First online: 17 May 2016

Planning and Development of BIM Curriculum for Kuwait

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***Abstract*-Building Information Modelling (BIM) is one of the most important developments in design and construction industries that is greatly affecting current practice activities. 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. However, in the Middle East and Africa, students are falling behind in attaining this new tool. Hence, there is a critical need in these regions to train future architects and engineers in BIM advancements. There are, nevertheless, a number of challenges facing academic organizations in embracing BIM in their curriculums for educating future professionals. This research aimed to address these challenges and provide a solution framework for introducing BIM to Kuwait students. The paper explored the current state and future approaches of incorporating BIM into architectural and engineering curriculum in Kuwait institutions and described both a general strategy and execution plan for BIM education in Kuwait.**

Keywords- Building Information Modelling (BIM); BIM Education; BIM Framework; BIM Knowledge; Training; BIM Curricula

I. INTRODUCTION

Building Information Modelling is a simulation prototyping technology and workflow that is being recognized as a revolutionary development currently reshaping the architecture, engineering, and construction (AEC) industry. The technology element of BIM benefits industry stakeholders in visualizing and investigating what is to be fabricated or constructed in a simulated environment and identifies any potential design, construction, operational, or maintenance issues. The workflow component allows collaboration and encourages integration across AEC disciplines. BIM is thus effectively changing the role of computation in building design by generating a database of building objects used for all facets of a project from conceptual design to construction and beyond. Researchers have cited that the collaborative use of BIM in the AEC industry results in completing projects with more resources, higher quality, and greater customer satisfaction [1, 2].

BIM is defined by The US National Building Information Modelling Standard (NBIMS) as the following: "*Building Information Modelling (BIM) is a digital representation of physical and functional characteristics of a facility. A building information model is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition*." *(Building SMART, 2015)*. Thus, BIM's overall scope is broad, covering many aspects of the intelligent digital representation of data regarding a facility. BIM authoring tools, platforms that generate original information and digital representations, and intelligent virtual models create and aggregate information which were developed initially as separate tasks with non-computable information systems such as traditional computer aided drafting (CAD) or paper-centric process. Furthermore, BIM is a collaborative process that covers business drivers, automated process capabilities, and open information standards used for information sustainability and fidelity. Lastly, BIM covers facility lifecycle management for all relevant information exchanges, workflows, and procedures that are based on reproducible, verifiable, transparent, and sustainable information used throughout the building lifecycle.

In practice, the BIM workflow has a more widespread application today and will continue to be in the future because it does not only refer to the physical and functional properties of a building, but also how to manage all relevant information throughout its lifecycle. This includes, for example, links to resources, processes, written documentation, and additional information that contribute to the success of the project or that can be combined with other tools. The principle of a continuous, centralized, and object-based management and coordination of project information system is a fundamental shift from the traditional single drafting file approach such as CAD systems. BIM has a significant impact on the industry. It benefits clients, designers, engineers, educators, craftsmen, and construction companies.

At the center of the evolution of BIM is education. Contrary to the BIM evolution in the US and Europe, however, there are various issues facing the complete adoption or integration of BIM in architecture and engineering education in the Middle East and Africa. This is attributed to the fact that BIM is perceived by academia as a professional advancement in project design, development, delivery, and operation that lacks the theoretical construct of traditional courses, such as structural analysis and environmental technology. Furthermore, most academic institutions are struggling with BIM adoption because to date, there is no common understanding of what skills are needed in the industry, nor of what should make up the content, principles, and

DOI: 10.5963/JCES0501003

methods of education in fields that include BIM [3].

One of the main issues regarding BIM in education is the fact that the lack of proper incorporation of BIM as a valid discipline or area for scholarship may dissuade faculties from allocating time and energy to educate themselves or from integrating BIM into their teaching or research. In the US and other countries, AEC institutions have employed a variety of pedagogical methods for introducing BIM into their programs. These vary from using BIM in architectural studio, sustainable design, and construction management to Civil Engineering [4-8]. For instance, Önür and Sharag-Eldin & Nawari described how BIM was integrated into architectural curriculum [4, 5]. Sacks, et al. introduced BIM as an integral part of freshman year civil engineering education [7].

Exploring BIM education in the US and other countries showed that different methods have been implemented to integrate BIM into their curriculums. However, there is no commonly-agreed-upon approach for teaching BIM in AEC programs [7]. Usually, BIM is offered only as one or two different courses. Many courses limit their coverage to a short period (three to four weeks) [9]. In many cases, the BIM course is limited to a single discipline [7]. Joannides, et al. surveyed a number of schools in the United States regarding implementing BIM courses in architecture and construction schools [10]. Their results indicated that most architecture and construction schools either have an interest in or have already implemented BIM into their curriculum. In the majority of the schools, BIM was perceived as important to the industry, and planned to fully integrate BIM into their curriculum [10].

Quite often, schools offer BIM on a basic level by teaching a particular software platform, limiting their perspective on BIM to viewing it simply as another CAD productivity enhancement tool for creating 2D and 3D drawings [3]. Nevertheless, BIM actually goes far beyond digital drafting [1]. A more comprehensive literature review on the topic can be found in the work of Barison, et al. and Sacks, et al. [3, 6]. Their main findings indicated that schools wishing to implement BIM in their curriculums were likely to face many complications. The greatest challenge facing these schools was promoting integration between different areas of the curriculum using BIM and finding programs from other departments or units that were willing to promote important aspects of learning and teaching such as essential BIM skills and integration. Additionally, the current shortage of building design educators, trained in BIM workflow and construction practices, remains a serious barrier to the adoption of BIM collaborative design into curriculums. Further related research efforts are summarized in Table 1 illustrating the main concentrations of each study.

TABLE 1 SUMMARY OF RESEARCH WORKS PERTINENT TO BIM IN EDUCATION

Year	Major focus of BIM investigation	References
2008	Presents basic ideas that assist educators develop a BIM education strategy tailored to specific circumstances.	[11]
2008	Student-centered BIM curriculum development, BIM integration approach into construction curriculum, and collaborative design and construction. Efforts to incorporate BIM in the construction management, building technology and quantity surveying courses.	[12]
2009	Collaborative benefits of BIM and teaching approaches.	[13]
2010	Teaching basic skills of BIM tools and pedagogical methods.	[7]
2010	Teaching basic skills of BIM tools and integration strategies in architectural studio and technology courses.	[5, 6]
2010	Teaching basic skills of BIM tools, collaboration strategies in construction management curriculum, and outcomes evaluation criteria.	[14]
2011	Teaching basic skills of BIM tools, integration strategies, teaching methods including typology that helps target varying degrees of BIM utilization and diffusion in given subjects, and transitional requirements for both faculty and students.	[15, 16]
2013	Integrated approach to the teaching of AEC subjects, including a framework to assist academics in adapting their existing curricula using BIM.	[17]
2013	Teaching BIM as a collaborative process rather just a software tool; issues related to bridging educational silos; innovative approaches in developing a collaborative BIM curriculum that requires integration across different educational disciplines.	[18]
2013	Framework for BIM education that lays out the necessary topics and the levels of achievement required at each stage of degree programs. Using the cognitive domain of Bloom's taxonomy and Gap analysis, a framework for the development of BIM content was proposed.	[19]
2014	Tool that assists teachers in planning courses with BIM content.	[20]
2015	Teaching basic skills of BIM tools, collaboration strategies, and teaching methods. BIM as an important component of Integrated Project Delivery (IPD) since it is a core enabling process for the enhanced collaboration that IPD demands. How BIM processes can combine design, fabrication, construction, and project schedule information in a single source, thus, providing a sound platform for IPD.	[21]

As BIM differs fundamentally from traditional computer aided drafting (CAD), it needs new methods of thinking regarding the pedagogical aspects. For example, BIM promotes collaboration and teamwork across disciplines that must be incorporated

DOI: 10.5963/JCES0501003

into teaching BIM courses. Moreover, BIM offers rich visualization of building components and parametric modelling of behaviour, which can enhance students' learning experiences in virtual construction such as understanding how building elements fit together as they do on a physical site [1].

This work navigated the current state of BIM education in Kuwait universities and institutions. It also developed an educational framework for introducing BIM courses in Kuwait. Furthermore, the study focused on defining objectives and content requirements for various levels of courses in higher education.

II. EXISTING CONDITIONS

The current state of BIM education in Kuwait was studied by examining the syllabi of architecture and civil engineering programs at various institutions. In terms of BIM adoption in Kuwait AEC industry and according to the authors' conducted survey, it is limited to isolated large projects, although the industry as a whole is growing. It appeared that education is likely to take the lead in bringing BIM awareness and adoption in Kuwait construction industry.

This section explored the prevailing undergraduate and graduate courses that focus on teaching and training of BIM. Moreover, it discussed limitations and requirements of BIM curricula in Kuwait.

A. Kuwait University

The Department of Architecture at Kuwait University first introduced BIM tools to students during the academic year of 2013-2014. BIM tools were first applied in the Structural Analysis II course. Students were asked to construct a virtual model of structural components of an existing residential structure in Kuwait. This exercise intended to introduce structural BIM in an effort to challenge the students to understand the 2D structural plans and convert the plans to a virtual BIM. The exercise also aimed at demonstrating the various structural components of the building with respect to size and proportion according to their functions. Students were also required to produce a bill of quantity of the structural elements using BIM authoring tools.

BIM tools have also been offered to students in the "Computer Applications in Architecture" course in conjunction with the predominant AutoCAD® software. BIM was introduced as a replacement for other 3D software programs such as 3ds Max®. In addition, BIM tools were offered in one of the "Design Studio" courses during the same year. Students autonomously learned BIM tools to complete their final studio projects.

The application of BIM was also encouraged by seminars provided by program vendors as well as workshops conducted by the student organizations in the Architecture Department.

In higher design studio classes, students had the choice of using any digital tools to execute their design projects. Some students chose BIM only for its 3D drawing advantages. BIM has not yet been fully utilized beyond the 3D capabilities in design studio courses. In a shy effort, some students used BIM tools for the "Working Drawings" class offered by the Architecture Department. Others hesitated due to the detailed nature of the projects in this course because of their limited exposure and knowledge of the BIM tools. Others chose to use BIM for the general design of the floor plans, elevations and sections; for detailing they used the AutoCAD® software program. Nevertheless, all students turned to manual calculations for the preparation of the Bill of Quantities (BOQ) in the class.

Despite all efforts of advocating BIM to students, the experience was still young and based on individual efforts from only a few faculty members. The Architecture Department and College of Engineering are yet to mandate BIM into their curricula.

So far, the Department of Architecture is the only department offering BIM tools to students. This BIM offering in the department of Architecture at Kuwait University (KU) is currently very limited and primarily being introduced as BIM tools for the "Working Drawings" class. Other departments such as Civil, Mechanical, and Electrical Engineering are still in the process of investigating the value of incorporating BIM into their curricula.

B. Other Institutions

KU is the only public university in Kuwait. Other private universities and colleges are available including the American University of Kuwait (AUK), the Gulf University for Science and Technology (GUST), the American University of the Middle East (AUM), the Arab Open University (AOU) – Kuwait, the Australian College of Kuwait (ACK), the American College of the Middle East (ACM), Box Hill College Kuwait (BHCK) – Higher Education for Women, and the Kuwait-Maastricht Business School (KMBS). Table 2 summarizes the engineering and architectural programs offered by universities and institutions in Kuwait ranging from the two-year diploma in engineering to Masters programs.

Kuwait University is the only institution in Kuwait that offers a degree in Architecture. The College of Engineering at KU offers a wide variety of engineering degrees including Civil Engineering. On the other hand, three private institutions also offer engineering degrees. The AUM offers engineering degrees limited to Industrial and Computer Engineering. The ACM offers an Electrical Engineering Technology Program. The ACK offers two degrees under the Department of Civil Engineering. The first degree is a two-year Engineering Diploma of Civil Construction Design. In this degree, students are taught engineering drafting standards and given access to CAD packages such as AutoCAD and surveying along with other Civil Engineering

DOI: 10.5963/JCES0501003

principles. The second degree is a Bachelor of Engineering Technology (Civil). The degree is licensed by the Central Queensland University, Australia (CQU). The second degree requires two additional years after the successful completion of the first degree.

TABLE 2 KUWAIT ACADEMIC INSTITUTIONS PROGRAMS

Institution \ Programs	Diploma Civil Engr.	B.Sc. Architecture	B.Sc. Civil Engr.	B.Sc.Engr. (Non Civil)	M.Sc. Architecture	M.Sc. Civil Engr.	M.Sc. Engr. (Non Civil)
Kuwait University	-	Yes	Yes	Yes	Yes	Yes	Yes
American University of Kuwait	-	-	-	Yes	-	-	-
University of the Middle East	-	-	-	Yes	-	-	-
American College of the Middle East	-	-	-	Yes	-	-	-
Australian College of Kuwait	Yes	-	Yes	-	-	-	-
Public Authority of Applied Education and Training	Yes	-	-	-	-	-	-
Gulf University for Science and Technology	-	-	-	-	-	-	-
Arab Open University	-	-	-	-	-	-	-
Box Hill College Kuwait	-	-	-	-	-	-	-
Kuwait-Maastricht Business School	-	-	-	-	-	-	-

The other governmental institution in Kuwait is the Public Authority of Applied Education and Training (PAAET). It offers a wide range of degrees including a two-year degree in Civil Engineering offered under the Civil Engineering Department at the College of Technological Studies. Students have the option of joining any of the three sub-specialties including Building Technology, Highways and Roads, or Surveying. AutoCAD® software is the only drafting program taught at PAAET. Thus, KU is the only university offering BIM in the curriculum.

III. ANALYSIS OF BIM IMPLEMENTATION

To investigate curriculum development for BIM in Kuwait, a survey questionnaire was designed and conducted at Kuwait University at the College of Architecture and the College of Engineering. The survey questionnaire consisted of 20 questions for students and 20 questions for faculty. The questionnaire aimed to cover the following areas:

- Background of students and faculty
- Knowledge of BIM
- Use of BIM tools (Autodesk Revit, Graphisoft AchiCAD, Bentley Systems, TEKLA)
- Reasons for using BIM
- Methods of gaining BIM knowledge
- Perception of BIM significance in Education
- Perception of BIM significance in the industry
- Methods of teaching BIM courses

The questionnaire instrument used in this investigation involved the Qualtrics system through University of Florida (UF) technology website (UF Qualtrics license). This instrument is a robust, reliable service for creating and delivering web-based

DOI: 10.5963/JCES0501003

surveys. Participants were asked during various classes to complete the survey. For faculty, emails were sent with a link to the survey. In the next sections, results of the survey were analyzed using expressive statistics and the categorical data of the cross tabulation method in order to provide basic information about the interrelationship between responses.

A. Students and Faculty Background

The student survey results included 65% of the respondents from the College of Architecture, 30% from College of Engineering at Kuwait University (KU). Faculty respondents were mainly from the College of Architecture. Student respondents were asked about their gender, major, and academic level of classes. Faculty respondents were asked about their main areas of teaching, research, and years of teaching at KU.

The number of respondents from the College of Architecture was 207. Female respondents represented 77% of the architectural students' respondents. The academic level of classes of the respondents for architectural and engineering students are shown in Fig. 1. It is important to acknowledge the fact that the number of participants in this survey was not balanced and were mostly from the design discipline.

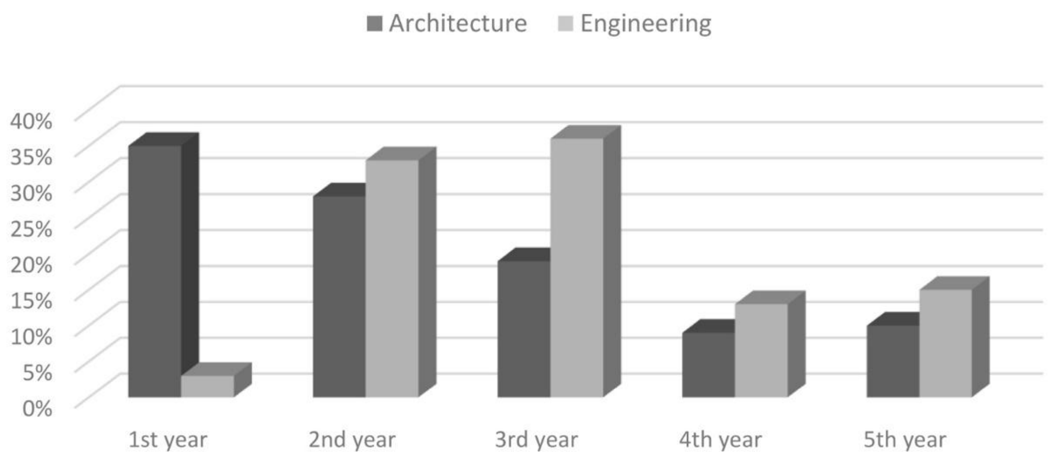

Fig. 1 Respondents' population in Architecture and Engineering

In architecture student surveys, first year respondents represented 35% of the total first year students, second year student respondents were 28% of the second year students, third year respondents were 20% of the total third year students, 4th year respondents represented 8% of the 4th year students, and 5th year respondents were about 10% of the total number of 5th year students.

Most faculty surveyed were from the College of Architecture. Their main subject areas of teaching and research are shown in Fig. 2. From this figure, it is important to note that the number of participants per area was not balanced and most participants were mainly from the design discipline.

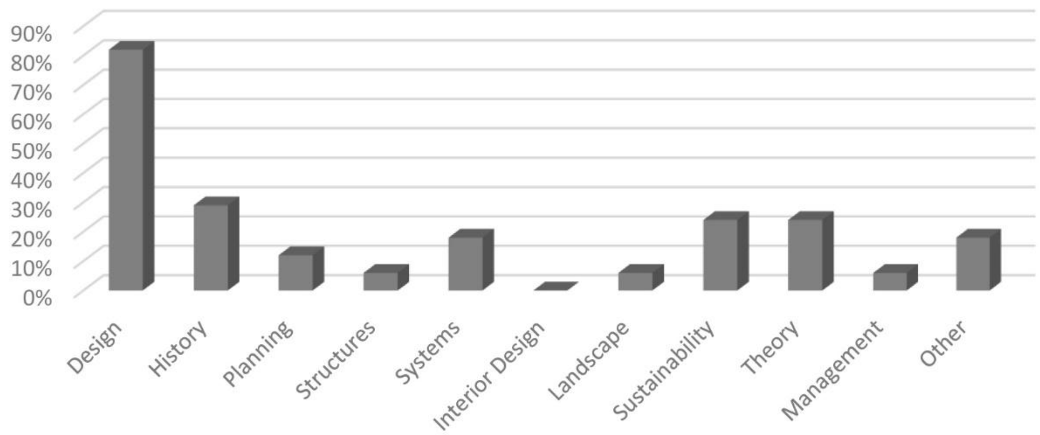

Fig. 2 Faculty's main areas of teaching and research

B. Knowledge of BIM

Students respondents were asked about any prior knowledge of BIM and if any, what level of familiarity with BIM

DOI: 10.5963/JCES0501003

technology and processes. Respondents from the College of Architecture made up about 75% of the total number of enrolled students; engineering student respondents represented 35%. Only 42% of the architectural students indicated that they had heard about BIM, while only 10% of the engineering students said that they had heard about BIM. From those, 65% said they had less than one year of experience with BIM (see Figs. 3-5).

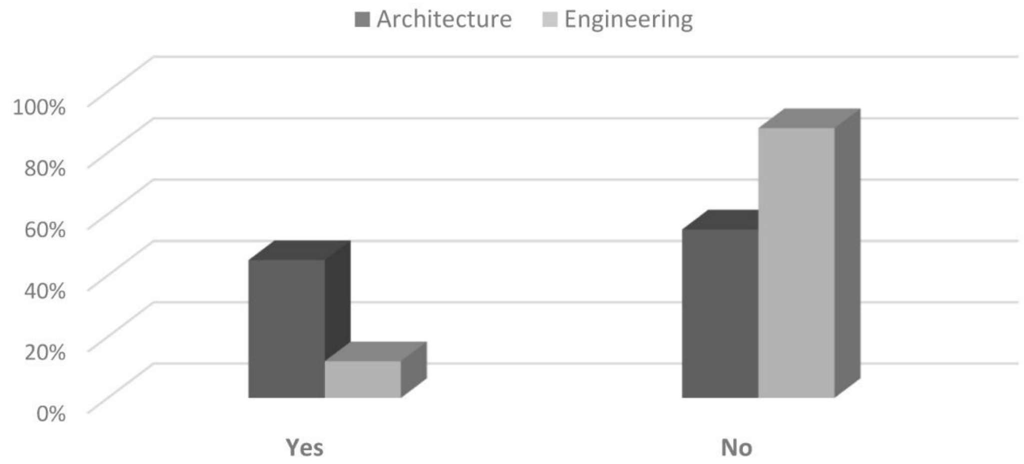

Fig. 3 Architectural and Engineering students' responses to "Have you heard about BIM?"

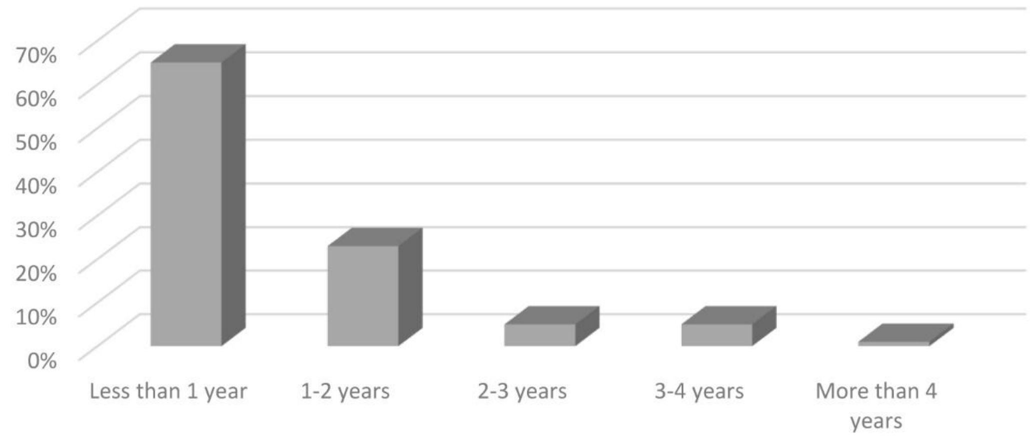

Fig. 4 Response for architectural students about their years of experience with BIM

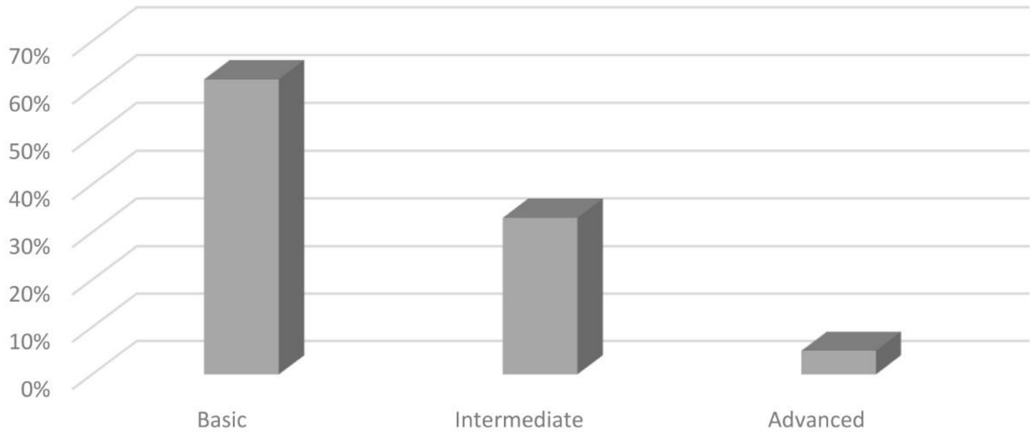

Fig. 5 Level of BIM knowledge (Architectural student responses)

Most of the architectural students' respondents (62%) said they had just a preliminary knowledge of BIM. A number of them (32%) indicated that their skill could be considered as intermediate. Only 6% of the student respondents claimed a high level of experience. Engineering student respondents indicated that they had no knowledge of BIM.

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Regarding the faculty respondents' knowledge of BIM, more than 35% said they had not heard of BIM, while about 60% indicated that they had (Fig. 6).

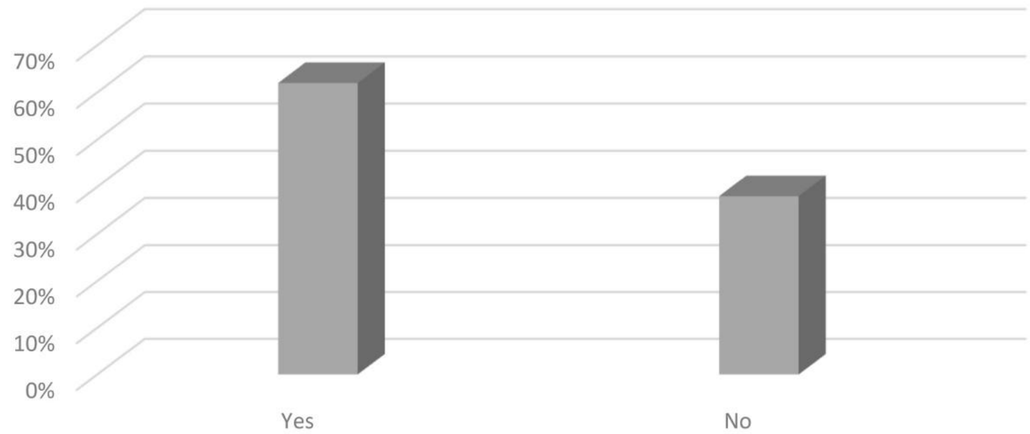

Fig. 6 Faculty responses to "Have you heard about BIM?"

C. Use of BIM Tools

Most of the student respondents indicated that they primarily used Autodesk Revit software (82%). A few responses, namely 9% of the architectural students, showed ArchiCAD as their main BIM software tool (Fig. 7). None of the student respondents from either college indicated experience with Bentley or TEKLA.

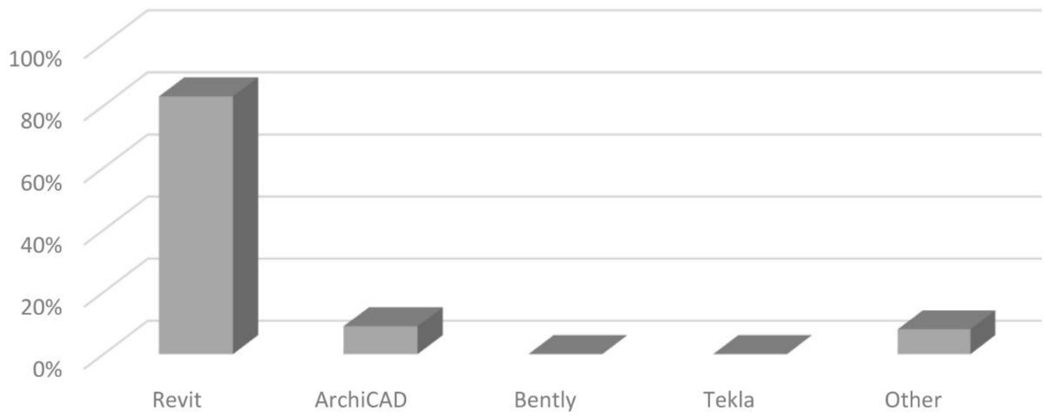

Fig. 7 Architectural student responses to the question about BIM software experience

D. Purpose of using BIM Tools

Students and faculty were asked to describe the main purpose of using BIM tools. Respondents were able to select one or more of the following BIM implementations: visualization and creating 3D renderings, technical design implementation in courses such as structural design courses or environmental design, and construction management courses. The majority (56%) of architecture students indicated that the main reason for using BIM tool was for 3D visualization. Responses indicating the use of technical courses totalled 32% and construction management made up 6%. These results are depicted in Fig. 8.

Engineering students indicated that they use BIM tools mainly for technical design and construction management (Fig. 9).

Most faculty respondents (70%) from the college of architecture indicated that the main reasons for using BIM tools was for technical design and construction management purposes (Fig. 9). Only about 10% of faculty respondents indicated that BIM tools were used primarily for visualization.

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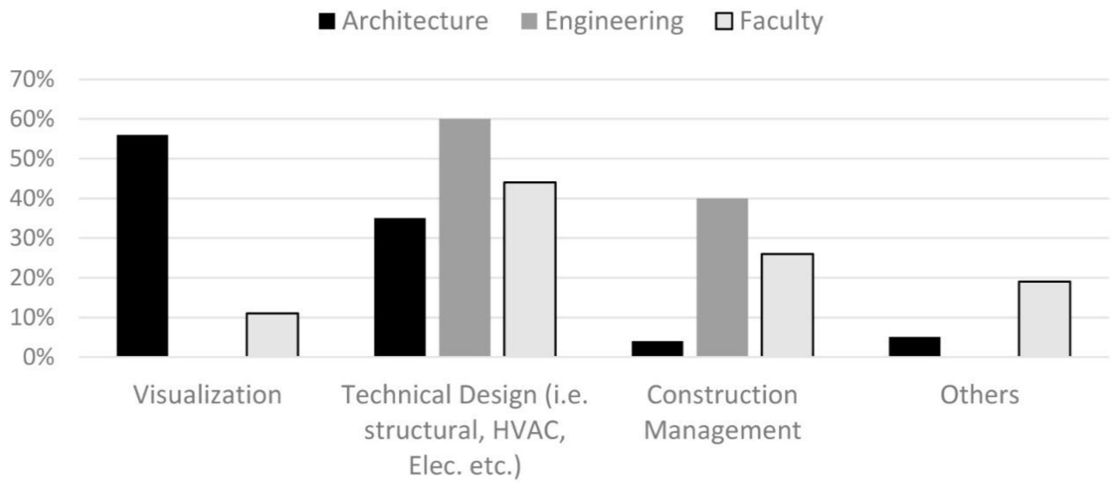

Fig. 8 Main purpose of using BIM tools as indicated by architectural students, engineering students, and architectural faculty

E. Methods of Gaining BIM Knowledge

Respondents were asked about the method by which they learned about BIM. Most of the respondents from the school of architecture indicated that they learned about BIM either through technical courses (38%) or were self-taught (27%). Some students (15%) said they learned BIM from design studio courses. Fig. 10 illustrates the students' responses from the college of architecture.

Most of the faculty from the college of architecture (80%) indicated that they acquired BIM knowledge through their own efforts (Fig. 9).

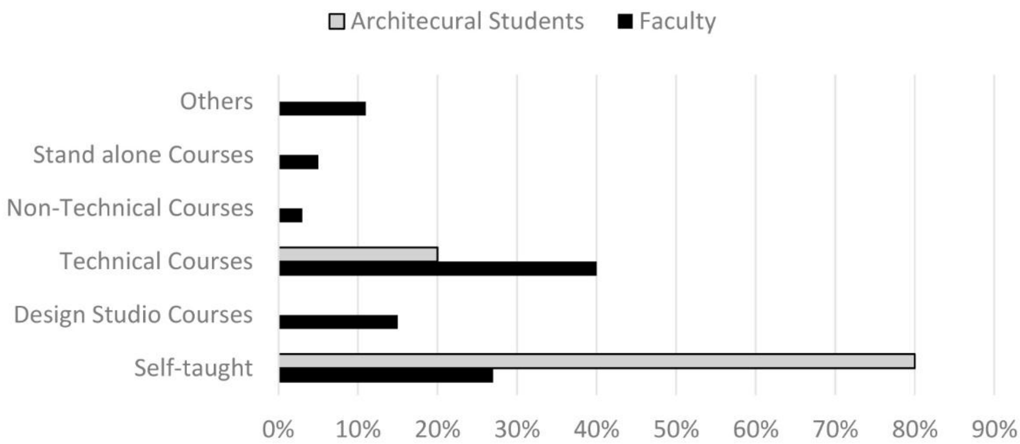

Fig. 9 Architectural students and faculty responses to the question about methods of learning BIM software

F. Perception of BIM Significance in Education

Regarding how BIM importance in education is perceived by students and faculty, the following results shed light on this critical question. A total of 55% of the architectural students agreed that BIM is critical for their major. Almost 85% of students confirmed that BIM is very important or important (Fig. 10).

More than 40% of engineering students indicated that BIM is crucial for their major. Almost 35% of students confirmed that BIM is very important and about 20% said it is somewhat important. About 3% of engineering students believed that BIM was not important for their major (Fig. 10).

Above 70% of architecture college faculty confirmed that BIM was very important or important for architectural education (Fig. 10). About 22% of faculty considered BIM somewhat important for architectural curriculum.

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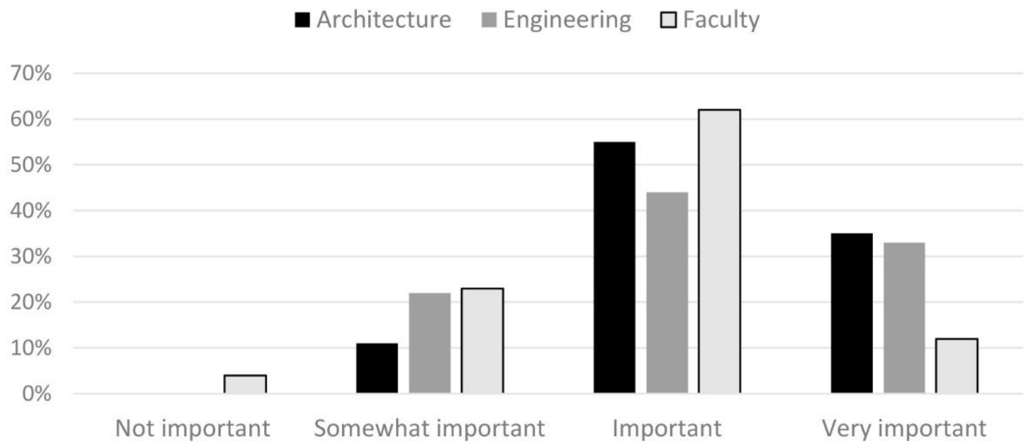

Fig. 10 Significance of BIM in education as indicated by architecture and engineering students and architectural faculty

G. Methods of Teaching BIM Courses

Respondents were asked whether the current curriculum covered BIM sufficiently. Most respondents (75% of architectural students; 80% of engineering students) stated that their program did not cover BIM adequately. About 95% of architectural faculty indicated that the current curricula did not cover BIM adequately (Fig. 11).

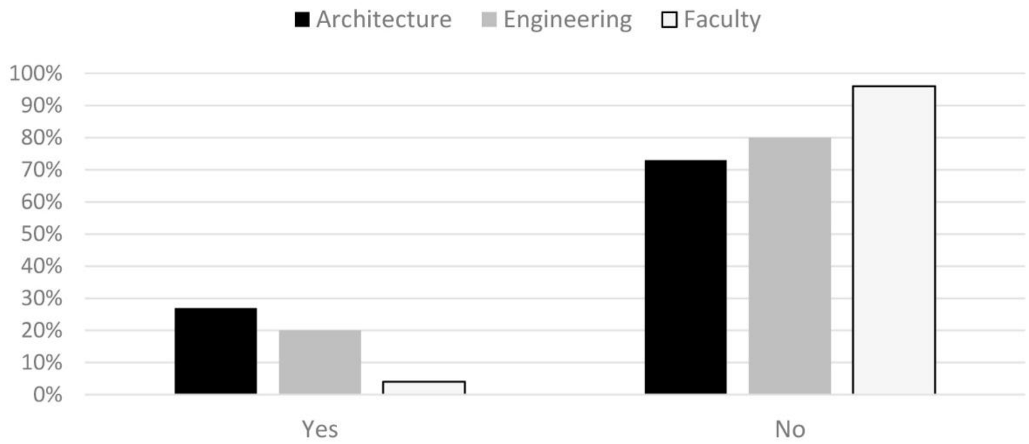

Fig. 11 BIM adequacy offering in the current architectural and engineering curriculums

Also, students were asked to answer the question about the BIM basic course and if it should be a required course. Overwhelmingly (more than 93%), students indicated that a basic BIM course should be a required course. Faculty answered this question in a similar fashion.

Furthermore, respondents were asked about the most effective way to teach BIM courses. Most of the architectural students (75%) indicated that more than one BIM course was desired as both a standalone course and integrated with other courses (Fig. 12). About 28% of those stated that they preferred more than one BIM course. Similar results were obtained from the engineering students (Fig. 12).

About 60% of the engineering students indicated that BIM courses should be elective while 20% said that at least one BIM course should be required. The other 20% of the engineering respondents indicated that there was no need for BIM courses.

Faculty of engineering and architecture were asked why they did not incorporate BIM courses into their curriculums. Approximately 75% of faculty attributed this omission to the lack of faculty with BIM expertise (Fig. 13).

Faculty were asked if BIM tools limited the architectural and engineering design education. Most faculty (80%) answered this question with a “no” answer. Moreover, faculty were asked to mention any limitation or constraints that BIM tools may have in educating architectural students. About 80% of faculty indicated that BIM tools may constrain the creativity of students (Fig. 14). Also, some of the faculty (20%) considered BIM software complexity as another constraint along with its learning curve (Fig. 14).

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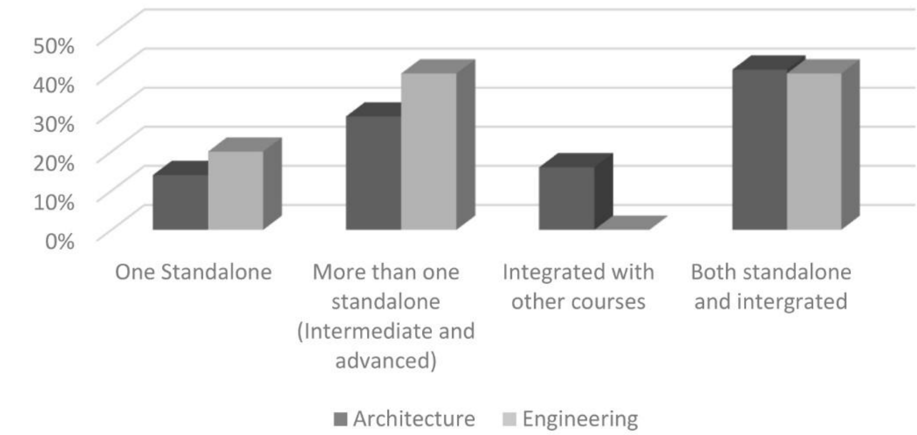

Fig. 12 Methods of teaching BIM courses as seen by architecture and engineering students

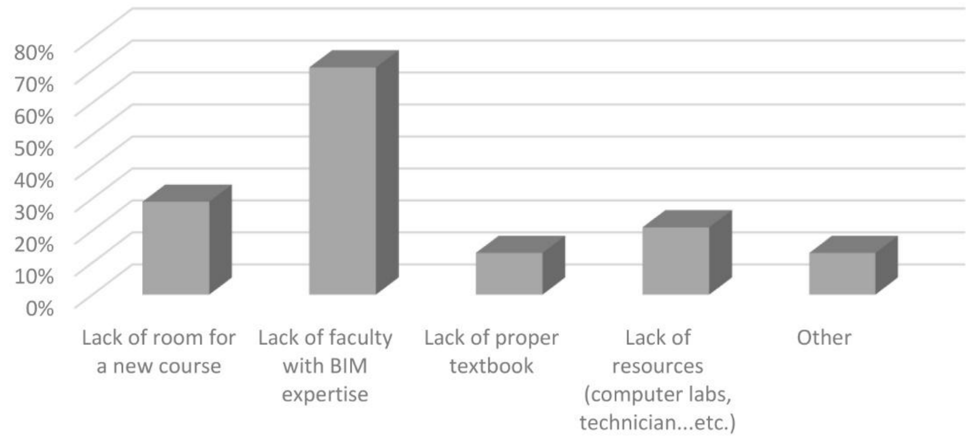

Fig. 13 Reasons for not covering BIM sufficiently in the current curriculum, as indicated by faculty

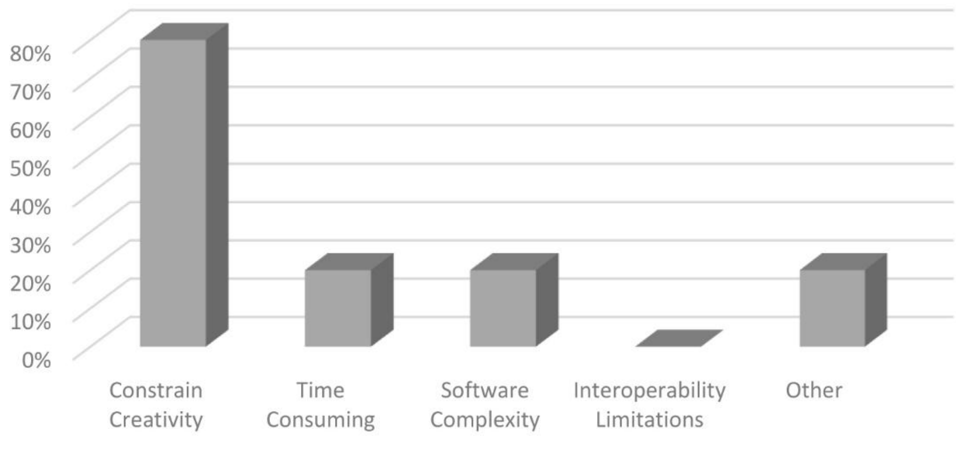

Fig. 14 Limitations and constraints of BIM tools in education

IV. DISCUSSION

The analysis of data in Section III covered epistemological, cognitive, and pedagogical aspects of BIM education in Kuwait. The results showed that the majority of students in architecture and engineering schools hadn't heard about BIM. Knowledge about BIM was very limited among those who had had some exposure to BIM. Most faculty in the college of architecture were aware of BIM; however, they possessed no or limited experience with BIM. Students and faculty of both architecture and engineering stressed the importance and significance of BIM and how to teach and integrate BIM into the colleges' curriculums. The major barrier seen by faculty in incorporating BIM into their curriculum was their lack of expertise with BIM

DOI: 10.5963/JCES0501003

education. The analysis indicated a number of misperceptions about BIM. For instance, some faculty expressed concerns about the limitations of BIM tools in teaching design studio. They perceived BIM tools as a constraint on students' creativity in architectural design studio.

Most of the students perceived BIM as a tool for better visualization and technical drawings. Students and faculty surveyed in Kuwait University were not aware of the other benefits of BIM education such as the ability to create an intelligent building model to enhance the creative and operational process of building design, modelling interoperability, collaboration and sharing models across other disciplines, virtual prototyping, and various simulation analysis such as energy, acoustic, and structural analysis.

The themes derived from the analysis concentrated on the recommendations of how BIM could be taught and integrated into a curriculum, the barriers for the introduction of BIM at Kuwait University, and how to correct the various misconceptions. The need to introduce BIM courses as a basic required (standalone) course and an advanced course centered on collaborative model are highlighted (Fig. 15).

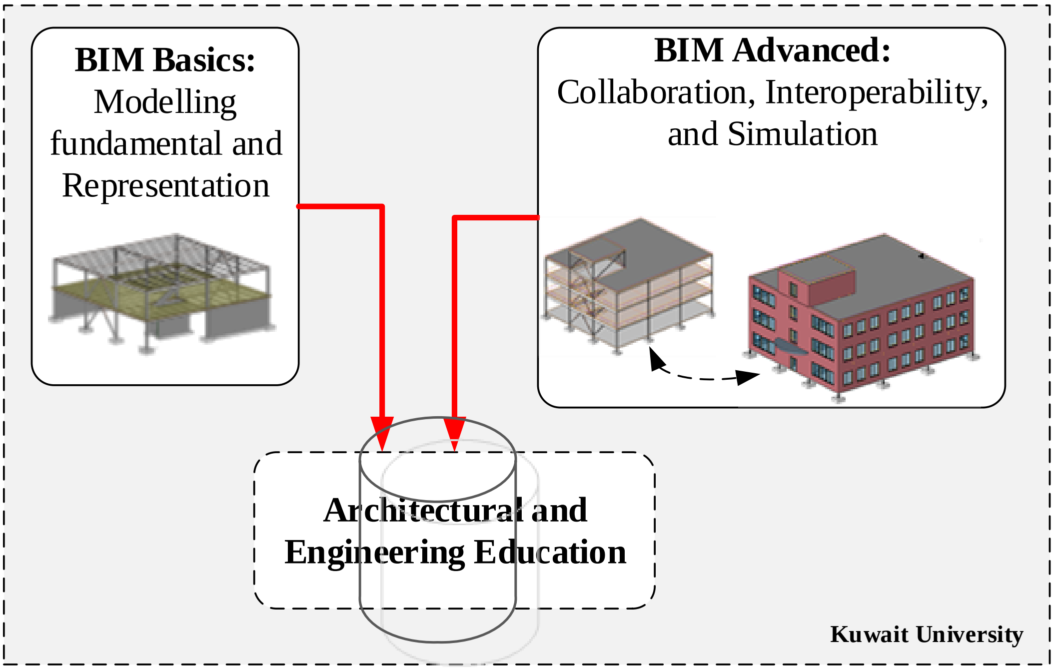

Fig. 15 Needs identification for BIM in Kuwait

V. PROPOSED FRAMEWORK AND GUIDELINES

The architecture, engineering, and construction industry is embracing BIM technology quickly, incorporating new opportunities to streamline the design, construction, and operation processes and to save time, money, and other resources. Academic institutions should move more deliberately and thoughtfully to incorporate BIM technology and processes into their curriculums.

There are several education techniques that can be employed for introducing BIM education into AEC programs. However, three main methods were considered critical for Kuwait: (i) Standalone BIM courses; (ii) BIM intermingled with existing courses; and (iii) BIM integrated in students' assignments only. Fig. 16 depicts the schema for the proposed framework for BIM education in Kuwait.

As for the standalone courses, three courses of different levels were proposed. An introductory course should be required for all AEC students. The specific learning objectives and curriculum outlines, along with evaluation criteria, are depicted in Table 3. Two additional courses are recommended to be tailored towards each specific discipline, as shown in Fig. 15. These courses cover intermediate and advanced topic for higher level students. For example, Table 4 and Table 5 depict goals and contents outlines for the intermediate and advanced standalone courses, respectively, for structural engineering curriculum.

After the introductory standalone course (Table 3), BIM can be also taught in conjunction with other courses. For example, in Material and Methods classes, BIM tools can be utilized to address and answer homework problems related to wall sections, material selections, and definitions, as well as elevations and sections details (Method (ii)). Another module relates to the implementation of BIM tools for a specific project assignment such as for architectural studio courses (Method (iii)). Details about Methods (ii) and (iii) will be addressed in a separate paper as their requirements and pedagogical process are different than Method (i).

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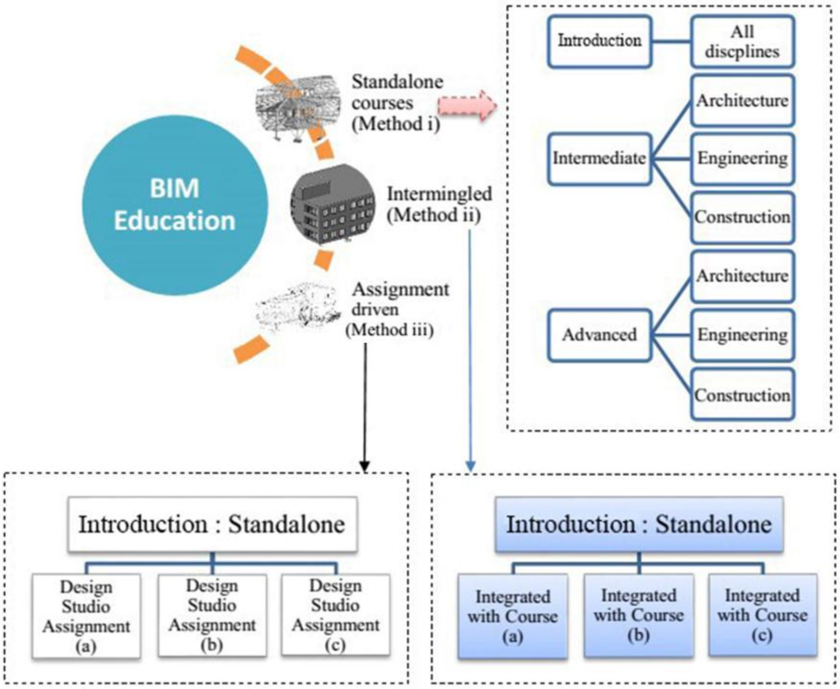


Fig. 16 Schema of the proposed framework for BIM education in Kuwait [22]

TABLE 3 BIM INTRODUCTORY COURSE [22]

Objectives	Contents outline	Evaluation	Outcomes
Provide fundamentals of BIM technology and process in order to understand parametric, object-oriented, and geometric modelling to support design, engineering analysis and performance simulation, construction planning, and design communication for facility construction	- BIM concepts and history of CAD - Parametric and object-oriented modeling - BIM authoring tools, central databases and information repositories - Methods to store and share information - Develop, coordinate, and communicate BIM model - Modeling with standard libraries of elements - Creating and modelling with custom building elements - Conceptual massing and solid modeling	- Weekly homework assignments - Two to three projects aiming to assess knowledge conveyed - Research paper focusing on the emerging technology and process of BIM in the industry	- Understand basic BIM concepts - Distinguish between BIM and traditional CAD processes - Have a basic knowledge of BIM tools

TABLE 4 BIM INTERMEDIATE COURSE FOR STRUCTURAL ENGINEERING CURRICULUM

Objectives	Contents outline	Evaluation
To provide principal of structural modelling, digital design, and analysis of structures	- Structural planning - Structural BIM using one of BIM authoring tools - Modelling columns, beams, floor slabs, roof decks, walls, framing, foundations, and rebar - Examples: concrete buildings, steel buildings, wood framed buildings, hybrid buildings - Sheets and construction documents - Creation of customized library of structural elements - Quantity take-off - Scheduling (4D), cost estimation (5D), and basic tendering	- Weekly lab assignments - Two to three term projects

DOI: 10.5963/JCES0501003

TABLE 5 BIM ADVANCED COURSE FOR STRUCTURAL ENGINEERING CURRICULUM

Objectives	Contents outline	Evaluation
Emphasizing cross-disciplinary collaboration and provide students with means through which integrative pedagogical goals are attained through BIM	- Visualization and renderings for aesthetic assessment - Generate multiple design alternatives and project phases - Model sharing and collaboration: internal and external sharing - Management of information flows - Perform structural analysis - Productivity, Interoperability - Check code compliance - Clash detection - Construction site logistics - Automated generation of drawings and construction documents - Manufacturing of pre-fabricated elements - Perform discrete event simulation - Integrated practice: contractual and legal aspects of BIM implementation; BIM standardization	- Weekly lab assignments - Two to three term projects

Table 4 lists the content for an intermediate BIM course for structural engineering students. The course emphasizes the applications of the BIM platform to develop structural planning and modelling basic structural systems for the conceptual and developing phases of a project. Furthermore, the course introduces the creation of construction sheets and documents from the BIM model, customized building components, quantity take-off, cost estimation, and basic scheduling of structural objects.

The curriculum for the BIM advanced course is depicted in Table 5. The course contents center on model sharing and internal collaboration among structural students' team and external collaboration with architectural students as well as performing structural analysis and design. Moreover, the course covers clash detection between different elements of the model, code compliance checking, understanding interoperability and IFC (industry foundation classes) format, preparing model for pre-fabricated elements, legal and contractual aspects of BIM workflow, understanding the level of development (LOD) and BIM standards.

VI. IMPLEMENTATION

In the spring semester of 2015, the proposed framework was implemented, and an introductory BIM class was taught at Kuwait University. To evaluate and measure the outcome of the course, weekly homework along with two main projects were assigned. Most of the assignments and the final projects were tied to the local construction and architectural design practices in Kuwait. The goal of the first project was to reinforce fundamental understanding of BIM and basic skills of modelling architectural and structural systems. Students were asked to model existing residential buildings, preferably typical Kuwait single family residential buildings. In the second projects, students were required to model a high-rise commercial building in Kuwait City. CAD files for each selected building were provided to students. These CAD files included plans, elevations, sections, and structural details. The project had two phases. Phase 1 consisted of modelling all architectural components of the building. The second phase focused on creating various schedules to compute areas, material volumes, windows, and doors. Students were asked to link the structural model developed by a different group to their architectural model. Furthermore, the project required that areas for long and short permanency, and wet and dry should be determined for each floor as well as the overall ratio between these parameters and make recommendations on how to improve them.

Students' results after the completion of the course were very good, with an overall average grade of B+. Most students who took the class showed appropriate levels of cognitive thinking in regard to the application of BIM tools in the design projects. BIM tools allowed students to understand the architectural design and the structural details on a much deeper level as can be seen from the student sample projects (Fig. 18) and the final verbal presentations. The course clearly provided a great opportunity to engage students more effectively and to aid them to understand how buildings elements are related to each other and how the overall configuration and construction assembly of various building materials look. Further benefits noted by students included exploring new ways of illustrating construction details and methods, opportunities for greater communication, and conceptually understanding the eventual paradigm shift from 2D documents to full 3D model-based construction documents. Some limitations noted by students included the inability of the curriculum to comprehensively teach students how to collaborate with other disciplines and the lack of a dedicated BIM laboratory to allow students to accelerate their knowledge of construction and BIM applications. Regardless of their single performance in the class, all students showed great enthusiasm and commitment to the BIM course, very clearly understood the importance of BIM in today's construction industry, and appreciated its value for their future careers.

At the end of the semester, evaluations were performed to measure the content and delivery of the course. In total, 30 students were registered for the class. About 60% were 3rd year undergraduate students, 30% were 4th year students, and 10% were 5th year students. The outcomes of the course were very positive, as demonstrated in the evolution done after the course

DOI: 10.5963/JCES0501003

(Fig. 17). As presented in the figure, the course received an overall rating of 85% while the questions related to the various instructional aspects of the course varied from 78% to 100%. A 100% response rate was recorded for this evaluation.

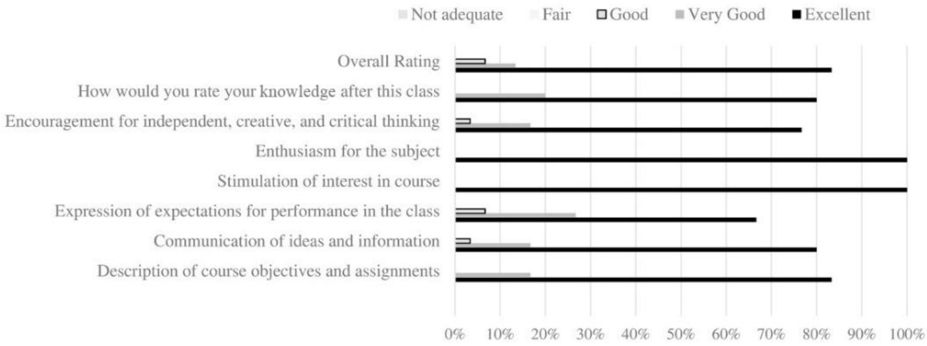
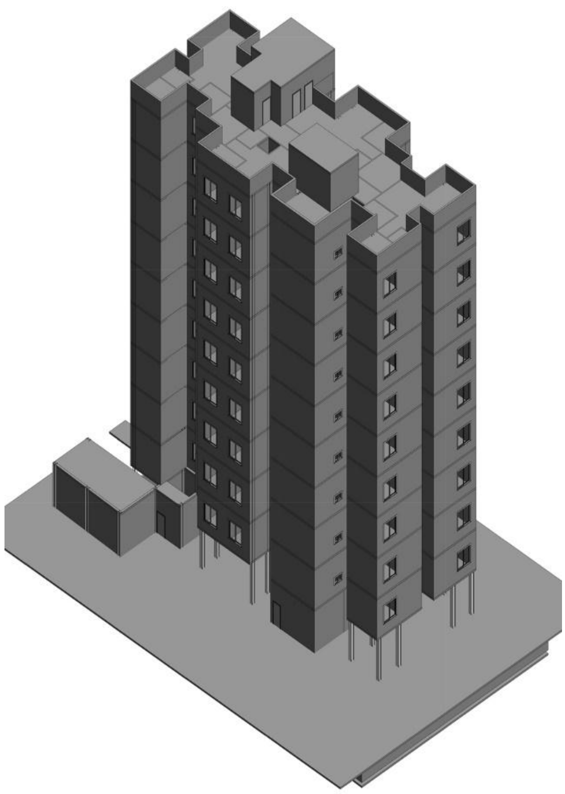
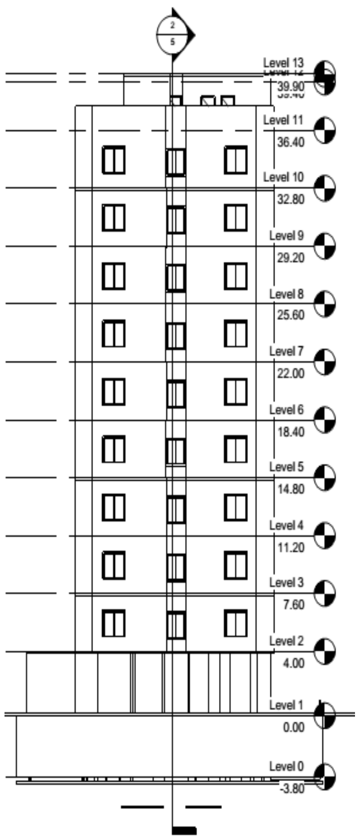


Fig. 17 Students' responses after course implementation

Project	Description
Project 2	Students were required to model a high-rise residential building in Kuwait. CAD files for each selected building were provided to the students. These CAD files included plans, elevations, sections, and structural details. The project had two phases. Phase 1 consisted of modelling all architectural components of the building. The second phase focused on creating various schedules to compute areas, material volumes, windows, and doors. Students were asked to link the structural model developed by a different group to their architectural model. Furthermore, the project required that areas for long and short permanency, and wet and dry should be determined for each floor as well as the overall ratio between these parameters and make recommendations on how to improve them.  

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Typical Plan:

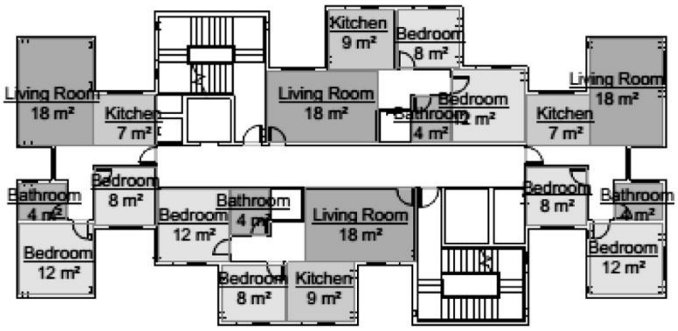
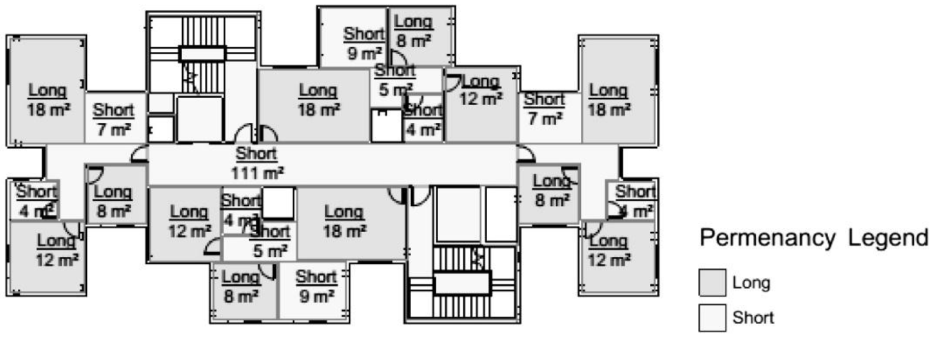
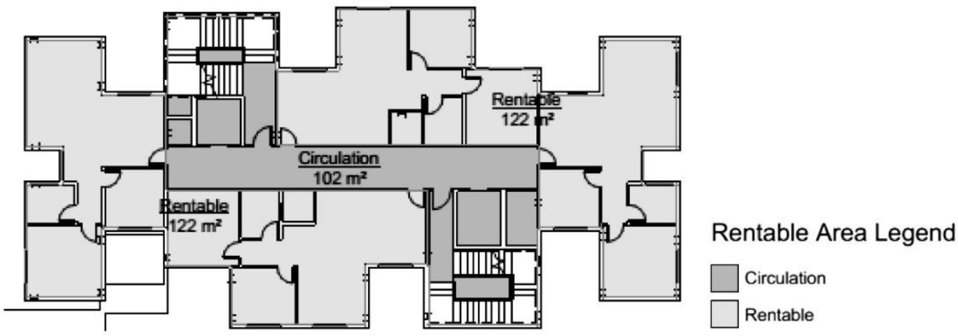


Fig. 18a Summary of BIM class project assignments

Permanency Areas:



Rentable Areas:



Dry and Wet Areas:

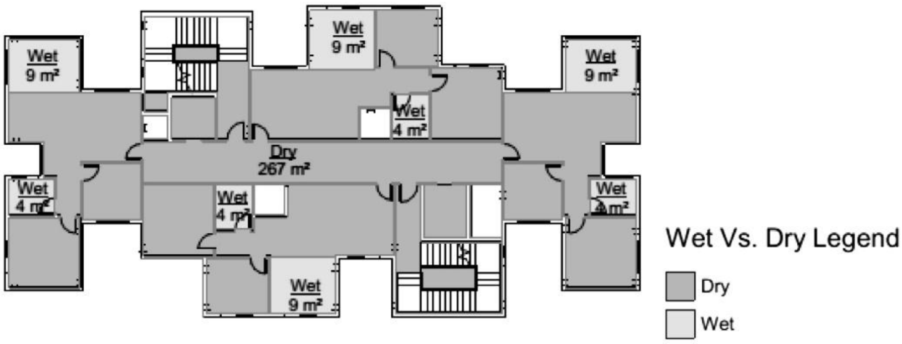


Fig. 18b Summary of BIM class project assignments

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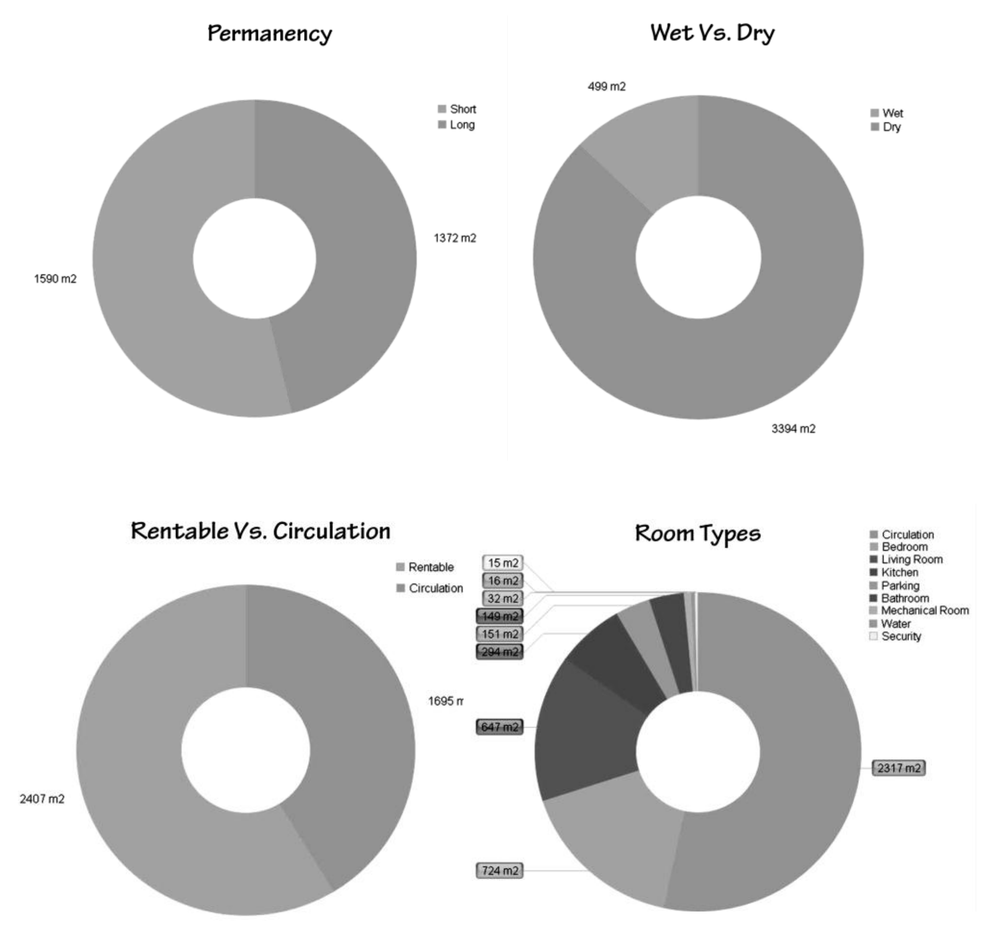

Fig. 18c Summary of BIM class project assignments

VII. CONCLUSIONS

BIM education is different than just teaching computer-aided drafting (CAD) in architecture and engineering programs. Building Information Modelling (BIM) is often only considered a new technology tool for generating design documents. However, BIM is also a comprehensive process for information management and analysis that architecture and engineering schools in the Middle-East and Africa should recognize and incorporate into their programs.

This research addressed the present conditions of BIM education in Kuwait Universities and institutions, and conducted a detailed survey about the topic for students and faculty at Kuwait University. According to the survey results, most students and faculty at Kuwait University lacked accurate BIM knowledge. At the same time, they acknowledged the significance of BIM in their majors. The survey results also indicated the necessity of including one or more BIM courses in the architectural and engineering curriculums. The main constraints identified by faculty for not introducing BIM into their current curriculum included the lack of faculty with the appropriate expertise in BIM as well as the faculty's perception that BIM tools may constrain creativity of architectural students. Furthermore, some of the faculty considered BIM software complexity as another limitation along with its steep learning curve. Many students and faculty surveyed in the study were not familiar with other benefits of BIM education such as the ability to create an intelligent building model to enhance the creative and operational process of building design, modelling interoperability, collaboration and sharing models across other disciplines, virtual prototyping, and various simulation analysis such as energy, acoustic, and structural analysis.

The subjects developed from the analysis focused on the recommendations of how BIM can be introduced and integrated into a curriculum, the barriers to the introduction of BIM, and how to resolve the various misconceptions. Consequently, the study centered on defining goals and content requirements for various levels of BIM courses in higher education. It developed a framework for teaching BIM courses in Kuwait. The intrinsic aim however, was to make this framework an essential part of the AEC education in Kuwait while continuing to keep the rigor and academic constructs of educational exercises. The framework recognized the conditions of Kuwait along with the characteristics of BIM and provided a systematic and holistic approach to introducing BIM in Kuwait universities and colleges.

The suggested framework developed different approaches for teaching BIM: standalone courses, BIM interlaced with other courses, and project-driven BIM. This work addressed the standalone approach and described objectives, curriculum content,

DOI: 10.5963/JCES0501003

and evaluation for the standalone approach. An introductory standalone course was defined as a required course for architecture, engineering, and construction students. This course emphasized the fundamentals of building information details, theory of modelling building elements, and the technical characteristics of BIM tools. Intermediate level courses were suggested to incorporate BIM as a part of the core architectural and engineering courses, concentrating on teaching BIM for specific discipline, such as architectural design, construction management and planning, structural engineering, and MEP engineering. A third course was proposed as an advanced BIM course which emphasized collaboration, team work, and cross-discipline activities as well as management of BIM projects across organizations.

The proposed BIM framework was successfully implemented in the college of Architecture, Kuwait University in the spring 2015 semester. An introductory stand-alone BIM course was taught and the course outcomes were very positive. After the completion of the course, most students indicated that their knowledge and understanding of BIM had been appreciably enhanced. With this suggested BIM framework for integrating BIM into the curriculum, one would expect that the academia would have a great opportunity to impact and advance the entire AEC industry in Kuwait or other Middle-Eastern and African institutions.

ACKNOWLEDGMENT

Authors are sincerely grateful to Fulbright U.S. Scholar Program and Kuwait University for funding and supporting this research. Also, authors would like to express their gratitude to College of Design, Construction and Planning at the University of Florida as well as the School of Architecture at the University of Florida for promoting the international exchange activities and facilitating various supportive information and tools.

REFERENCES

[1] Eastman, C, Teicholz, P., Sacks, R., and Liston, K., *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*, 2nd Ed., John Wiley and Sons, New York, 2011.

[2] Jävjä, P., Suwal, S., Porkka, J., and Jung, N., "Enhancing customer orientation in construction industry by means of new technology," *Proceeding of the 7th Nordic Conference on Construction Economics and Organization)*, Akademika forlag, vol. 2013, pp. 215-226, 2013.

[3] Sacks, R. and Pikas, E., "Building Information Modeling Education for Construction Engineering and Management. I: Industry Requirements, State of the Art, and Gap Analysis," *J. Constr. Eng. Manage. ASCE*, vol. 139(11), pp. 04013016, 2013.

[4] Önür, S., "IDS for ideas in higher education reform," P*roc., 1st Int. Conf. on Improving Construction and Use through Integrated Design Solutions, VTT-Technical Research Centre of Finland*, Espoo, Finland, pp. 52-71, 2009.

[5] Sharag-Eldin, A., and Nawari, N.O., "BIM in AEC Education," *2010 Structures Congress joint with the North American Steel Construction Conference in Orlando*, Florida, May 12-15, 2010, pp. 1676-1688.

[6] Barison, M. B., and Santos, E. T., "BIM teaching strategies: An overview of the current approaches," *Proc., Int. Conf. on Computing in Civil and Building Engineering*, W. Tizani, ed., Nottingham University Press, Nottingham, UK, pp. 577-584, 2010.

[7] Sacks, R., and Barak, R., "Teaching building information modeling as an integral part of freshman year civil engineering education," *J. Prof. Issues Eng. Educ. Pract.*, vol. 136(1), pp. 30-38, 2010.

[8] Wong, K. A., Wong, K. F., and Nadeem, A., "Building information modelling for tertiary construction education in Hong Kong," *ITcon. J. Inf. Technol. Constr.*, vol. 16, pp. 467-476, 2011.

[9] Becerik-Gerber, B., Gerber, D. J., and Ku, K., "The pace of technological innovation in architecture, engineering, and construction education: Integrating recent trends into the curricula," *ITcon. J. Inf. Technol. Constr.*, vol. 16, pp. 411-432, 2011.

[10] Joannides, M.M., Olbina, S., and Issa, R. R. A., "Implementation of Building Information Modeling into Accredited Programs in Architecture and Construction Education," *International Journal of Construction Education and Research*, vol. 8, pp. 83-100, 2012.

[11] Hietanen, J., and Drogemuller, R., "Approaches to university level BIM education," *The IABSE Symposium Report*, vol. 94, no. 15, 2008.

[12] Taylor, J., Liu, J., and Hein, M., "Integration of building information modeling (BIM) into an ACCE accredited construction management curriculum," *Proceedings of the 44th ASC National Conference, Associated Schools of Construction National Conference*, 10 pages, 2008.

[13] Sabongi, F. J., "The Integration of BIM in the Undergraduate Curriculum: An analysis of undergraduate courses," *Proceedings of the 45th Annual Conference of ASC*, 3 pages, University of Florida, Gainesville, April, pp. 1-4, 2009.

[14] Clevenger, C. M., Ozbek, M., Glick, S., and Porter, D., "Integrating BIM into construction management education," *EcoBuild Proceedings of the BIM-Related Academic Workshop*, 8 pages, Washington D.C., 2010.

[15] Forsythe, P., Jupp, J., and Sawhney, A., "BIM in tertiary construction project management education: A program wide strategy," pp. 192-211, Conference Papers. Paper 15, 2011, http://epublications.bond.edu.au/aubea_2011/15.

[16] Barison, M. B., and Santos, E. T., "BIM teaching: current international trends," *Gestão e Tecnologia de Projetos*, vol. 6(2), pp. 67-80, 2011.

[17] Macdonald, J.A. and Mills, J.E., "An IPD approach to construction education," *Australasian Journal of Construction Economics and Building*, vol. 13(2), pp. 93-103, 2013.

[18] Panuwatwanich, K., Wong, M. L., Doh, J.-H., Stewart, R. A., and McCarthy, T. J., "Integrating building information modelling (BIM) into Engineering education: an exploratory study of industry perceptions using social network data," *Proceedings of the 2013 AAEE*

DOI: 10.5963/JCES0501003

Conference, 9 pages, Gold Coast, Queensland, 2013.

[19] Sacks, R. and Pikas, E., "Building information modeling education for construction engineering and management. I: Industry requirements, state of the art, and gap analysis," *Journal of Construction Engineering and Management*, vol. 139(11), pp. 04013016, 2013.

[20] Barison, M. B., and Santos, E. T., "A Tool for Assisting Teachers in Planning BIM Courses," *Proceedings of the Conference on Computing in Civil and Building Engineering 2014*, ASCE, June 2014, DOI: 10.1061/9780784413616.268.

[21] Finio, M., Stedman, B., Fleming, J., Messner, J., Holland, B., and Poerschke, U, *IPD in Education: Best Practices Autodesk Inc.*, Mar. 10, 2015.

[22] Nawari, N. O. and Alsaffar, A., "BIM Education: A Framework for Kuwait," *Proceedings of the 14th International Conference on Construction Applications of Virtual Reality*, 16-18 November 2014, Sharjah, UAE, pp. 132-139.

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DOI: 10.5963/JCES0501003