building elements. The establishment of reference points for projects suggests that there was a level of coordination in BIM processes among the construction professionals. All the same, the specification code for information management for the delivery phase of construction projects using BIM was not being used among the construction professionals as the level of usage of PAS 1192-2 guidelines ranked least among the rules for BIM processes. This is understandable as the construction professionals were not familiar with BIM protocols but had been modelling building information using a modified traditional process of working.

It could also interpreted that Architects, Builders and Structural Engineers who ranked first, second and third respectively had been acting as BIM managers in BIM-based projects and discharging their duties by identifying the building information that requires modelling, identifying the potential uses of building information models, specifying when the information models will be created, specifying how the information models will be created, establishing rules and conventions for information models, developing discipline specific information models and integrating the information models.

In summary, the study shows that the level of usage of BIM protocols and rules was higher among the Architects, Builders and Engineers as compared to the other professional groups. It also seems to be the case that BIM process among construction professionals was dominated by Architects, Builders and Engineers. As part of the process of BIM, the information models were required to be integrated to develop a building information model which serves as the database for the project. Traditionally, Architects or Builders were responsible for the management of building projects and Civil/Structural Engineers for the management of civil and infrastructural projects. The findings of this study show a link between the traditional roles of Architects, Builders and Civil/Structural Engineers and their roles in BIM process. Another reason for the domination of BIM process by Architects, Builders and Engineers may be that as leaders of design and construction teams who were also qualify to manage the BIM process, they were actually discharging their duties by establishing project reference points for their respective teams.

6. Implications

The findings of this study necessitate the needs for Nigerian construction professionals to be practising full collaboration as it would help to solve the problems of fragmentation in the Nigerian construction industry. Also, the findings call for digital exchange and integration of building information on interoperable BIM tools and platforms. Adhering to the processes and protocols of BIM would sanitize the Nigerian construction industry and would facilitate professional development and excellence among the Nigerian construction professionals.

7. Conclusion

Full collaboration was not being practiced among the construction professionals, as over two-third of the respondents were not sharing information models collaboratively. Also, more than one-third of the respondents were using paper-based platform for BIM; while about one-third were using compatible software platform as BIM platform. The majority of construction professionals were still not embracing full collaboration, integration of information models and interoperable BIM platform because they did not understand the collaboration protocol and information sharing requirements of BIM. The form of collaboration among the construction professionals did not follow any guidelines on collaboration working required in BIM. They employed a form of convenient collaboration-a collaboration based on the contacts and capabilities of the consulting organizations, whereas a truly well-implemented BIM requires the involvement of the key participants in order to achieve full collaboration. Architects and engineers mostly model building information independently without any input from other professionals, although some Architects and Engineers collaborate with Builders or Quantity Surveyors or Facilities Managers to model building information, but only few engage in full collaboration.

The examination of the BIM protocols and processes among construction professionals showed that more than two-third of the construction professionals surveyed rarely follow the steps involved in the process of modelling building information. There was statistically significant differences in the level of usage of BIM rules in controlling the modelling of building information among the construction professionals. The kruskal Wallis test revealed that the level of usage of BIM rules was higher among architects, builders and structural engineers and lowest among facilities managers. However, more than one-third of the construction professionals surveyed were using file naming standards and file version to control the way they model building information. Construction professionals were not adhering to BIM rules, conventions and protocols in projects owing to lack of Nigerian national BIM standard. This makes the production of BIM to be disorganized among construction professionals; however, they were adhering to contractual obligations and were employing file naming and version to control BIM.

The process of modelling building information in projects was being dominated by architects, engineers and builders, and only architects were providing intellectual property right for building information. Construction professionals rarely understood BIM terminologies, processes and protocols. Architects and Builders had been acting as BIM managers in projects but they did not fully understand the responsibilities of a BIM manager. This explains why builders manually coordinate information models supplied by other professionals to detect clashes and discrepancies.

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