INVESTIGATING THE EXTENT OF USE OF BUILDING INFORMATION MODELLING (BIM) IN DEPARTMENT OF ARCHITECTURE, COVENANT UNIVERSITY OTA, NIGERIA

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Abstract

BIM is an acronym for building information modelling, or building information model. It describes the process of designing a building collaboratively using one coherent system of computer models, rather than as separate sets of drawings. This allows for proper and effective management of information which in turn creates smarter and more informed professionals in a construction industry that looses billions per year, due to ineffective communication.

This research aimed at examining the extent of use of **BIM** in Covenant University‘s department of architecture focused on three major variables; awareness, effective use and application of the subject matter outside the classroom.

The result of this research however suggests that the more advanced facets of **BIM** are used at marginally low levels, compared to the rather basic facets such as 2D and 3D **BIM**. Nonetheless, this research did not give room for fallacy of generalization as extensive means of cross analysis were used to properly examine awareness, use and application of **BIM** outside the classroom‘ (amongst other variables) across the several levels of study. Hence, allowing for more detailed and precise findings

1 INTRODUCTION

Digital technologies has greatly influenced and is continuing to influence the way humans work and conduct their business globally and architects however have not been left out of this trend. Often associated with large volumes of drawings and complex designs to produce, the computer has greatly come to our aid and architects have become more and more reliant ever since. Example gratia, Frank Gehry an American architect, enjoyed the playfulness Deconsrtuctivism allows. Gehry‘s designs range from a kind of austere modernism in the early 1970s to increasingly irregular compositions in the late 1980s and 1990s, with colliding angular forms and other unusual juxtapositions. As the geometries of his buildings became more complex and with the introduction of compound curves, Gehry relied more on Computer Aided Design (CAD), adapting software developed in France for aircraft design. (Roth, 2008)

Ivan Sutherland invented computer aided design **CAD** in 1961 when he described a computerized sketchpad in a doctoral thesis while attending the Massachusetts institute of technology (MIT). He designed **CAD** to replace the traditional drafting board and other tools drafters used, such as the ink pen, plastic stencil and electric eraser. Conversely, early **CAD** software ran on large, expensive computers, but today architects can run **CAD** on personal computers or **UNIX** workstations. (Gabrowski, 2008)

CAD software basically refer to tools for architectural drafting such as AUTOCAD and Vector works which is used in the design and documentation of building projects. However, as earlier postulated, change is a constant variable that ripples through time, and to this regard, the notion **BIM** emerged in the 1970s as an improvement upon **CAD** systems as they did not only manage computer graphics, but they also manage information which allows for the automatic generations of drawings and reports, design analysis, real world setting simulation, schedule simulation, and facility management- ultimately enabling the construction team to be better informed. Contrariwise, it was not until 1992 that the term ‘**building information model’** was used in a paper by **G.A. van Nederveen and F. P. Tolman.** The idea of building information model would later be referred to as ‘**building information modelling**‘by Autodesk and Vector systems, ‘**virtual building’** by Graphisoft, and ‘**integrated project model**‘by Bentley systems. Eventually, the acronym **BIM** would be adopted as a general term that referred to the digital representation of the building process. Example of **BIM** software include; Autodesk Revit, ArchiCad, and ARCHIBUS with BIM 4.0.

BIM as a digital tool is multi- faceted and by popular opinion is divided into six major facets which are: BIM 2D: Two dimensional drafting, BIM 3D: visualization and augmentation of the three primary spatial dimensions which are- length, breadth and width, BIM 4D: Time as the fourth dimension in terms of simulations, BIM 5D: Costing and Estimation, BIM 6D: Energy simulation and sustainability analysis and BIM 7D: Facility management applications.

1.1 Problem Statement

Architecture as a practice can be described as an ever changing field, with advancement in science and technology playing a major role. This constant change in the professional world is not however reflected in the classroom, hence leading to obsolete graduates upon their emergence into the real world of practice. (Omotosho, 2015) This syndrome is prevalent in many Nigerian universities, because the syllabus is not changing as quickly as newer solution models are introduced. Building information modelling is one of these grey areas in many architectural institutions.

Architectural education in recent times has employed the inclusion of software used by professionals in the curricula so as to ready students for practice. To this effect, CAD and BIM systems are being taught to students of architecture across all stages of architectural development.

At the covenant university department of architecture, AutoCAD is taught to students in the third year and they are taught exclusively 2D and 3D aspects of AUTOCAD while Autodesk Revit is taught to students at the fourth year, and is being used, up until the sixth year and subsequently at all strata of post-graduate study. Nevertheless, it is only taught and learnt to certain extents. Hence, differing levels of knowledge of BIM across a class.

1.2 Research Questions

The following are basic research questions of this study;

i. Are students more productive using BIM, are they able to communicate their ideas effectively using same?
ii. Is BIM effectively inculcated into the curriculum of architectural education in Covenant University‘s department of architecture?
iii. What do students use BIM for?
iv. How does the availability of quality human and physical infrastructure affect students‘ knowledge of BIM?
v. Do students use BIM outside the classroom? Does it affect the quality of their knowledge?

1.3 Aim of Study

The aim of the study is to understand the range of knowledge of **BIM** as a subject by students of the Covenant university department of architecture.

1.4 Objective of Study

i. To examine the influence of **BIM** on students' ability to communicate design ideas effectively.
ii. To understand the extent to which **BIM** is used in the Covenant university‘s department of architecture
iii. To examine students‘ awareness, and effective use of the several facets of **BIM**
iv. To examine the availability of infrastructure (both human and physical) and how it affects the level of knowledge of the students
v. To examine the varying levels of knowledge of the subject matter across board of every class (third year and above)

1.5 Scope of Study

The scope of this study is constrained around Covenant University with specificity to the Department of Architecture with extents to the differing levels of knowledge in the use of BIM, understanding the approach in the pedagogy and learning of BIM and the examination of the BIM curricula.

2 LITERATURE REVIEW

2.1 ARCHITECTURAL EDUCATION IN 21ST CENTURY NIGERIA AND THE FUTURE OF THE PRACTICE.

Architectural education in Nigeria has matured and developed. It has witnessed drastic changes over a period of time since it was presented into the country in 1952. The first school of architecture, science and technology located at Ibadan in 1952, which was later repositioned to Zaria, in the present Kaduna State in 1955.

At the inception and indoors this period, only diplomas in Architecture were awarded to students. The diploma being endowed qualified the students upon graduation to be exempted from parts I and II of RIBA (Royal Institute of British Architects) Professional examinations; but only to sit for the final phase before being licensed a registered architect. In quintessence, the Nigerian architectural educational system was made-to-order after the British education and to a greater extent in line with the syllabus of our colonial masters.

The alliance with RIBA was sustained until 1968, when the course program was again reorganized into two-tier, with the offer of the Bachelors Science (BSc) and Master of Science (M.Sc.) degrees in architecture.

It is germane to note that, the University of Nigeria, Nsukka was established in 1962. Hence making it to be the second institution to offer the architecture programme in the country. In 1970, the University of Lagos, Akoka, established its school of architecture, thus, making it the third school.

2.2 THE TEACHING AND LEARNING PROCESS

Teaching can be defined as systematic presentation of facts, ideas, skills, and techniques to students. Although human beings have survived and evolved as a species partly because of a capacity to share knowledge, teaching as a profession did not emerge until relatively recently. The societies of the ancient world that made substantial advances in knowledge and government, however, were those in which specially designated people assumed responsibility for educating the young. (Mazur, 2009)

Learning can be defined as a cognitive process of acquiring knowledge or developing the ability to perform new behaviors. It is common to think of learning as something that takes place in school, but much of human learning and indeed architectural education occurs outside the classroom, and people continue to learn throughout their lives.

Just as any other concept or field of study, **BIM** is taught by the person of the instructor demonstrating the application and use of the software, and it is learnt by repeating or following steps the instructor has taken in order to arrive at the proposed outcome. The instructor then attempts to expand on the knowledge base of his students by issuing assignments and projects. Finally, he tests the quality of the knowledge of the students by giving an examination or test.

This method is however, short of adequate because students are not exposed to the full capabilities of the software; which is to create an integrated and intelligent model which is created by the input of several professionals in the construction industry.

The painted scenario above, requires the students to accommodate for the shortfall in the classroom by learning the deficit in the field or the professional world as it were. This forms the core of architectural education; which indeed is learning through practice.

2. 3 ARCHITECTURAL EDUCATION CURRICULUM DESIGN FOR NIGERIAN INSTITUTIONS.

Olotuah and Adesiji had noted that the objective of architectural education in Nigeria to a large extent is in sync with the national aspiration as enunciated in the 3rd National Development Plan.

Some of these national aspirations include:

- Reforming the content of general education to make it more responsive to the socio-economic needs of the country; Consolidating and developing the nation‘s system of higher education in response to the economy‘s manpower needs;
- Rationalizing the financing of education with a view to making the educational system more adequate and efficient; and
- Making an impact in the area of technology education so as to meet the growing needs of the economy. By and large, architectural education in Nigeria is centered on these seven specializations:- Architectural Design; Arts and Drawing; Historical and Theoretical Studies; Building Systems Technology; Humanities and Social Studies; Environmental Control System and Physical Sciences

2.4 APPLICATION OF BIM AND ITS RELEVANCE TO THE CONSTRUCTION INDUSTRY

BIM helps architecture, engineering, and construction (AEC) service providers apply the same approach to building and infrastructure projects. Unlike CAD, which uses software tools to generate digital 2D and/or 3D drawings, BIM facilitates a new way of working: creating designs with intelligent objects. Regardless of how many times the design changes—or who changes it—the data remains consistent, coordinated, and more accurate across all stakeholders. Cross-functional project teams in the building and infrastructure industries use these model-based designs as 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. Models created using software for BIM are ―intelligent‖ because of the relationships and information that are automatically built into the model. Components within the model know how to act and interact with one another. A room, for example, is more than an abstract concept. It is a unique space contained by other building components (such as walls, floors, and ceilings) that define the room‗s boundary. With BIM, the model is actually a complex database and the room is a database element that contains both geometric information and nongraphic data. Drawings, views, schedules, and so on are ―live views of the underlying building database. If designers change a model element, the BIM software automatically coordinates the change in all views that display that element—including 2D views, such as drawings, and informational views, such as schedules—because they are all views of the same underlying information. (Race, 2011)

3 METHODOLOGY

The research adopted a survey approach with the following instruments: questionnaire and non-participant observation. These strategies were chosen to enable the collection of both qualitative and quantitative data from students of the Covenant University department of Architecture (300 level-Msc2). A sample frame of 186 students was used with a confidence level of 99.9%, and a margin of error of 2.5% from a population of 200 students.

The units of analysis are the variables used in measuring concepts highlighted in the questionnaire distributed. A total of 100 were administered, and 97 were collected. Two basic types of data were obtained from the field work; qualitative and quantitative data. The qualitative data were obtained from categorical responses from the students were measured using the nominal or ordinal scales. The quantitative data were derived from numerical responses measured on an interval scale. They were discrete in nature. The variable used in deriving the extent of use of BIM in Covenant University‗s department of architecture are as follows;

Availability of infrastructure (human and material.): in line with the objectives of this research, this variable attempts to examine the effect of the conditions of provided infrastructure on students' knowledge of **BIM;**

The use of **BIM** outside the classroom by students‗: the use of this skillset outside the classroom greatly influences the knowledge of the students on the subject matter. Avenues such as internship programs, non-academic designs and personal development are pointers which evaluate students' use of **BIM;**

The facets of **BIM**, and the extent of the knowledge of students as regards them: As earlier postulated, **BIM** is multi-faceted. Hence, understanding the extent of the students‗ knowledge on such facets is of great importance;

Influence of **BIM** on the students‗ productivity, and ability to communicate design ideas effectively.

4 RESULTS

The results are hereby presented:

AWARENESS OF THE USE OF BIM IN THE TEACHING, LEARNING AND PRACTICE OF ARCHITECTURE

It was discovered that 98% of the respondents were aware of the use of BIM. In the teaching learning and practice of architecture in high contrast to a corresponding 2% of the respondents who did not. This suggests that there is a high level of awareness of BIM in Covenant University's department of architecture

PROFICIENCY IN THE USE OF BIM

Table 4.1 Frequency and percentage distribution of varying levels of ***BIM*** *proficiency*

	Frequency	Percent	Valid Percent	Cumulative Percent
beginner	19	19.4	19.4	19.4
intermediate	74	75.5	75.5	94.9
expert	5	5.1	5.1	100.0
Total	98	100.0	100.0	

In the 300 level class, a majority of the students are beginners in **BIM**, largely owing to the fact that they are not being taught **BIM** as earlier postulated.
Nonetheless, a slightly larger majority are intermediate users. This may be due to a number of factors which include; experience from internship programs, personal development, etc.
However in the 400 level class, there is a high contrast to the previous class because students in this class are being taught **BIM**. This parallel has resulted in a high number of intermediate users, a lower percentage of beginners, and an even much lower percentage of expert users.

In the 300 level class, no respondent can use the animation face of **BIM** effectively. The M.Sc. 1 class has a higher count per population of study level that can effectively use this facet.

By means of summarization, 61.1%, 27.8%, and 11.1% of respondents who can effectively use this facet of **BIM** belong the 400 level, M.Sc. 1, & M.Sc. 2 classes respectively, while 13.9%, 60.8%, 8.9%, and 16.5% of students who cannot effectively use this facet belong to the 300 level, 400 level, M.Sc. 1 and M.Sc. 2 classes respectively.

Table 4.2 Cross table showing frequency distribution of the relationship between variables in the previous chart

	BIM 6D (energy and sustainability analysis)		Total
	Yes	no	
300 level	14.7%	9.5%	11.3%
400 level	64.7%	58.7%	60.8%
M.Sc. 1	8.8%	14.3%	12.4%
M.Sc. 2	11.8%	17.5%	15.5%
Total	100.0%	100.0%	100.0%

With regards to the awareness of the 6D facet of **BIM**, one thing is clear across all levels of study; the amount of students who are aware of this facet are lower than does who do not by very clear margins, in exception to students in the 300 level.
So therefore, an overwhelming majority of the respondents cannot effectively use this facet of **BIM**, in stark comparison to an insipid minority of respondents who can effectively use this facet
The total count of respondents who can effectively use this facet, is less than 5
As earlier postulated, it becomes an imperative for the department to introduce this facet of **BIM** to its students, because of its modern day importance to design.

EFFECT OF INFRASTRUCTURE (HUMAN & PHYSICAL) ON THE LEARNING OF BIM

Table 4.3 Table showing mean values of responses as regards the attributes

Descriptive Statistics		
	N	Mean
the digital studio is well lit and it aids the learning process	95	1.8105
the digital studio is thermally accommodative, hence learning is easier	95	1.9053
the monitors in the studio function properly and are effective as regards the tasks performed in class	95	3.0947
the projector functions properly and all students can see the teaching surface clearly	95	2.1684
the tables and chairs are in good condition and are comfortable	95	2.4105
the instructor(s) is audible and communicates effectively	95	1.8632
the instructor(s) student ratio is effective for proper learning to occur	95	2.2421
the color scheme of the studio relaxes the learning process	95	2.3579
Valid N (listwise)	95	

Note; 1- strongly agree, 2-agree, 3- undecided, 4- dis-agree, 5- strongly dis-agree

From the mean table above, the following can be drawn;

The provision of infrastructure (human &physical) definitely has a ripple effect on students' learning of any concept or field. As regards the learning of **BIM**, students agreed on the following;

- □ The digital studio is spatially adequate and comfortable
- □ The studio is well lit, which in turn aids the learning process
- □ The digital studio is thermally accommodative. Hence, learning is easier
- □ The tables and chairs are in good condition and are comfortable
- □ The medium of teaching is effective for proper leaning to occur
- □ The instructor is audible and communicates effectively
- □ The instructor-student ratio is adequate for proper learning to occur
- □ The color scheme of the studio relaxes the learning process

However, they did dis-agree about one thing;

- □ The monitors in the studio are not capable of effectively handling the design tasks in the classroom.

INVESTIGATING STUDENTS' ENGAGEMENT WITH BIM OUTSIDE THE CLASSROOM

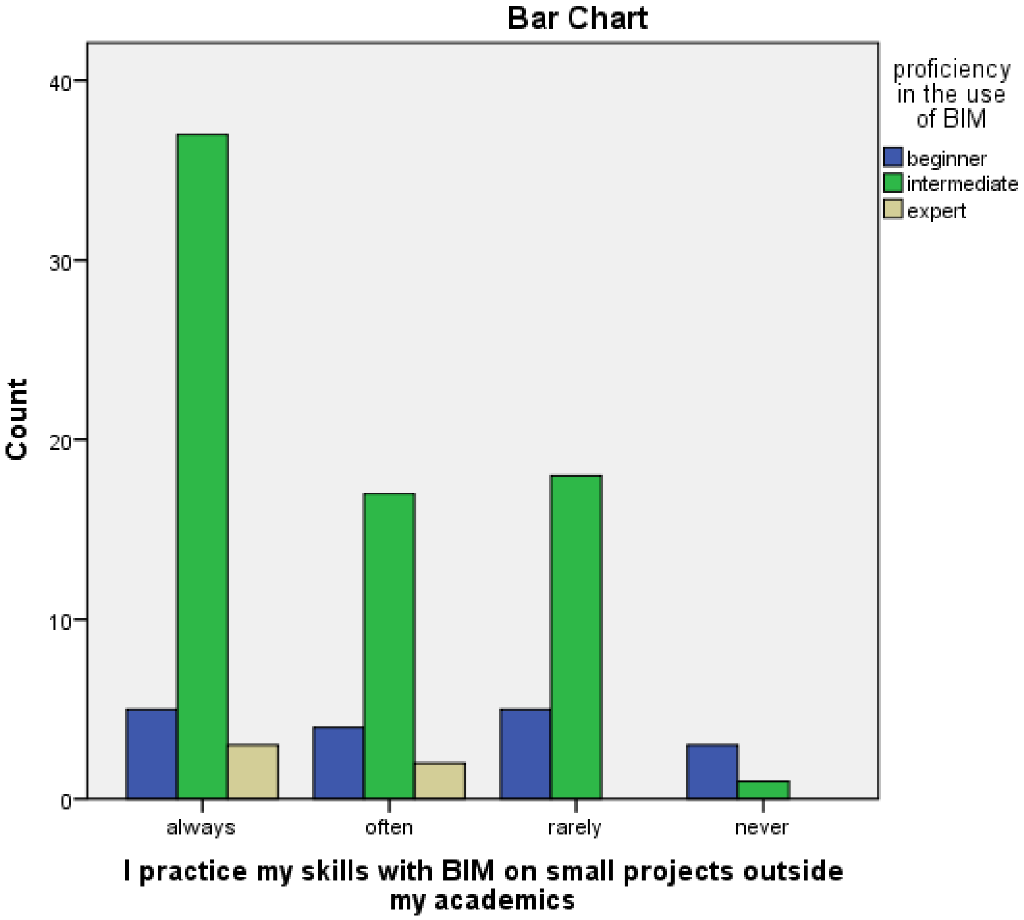

*Figure 4.1: Cross-chart showing the relationship between **variable 1** (proficiency in the use of **BIM**) and **variable 2** (I practice my skills with **BIM** on small projects outside my academics.)*

The chart in the above shows the relationship between the respondents' proficiency in the use of **BIM** in correlation the practice of their skills with **BIM** on small projects outside academics.. The below stated scenarios however arise;
The beginners: 29.4% of respondents always practice their **BIM** skills with small projects outside their academics, while 23.5%, 29.4% and 17.6% of respondents, often, rarely and never respectively practice their **BIM** skills with small projects outside their academics;
The intermediate users: 50.4% of respondents always practice their **BIM** skills with small projects outside their academics, while 23.5%, 29.4% and 17.6% of respondents, often, rarely and never respectively practice their **BIM** skills with small projects outside their academics;
The expert users: it was observed that 60% and 40% of expert users always and often respectively use their design studio as a means of learning new aspects of **BIM.**

INVESTIGATING THE INFLUENCE OF BIM ON STUDENTS'PRODUCTIVITY AND ABILITY TO COMMUNICATE DESIGN IDEAS EFFECTIVELY.

42.9% of the respondents effectively communicate design ideas using **BIM**,
40.8% of the respondents visualize design ideas effectively using **BIM**
54.1% of the respondents easily retrieve stored designs using **BIM**, while
46.9% of the respondents can easily re work designs using **BIM**

5 CONCLUSION

Following the research questions of this study, the conclusion of this study can be discussed below

- **Are students more productive using BIM, are they able to communicate their ideas effectively using same?**

When respondents were asked their responses to attributes pertaining this question such as ; I use lesser time in design tasks using **BIM**, I visualize design concepts easier using **BIM**, etc. the employed mean values suggested that students agreed to such attributes which ultimately implies that students are more productive using **BIM**, and are able to communicate their ideas using same.

- **Is BIM effectively inculcated into the curriculum of architectural education in Covenant University's department of architecture?**

It was discovered upon research that **BIM** was taught to students at the 400 level of study and the masters' degree program for a semester only. **BIM** multi-faceted, and indeed a large subject matter. The length of time given to address all the facets of **BIM** is not sufficient, therefore, a scenario appears where a majority of students are well grounded in the two and three dimensional facets of **BIM**, and are almost negligent of the other four. To this end, **BIM** is not effectively inculcated into the curriculum of architecture at Covenant University's department of architecture.

- **What do students use BIM for?**

In order to properly answer this question and satisfy the main objective of this research; ‗investigating the extent of use of **BIM** in Covenant University's department of architecture', respondents were asked the facets of **BIM** they could effectively use. The majority of the responses fell into the category of either or both 2D drafting and 3D modelling, while sparring numbers could effectively use the other facets.

- **How does the availability of quality human and physical infrastructure affect students' knowledge of BIM**?

It was revealed that on the average, respondents agree that the availability of infrastructure does in fact affect their learning process, which in turn affects the quality of their knowledge on the subject matter.

- **Do students use BIM outside the classroom? Does it affect the quality of their knowledge?**

Respondents were asked the above question, and the average response was ‗yes'. However, a cross analysis of their proficiency and their response was carried out, and it was discovered that the expert users often and always use **BIM** outside the classroom via avenues such as; downloading tutorial videos, practicing their skills with smaller projects outside their academics, etc. so therefore in conclusion, students use **BIM** outside the classroom averagely, and this does in fact affect the quality of their proficiency on the subject matter.

Other findings pertaining other focus areas of this research (awareness and effective use of **BIM**) suggests thus; asides the 7D facet of **BIM**, students are on an average aware of the several facets of **BIM**. However, in examining the facets which they can effectively use, it is also pertinent to know the facets which students are required to effectively use. Upon this realization, it was discovered that the facility management dimension of **BIM** (**BIM 7D**) cannot be effectively taught and learnt by students as it incredibly vast and requires real life subject buildings as a virtual model is no longer sufficient. Contrariwise, all the other facets of **BIM** should be taught to students in both their under-graduate and post-graduate studies. An effective structure of how is can be achieved is postulated below, as it takes into consideration overlapping facets which can be taught simultaneously since **BIM** as a subject matter is however parametric

 BIM 2D(drafting) **& BIM 3D**(3D modelling): As opposed to earlier CAD systems, these operations are more or less simultaneous, but in many ways are independent of one another**.** I would recommend these facets taught across a 2-year period, that is, the second and third year. One might wonder why such a large extent of time, the foundational aspect of these operations aside, they form key thresholds of one's knowledge of the subject matter. It would also be pro-active to allow students use this medium of **BIM** to achieve creativity and productivity in their design studio and other relevant assignments.

 BIM 4D (animation): This can be taught to students in the final year of their under-graduate study, as they are expected to be well grounded in the 2D and 3D facets. The 4D facet allows for a more sophisticated presentation, as students can show their designs in real time setting.

 BIM 5D (cost estimation) and **BIM 6D** (energy and sustainability analysis): since these operations require applied knowledge, they can be taught on the post-graduate platform.

On extensive examination of collected data, coupled with the researcher's observation and all findings, **BIM** is not extensively used in Covenant University's department of architecture. It then becomes an imperative for the department to curtail these shortcomings.

As repeatedly stressed in this project, **BIM** is the future of design construction, as already being realized in more advanced economies. So therefore, if educational institutions are poised to produce professionals that will solve our tomorrow's problems today, then they must be well equipped with relevant skillsets

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