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Assessing the State of Building Information Modeling (BIM) Education in the Architecture Department of KNUST

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A B S T R A C T

The processes in the Architectural Engineering and Construction (AEC) industry have been undergoing improvements over the years, and these transformations bring about curriculum reform in tertiary institutions. The introduction of Building Information Model (BIM) concepts and technologies into the industry has also brought the need for BIM to be included in the academic curriculum. This study is focused on assessing the state of BIM Education in the Architecture Curriculum in KNUST, and aimed at coming up with factors to improve upon the state of BIM Education. Case studies were conducted on some selected tertiary institutions around the globe to find out how they have been able to successfully integrate BIM into their curriculum. In generating and gathering data, students, and lecturers used structured questionnaires and interviews based on literature review respectively. The data from the students centered on their awareness and interest in BIM, the design software they use, and their opinion on the relevance of BIM in academia. That of the lecturers were on their perception of the essence of BIM in academia, their plans towards BIM integration, and finally the possible challenges in BIM integration. The findings reveal that the Architecture Department has no official or appropriate BIM education structure and strategies but offers only AutoCAD training as an official software course. However, most students from 3rd year upwards know about BIM but a greater percentage know that BIM is only about software. Only a few know the concept of BIM. In terms of constraints, the most pressing ones are; BIM being too expensive for developing; low level of motivation to research BIM in a local context; finally and no BIM awareness programs.

Keywords: Building Information Modelling, Computer-Aided Design, Architecture Engineering, and Construction, BIM Education

1. Main text

Architecture has been through a series of evolutionary phases since its existence and in the past, architectural drawings were created on paper (Steadman, 2008). Everything was sketched onto paper from design to construction, later there was the introduction of computer-aided design software (CAD) to aid in the accuracy and efficiency of architectural and construction work. This process has helped massively in the Architectural, Engineering, and Construction (AEC) industry.

1.1 Structure

The responses to the problems in architecture and construction have brought about the application of advanced technologies in the AEC industry. Technology is growing at a fast pace in the industry and it is taking over a lot of roles by professionals which encompasses Building Information Modeling (BIM), computational design (algorithm in architectural design), virtual reality and augmented reality, drones for construction, 3D printing, 3D laser scanners, among others. Among all, the most unambiguous transition undergoing by the AEC industry worldwide is the adoption of Building Information Modelling (Wu & Issa, 2013). The adoption of BIM is the most reliable to solve most of the problems faced by the industry. BIM has been in existence for more than a decade now. The UK government and some other organizations have set policies and standards to help to improve BIM technology every year. Those initiatives ensure that BIM has a lasting future. Its existence and benefits have brought about the need for it to be taught in tertiary institution to equip upcoming professionals to have enough skill set in the area of BIM. Many architectural schools worldwide have joined hands in either researching BIM or integrating it into their academic curriculum. The effort from the UK government and the other standardization organization is gradually a lot of countries to BIM adoption, and it will finally flood Africa as well. First point

BIM is becoming a common language in the architecture, engineering, and construction (AEC) industry and is being recognized as a driver for change on a global scale (Nawari & Alsaffar, 2016). The underlying supply-demand relationship between universities and the industry has been more reliant on students' intellectual (Bilbo et al 2000) and technical (Barison and Santos 2010a) readiness, especially in the case of BIM. Current literature and local research conducted with employers strongly indicate that skills associated with BIM will rank highly in skills demanded of future graduates in the built environment disciplines (McLernon et.al. 2015). Therefore, the effective inclusion of BIM into the college curriculum has become both a pedagogic and practical imperative in preparing future employees for the AEC industry (McGraw-Hill 2009; Crumpton and Miller 2008). However, in the Middle East

and Africa, students are falling behind in attaining this new tool. (Nawari & Alsaffar, 2016). The use and adoption of BIM in the AEC industry are hindered by the lack of adequately trained BIM personnel (Becerik et al 2011). BIM education is considered a solution to quicken the BIM learning curve, thus, training future architects and engineers in BIM advancements for companies to recruit ready-made BIM experts when the students graduate (McGraw-Hill 2008; Nawari & Alsaffar, 2016).

For the successful adoption of BIM in the country of Ghana, the burden on organizations to train their personnel about the concepts of BIM must be taken over by the tertiary institutions by training students before they are graduated into the industry. The cost of training as well as the timeframe for training always deters organizations to decline the adoption of BIM. In the case of Ghana, there are only two architectural schools present, however, this research focuses on one, thus, Kwame Nkrumah University of Science and Technology (KNUST) focus on KNUST because it is the main architectural school, awards both undergraduate and post-graduate certification. Unfortunately, in Ghana, there is no form of BIM education present in the schools of architecture. The situation is posing future architects and engineers in danger. The need for BIM education in Ghana's architectural schools in very vital in the future trend of practice in architecture, and that is what this research aims to address. Please do not alter the formatting and style layouts that have been set up in this template document. As indicated in the template, papers should be prepared in a double-column format suitable for direct printing onto paper with a trim size of 210 x 280 mm. Do not number pages on the front, as page numbers will be added separately for the preprints and the Proceedings. Leave a line clear between paragraphs. All the required style templates are provided in the file "MS Word Template" with the appropriate name supplied, e.g. choose 1. Els1st-order-head for your first-order heading text, els-abstract-text for the abstract text, etc.

1.2 BIM Education

BIM is a wide array of evolving technologies, processes, and policies. A great number of industry stakeholders (AIA-CA, 2012, p. 4) are still exploring identifying how to best teach or learn about BIM. BIM Education represents the process of acquiring the necessary knowledge and the required skills to generate BIM deliverables and satisfy their respective requirements (AIA-CA, 2012, p. 7). BIM Education is the process of learning the sum of conceptual and practical knowledge relating to BIM technologies, workflows, and protocols. Underlying BIM Education are many technical (e.g., data management), procedural (e.g., team collaboration,) and regulatory topics (e.g., risk management). Extract from (Silverio, et al., 2018) says; BIM education is a continuous learning process that covers the knowledge required for individuals to be capable of being part of and understand what a BIM process is. Such a learning process needs to include the essential aspects of BIM implementation, the performance of the participants, and the technical skills individuals need to acquire depending on the discipline they belong to and their role in the construction team. However, there are differences between BIM education and BIM training, even though they two achieve a common goal.

1.3 The Need for BIM Education in Architectural Curriculum

The AEC industry has been undergoing transitions to address the importance and urgency to improve business efficiency and profitability due to tight budgets and higher expectations from clients and developers. The most unambiguous transition undergoing by the AEC industry worldwide is the adoption of Building Information Modelling (Wu & Issa, 2013). BIM is believed to be the potential workflow to meet the demands of the need stated above (Azhar 2011). Due to the transition, the AEC industry seeks to recruit students with skills to supply the demands. Current literature and local research conducted with employers strongly indicate that skills associated with BIM will rank highly in skills demanded of future graduates in the built environment disciplines (McLernon et.al. 2015). The academic community has also responded to the transition by integrating BIM as part of their curricula, creating course content, and also experimenting with BIM pedagogic approaches (Wu & Issa, 2013). There is a growing number of universities worldwide that are either researching BIM or integrating it into a multidisciplinary curriculum at undergraduate and graduate levels (AIA-CA, 2012), even though they do have not the full expectations yet (Wu & Issa, 2013). Both the industry and academia have acknowledged that BIM Education is critical for quickening the learning curve and also producing ready-made BIM professionals for the industry (Wu & Issa, 2013).

BIM Education is the best solution to overcome the lack of BIM knowledge and experts which is negatively affecting the implementation of BIM in the AEC industry. This implies that BIM Education is vital to the implementation of BIM (Silverio, et al., 2018). According to the (AIACA, 2012, p. 7) report, BIM Education is a foundational activity, a critical need for both industry and academia and a priority due to the apparent skill shortage in this sector. The report further states that the nature of the future collaboration process, thus, open BIM, leads to a growing need for industry practitioners to be educated about collaborative work practices and processes that make use of BIM technologies. Industry stakeholders – whether they are professionals, academics, or tradespeople – need to unceasingly match their knowledge and skills with evolving market requirements. All need to learn and all need to educate others.

1.4 Barriers Associated with the Integration of BIM Education

Contrary to the BIM evolution in the USA and Europe, there are however various issues facing the complete adoption or integration of BIM into Architectural and Engineering education in the Middle East and Africa (Nawari & Alsaffar, 2016). In 2016 (Nawari & Alsaffar) studies showed that one of the reasons is due to the fact that BIM is perceived by academia as professional advancement in project design, development, delivery, and operation that lacks the theoretical construct of the traditional courses such as structural analysis and environmental technology.

Further struggle with the adoption of BIM Education in academia in regions of the Middle East and Africa to date is because there is no common understanding of what skills are needed in the industry nor what should make up the content, principles, and methods of education in the field of BIM (Nawari & Alsaffar, 2016). (Abdelhameed, 2018) confirmed this problem, thus, the task complexity of the design of BIM education pedagogy.

Research over the years by different researchers has found that the inadequate BIM skilled professionals in the industry pose a major setback to integrating BIM into education. Studies by (Silverio, et al., 2018), in the Dominican Republic also confirm the problem above.

2. Materials and Methods

The geographical location for this research is the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The aim of this research is to find out the possibility of Architecture schools in Ghana producing BIM literate Architects to meet the future demands of such professionals.

After these target groups were identified, the researcher used the purposive sampling method to get to the respondents. The Faculty of Built Environment (FABE), and College of Engineering (CoE) were the target. The selected departments under the FABE are; Architecture, Building

Technology (BT), and Quantity Surveying (QS). The selected departments under CoE are Electrical Engineering, Mechanical Engineering, and Civil Engineering. Both lecturers and students are involved. Since the students do not have the competency to contribute to the implementation of BIM education, discussions related to implementation are directed to the lecturers in the various faculties. The students are only assessed on their awareness of BIM, their interest in BIM, the design software they use, and their opinion as to whether or not BIM education is important. The type of interview was semi-structured. The methodology for collecting data for this research is open-ended interviews and self-completed questionnaires.

In identifying the state of BIM education in KNUST, the students from the Architecture were given questionnaires to fill. The students are only assessed on their awareness of BIM, their interest in BIM, the design software they use, and their opinion as to whether or not BIM education is important.

In achieving objective 4, interviews were conducted with some selected lecturers from the departments of Architecture. The interview covered the areas of; their perception of BIM, their attempt to integrate it in their schools, the challenges, and their plans towards BIM integration.

Comparative analysis was employed for analyzing the data obtained from the walkthrough in the selected facilities. The findings were presented in the form of diagrams and pictures. Data from the closed questionnaires found in the questionnaire were statistically analyzed using Microsoft Excel and Microsoft Word and presented in the form of graphs, tables, and charts. Suggestions from the open-ended questions were related to some closed questions and were stated and explained in conjunction with the corresponding questions.

3. Results and Discussions

The chapter gives a clear representation of data analyzed using Statistical Package for Social Sciences (SPSS) version 17. The chapter is subdivided into two; presentation of results and discussion of the presented results Data was collected from two categories of people; lecturers in the College of Built Environment, and students in the same college. making a total of four hundred and fifty-three respondents. Analysis was done using tables, percentages, and frequency graphs. The results obtained are categorized into three sections

Section one deals with data obtained from the Department of Architecture; section two deals with data from the College of Engineering; and section three deals with data from the Department of Construction Technology. Each section is subdivided into two. A part that deals with students, and another which deals with the lecturers.

Data from the students are centered on their awareness of BIM, their interest in BIM, the BIM software they use, and their perception of the relevance of BIM education in the country. On the other hand, data from the lecturers (Departments) are centered on their awareness of BIM, their perception of its implementation in academia, their plans towards its adoption to be part of the theory causes, and finally possible constraints in the integration of BIM in academia.

Questionnaires were administered students in Architecture, Construction Technology & Management, and lastly those in the engineering. Under the department of architecture, 105 people responded to the questionnaire. Out of the 105, 25% were from 2nd year class, 42% were from the 3rd year class, 30% were from the 4th year class, 20% from 5th year and 18% from the 6th year. The least percentage was from the 1st year which was 5%.

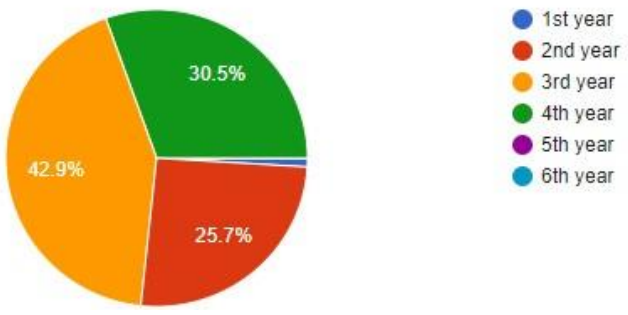

Figure 1. Year of students

3.1 Students awareness of BIM existence

Out of 115 responses greater portion of the students which represented 75% do not know that there is something called BIM. The remaining 25% know about the existence of BIM.

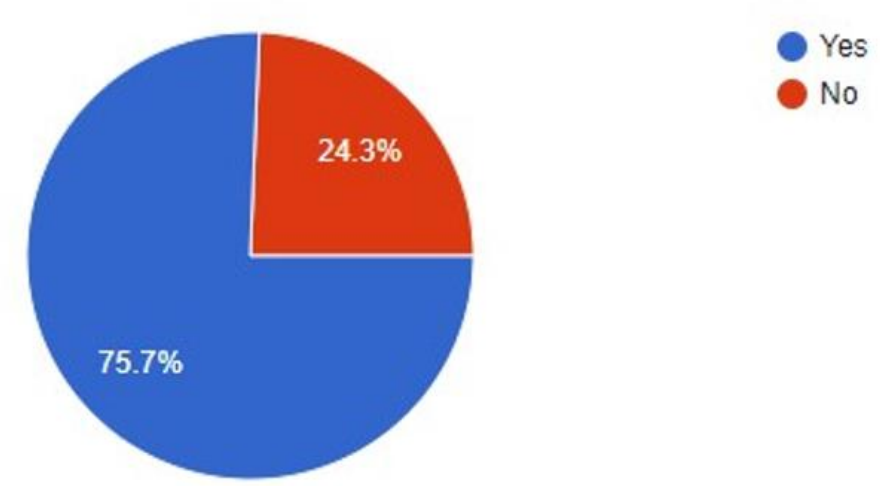

Figure 2 : Students BIM awareness

3.2 Year of BIM awareness

Concerning the year in which a student was when they heard about BIM, most student got to know about BIM in their upper years. In the 6th year class, the proportion of student who know about BIM is more than when compared to the 5th year. The trend follows down to the 1st year.

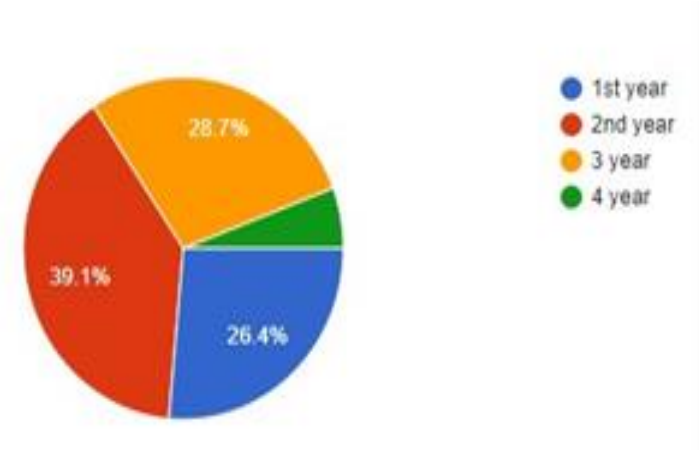

Figure3: Year of students BIM awareness

3.3 Extra knowledge learned on BIM

Some students claim they have learned extra about BIM and some have not learned anything extra about BIM. The majority of the students indicated that they learned it on their own. A few learned it from their senior colleagues. However, the majority of them are those who have not learned anything extra.

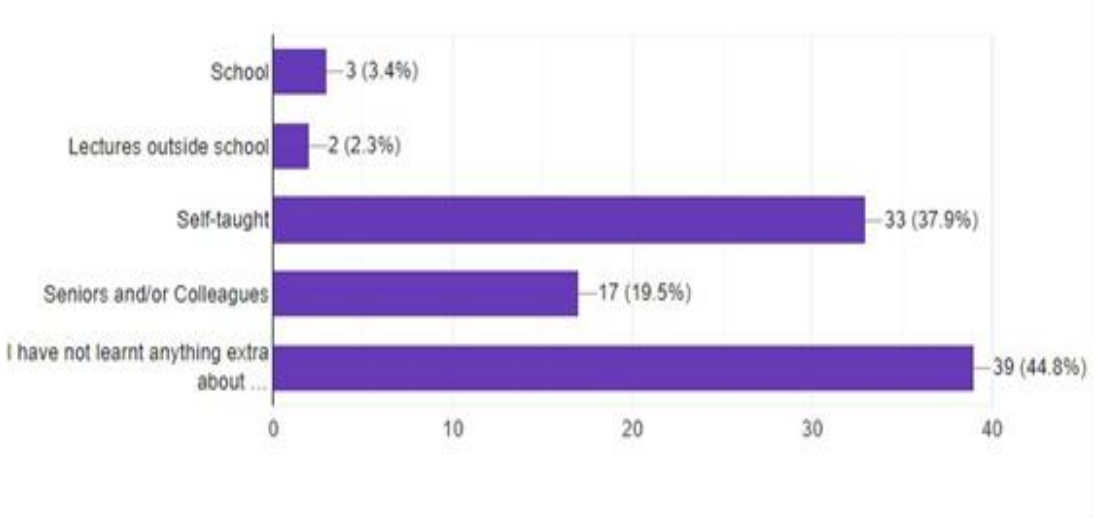

Figure 4: Additional BIM Knowledge

3.4 The need for BIM in school

The majority of students, 77% saw the need for BIM to be taught as a course in the university, however, a few do not see the essence of teaching BIM in the school.

Ranking the software usage by the student, Revit is used by 78% of the students, followed by AutoCAD which is 25%, and then Sketch Up which is 20%. Some other students use AchiCAD and Rhino for their design works.

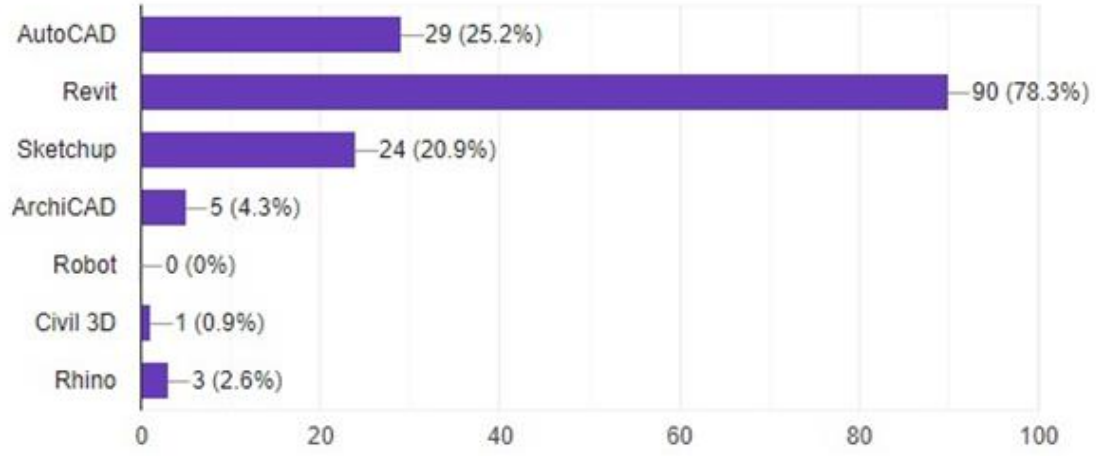

Figure 0.8: Choice of Software

Concerning the use of the software's the students use, the data indicated that majority use it for 3D modeling and 2D drawings. Few of the Revit users do their 2D drawings in AutoCAD but majority of the Revit users do both 2D and 3D in Revit. Almost all the Sketchup users do their 2D drawings in AutoCAD. However, there are some students who also use AutoCAD throughout.

Majority of the students learn the software from senior course mate but a few learn it from training centers. However, they all finish it up by themselves through online video training. A few of them also get to learn the software during their internship. The department teaches only AutoCAD as a software course.

The students were asked if they are aware that BIM softwares are different from CAD software. 57% do not that BIM software is not the same as CAD software. The minority, 42% new about it.

3.5 Discussion of Results

The data from the students reveal that even though most students have heard about BIM, they only know about BIM software's especially Revit. Some students even think that Revit is BIM. The other BIM software's are unknown to a lot of students because they don't use them. It was also observed that the 99% of the first year students do not know anything about BIM. It can be attributed to two factors; either because they are fresh in architecture or because they do not use any architectural software. However, from second year upwards, students know about BIM, but the chances of knowing about BIM increase as they move to the upper years

Some students were interested in BIM whiles others were not. It is seen that those who know about it have interest in it. Moreover, level of interest is dictated by the level of knowledge a student has in BIM. The interested ones saw the need for BIM to be taught as a course.

some years ago, AutoCAD was the mainstream software for design works, however, it is no more so. Some past students got to how to use Revit and Sketchup, and started teaching their colleagues. Due the 3D aspect of the two software's many students shifted to use, they and they have become the mainstream software's in the department. However, about 80% of the students use Revit because of the BIM features. Although, the department teaches AutoCAD as a course, most student deliver their works with Revit.

3.6 Their perception and awareness of BIM

Three lecturers were interviewed in the department of architecture. They are all aware of the existence of BIM. Unlike majority of the students, the lecturers know about the concepts of BIM technology, its softwares, standards, barriers and also the benefits it carries along. Their perception about BIM is positive, in the sense that they all accept fact that BIM is a game changer, reshaping the nature of the construction industry and hence needs critical attention.

3.6.1 Importance of BIM education

To the departments, BIM education is very important to be considered. One respondent said, 'If we really want to improve as a department or a country, then we really need to think about BIM.

3.6.2 Plans towards BIM integration

There has been an attempt to build a bi lab by the Department of Construction Technology but it is still not built due to funds for the construction. The architecture Department has plans of introducing a learning strategy which is Integrated Studio Design. This strategy is intended to improve collaboration by allowing students from different disciplines of the AEC departments to work on one design assignment.

3.6.3 Possible constraints

The department revealed some possible constraints that impedes successful BIM integration in education. The 1st constraint is the fact that awareness of the importance of BIM is very low. The higher the awareness level, the higher the chances of interest in BIM.

Secondly, the research department (Academia) receive no motivation or regards from the government to research into BIM in the context of Ghana.

Moreover, the cost involve in aligning to BIM is very expensive. The department will have buy softwares on each computer and also renew license every year, change the classroom layout to suit the workflow of BIM.

Furthermore, as many research reveals, the supply of BIM specialists into the academic community has been one major setback for BIM education, KNUST also have the same situation. In other words, even when BIM education is adopted in KNUST, who are going to teach its courses

As the supply of BIM specialists being a headache, the design of the BIM course contexts is more complex. This particular issue is also found by several researchers as one other deep impediment.

Finally, the last identified barriers which is that the industry has placed no demand for BIM skilled graduate architects from the schools. The demand of skills from the industry is always what the academia teaches students to be able to fit into the industry after school. This means that if the building industry, especially in Ghana is not demanding BIM skills from architecture students, hardly will it be for KNUST to teach BIM.

4. Conclusion and Recommendations

This chapter presents the conclusions and recommendations. The summary considered the research topic, problem statement research objectives, methods used and findings. The conclusion and recommendations was based on the analysis of data collected from the respondents and from existing cases.

4.1. Summary of Findings

The findings reveal that the Architecture Department of KNUST has no official or appropriate BIM education structures and strategies. The department only offer AutoCAD training as official software training.

4.2. Recommendations.

The study revealed the state of BIM education in KNUST Department of Architecture. Due to this, the following recommendations were given as solutions to the shortfalls to improve the state of BIM education in the school.

First, because there is a formally designed course for teaching AutoCAD, the BIM integration can start from there by replacing the AutoCAD with Revit Architecture Software. Since most students are aware of BIM in the aspect of software, starting with the teaching of BIM software will be the best idea. From there, the school can think of teaching the concepts and other aspects of BIM. Now since the BIM system require curriculum reform, it will take time to wait till an official curriculum to be designed. The suggestion is that the school invites BIM specialists and advocates to be giving BIM talks and conferences from time to time, which will be also less expensive. The idea is that as the BIM course content is being designed, the school will still be feeding the students BIM knowledge. The school will also have to research and develop guidelines in integrating BIM in context to the Ghanaian AEC industry. That will yield in an optimal curriculum. The course may optionally start with one-year group or from year one to for at the start. After all these being done successfully, there can a horizontal integration where other discipline like Construction Technology and or Engineering be involved in the BIM education.

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