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BIM EDUCATION ONTOLOGY: TOWARDS A RESEARCH AGENDA FOR NON-INDUSTRIALISED ECONOMIES

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BIM education is the cornerstone in addressing the shortage of BIM knowledgeable practitioners, currently experienced by the construction industry. To address this shortage, most industrialised economies are at the least, fine-tuning the incorporation of BIM education into higher education. BIM education ontology, though similar in nature, applies differently across the industrialised and non-industrialised economies, thus demanding differing approaches toward managing research gaps. While several studies on BIM education have been carried out in the non-industrialised economies, there is a lack of common frame of reference for managing research gaps in BIM education within these economies. By undertaking critical literature review, this paper explores the main themes within BIM education field of research. Relying on the theoretical research gap framework proposed by Miles (2018) to espouse the main considerations (in terms of concepts and properties) in BIM education research and their interdependencies, a conceptual model for BIM Education ontology is proposed. Based on the conceptual model, global considerations in BIM education centres around three main themes: curriculum, integration and implementation. Research gaps within curriculum are largely focused on insufficient curriculum, lack of unified method of assessment/evaluation, and lack of specific teaching methods; those within integration are inadequate collaboration between academia and industry; while those within implementation concentrates on lack of strategies on BIM implementation and competency deficits. Drawing upon the differentials between the industrialised and non-industrialised economies, the paper concludes by providing insights to newer research directions particularly targeted at addressing the challenges of incorporating BIM education into Higher Education in non-industrialised economies.

Keywords: BIM education, conceptual model, higher education, non-industrialised economy, ontology

INTRODUCTION

Building information modeling plays important role in successful project delivery in construction industry. The BIM concepts provide bases for all construction

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stakeholders to shared one integrated model that contain both parametric and non-parametric information within a given project cycle (Ibrahim et. al., 2020; Kamari et.al., 2021). BIM allows early assessment of constructability, buildability, cost management, energy/structural analysis, and life cycle information of the physical asset (Matti et.al., 2015; Mohamed, A. 2019). Evidently, BIM ensure perfect modeling, construction, facility management and operations which thus increases the effectiveness and efficiency of construction industry as against the traditional methods of project delivery system (Alizadeh & Yitmen, 2018; Rosayuru et. el., 2019). However, continuously improvement and development of this concept and its practice among the industry stakeholders can accelerate its acceptance and adoption by the tertiary institutions in non-industrialised economies. In developed economies, statistics have shown that over 56% of tertiary institutions have integrate BIM education into their undergraduate programs in the built environmental courses (Sunil Suwal & Vishal Singh 2018; Jung et. al., 2019). Developing BIM education in the non-industrialised economies has also become imperative to the construction industry and educational institutions, particular in the mix of wide gap of both building and infrastructural deficits in most of the countries, this signifies need for innovation and personnel development who will fill the existing gaps of practice in the industry.

However, industrialised economies are independent state that have effective rate of industrialisation and individual income, while the developing economies are further subdivided into two the emerging and least developed economy countries (UNIDO, 2018; UNCTAD, 2019). The emerging economies are those countries that rapidly expanding, meaning that they are developing industry and wealth to compete on a global level. The least developed economies are weak countries which have a lot of obstacles in development, with low industrialization and low levels of human assets. These economies can be further subdivided base on the following characteristics namely; strong political well, strong economical resources, sound legal structure and natural resource or on other hand PESTEL can be used to describe them by the of the following political, economic, social, technology, environmental and legal framework . For the industrialised economies they both manage all most all the attribute mentioned above, while the non-industrialised economies might have only a few of these attribute.

BIM education importance cannot be overemphasis with huge benefits and impacts it has on construction industry. According to Swallow & Zulu (2019), BIM education provides a better market opportunity and a competitive advantage for student's and professional's equipped with BIM proficiency. Furthermore, the education sector is at the forefront of developing potential construction professional with BIM skills and knowledge to meet the industry's demand (Khosrowshahi & Ariyaci, 2012). The education has developed other success of vocational education training programmes to facilitate training other members of the construction industry to increase the workforce in the industry.

Globally, the researcher has concentrated on different areas in BIM education towards delivering the needed sought skills and knowledge in the industry. Some of these areas include curriculum, integration and implementation. Curriculum fields have subcategories which include content, development, learning and development. The curriculum consists of an outline of concepts to be taught to

students (Chong et al., 2017), contents are further requirements to be added in knowledge, skills, attitude and value transfer (Chong et al., 2017), Development requires steps-by-steps used to create positive improvements in courses offered by tertiary institutions (Oluwole, 2018), learning is that methods used in delivering required knowledge using different techniques to transfer knowledge (Justin & Alex, 2020). Integration of BIM has several approaches, researchers concentrate more on the synergy between the industry and academia as the most important tool required for collaboration between the two to achieve the needed knowledge transfer between the industry and academic environment (Amarnath et. al., 2016). However, implementation was classified into four by other researches to includes individual BIM (stand-alone), collaborative BIM (cross-discipline), Complementary BIM (integrating into existing courses) and capstone (project-based).

However, research work in BIM education, have attracted major interventions in research with attempted solutions to some of the identified problems in BIM education. This paper reported six (6) areas where the BIM education gave more attention as panacea to the problems. These includes lack of strategies in BIM implementation, deficits of competency, insufficient curriculum, inadequate collaboration and integration, non-effective teaching methods and improper methods of assessment. Despite, the extant work there is still low patronage of BIM education implementation among the non-industrialised economies. The paper concludes by providing insights to newer research directions particularly targeting at addressing the challenges of BIM education implementation into higher education in non-industrialised economies, using the existence evidence or strategies from the industrialised economies to propose solutions that could be achievable within the tenants of non-industrialised economies, looking at the peculiarities of the two economies. The following research questions are addressed;

i. What is BIM education and its existence in educational practice?

ii. What distinguish between industrialised and non-industrialised economies in relation to BIM education implementation in tertiary institutions?

iii. What were the steps used by developed economies in integrating BIM education?

iv. What are the strategies developed for BIM education implementation in tertiary institutions?

This is a step in addressing the broader research problem on how BIM education implementation can be improved to leveraged the current gaps in built environment programmes in tertiary institutions. The work is important in the sense that it opens up another chapter for evaluating existing studies on the methods and approaches used by the early adopters of BIM education to facilitates its replication in the non-industrialised economies based on their own characteristics. BIM education ontology is about the existence of this technology in the built environment and its epistemological understanding and practice in the tertiary institutions.

LITERATURE REVIEW

Building information modelling education and its existence (ontology)

According to Succar (2012) define BIM education as the process of learning the total concepts and practical knowledge of BIM technologies, protocol and workflows processes. BIM education are built on data management (technical), team collaboration (procedural) and risk management (regulatory topics). Xin & Aziz (2020) argued that BIM education starts with the diffusion of BIM awareness, followed by understanding the intellectual, concepts and mastering the BIM tools for application (Underwood, 2015). Succar further stressed that BIM education learning should considered as a triangle that comprises of the learner, the learning provider and learning spectrum.

Early research works have confirmed the existence of BIM education practice in tertiary institutions (Barison & Santos, 2010; Sacks & Pikas 2013; WU & Issa, 2014; Succar, 2013 and Onosesen et al, 2020) studies thus includes BIM education framework, curriculum development and contents and collaboration. This indicate that the early adopters of BIM innovation into construction industry extended the knowledge to institutions that will produce BIM proficient graduate for the industry.

Distinction between industrialised and non-industrialised economies in relation to BIM education implementation in tertiary institutions

Industrialised economy (or industrialized country, high-income country, more economically developed country (MEDC)) is a sovereign state that has a high quality of life, developed economy and advanced technological infrastructure relative to other less industrialized nations. Most commonly, the criteria for evaluating the degree of economic development are gross domestic product (GDP), gross national product (GNP), the per capita income, level of industrialization, amount of widespread infrastructure and general standard of living (UNIDO, 2018; UNCTAD, 2019). These are yardsticks used in measuring a countries development strength among nations. The lower the strength of the attribute mentioned above the more qualified the economies is to non-industrialised economy (UNIDO, 2018; UNCTAD, 2019).

BIM education acceptance and adoption by industrialised economies was as result of massive advancement in research and development, resource, manpower, experts, tertiary institutions and government support. However, developing economies like Nigeria and South Africa are two developing economies with difference in terms of aforementioned attributes that either act as a driver or deficiency to the development of the BIM education. Some of the attribute could difference per income, innovation integrations experts in the BIM field.

Steps used by developed economies in integrating BIM education

There are several methods used by early adopters of BIM education to extend the BIM knowledge. Table one (1) have reported several studies on steps used in integrating BIM knowledge among the professionals and undergraduate students. (Sack & Pikas, 2013; Abdrid et al, 2016; Onososen & Adeyemo, 2020).

Strategies developed for bim education implementation in tertiary institutions

Researchers have reported enough strategies to implement and teachers BIM education through share responsibility among construction industry stakeholders and the academia (). Other researcher like Huang (2018) argued that effective approach to BIM implementation in tertiary institutions may be achieved via BIM domestication in curriculum teaching the course as standalone, cross-discipline course and project courses/capstone project. However, all these effort made by industrialised economies to improve their industry and education by teaching BIM education, little is known on methods/approaches used by n0n-industrrialised economies to implement BIM education

BIM education integration

A literature review of the academic peered review articles was carried out to identify journal and conference papers that have attempted to address BIM education in higher education institutions (HEIs). All related cases on BIM education in built environment programmes in tertiary institutions were collected and analysed. The criteria for literature search and analysis process were described in section 1. Section two (2) presents the inferences from reviewed literature and the following outcomes were discussed and interpreted. section three (3) codification of BIM education classification and a conceptual framework for BIM education implementation was developed before conclusions and implications for further studies.

RESEARCH METHODOLOGY

Literature review article provide a complete overview of literature linked to a theme/method and synthesis prior studies to support the foundation of knowledge (Justin & Alex, 2020). Systematic reviews are "rigorously designed and conducted literature reviews the aim to exhaustively search for, identify, and appraise the quality of article and syntheses all the high-quality research evidence in order to answer a specific question" (Philips, 2018; Theophilus, Emlyn & Irene, 2020).

This method enables the broad review of extant literature within the space of the research in a replicable and rigorous manner and, additionally, the results of systematic literature reviews have been contended to be as valued as those of any other evidence-based methodologies in educational interventions (Evans & Benefield, 2001; Phillips et al., 2018; Theophilus, Emlyn & Irene, 2020).

The methodology adopted for this research followed the recommendations of (Gough, 2007; Bearman et al., 2012 & Paul et al., 2020) for conducting systematic literature reviews. The initial step in this process is to explain the rationale of the review. The principal goal is to identify the implementation level of BIM in the education sector. The next step involved in the search for evidence from database. In turn, this stage was divided into several sub-stages: literature collection, literature filtration and literature synthetization. In order to do the literature collection, a document search was made from google scholar. The search was restricted to the last 7 years (2013–2020) in line with other recently published articles with emphases from initial publication from BIM (Soust-Verdaguer et al., 2017; Anand et al., 2017; Luque & Sanchez-Martin, 2019) on the other hand, the search was restricted to works published in English. All the documents analyzed

were peer reviewed to ensure the quality of the review (Chong et al., 2017; Luque & Sanchez-Martin, 2019).

The subsequent stage comprises of screening and filtering the articles obtained from the database, some references only touched in a very peripheral way the analyzed topic, others were uneconomical/falsely reported (articles that were not about Building Information Modelling). Subsequently, the documents were read via the abstract, information was synthesized and tabulation, with main aspects dealt with the work, was realized.

Establishing the review question: The review question was developed to guide the direction of this study: what is the existing research work on BIM education in built environmental programmes. Defining the inclusion and exclusion criteria: All academic publications relating to BIM education in built environment from any country were included, but only those published in English language were considered. Academic publication refers to blind reviewed journal articles and conferences proceedings that report on research on any aspect of BIM education in tertiary institutions. Non-academic articles, and other trade publication sources and books were excluded on the ground that the quality of their contents could not be granted. Search strategy on articles was conducted on google scholar database to identify the suitable search terms. The Boolean operators were used as follows: ("Building information modeling" OR "BIM") AND ("Education" OR "learning" OR "Training") AND ("Built environment" OR "AEC" OR "Architecture, Electrical & Construction"). The articles returned from the search of database were 3500 references, the results were further downgraded based on the inclusion and exclusion to 150 articles. Finally, based on eligibility only 53 articles were used for the reviewed process as shown in Figure 1.

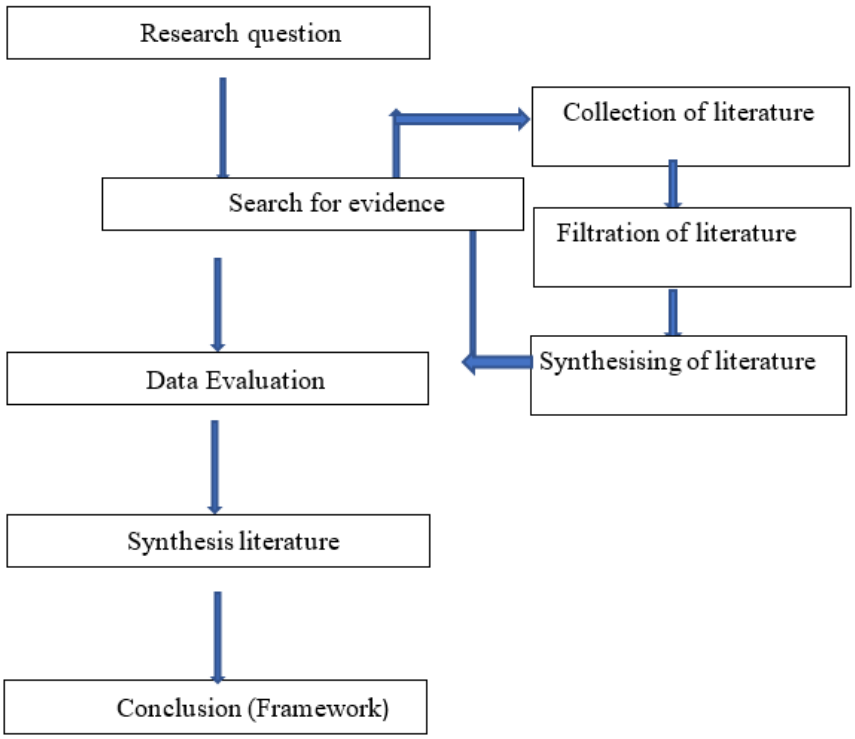


Fig. 1 Demonstration of review process based on Pawson et al., and Chong et al.,

Regarding the author's corresponding affiliation, table 1 shows that United State institutions had the high level of research works on BIM education. This clearly point out how time, knowledge and resources were expanded to realized the objective of BIM practice in the industry.

Based on the scrutiny of extant literature above, the following section analysed BIM education as catalyst to BIM implementation in the built environment programs of tertiary institutions.

ANALYSIS AND RESULTS

From the relevant literature reviewed, BIM education articles centered on three main areas. These are the curriculum aspect, integration and implementation in the industrialised and non-industrialised countries.

Curriculum: the term curriculum refers to the lessons and academic content taught in a school or in a specific course or program (Brown, 2006). Therefore, BIM education curriculum should contain those relevant academic contents of all programs in specific and general domain within the built environment programs to enable smooth delivery of BIM lessons. In the industrialised economies several attempts were made to have more of specific curriculum than collaborative contents in the institutions (KOUIDER et. al., 2018). Curriculum literatures were reported with other sub-categories mainly development, contents, learning and delivery.

Curriculum in BIM education, for the early adopters of this innovation, they have made efforts to develop curriculum that will suits different discipline in built environment programs in the industrialised economies (KOUIDER et. al., 2018). The curriculum development and design are contextualized in nature in most of the countries, institutions and programs who had incorporate BIM in teaching and training. The curriculum in its nature is heterogenous because of its context base right from planning to delivery.

Some of the early researchers on BIM curriculum in AEC programs, (Barison and santos, 2010) classify BIM curriculum into introductory, intermediate and Advance stage to enable seamless delivery of BIM knowledge across the stages for optimum practice. Abdirad et.al., (2016) study BIM curriculum design in Architecture, engineering and construction programs in United State of America. These are universities or tertiary institutions with state of arts facilitates that motivate delivery of BIM with ease as a result of technology advancement and they also have experts to train the personnel on BIM operations.

BIM delivery methods are subject of discussion in both the industry and academia, though delivery used in teaching the curriculum contents been developed are classified based on requirement at the different levels (Oluwole, 2018). for instance, some delivery requires both practical and theoretical methodology. Previous studies have reported, face to face method, problem-based-learning, project-based-learning, collaborative learning using electronic facilitates. The delivery method adopt depends on the target audience in BIM processes.

BIM contents these are provided by extant research work and demand of the industry, which are develop over the time as the process of BIM evolves. Some of these contents are both specific and domain related (Oluwole, 2018).

BIM curriculum learning makes learning easier from progressively from simple to harder concepts/problems. This process is well documented as part of the requirement to achieve BIM education system in the industrialised economies (Barison and santos, 2010).

Integration of BIM into built environment programs, were specifically based on synergy between the academia and construction industry. This synergy is structured to enable the industry determine identify contents the academia needs to include in their curricula to enable delivery of BIM training in the tertiary institutions (MacDonald, 2012)

Implementation process varies from institutions to institutions, there are some basic requirements that determine the implementation process, the available programs in the built environment, collaborative institutions, availability of experts/professionals, facilitates, students and staff of the programs (KOUIDER et. al., 2018). Implementations among programs varies some have the following capstone/final project, cross discipline, collaborative and standalone courses.

Table 1. Major descriptive faces of incorporated studies (n=53)

S/N	Title	Problem solved	Reference	Year	Findings	Article Type	Location	Method
1	Teaching strategies in integrating BIM education for the QS courses in Malaysia higher education institution (2020)	Lack of strategies embedding BIM	Yap, Pei Xin and Aziz, Nur Mardhiyah	2020	lecture, workshop, collaboration, open learning platform and project-based learning	Journal	Malaysia	Case study
2	BIM educational framework for the QS students: Sri Lanka perspective	Missing skillsets/knowledge required for BIM usage	Anushka Rathnayake	2017	Framework developed for QS programs	Conference	Sri lanka	survey
3	Barriers to the incorporation of BIM into quantity surveying Undergraduate curriculum in Nigeria universities 2019	Missing factors for BIM incorporation	Solomon Olusola Babatunde, Damilola Ekundayo	2019	Culture, resistance, environment, staff security and high cost of implementation	Journal	Nigeria	survey
4	Developing a three-level framework for BIM education in construction management. 2018	Non-comprehensive BIM framework for BIM incorporation	Huang, Yilei	2018	IMAC was used	Journal	USA	Case study
5	A comparative diagnosis of student's proficiency in BIM construction related graduate programs in Brazil and USA 2018	Unclear extent of BIM adoption and its effectiveness	Silvio Burrattino Melhado, Aline Valverde Arrotéia, Daniel Paes and Javier Irizarry	2018	Literature	Conference	Brazil	Case study
6	BIM curricula design in AEC education: A systematic review 2016	Lack of Comprehensive reviewed on BIM curriculum	Hamid Abdirad, Carrie S. Dossick	2016	Literature-based BIM curriculum	journal	USA	review
7	Knowledge, skills and functionality requirement for QS in BIM environment: An international Delphi study 2019	Deficit's skill/knowledge affect BIM practice	Abdullahi Babatunde Saka & Daniel W.M. Chan	2020	QS BIM skill requirement	Journal	Nigeria	Delphi survey
8	Assessment of strategies for BIM skills problem-based	Lack of prior assessment	Rahman, Rahimi A. and Ayer, Steven K	2017	using a single strategy might not be	Conference	USA	Review

	learning pedagogies 2017	strategies for skills in PBL			adequate for assessing BIM skills			
9	Integrated experiential learning-based framework to facilitates project planning in civil engineer and construction mgt courses 2019	insufficient research on upskilling students' competency	Jingxiao Zhang, Haiyan Xie, Klaus Schmidt, BoXia, Hui Li and Martin Skitmore	2019	Framework design to improve BIM delivery	journal	china	Case study
10	BIM practice: training and education of Nigeria QS's in preparation for BIM adoption 2020	Non-in-depth analysis of curriculum affects application	Onososen A.O. and Adeyemo	2020	Nonexistence of BIM in tertiary institution with single teaching introductory BIM education	Journal	Nigeria	Content analysis
11	Evaluation of BIM for QS: A review of teaching approaches 2019	Uncertainty of framework providing industry demand	Suhaida S.K, Nurul Aini Osman, Nadeera Abdul Razak, and M A Shazwan	2019	cross-disciplinary module or approach in QS education framework	Conference	Malaysia	review
12	Probing BIM education in construction engineering and mgt programs using industry perception 2013	Deficient BIM courses in CM undergraduate program	Namhun Lee and Donna A. Hollar	2013	Perceptions on education	Conference		survey
13	Gearing up academics for collaborative BIM education 2015	Scarcity of BIM training support to academics	Carol K.H. Hon, Erezi Utiome, Robin Drogemuller, Robert Bob Owen, Madhav Nepal, Jason Gray, Vaughan Coffey	2015	Teaching and learning intiated will break the barrier for non-compliance to BIM collaboration	Conference	Australia	Pilot study
14	Sustainable BIM based construction engineering education curriculum for practice-oriented training 2019	inadequate AEC curricula affects BIM skills	Lee S, Lee J, Ahn Y	2019	A suitable curriculum was developed to suit the korean BIM requirement	Journal	Korea	
15	Curriculum to prepare AEC students for BIM enabled globally distributed projects 2019	Challenges of curriculum on multidisciplinary global project	Anne Anderson, Carrie Sturts Dossick & Laura Osburn	2019	Findings on how different students collaborate on BIM project	Journal	USA	PILOT STUDY
16	AEC student's perceptive in the learning process of CAD & BIM (2016) BIMAS	Challenges of techniques to teach CAD & BIM	Gulbin Ozcan-Deniz	2016	Findings reveals important of learning BIM tools at both undergraduate and graduate	BIM symposium	USA	survey
17	Advancing BIM knowledge through engaging stakeholders at local and regionals 2016	challenges of KSA to deliver BIM	Gonzalez Michael Angel	2016	Emphasis on collaboration to achieve breakthrough in BIM education	BIM symposium	USA	concept
18	Integrating BIM across an undergraduate const. mgt curriculum experiential learning through a Tiny house project 2016	Deficient pedagogical delivery affects students learning	Wei Wu and Brad Hyatt	2016	Establish the important of pedadogical teaching and experiential learning by students	BIM symposium	USA	Case study
19	Development of a peer review-based activity to impose students BIM process mapping understanding 2016	Challenge students encounter in mapping BEP	Michael Beauregard, Suleiman Alsafouri and Steven K. Ayer	2016	Establish pedadogical approach to team work among students in collaborative studies	BIM symposium	USA	Case study
20	BIM skills for career success 2016 BIMAS	Difficult synergy of educator and industry affects manpower	Rahimi A. Rahman, Suleiman Alsafouri and Steven K. Ayer	2016	Chances of BIM experts becoming project manager in BIM project	BIM symposium	USA	survey
21	Developing an international framework for BIM education in the high education sector 2016	Unsettled dilemma on mode of BIM incorporation	Shelbourn, M.A.,Macdonald, J., and Mills, J.	2016	IMAC framework was tested and result shows that more is needed to implement BIM in Universities in Australia	BIM symposium	Australia	Mixed method

22	Knowledge transfer into a BIM course through technology driven solutions for real world construction projects	Difficulties in learning using traditional education	Marcel Maghiar	2016	Establish the importance of collaboration with industry to drive real practical solution to BIM implementation	BIM symposium	USA	Case study
23	Collaboration with BIM an experiential learning case 2016	Major programs lack strategy to embed BIM	Julide Bozoglu et. al.	2016	Establish importance of industry collaboration in BIM delivery	BIM symposium	USA	Case study
24	Enhancing BIM education experiences with integrated keystroke capture software	Difficult students face assimilating BIM training	Nathan Blinn and Raja R. A. Issa	2016	Establish the importance of screencast technology in lectures by students (Autodesk)	BIM symposium	USA	Survey 29 students
25	Incorporating BIM into the preconstruction services course at BYU 2016	Inadequate space hours affect BIM incorporation	Kevin R. Miller	2016	Effective system of BIM integration into exiting QS courses	BIM symposium	USA	CASE study
26	Integration of BIM (3D CAD) throughout the industrial construction education track 2016	Shortfall of 3D industry-level knowledge affect BIM	Carol J. Friedland et. al.,	2016	Develop a framework to incorporate 3D modeling in industrial education	BIM symposium	USA	framework
27	BIM curriculum development	lacks of well-developed AEC BIM curriculum	Richard Faust	2016	Researcher gave an insight to development of BIM curriculum	BIM symposium	USA	Concept
28	BIM implementation at Building systems course @ United Arab Emirates university	Deficiency in harmonizing traditional-BIM courses	Jose Ferrandiz	2016	Incorporating 3D modeling into architecture programs using PBL	BIM symposium	UAE	
29	The development of a BIM enabled curriculum: planning freshman year	Inadequate strategies to incorporate traditional-BIM courses	Scott P. Vlasek	2016	Proposed models, management and graphics courses for beginners	BIM symposium	USA	
30	Benefits of inter-institutional collaboration in the delivery of BIM education in Ireland. Reflections of an Irish master's program	Challenges of inter-institutional collaboration in BIM master program	Alan V. Hore et. al.,	2016	There benefits if well supported by all stakeholders at both industries, professional and the academia. Overall is govt enforcement	BIM symposium	Ireland	Survey
31	Preliminary review of BIM tertiary education in the province of Ontario	Lack competency to train graduate level	Christopher J. Willis	2016	Findings is that non-existent of BIM education in Ontario university	Conference	Ontario, Canada	Case study
32	Education Needs to Support Architecture, Engineering, and Construction Collaboration Using Building Information Modeling 2019	Bottleneck in accepting BIM by AEC	Rostam, D. M.	2019	Collaborative culture needed by players via undergraduate programs to achieve effective BIM practice	Journal	UK	Survey
33	Building Information Management (BIM) education in the Dominican Republic: An empirical study, 2017	Difficult task with provision of BIM education	Ana Karina Silverio Rodriguez et. al.,	2017	They lack of experts and BIM education, but currently depend on BIM software training	conference	Dominican Republic	Interview (9 professionals)
34	Building Information Modelling Uptake: Tool Training in Nigerian University	Slow uptake of BIM in universities	Hamma-Adama M. et. al.,	2018	This reveals a clear setback in the tools training to carter for the BIM uptake in the country	Journal	Nigeria	Survey
35	BIM for Quantity Surveying: An Investigation into its Adoption and Education in Hong Kong 2019 unpublished	Insufficient BIM level and its deficiency	Calvin KEUNG	2019	BIM models in practice not sufficient for QS task and BIM education found only in basic course but lacking at advanced and	Unpublished thesis	Hong Kong	Mixed method

					interdisciplinary level.			
36	Toward deep impacts of BIM on education 2019	no common/finite set of symbols in BIM	Ziga Turk and Andreja I. S.	2019	T-shaped method of integration was suggested for BIM engineering programs	Journal	Slovenian	Concept
37	Building Information Modelling (BIM) Educational Framework for Quantity Surveying Students: The Malaysian Perspective	Insignificance Skills/knowledge required for BIM usage	Kherun N. Ali et. al.,	2016	Framework was developed based IMAC for BIM education in QS program	journal	Malaysia	Focus group discussion
38	BIM education - Case New Zealand	Lack of BIM educational in NZ	Taija Puolitaival et. al.,	2017	knowledge and skill gaps among faculty, crowded curricula, and limited time for development work	Conference	New Zealand	Case study
39	FRAMEWORK FOR INTEGRATING BIM EDUCATION IN THE CURRICULUM OF AEC PROGRAMS 2019	Complex challenges affect quality of BIM	Oluseye Olugboyega and Abimbola Windapo	2019	Teaching BIM in two stage at secondary and tertiary institution, to reduce the spatial load in the university	conference	South Africa	Concept paper
40	A framework for Building Information Modeling implementation in engineering education	lack of guide to BIM implementation	Conrad Boton, Daniel Forgues, and Gilles Halin	2018	Identify some implementation strategies	journal	Canada	Case study
41	A Framework for Collaborative BIM Education across the AEC Disciplines	Shortage of BIM professionals affect the training	Jennifer A. Macdonald	2011	IMAC framework was developed to assess the BIM education	Conference	Australia	Framework
42	BIM (Building Information Modeling) Education Program in KSA: A Case Study of BIM program at Prince Sultan University	Scarcity of teaches to deliver BIM training	TaeYeua Yi1 and SukHee Yun	2018	BIM implementation strategy was developed for PSU	Conference	KSA	Case study (PSU)
43	Conceptual Framework for the Use of Building Information Modeling in Engineering Education 2019	Inadequacy of teaching methods in BIM education	FRANCISCO ZAMORA-POLO et. al.,	2019	Framework for teaching BIM	Journal	Brazil	Review
44	Implementing a Vertically Integrated BIM Curriculum in an Undergraduate Construction Management Program 2014	Challenges of mainstream BIM curriculum in CM	Arundhati Ghosh et.al.,	2014	It improves the student pruriency in information management in BIM	Journal	USA	Case study
45	BIM Education and Recruiting: Survey-Based Comparative Analysis of Issues, Perceptions, and Collaboration Opportunities 2014	Deficits of Gap between students and workforce	Wei Wu and Raja R A. Issa	2013	There is improvement in BIM implementation & adaptation, but gap exists in growth and incentive	Journal	USA	Survey
47	Overview of BIM education in the field of construction management at the Faculty of Civil Engineering in Košice and the Faculty of Civil Engineering in Zagreb, 2017	Insufficiency of BIM courses in CE	Sonja Kolarić et. al.,	2017	Findings reported that only stand-alone program is been run in the faculty	Conference	Croatia and Slovakia	Case study
48	Building Information Modelling in Tertiary Construction Project Management Education: A Programme-wide Implementation Strategy, 2013	Low uptake of BIM in HEI's	Perry Forsythe, Julie Jupp & Anil Sawhney	2013	Developed a process that binds the people and process of BIM practice with the technology as supportive	Journal	Sydney	Case study
49	Incorporating BIM in the Final Semester Undergraduate Project of Construction 7	Missing of BIM final year project	Wang L., Yan X., Fan B., Jin R., Yang T., and Kapogiannis G.	2020	Perception of the study groups were positive based on the activities	Journal	China	Case study

	Management-A Case Study in Fuzhou University, 2020			involved in BIM practice at the final semester projects			
50	Fundamental of implementing BIM in architecture education at the graduate school level, 2020	Lack of guideline to establish BIM @ graduate level	Kausar, M., Mahanta, N. R., & Samuel, A.	2020	Evaluates the teaching methods before considering BIM integration	Conference	UAE	Case study
51	Use of BIM at higher learning institutions: Evaluating the level of implementation and development of BIM at built environment schools in South Africa. 2018	Uncertainty on level of BIM spectrum implementation	Pillay, N., Musonda, I. & Makabate, C	2018	Findings reported are 2D and 3D CAD design were taught in some universities	Conference	South Africa	Questionnaire survey
52	Project Based Learning with Implementation Planning for Student Engagement in BIM Classes, 2018	Insufficient research on BIM capstone-real projects	Jingxiao Zhang, Haiyan Xie and Hui Li	2018	It provides a sound foundation for the instruction of BIM education in university teaching	Journal	China	Case study
53	University–industry collaboration for BIM education: Lessons learned from a case study, 2020	Missing collaboration between industries and Universities	Ke Chen, Weisheng Lu and Jing Wang	2020	Students learn more in collaboration with industry in both practical and theory	Journal	Hong Kong	Case study

Table 1 present the major descriptive of major findings incorporated in the study. The BIM education ontology, as reported due exists. The epistemological understanding of the knowledge of BIM is what matters to improve the level of BIM implementation in the non-industrialised economies. From the table above studies have shown the real existence of BIM in the developed economies, with strategic approaches to its implementation. The setback to the developing and emerging economies will be from state of art facilities in technology, culture, structure of construction industry, personnel and experts.

Table 2, reveals the problem solved; these problems can be further categories into six (6) headings.

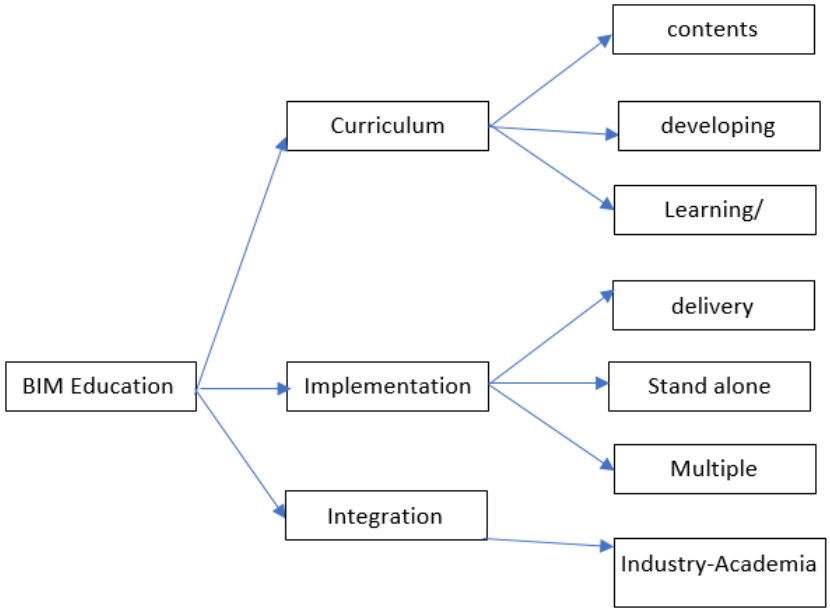
Table 2: Problems solved in extant research

Problems	Authors
Lack of strategies	1,4,23, 38,39, 40, 48,34,50
Insufficient curriculum	5,6,10,12,14,15,27,35,44,46,47,51
Serious gap in collaboration	20,21,30,45,
Lack of unified method of evaluation/assessment	8,49,54
Inadequate teaching methods	16,18,22,24
Competency Deficits	2, 7,9,13,17,19,26,31,33,37,41,42

A conceptual framework for BIM education

BIM education implementation framework was proposed from the studies above as an insight for built environment programs in developing countries.

Conceptual framework of BIM education for High Education in Non-industrialised Economy



Curriculum development, content, learning and delivery these variables are very important when it comes to BIM education as elaborated by previous researcher in industrialised economies, the global approach might be challenging to the non-industrialised economies due to some difference in development level, infrastructure, organization nature etc. The method to adapt might be from understand the current system of non-industrialise economies compare with advance countries then identify those gaps and abilities which can serve as a stepping stone in initiating BIM education into the existing programs. The development takes into account developing the content, objective of contents, method of delivery, (Knowledge, skills and abilities = competency) and assessment/evaluation. These variables are most important to BIM education implementation.

Integration, the developed nation achieved the milestone by full collaboration with the industry stakeholders, who demand for the BIM service and the academia supply the needed manpower to deliver BIM in the construction industry. Several case studies have been reported with exchange of knowledge between the industry experts and high education institutions via transfer of knowledge and practical to the students who will later take over the industry after graduation.

Implementation is very important variable to consider at high education institutions; even though lack of strategies and competencies are among major challenges hindering most of the higher institutions in levering on BIM implementation into their respective programs.

The study will further investigate the major difference of industrialise economies and non-industrialised economies in attributes to empower the emerging economies from domesticating in educational sector.

DISCUSSION AND CONCLUSION

The literature is almost unanimous on the importance of understanding the early adopter of BIM education as a catalyst for emerging economies to flow suits to attain the level of industry growth by the developed countries. This confirmed the submission by Barison and Santos (2010) that BIM education can be achieved by proper diffusing the knowledge into various programmes in tertiary institutions.

The multi-dimensional approach to BIM education globally requires careful evaluation, to determine a realistic approach to BIM in non-industrialised economies. The approaches are not homogenous in nature, they are heterogenous because all developed countries have their different methods used in BIM education development processes.

The study has highlighted a conceptual framework based on available theory on BIM education to serve as starting point into mapping process for BIM education implementation in Nigerian tertiary institutions.

However, for a developing country like Nigeria, a suitable study approach is required to plan strategic methodology for incorporating BIM education into higher education of tertiary institutions, who are the bridge to the construction industry. This preliminary study to initiate doctoral research has review literature identified with BIM education for built environment.

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