ADOPTING BIM AS A TOOL FOR COLLABORATIVE DESIGN IN ARCHITECTURE SCHOOLS IN NIGERIA

EVALUATING THE IMPACT OF BIM EDUCATION ON STUDENTS' DESIGN IN ARCHITECTURE SCHOOLS IN NIGERIA

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ABSTRACT

Building information modelling(BIM) combines both technological platforms and design processes to help architects design in a collaborative and efficient manner. BIM is fast becoming the industry standard in the design and construction of buildings globally, therefore there is a need that students graduating from schools of architecture are taught about it. Currently, there exists very little literature on the effect of BIM adoption on architecture education and its impact on the design practices among architecture students in Nigerian universities. The paper therefore seeks to evaluate the impact of BIM adoption, on the design processes and quality among architecture students in Nigerian universities. The paper also seeks to contribute to the existing literature in this area of research. The study focused on fifth year students during the 2019 first semester studio design, in the University of Nigeria, Enugu Campus. The students worked on their semester design using Autodesk Revit, and at the end of the semester, their designs were assessed based on sustainability, functionality and creativity, to ascertain the impact of BIM on their design and processes, in comparison with students that didn't use BIM. The results show that the introduction of BIM tools can aid students in producing sustainable and functional design solutions, while improving their ability to communicate and collaborate their design ideas more effectively.

KEY WORDS

BIM, Nigeria; Architecture Schools; Collaborative Design; University of Nigeria; schools of architecture

INTRODUCTION:

Functional, creative and sustainable solutions are the core precepts that every school of architecture aims to imbibe into its students. Architectural education in Nigeria has virtually remained unchanged since its inception in the country in the 1960s. Design studios are mainly centered around the drawing board, and presentation of semester design projects are still done on ink and paper. The popular conception amongst many educators in schools of architecture in Nigeria, is that students must first be proficient in hand-drawings before learning to work with computers. This is because many lecturers from personal experience are of the opinion that students who worked with CAD tools, may end up producing aesthetic designs without understanding of the core concepts and functional requirement of the building. This is one of the major factors hindering the adoption of Building Information Modelling- BIM- into the curriculum in many schools of architecture within the country. Though this claim in some cases can be valid in the case of CAD drawings where students mainly focus on the façade of the building without considering other several factors in the design, it cannot be said to be right in the case of BIM. This is because BIM seeks to integrate the design process with the design solution, ensuring all information needed are provided and encourages collaboration and inputs from other stakeholders. As Jennifer A.M postulates; 'There is a great opportunity to engage students more effectively and to aid understanding of how buildings are constructed.'[1]

However, within the past two decades many schools of architecture in Nigeria have begun introducing computer Aided Drafting (CAD) tools into their syllabus and students are usually taught the rudiments of the software without proper integration into their semester design for practical application. With the current drive in technological industrialization around the world, and the need for buildings to be smarter and more sustainable, the graduate architect must be taught to be able to tackle the current challenges using the technological capabilities of the industry. Building Information Modelling (BIM) is the industry's solution to efficient and sustainable design of buildings in the 21st century. BIM can be summarized as the technology, policies, and processes, that computes all the building information in one unified output, for effective coordination and collaboration between professionals and occupants throughout the lifecycle of the building.

BIM is fast becoming standard form of practice, and it is therefore paramount that schools of architecture in Nigeria begin to incorporate BIM into their curriculum. The aim of this paper therefore is to ascertain the impact of the introduction of BIM education on the design of architecture students in Nigerian universities.

BIM_ 'BUILDING INFORMATION MODELLING'.

BIM Building information modelling, as defined by Gu and London[2], *is an IT enabled approach that involves applying and maintaining an integral digital representation of all building information for*

[1]Jennifer A. Macdonald, (2012). A framework for collaborative BIM education across the AEC disciplines.

[2] GU, N. & LONDON, K. 2010. Understanding and facilitating BIM adoption in the AEC industry. Automation in Construction, 19, 988-999.

different phases of the project lifecycle in the form of a data repository. The building information involved in the BIM approach can include both geometric data as well as non-geometric data."

BIM is made up of 3 main pillars namely_ technology, process and people. This paper focuses on the technological aspects of BIM. The benefits of BIM as a technological tool in the practice of architecture is discussed as follows:

At the core of BIM, is a repository of data that is systematically organized according to predetermined rules.[3] Every element in a BIM model is made up certain characteristics often referred to as 'object/element parameters'. The concept of parametric data about the object is paramount[4] in producing useful BIM models. Parametric objects would contain vital information about itself such as height, length, depth, weight, spatial/geo-spatial location, material/element properties, spatial relationship to adjacent objects.[5]

BIM is a technological tool that enables architects and designers, to create 6-dimensional, intelligent and realistic models of the buildings they are designing. It is important that modelling instead of drafting in BIM enables designers to better visualize and communicate their ideas very early on the design process.[6] This will enable all stakeholders make inputs and also give the designers ample opportunity for effective design iteration that is more inclusive at the end product.

BIM also encourages effective communication and collaboration between those involved in the design process. According to Pressman (2007: p3),

"Many academic programs still produce students who expect they will spend their careers working as heroic, solitary designers. But integrated practice is sure to stimulate a rethinking of that notion. Pedagogy must focus on teaching not only how to design and detail, but also how to engage with and lead others, and how to collaborate with the professionals they are likely to work with later."[7]

Introducing BIM into the design landscape in schools, will encourage students to think in terms of models (3-dmensions) very early in the design process, instead of making 2-dimensional sketches that they may not be able to clearly realize in models. Thinking in terms of models rather than sketches have been shown to improve design creativity/efficiency in practice.

[3] Sourced from: John, P.R (2013) thesis on The strategic adoption of BIM by Malaysian engineering consulting services firms; where he quoted -McGraw-Hill-Construction, 2009.
[4] John, P.R (2013) thesis on The strategic adoption of BIM by Malaysian engineering consulting services firms;
[5] The following authors give credence to the parametric objects as the core of BIM in Architecture. They include; Eastman et al., 2011. BuildingSMART,2012. Dwyer, 2012.
[6] John, P.R (2013, P.63) discusses the dimensions and capabilities of BIM in depth.
[7] Pressman, A. (2007), "Integrated Practice in Perspective: A New Model for the Architectural Profession", Architectural Record, May 2007, http://archrecord.construction.com/practice/projDelivery/0705proj-3.asp (accessed December 2020)

ARCHITECTURE DESIGN METHODS IN NIGERIAN SCHOOLS:

There is a relatively standard practice among Nigerian tertiary institutions regarding design studio projects, especially in mentoring and the final presentation. Based on observation over a period of time, the authors outlined the structure adopted by architecture students and mentors in carrying out a semester design project: A design brief for the semester is assigned to the students, and a design mentor (usually a lecturer in the department) is assigned to guide them through the semester;

1. The students set off to conduct some preliminary research about the project and present the reports to the design mentors, and if approved, the student is permitted to continue with the design;
2. The students then work on the site analysis and formulate design concepts for the design problem. After a series of iteration with their mentors, the students proceed to design their buildings, usually starting off with the floor plans;
3. Most students are mentored for the rest of the semester mostly on the functionality of their floor plans, with very little attention paid to the building facades, massing, aesthetics and general composition;
4. The end results mostly consist of functional floor plans, disjointed elevations and generally poorly developed design solutions.

This structure of mentorship/supervision has presented recurring challenges in both training and professional practice. Due to the difficulty of presenting all their sheets every week, students often prefer to show their design mentors only parts of their works on a weekly basis. Also, most lecturers/mentors only get to see their students' complete designs at the final jury, and are surprised at the enormous discrepancy between the final designs and the relative amount of work input by the students based as observed during the mentoring sessions.

Another major challenge with this method of mentorship is that students are poorly trained in understanding building composition and massing, construction methods and materials, since so much attention is paid to functionality at the detriment of creativity and sustainability.

This study was conducted after introducing BIM to students, by incorporating it into their course syllabuses, and the results of the study indicate how this incorporation has influenced the outcome of the students' design projects, general knowledge and proficiency in architectural practice.

SOME BENEFIT OF BIM ON ARCHITECTURAL DESIGN PROCESSES

The following benefits of BIM, makes it a very good fit, for use in architectural education. Randy Deutsch[8] discusses some benefits of BIM implementation in architectural practice. The benefits discussed below are influenced by his research;

1. Bidirectional associativity; In the traditional method of correcting students' designs, lecturers may find it difficult to explain the effect of one change on the areas of the

[8] Randy Deutsch (2011, p.17) BIM and Integrated Design STRATEGIES FOR ARCHITECTURAL PRACTICE.

building. But when designing on BIM platforms, a change anywhere is a change everywhere; this allow for the effect of the changes to be seen and understood.

2. Requires designer to be more knowledgeable; Using BIM in the design process, will require the student architect to be more conscious of the effect of design decisions by ensuring knowledge of components and their parameters.
3. Analyze and Visualize projects digitally; This is because students work on all aspects of the projects almost simultaneously, since they are able to see how the floor plans relate with the site and how the forms of the building will impact the environment without having to create physical models. This benefit of BIM allows students to accurately visualize building appearance, and communicate it with their supervisors and colleagues very early in the design. This allows for more collaboration and coordination.
4. Simulates real-world performance: BIM allows designers to simulate real-world settings, helping students to better understand the building characteristics and its impact on the environment.
5. Increases Productivity; Students are able to produce more detailed works in shorter times, allowing more time for design refinement.
6. Increased enthusiasm: As a result of a better visualization and understanding of building composition, components and massing, brought about by the use of BIM software.

METHODOLOGY:

The research was conducted in the department of architecture, university of Nigeria, Enugu campus. The authors are lecturers within the department and therefore were able to conduct the research first hand.

The research was conducted in three phases namely;

a. BIM was introduced to students from their second year (200 level) up until their fourth year (400 level) of study in the department of Architecture. Students were introduced to BIM incrementally.[9]
b. Students used BIM to carry out design with emphasis on sustainable, functional and creative solutions.
c. Their designs were assessed using specific criteria.

PHASE 1: INTRODUCTION TO BIM SOFTWARE

The students were first introduced to BIM in their second year in 2017. The course Computer application in Architecture II and III (with course codes ARC 271 and 272), was used as anchor point to introduce the students to BIM. The authors redesigned the course content to accommodate the learning of AUTOCAD ARCHITECTURE in the first semester, and AUTODESK REVIT

[9] The IMAC (Illustration, Manipulation, Application and collaboration) framework served as a guide in exposing the students to BIM. For further reading please refer to; Jennifer A. Macdonald (2013) A FRAMEWORK FOR COLLABORATIVE BIM EDUCATION ACROSS THE AEC DISCIPLINES.

ARCHITECTURE (Beginner and Intermediate Levels) in the second semester. The students were also taught descriptive geometry by the authors during their second year as a means to further integrate the different projections taught in descriptive geometry, REVIT ARCHITECTURE was used to explain all projection types (orthographic, isometric, perspective, axonometric) and how to communicate effectively using them. The advantage of integrating descriptive geometry and Computer application in architecture, is that the students were able to understand the principles of the different projection types and interpret them manually while simultaneously applying them using computer applications such as REVIT in producing simple sketches and layout plans.

Many students who hitherto were not interested in descriptive geometry, became more active and participated more in studio works, due to the ability to see how the lessons learnt in the course could be applied in communicating details and methods while working on their semester designs.

In their third year and fourth year, the students were taught more advanced classes on REVIT ARCHITECTURE, as these lessons were incorporated into the course Computer Application in Architecture IV (ARC 371) in third year. They were able to produce detailed drawings and schedules. The ability to create parametric masses, locating their buildings using built in maps, performing solar studies, assigning materials and rendering were covered during this period.

During their fourth year, through the course Computer Application in Architecture V (ARC 471) the students were given assignments/projects that required them to use BIM concepts that involved collaboration and coordination, students were encouraged to interface design decisions with their supposed clients/end-users, with the aid of BIM tools in REVIT.

PHASE 2: MENTORING:

Students used BIM software to carry out design projects. The design studio mentors (also called studio coordinators) placed emphasis on sustainable, functional and creative solutions.

The second stage involved the students been given opportunity to use the BIM tool REVIT in producing their semester design.[10] The method of supervisor mentorship was improved upon due to the digital nature of BIM. Lecturers were able to continually analyze the design within context. The lecturers and students were able to communicate effectively. Students' ability to visualize functional forms very early in the design, while ensuring sustainable and creative design solutions were the goal of the mentorship. Projectors were used by students to present their works in 3 dimensions, rather than conventional 2-dimensions. The idea of presenting from the projector, even during normal informal discussions in the studios, helped build confidence for shy students.

STAGE 3: ASSESSMENT

[10] It is important to note that not all not all the lecturers have been receptive to the idea of students using BIM for their designs at the undergraduate level, as a result some students still resort to manual means (pencil and paper), while the more receptive/lenient mentors permit their students to make use of the BIM software.

Assessment and grading of semester design projects serves as the examination for the design studio course taken by the students, and usually involves the entire architecture department. The students to be examined are divided into groups, depending on their number, and each group is examined by a panel/jury made up of not less than three lecturers of the department. Lecturers who were not part of the studio design coordinators usually make up the majority of the panel. In the past two years however, it is becoming a practice to ensure that each panel includes at least one of the studio coordinators assigned to the class being examined. The students' design projects are also assessed based on criteria determined by the studio coordinators.

These criteria are centered on creativity, functionality and sustainability. Usually these criteria are expanded or further broken down into Graphics, Conceptual development, Design functionality, Structure and details, Model. The students' appearance and confidence in presentation are also assessed. Hence, the authors adopted these criteria as basis for assessment and used them to determine the extent to which the use of BIM influenced the design outcomes of the students, as well as their knowledge of design processes and collaboration.

RESULTS:

From the assessment conducted on students that used BIM (Autodesk REVIT ARCHITECTURE), there was a clear improvement in their ability to confidently communicate their designs, while offering;

1. Functional solutions: The form and layout of the building was better understood as one integral unit, and not worked upon like two unrelated parts.
2. Sustainable solutions: Conducting designs while modelling enabled students to iterate faster to come up with workable sustainable solutions.
3. Creative solutions: The ability to visually analyze building models allowed students to explore creative solutions, that were difficult.

1.


2.

[fig. 1] Final year design: Multi-level Car park by Anosike Chisom.
[fig. 2] Final year design: Museum by Alagboso Chiedozie.

The Authors also conducted semi-structured interview with the students. They were able to confirm the following;

1. Students reported more coordinated and fruitful interactions with their mentors and recommended that more lecturers be involved in BIM adoption into the curriculum.
2. Students reported that they were faster in producing their works, even though they spent more time designing.
3. The students reported improved confidence during presentation and ability to communicate their ideas.

CONCLUSION AND RECOMMENDATION:

The authors set out to evaluate the impact of BIM education on students' design works in architecture schools in Nigeria. The paper suggests confirms that BIM as tool, can be very effective in

Architecture education in Nigeria and therefore should be adopted into the design studio of architecture students from their Second year through to their final year.

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