Proposing a Framework for Introducing the Concept of Engineering Digitization to Develop Curricula: Case Study - Tishreen University, Faculty of Civil Engineering

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Abstract

The emergence of Building Information Modeling (BIM) technology has made a major development in the fields of engineering and construction and has provided a means for documentation and design management throughout the building's life cycle. Despite this, the construction sector suffers from a clear shortage of specialists equipped with work skills, and therefore there is a gap and lack of skills. In order to meet the future needs for the skills of using (BIM) technology in the labor market, it was necessary to take serious steps to introduce BIM in education programs in Syrian universities to prepare future specialists, so this study aimed to identify the current reality of teaching Building Information Modeling (BIM) and to identify obstacles and challenges that prevent the application of (BIM) and propose a framework for introducing the concept of engineering digitization to develop curricula at Tishreen University, Faculty of Civil Engineering. The study used the descriptive survey method, and to collect data, two questionnaires were developed, which were applied to a sample of (32) faculty members from all disciplines of the Faculty of Civil Engineering. The study also used the statistical package for social sciences (SPSS) program to analyze the results of the questionnaire. The study showed a positive awareness of the culture of building information modeling among the various disciplines of civil engineering, despite the presence of many challenges and obstacles facing the implementation of BIM, and the study provided a general framework for the integration of building information modeling (BIM) technology with curricula The most important recommendations indicate the need to enhance awareness of the BIM culture and its applications by offering specialized training courses for academics in the use of modern technological tools based on BIM as an effective educational tool that can be integrated into the teaching curricula.

Keywords: Building Information Modeling (BIM); Higher education; Civil engineering curricula; BIM integration

1. Introduction

Over the past decade, the construction industry has witnessed an industrial revolution where advanced technology and applications have been deployed leading to the world of smart building which is a process of planning, organizing, building, and operating a structure using computerized digital technologies that improve project feasibility, sustainability, design quality and reduce costs [1]. The construction industry has largely adopted Building Information Modeling (BIM) technology which is a well-known new technology used to improve the construction process by completing projects on time and within budget and reducing the risk of losing project construction details as a database that stores all information and facilitates the process of integrating information into a project and document management is improved within it [2]. The adoption of Building Information Modeling has increased

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dramatically over the past few years [3], where a survey done in [45] showed that more than half of the respondents (89 total) on the survey that authors made said that they are using BIM tools (Revit), not only because of BIM's ability to solve massive problems for AEC projects but also to improve project performance and efficiency [4], in addition to improving stakeholder behavior in huge construction projects through healthy interaction between them, which leads to less conflicts and allows knowledge sharing [5]. Globally, many construction companies, especially those responsible for large companies, are integrating BIM into their delivery systems, which has yielded beneficial results such as semi-automated and systematic digital workflows, effective collaboration, conflict detection, higher return on investments, and others [6], through the IE workflow strategy and its synergy with BIM & SM that is agreed upon between the different parties in mega construction projects (MCPs) from the beginning of the construction process [7], even in the developing country, such as Syria, the adoption of BIM is not only an option, but also a necessity [44].

The role of BIM champions as change leaders in these companies is highlighted as they measure and assess the needs for BIM implementation in each work site [8], And they work to improve the performance of BIM using the maturity matrix (BIM 3) [9] to reach an advanced level of BIM implementation maturity levels as in the Lithuanian AEC industry which has demonstrated the ability to fully transfer the maturity to Level 2 [10]. However, the level of BIM adoption is still much lower than expected [11], although many governments around the world play a vital role in accelerating the implementation of BIM [12], however, the most important barriers to adopting BIM are the lack of experience and the lack of standardization and protocols [13], in addition to personal issues associated with resistance to change and lack of awareness of the importance of BIM [14].

A methodology was proposed to implement BIM based on several steps, including raising awareness, enhancing the desired benefits, determining the readiness of the engineering and construction industry (AEC), identifying the capabilities of governments and institutions, identifying and removing the main obstacles affecting implementation [15]. This methodology will help the availability of trained professionals and increase awareness of the technology among stakeholders in the AEC industry by defraying the costs of BIM programs [13], where BIM integration can be applied with many areas of the AEC industry, including conducting risk management in construction projects, taking into account BIM technology, which differs from risk assessment by traditional methods [16], moreover, BIM can be applied in the transportation industry through road construction projects [17], and in achieving sustainability and improving energy efficiency and the life cycle of the building through the application of the skylights system and the Trombe wall system using BIM technology [18,19], in addition to the integration of BIM with nanotechnology, one of the integration processes between BIM and nanofibers achieved a positive relationship between the diameter of the needle and the diameter of the electro spun PVDF nanofibers [20]. According to many academics, there is a shortage of qualified experts and as a result work is being done to integrate and introduce BIM in higher education institutions, considering that professional bodies and the academic community are the main stakeholders in BIM education [21], in order to educate students and increase their knowledge of BIM capabilities and thus increase the number of BIM graduates in the future and to take advantage of the great benefits that BIM can provide to students in their potential careers as well as to meet the needs of the construction industry, it offers BIM professionals a variety of job options including BIM engineer, BIM designer, BIM project manager, BIM technician, BIM coordinator, IT managers, and other positions [1]. Integrating BIM into higher education curricula can help address the scarcity of BIM experts and develop an effective workforce that aims to balance the supply and demand equation in the labor market [20].

In Syria, the AEC industry is witnessing a shift from CAD to BIM to keep pace with the ever-evolving world of technology [22], where the digital transformation initiative in engineering work has been taken, which requires the adoption of BIM in the submission of engineering projects. This adoption will lead to an increase in the demand for the need for engineers specializing in BIM and will give them the opportunity to work in the reconstruction projects that Syria will witness in the coming period, which makes integrating and introducing BIM into the educational curricula an urgent necessity to meet this demand and trends in BIM adoption in the near term. Accordingly, the Syrian educational bodies need to allocate more time and effort to qualify engineers and help them keep up with the latest technologies [24]. Especially after many universities around the world made concerted and real efforts to introduce and implement the introduction of BIM in the educational curricula of engineering colleges in order to graduate engineers ready to work in accordance with the requirements of the construction industry. This is within the framework of the continuous improvement of the curricula to better meet the challenges of the future and to meet the global accreditation systems that

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are based on professional judgment to assess whether they meet the criteria set to improve the quality of engineering education that meets the needs of the construction industry in a dynamic and competitive environment, An educational plan was presented to the Faculty of Architecture at Al-Baath University in accordance with NARS and ARS standards to prepare a new generation of architects fully aware of building information modeling and its general ideas, which will help spread BIM education among other local universities [23].

2. The importance of the research and its objectives

The demand for BIM projects has been increasing dramatically in recent times and is expected to increase in the coming years, especially after moving forward with the proposed adoption policy and the work of the Central Engineers Syndicate to issue a guide on working within the BIM environment within the Syrian standards. Considering that civil engineering has a wide range of Sub-disciplines, there is a need to design, build and expand transportation systems, increase water supply, control pollution, construct buildings, repurpose existing building facilities, repair, replace and maintain existing roads, bridges and infrastructure, project management and integrated delivery, which leads to increased efficiency in the design, construction and maintenance process to meet these challenges. challenges. Therefore, civil engineering faculties must constantly review their programs to graduate engineers with high scientific and professional characteristics that enhance their contribution to the engineering market, especially with the increasing demand for highly qualified engineers to deal with the requirements of the construction industry and its future needs of increasing understanding of design parameters, load distribution, construction details, and Requirements for cooperation within the construction project team, production of 3D models, quality management based on the concept of BIM, familiarity with software tools such as Revit, Navisworks, and illustration of 4D, 5D models covering schedule management and cost management areas, and 6D, 7D that deals with facilities management and maintenance after the investment and operation phase and familiarity with important sustainability issues. The research objectives are summarized as follows:

1. Learn about the current reality of Building Information Modeling (BIM) education at Tishreen University, Faculty of Civil Engineering.
2. Identifying the obstacles and challenges that prevent the application of (BIM) at Tishreen University, Faculty of Civil Engineering.
3. Proposing a framework for introducing the concept of engineering digitization represented by (BIM) to develop the curricula of the College of Civil Engineering

3. Related work

Since BIM has become popular in the construction industry, many studies have analyzed the current reality of BIM education in universities that have begun to develop the BIM curriculum and identified the obstacles that limit its implementation. The current study was similar to these studies, as it was similar in its approach used, which is the descriptive approach that used the questionnaire as a study tool, whereas only 41.37% of universities in Pakistan teach BIM in undergraduate, postgraduate or doctoral level (AEC) programs, and it may take five years for universities to fully integrate BIM The most significant barrier to integrating BIM into CM construction management programs is the lack of trained faculty [25], the status of BIM in Moroccan universities is still at a very early stage, and limitations to data collection have emerged, such as lack of BIM materials, lack of experience among lecturers, and the high cost of BIM training[26], the barriers to effective educational integration of Building Information Modeling in Australian higher education institutions were: 1) Change management challenges. 2) Curriculum and Content Limitations 3) Teacher Problems 4) Industry Disconnected A comprehensive overhaul is needed to change the way industry, accreditation bodies, and government policymakers engage with higher education institutions to define BIM education programs [27], while some higher education institutions in Malaysia have begun to include BIM in their programs, there are challenges such as (low level of awareness among teachers, low knowledge and competent skills in BIM, the need to purchase hard and soft tools and the need to create collaborative training and educate students in all academic disciplines to industry requirements) [28]. Other studies provided a different approach analyzing the role of BIM in education in Kosovo towards the sustainability and performance of buildings throughout the building life cycle [29], while the content analysis approach was used to discuss three educational approaches in Hong Kong to teach BIM [30], the BIM educational program is offered as one of the regular engineering management courses at Prince Bin Sultan University (PSU) in Saudi Arabia [31], and the strategic approach taken at a large interdisciplinary school of civil engineering and construction in the UK was reviewed [32]. And through a process of literature review and textual analysis of the efforts of educators and

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researchers around the world to deliver academic BIM education in advanced engineering courses with visualization components categorized into six conceptual categories a) identifying BIM needs in higher education institutions (TEIs), and (b) identifying BIM skills (c) develop BIM educational frameworks, (d) develop BIM curricula, (e) pilot BIM courses, (f) develop strategies to overcome BIM educational issues [33].

As for strategies for integrating and introducing BIM into the curriculum, BIM principles can be introduced first in a subject, and then between disciplines. The first two years will focus on individual skills for modeling and model analysis, and subsequent years can focus more on teamwork through collaboration (BIM course, Design Studio and construction technology), while the last academic year can deal with actual construction projects in cooperation with companies (remote cooperation) [34], BIM can also be implemented gradually in students' tasks and projects, starting from the first semester and continuing until the end of the semester. In this case, it is recommended that the faculty members offer a BIM course as one of the elective courses in the curriculum in the seventh semester until the end of the semester, and each civil engineering student must choose three elective courses listed by the faculty starting from the seventh semester which gives students a great opportunity to learn about BIM instead of adding credit hours or taking many courses in one semester to learn about BIM in the curriculum[35], An evaluation of the course offered to all civil engineering students in the first semester of a bachelor's degree program at the Faculty of Applied Sciences at the University of Oslo and Akershus in Norway, entitled (Introduction to Construction Professions), confirmed that it can support an understanding of professional content as an initial learning outcome, Revit-based process modeling has increased understanding of design criteria, load distribution, and construction details, as well as information requirements for collaboration within the design team, thus, software competence is a necessary yet dependent skill in higher education and cannot be categorized as a separate task and this would create motivated students and increase overall learning[36], several proposals were made, including presenting studies on topics for a master's thesis in various fields of engineering that focus on identifying information at each step and how to perform interoperability between different stages using the (BIM) model, and for doctoral dissertations, where the student is expected to develop a complete project using BIM software, perform four-dimensional simulations, and detect conflicts between models through interoperability to transfer information between Revit and Navisworks programs, in addition to the importance of external training courses [37].

Frameworks have been proposed for the integration of BIM with the curricula in many studies, and this is consistent with the objectives of our current study, where an evaluation framework was presented to improve interdisciplinary BIM education in highway engineering and was designed based on the (CIPP) model (context - inputs - process -the product), and it was applied in a major interdisciplinary project in China's Chongqing Jiaotong University [38], an educational framework was developed to integrate BIM into the school curricula, and the proposed implementation plan relied on three main methods: independent BIM courses, integrating BIM with existing courses, and integrating BIM with student assignments only [39], given that it is difficult to teach and assess many of the standards required by accreditation organizations such as the Accreditation Board for Engineering and Technology (ABET) or the Canadian Engineering Accreditation Board (CEAB) with closed lectures and questions, a framework is proposed to provide decision makers with guidelines to address the challenges faced by universities in introducing Building Information Modeling (BIM) in engineering education which are summarized in seven main clusters: skills acquisition, teaching approach, assessment methods, technological environment, industry partnerships, implementation approach and timing [40], and this is what our current study was based on.

There were studies with innovative ideas that would develop curricula in higher education in the Engineering and Construction Management (CEM) program to enhance adaptation to the construction industry in the era of BIM, whereby the philosophy of Integrated Implementation of Projects (IPD) was utilized in applying the learning methodology based on the concept of BIM within Construction Project Management Division Considering a Building Information Modeling (BIM) methodology that integrates advanced information and communication technology with stakeholder collaboration as one of the most effective project development and delivery methods currently available in the AEC industry, it presented the IMAC framework through four integrated stages (clarification, processing, application, collaboration), and at any stage BIM was implemented within the framework of IMAC, the focus will be on five specific common areas (knowledge of building technology, understanding of the environment (materials and sustainability), management, information technology, specialization) This framework is directed specifically at the construction management system [41], a major new framework for integrating the Daft 4MF model and Building Information Modeling (BIM) technology

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into project-based teaching is also introduced to improve student competence, the framework included the Daft4FM model for definitions of efficiency expectations, practical presentation and systematic analysis of integrated project management, CEM learning stages for the vertical relationship between the main learning stages and a team-based learning environment with BIM technology for knowledge integration, the novelty of the research lies in the implementation of the Daft 4FM model for knowledge integration in the BIM capstone project, which is a practical and administrative model consisting of (four administrative functions including planning and organizing, leadership and control model) for choosing goals, defining responsibilities and monitoring activities), the framework was a cycle that was divided into the design phase, the tendering phase, the preparation phase for construction, and the hypothetical construction phase [42], a new educational program based on Team-Based Pedagogy (TBL) was presented and it was concluded that the combination of BIM learning modules and TBL pedagogy may stimulate student enthusiasm and enhance individual and group performance to the highest level of efficiency in the implementation of the BIM project, this can contribute to the body of knowledge by providing empirical evidence of the effectiveness of TBL pedagogy in college BIM education and may become a valuable reference as more CEM programs seek to incorporate the expertise of the collaborative, interdisciplinary team into BIM education to grow the BIM workforce and make it more efficient [43].

4. Research Methodology

To achieve the objectives of the research, the survey descriptive approach was used, as this approach is the most suitable for the purposes of this study, where the current reality of building information modeling (BIM) education was measured in the Faculty of Civil Engineering, Tishreen University from the faculty members' point of view, and a general framework was proposed for the integration of information modeling Building (BIM) with the curriculum of the Faculty of Civil Engineering and measuring its applicability from the point of view of faculty members. The quantitative part included the development of two research tools through the design of an electronic questionnaire that was distributed to 32 faculty members at Tishreen University, Faculty of Civil Engineering. The first study tool consisted of a questionnaire measuring the current reality of building information modeling (BIM) education and included two parts: the first section included demographic data on specialization and academic qualification, and the second section consisted of three axes:

the axis of awareness of the BIM importance, the axis of challenges and obstacles that prevent the implementation of (BIM), and the axis of characterizing the reality of (BIM) in the curricula of the Faculty of Civil Engineering, the second study tool consisted of a questionnaire to assess the possibility of applying the proposed framework to introduce the concept of engineering digitization to develop, and it included several dimensions (skills to be acquired - teaching methodology - implementation strategy). As for the qualitative part, the questionnaire included a set of open questions that express the opinions of faculty members, according to their personal experience, about the obstacles that prevent the implementation of BIM, the course that is currently being taught as a BIM course in the current curricula and the number of courses that can be integrated into the curricula in future plan, topics that can be taught in undergraduate curricula to provide BIM knowledge, competencies that must be included in BIM education in undergraduate curricula, and the technological environment necessary for the success of the BIM curriculum.

5. Analysis and discussion

5.1 Questionnaire Responses Analysis and Discussion

Responses to the questionnaire were collected from 32 respondents and analyzed statistically using the Statistical Package for Social Sciences (SPSS) program and their results are presented in Figures 1 to 13 given below along with the discussion respectively.

Demographic data of the respondents

The participants in the questionnaire were distributed according to demographic data according to their specialization and academic qualification, as Figure (1) indicates that 25% of the respondents are majors in construction engineering and management, while 18.75% of the structural engineering and transportation engineering specialists, and 12.5% of the water, irrigation and environmental engineering specialists, participated, while only 6.25% of the geotechnical and topographical engineering specialists participated.

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1- What is your major/department?

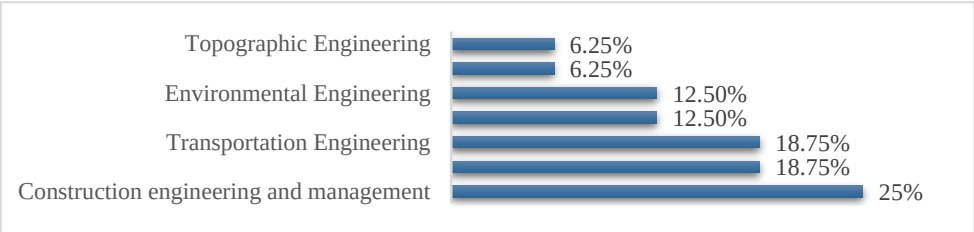

Figure 1: Participants specialization

While Figure (2) indicates that 37.5% of the respondents had an academic qualification (teacher) and 37.5% had an academic qualification (assistant professor), while 25% of the respondents had an academic qualification (professor).

2- What is the academic qualification?

Figure 2: Academic qualification of participants

5.2 Quantitative Analysis

The first axis question: What is the extent of awareness of the importance of Building Information Modeling (BIM)?

Ranked first in this category, the question that represents (Having knowledge of BIM tools will make the graduated engineer more attractive to employers in the labor market) and the question that represents (BIM offers various features that improve the productivity of the construction industry through the integration of technical specifications with costs and time plans and communication with stakeholders at every stage of the project), they got a completely agree rating with an evaluation rate of (89.075%), And in the second place, the question that represents (the integration of BIM in educational curricula allows progress in education and a better understanding of construction management systems) gets a score of "completely agree" with an evaluation rate of (85.95%), while the question that represents (It will be necessary to present BIM in all civil engineering disciplines) ranked sixth, it got an approval rating with an evaluation rate of (78.125%)

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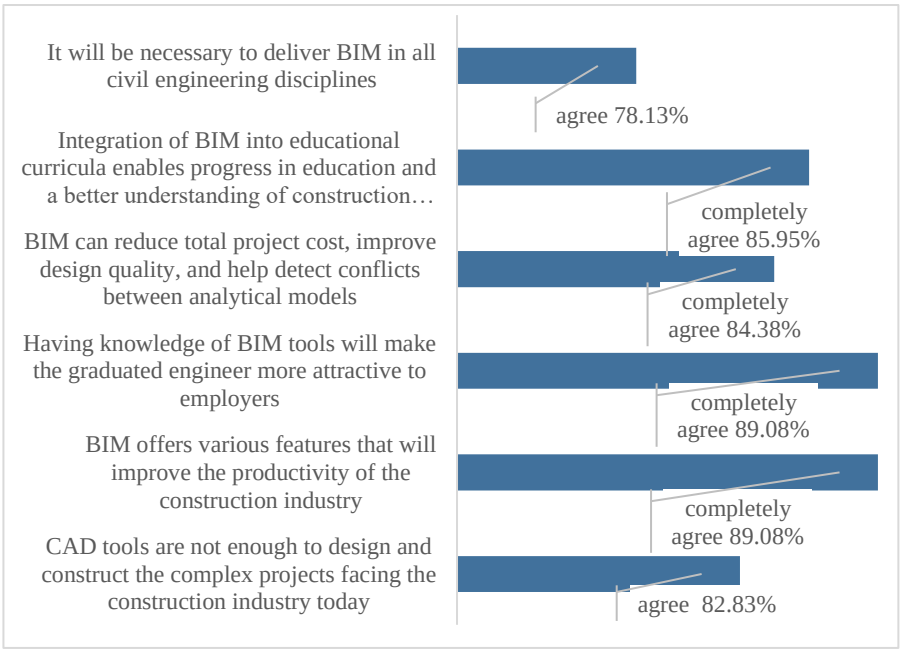

Figure 3: The extent of awareness of the importance of Building Information Modeling (BIM)

The second axis question :What is the assessment of the level of importance of the challenges and obstacles that prevent the implementation of (BIM) in the curricula of university education?

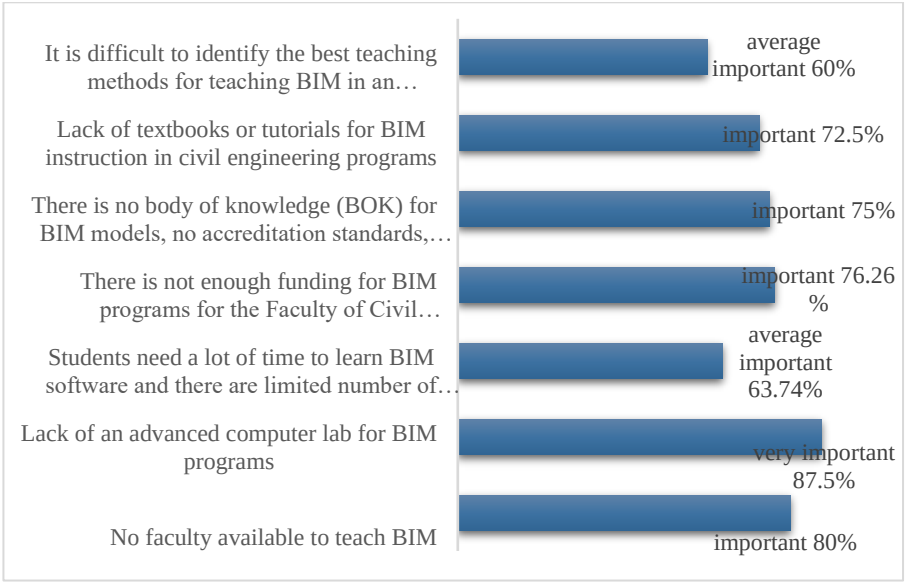

Figure 4: The assessment of the level of importance of the challenges and obstacles that prevent the implementation of (BIM) in the curricula of university education

Ranked first in this category, the question that represents (lack of an advanced computer lab for BIM programs) gets a very important rating with an evaluation rate of (87.5%), and in the second place the question that represents (the absence of an available faculty) gets an important rating with an evaluation rate of (80%), and in the second place The third question, which represents (There is not enough funding for BIM programs for the College of Civil Engineering), gets an important grade and an evaluation rate of (76.26),while the question that represents (it is difficult to determine the best teaching methods for teaching BIM in a multidisciplinary scale) ranked seventh, it got an average degree of importance with an evaluation rate of (60%).

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The third axis question: What is the description of the reality of BIM in the curricula of the Faculty of Civil Engineering, Tishreen University?

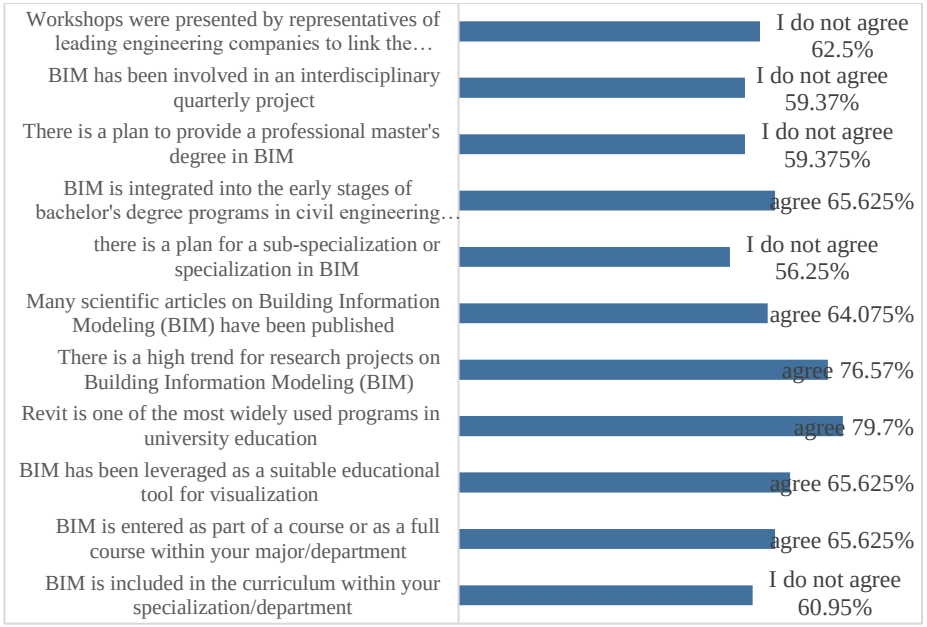

Figure 5: The description of the reality of BIM in the curricula of the Faculty of Civil Engineering, Tishreen University

Ranked first in this category, the question that represents (Revit is one of the most used software in the scope of university education) gets an approval rating with an evaluation rate of (79.7%). and in the second place, the question that represents (there is a great trend for research projects related to building information modeling (BIM)) gets an approval rating with an evaluation rate of (76.575%). and in the third place, the question that represents (BIM has been used as an appropriate educational tool for visualization) gets an approval rating with an evaluation rate of (68.75%). while the question representing (there is a plan for a sub-specialization or specialization in BIM) was ranked eleventh, it got a degree of disagreement with an evaluation rate of (56.25%).

Fourth Axis

A) What is the recommended level of introduction of BIM in undergraduate education curricula?

The results were analyzed and it was found that 68.8% of the faculty members chose the BIM Analyst level, followed by the BIM Manager level at 43.8%, then Levels BIM Software Developer, BIM Consultant, BIM Modeler, BIM Facilitator, BIM Advanced Consultant by 12.5%, then the two levels BIM Application Developer and BIM Researcher by 6.3%.

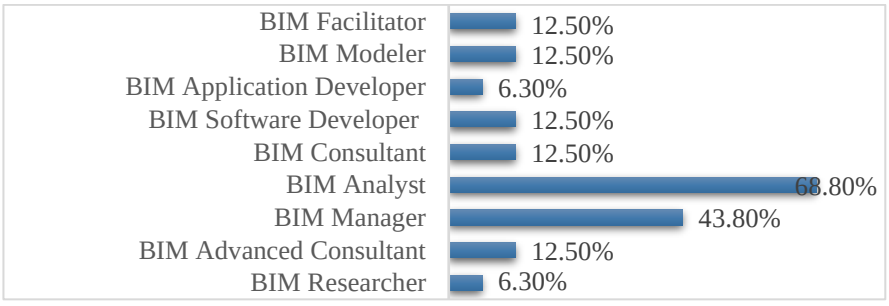

Figure 6: The recommended level of introduction of BIM in undergraduate education curricula

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B) What is the assessment of the level of importance of topics that can be taught in university curricula to provide knowledge of building information modeling (BIM)?

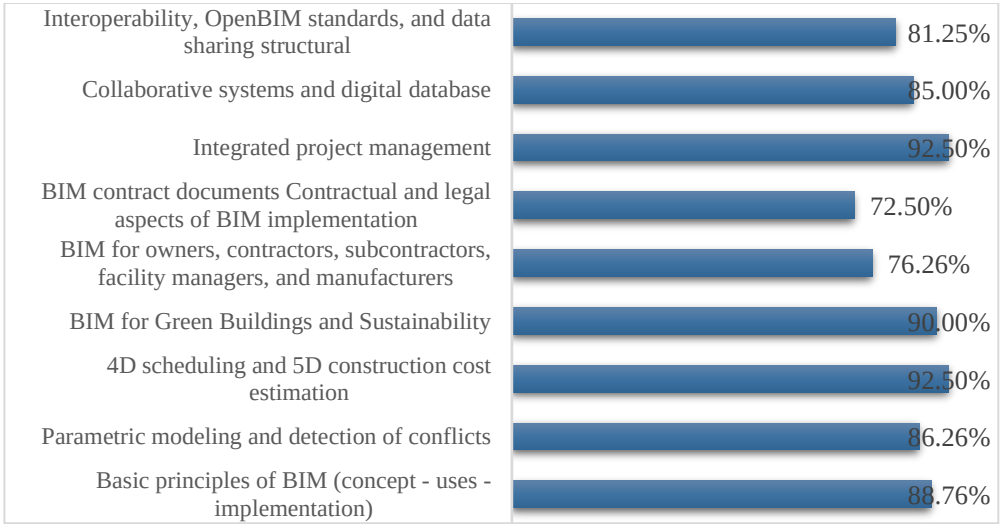

Figure 7: The assessment of the level of importance of topics that can be taught in university curricula to provide knowledge of building information modeling (BIM)

Ranked first in this rating, the question that represents (4D scheduling and 5D construction cost estimation) gets a very important grade with an evaluation rate of (92.5%), and in the second place the question that represents (Integrated Project Management) gets a very important grade with an evaluation rate of (92.5%),), and in the third place the question that represents (BIM for Green Buildings and Sustainability) gets a very important rating "with an evaluation rate of (90%), while in the ninth place the question that represents (contract documents in BIM format, the contractual and legal aspects of BIM implementation) gets a score An important estimate with an evaluation rate of (72.5%).

C) What is the assessment of the level of competencies that BIM teaching should cover in the educational curricula?

Ranked first in this rating, the question that represents (foundational competencies related to personal skills, self-management, thinking methods, and cognitive functions useful for all industries) gets a very important grade (85%), and in the second place the question that represents (technical competencies at the industry level) gets a grade An important estimate with an evaluation rate of (76.26%), and in the third place the question that represents (technical competencies for the industrial sector) gets an important estimate with an evaluation rate of (75%).

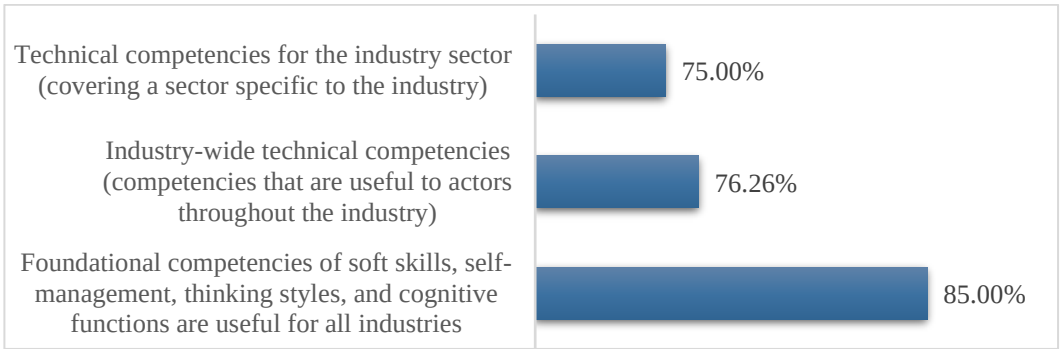

Figure 8: The assessment of the level of competencies that BIM teaching should cover in the educational curricula

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D) What are the most applicable methods of teaching BIM in undergraduate curricula in the Faculty of Civil Engineering?

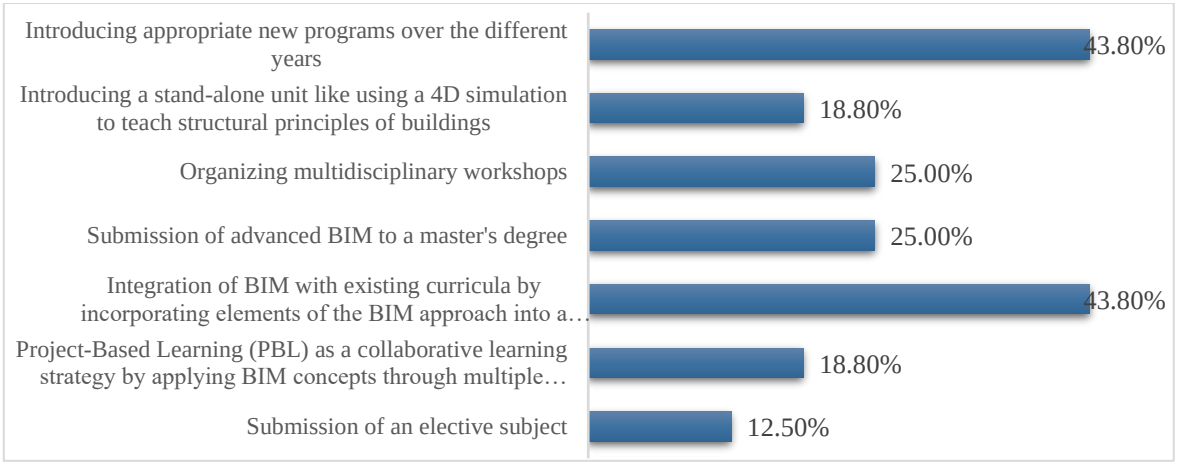

Figure 9: The most applicable methods of teaching BIM in undergraduate curricula in the Faculty of Civil Engineering

It was found that the most applicable teaching methods from the point of view of 43.8% of the faculty members are the two methods, the introduction of elements of the BIM approach in a large percentage of educational units in all curricula, and the introduction of appropriate new programs over the different years, then comes the method of presenting advanced BIM for a master's degree and the method of organizing interdisciplinary workshops with a rate of 25.0% , then, 18.8% of the faculty members chose two methods: project-based learning (PBL) and the introduction of a stand-alone unit such as using 4D simulations to teach the structural principles of buildings,12.5% chose to offer an elective subject.

E) What are the most applicable assessment methods to test the proficiency a student has gained from BIM education in undergraduate curricula?

It was found that the most evaluation methods for proficiency testing from the point of view of 81.3% of the faculty members is the final evaluation in the form of a final project, then a method of modeling exercises and tests in case the goal is to learn BIM technology and the number of students is not high by 43.8%, then, 25.0% of the faculty members chose the method of making oral presentations and preparing written reports, and 12.5% chose to evaluate students' learning against some specific criteria, while 6.3% chose the method of conducting an exam, interview, questionnaire and formative assessment by providing some useful notes in order to improve the teaching and learning processes.

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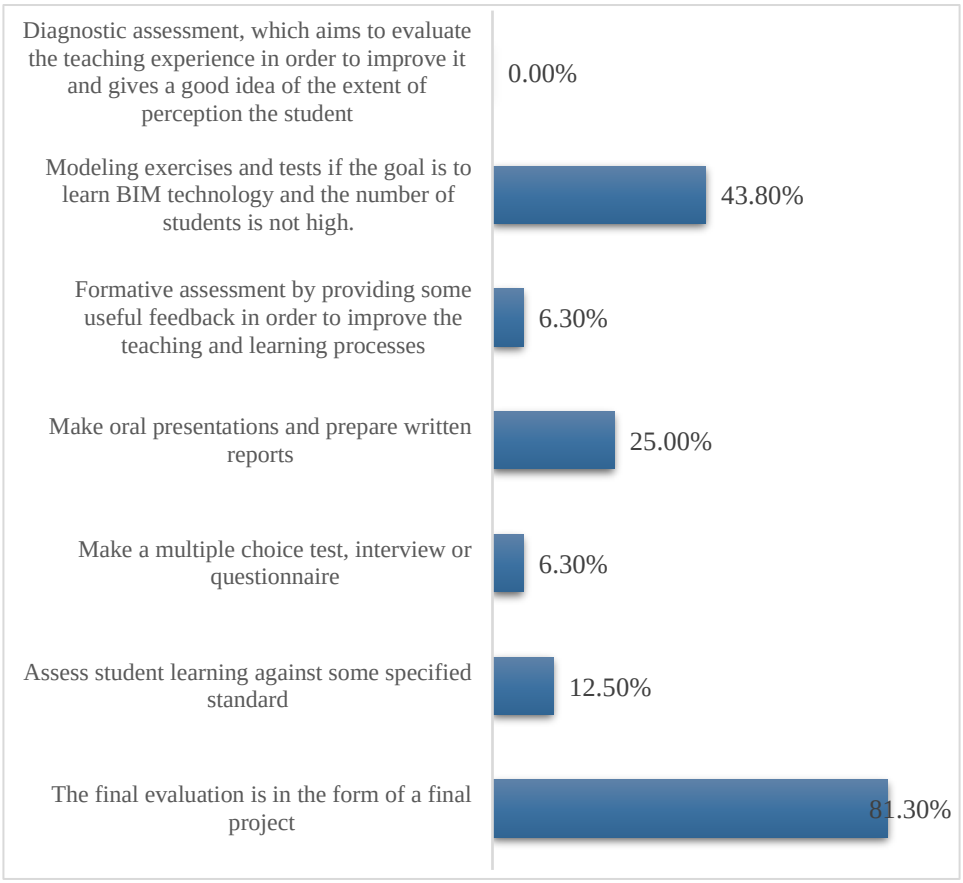

Figure 10: The most applicable assessment methods to test the proficiency a student has gained from BIM education in undergraduate curricula

F) What is the assessment of the level of importance of the technology environment necessary for the success of the BIM approach?

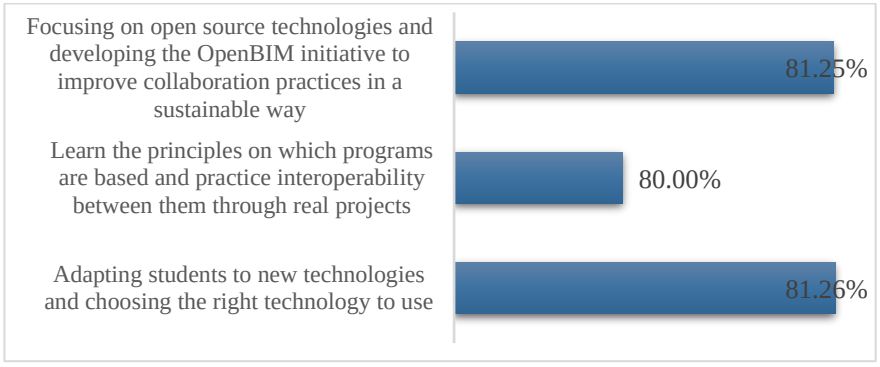

Figure 11: The assessment of the level of importance of the technology environment necessary for the success of the BIM approach

Ranked first in this rating, the question that represents (students' adaptation to new technologies and the selection of the appropriate technology for use) gets an important grade with an evaluation rate of (82.5%), and in the second place the question that represents (learning the principles on which programs are based and practicing interoperability between them through real projects) gets An important rating with an evaluation rate of (81.26%), and in the third place the question that represents (focusing on open source technologies and developing the Open BIM initiative to improve cooperation practices in a sustainable way) gets an important rating with an evaluation rate of (80%).

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G) What is the appropriate strategy for introducing BIM into the current academic curricula?

It is noted that 50% of the faculty members saw that the appropriate curriculum for the introduction of BIM in the academic curricula is a progression strategy based on selecting and introducing appropriate new programs over the different years, while 31.3% chose the standard strategy based on introducing a stand-alone unit, while 18.8% chose the integration strategy by introducing elements of the BIM approach in a large percentage of educational units in the school curricula.

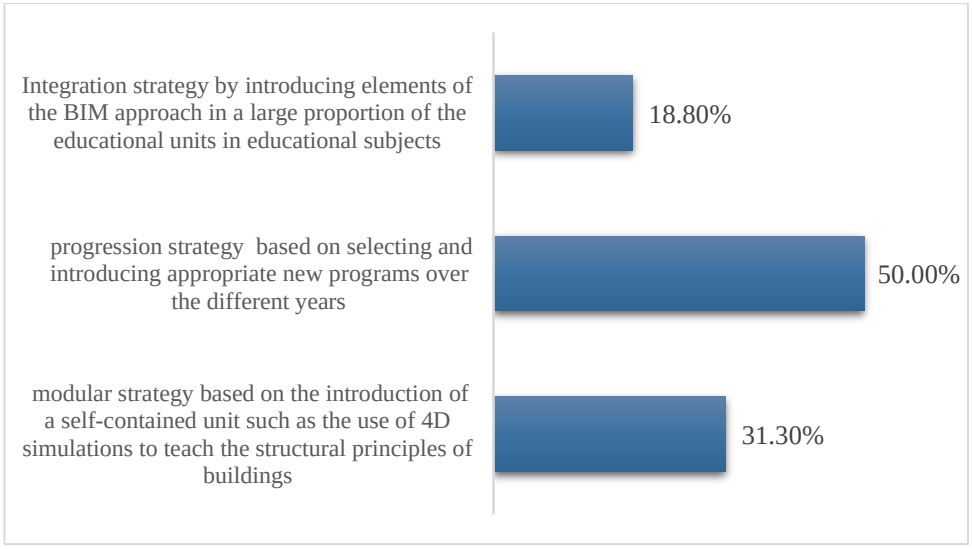

Figure 12: The appropriate strategy for introducing BIM into the current academic curricula

H) In any field can partnerships be between the university and engineering and industrial companies?

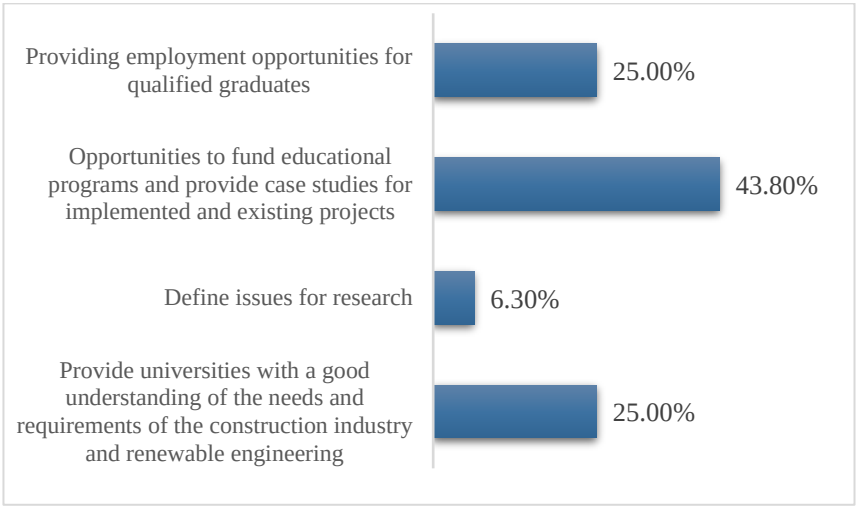

Figure 13: The field of partnerships between the university and engineering and industrial companies

It was found that 43.8% of the faculty members believed that the partnership between the university and engineering and industrial companies could be an opportunity to finance educational programs and provide a case study for implemented and existing projects, and 25.0% of the faculty members believed that the partnership between the university and the engineering and industrial companies can provide universities with a good understanding of the needs and requirements of industry and renewable engineering and can secure job opportunities for qualified graduates, while 18.8% believed that this partnership could help in identifying issues for research.

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5.3 Qualitative analysis

The questionnaire included a set of open-ended questions to conduct a qualitative analysis, which are related to the analysis of data of a personal rather than a numerical nature, as there were six questions, and their answers were analyzed using content analysis. When faculty members were asked about other barriers and challenges to implementing BIM according to their experiences, they suggested the following obstacles; Lack of sufficient motivation for the student and teacher to learn BIM due to the weakness of the labor market and the lack of government accreditation and the existence of mandatory decisions to adopt and apply BIM, the large number of students and the lack of computers covering the number sufficiently, and the lack of a culture of applying the integrated management system for engineering projects from small to large, the reality of electricity and the Internet And the financial situation in general, and especially the high cost of laptops. Wrong administrative decisions related to study plans and failure to link students to the needs of the labor market.

When faculty members were asked which course is currently being taught as a BIM course in the academic curriculum, based on their answers, the Computer Aided Design course in the Department of Construction Engineering and Management and Advanced Technologies in the Department of Transportation was chosen, as for the rest of the departments, there is no BIM course at the moment.

Then the faculty members were asked in their curricula about the number of courses that could be integrated into the curricula in the future plan. The answers ranged between (4-10) decisions. For the management department, BIM can be integrated into project management, building technology, and building construction courses.

Faculty members were asked about other topics that could be taught in undergraduate curricula to provide knowledge of Building Information Modeling (BIM). They proposed topics related to facilities management, BIM and SCADA integration in infrastructure projects (water, sewerage, electricity and communications). In addition, faculty members were asked about other competencies that BIM education should include in undergraduate curricula. Based on their answers, cooperation competencies, pre-industrial utilization management competency, engineering imagination, educational competencies for qualifying educational and training personnel, and intermediate technical competencies were proposed. Finally, faculty members were asked about other suggestions for the technological environment needed for the success of the BIM curriculum. They proposed to participate in integrated real projects, with a focus on introducing process automation concepts into the BIM system, such as (CGA, rules-based modeling...).

5.4 Discussion

The results showed that the degree of appreciation of the faculty members at Tishreen University, Faculty of Civil Engineering, about the extent of awareness of the importance of Building Information Modeling (BIM), came with a degree of complete agreement, with an arithmetic mean of (3.406) and a standard deviation of (0.486). This indicates that faculty members in various disciplines are aware of the culture of building information modeling and its importance to improve the productivity of the construction industry, whose requirements have become more complex in terms of designing and constructing non-standard projects, and to make progress in education, which will make graduates more attractive to employers in the labor market. This would make the introduction of Building Information Modeling (BIM) an urgent necessity in all civil engineering disciplines.

The results indicated that the degree of appreciation of the faculty members on the question related to the challenges and obstacles that prevent the implementation of BIM came with a “important” degree, with an arithmetic mean of 3.678 and a standard deviation of (0.767). This indicates the consensus of faculty members on the existence of many obstacles facing the implementation of BIM at Tishreen University, Faculty of Civil Engineering, which was represented in the lack of an advanced computer laboratory, the absence of an available faculty, and there is insufficient funding for BIM programs for the Faculty of Civil Engineering, in addition, there is no body of knowledge (BOK), no accreditation standards, and no BIM requirements have been specified. This result may be due to the absence of sufficient motivation for the student and the teacher to learn BIM due to the weakness of the labor market, the lack of government adoption, the absence of mandatory decisions to adopt and apply BIM, in addition to the living constraints of electricity, the Internet, and the expensive computers that do not adequately cover the large number of students, as well as the lack of Make administrative decisions

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that will develop and improve educational programs in line with developments in the engineering, construction and construction (AEC) industry.

The results indicated that the degree of evaluation by the faculty members in the question related to the description of the reality of BIM in the curricula of the College of Civil Engineering came with an "important" degree, with an arithmetic mean of 2.613 and a standard deviation of (0.702). This indicates the agreement of the faculty members regarding the description of the reality of BIM education, as the Departments of Construction Engineering and Management and Transportation began teaching two courses, Computer Aided Design and Advanced Technologies as BIM courses in the curricula, and it was used as an appropriate educational tool for visualization through the Revit program which is considered the most widely used software in the scope of education, in addition to the possibility of integrating BIM into the courses of project management, construction technology and building construction in the Department of Construction Engineering and Management, and there is a great tendency to prepare research projects for building information modeling, in addition to publishing many scientific articles. However, these steps are considered shy, slow, and limited to the departments of engineering, construction management, and transportation, to the exclusion of other departments, despite the emphasis of faculty members on the necessity of BIM integration in the early stages of undergraduate programs and at the master's level. This result may be due to the lack of administrative plans regarding the introduction of BIM in a professional manner or its inclusion in a sub-specialty, in addition to the absence of a link between the university and engineering companies to link the requirements of the construction industry with the objectives of developing the educational program for BIM.

As for the fourth axis, which stipulated: The proposed general framework for integrating BIM with academic curricula from the point of view of faculty members, the recommended level for introducing BIM into university curricula was the BIM Analyst and BIM Manager, and the most important topics that can be taught in university curricula to provide knowledge in Building Information Modeling (BIM) are 4D scheduling and 5D construction cost estimation, integrated project management, BIM for green buildings and sustainability, basic principles of BIM (concept-use-implement), parametric modeling, conflict detection, collaborative systems, digital database, facility management and integration BIM and SCADA in infrastructure projects (water, sewerage, electricity and communications). As for the most important competencies that BIM should cover in university curricula, they were the foundational competencies of personal skills, stimulating engineering imagination, self-management, thinking methods, and cognitive functions useful for all industries, cooperation, intermediate technical competencies, and pre-industrial utilization management competency.

While the faculty members consider that the most applicable teaching method in the undergraduate education curricula in the College of Civil Engineering is the method of integrating BIM with the current curricula by introducing elements of the BIM approach in a large percentage of the educational units in all curricula in addition to the introduction of appropriate new programs over the different years, The faculty members encouraged the idea of offering advanced BIM for master's degrees and interdisciplinary collaboration by organizing interdisciplinary workshops, The most applicable evaluation method to test the student's proficiency in BIM education in university curricula was the final evaluation in the form of a final project, exercises and modeling tests if the goal is to learn BIM technology and the number of students is not high. With regard to the technological environment necessary for the success of the BIM curriculum, the faculty members unanimously agree that this environment includes the adaptation of students to new technologies and a focus on introducing process automation concepts into the BIM system such as (CGA, rule-based modeling) and testing the appropriate technology for use by learning the principles on which the programs are based, as well as participating in real projects and practicing interoperability between them by focusing on open source technologies and developing the BIM Open Initiative to improve collaboration practices in a sustainable way.

While the faculty members are unanimously agreed that the appropriate strategy for the introduction of BIM in the academic curricula is the progression strategy based on selecting and presenting appropriate new programs over the different years. They unanimously agreed on the importance of partnerships between the university and engineering and industrial companies by providing opportunities for financing educational programs and providing case studies for implemented and existing projects, in addition to providing universities with a good understanding of the needs and

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requirements of industry and construction, which makes the graduated engineers sufficiently qualified to face the challenges of the labor market and understand its renewable requirements.

The results indicated that there were no statistically significant differences between the average estimates of the respondents on all axes (challenges and obstacles that prevent the application of BIM, describing the reality of building information modeling, the proposed general framework) according to the variables (specialization, academic qualification). This result is due to the agreement of all members of the study sample in civil engineering disciplines, as well as their agreement in all academic qualifications about the reality of building information modeling and the proposed general framework. Except for the axis (the extent of awareness of the importance of building information modeling), where the results showed that there were statistically significant differences according to the academic qualification variable, and this result is attributed to the fact that the difference in academic experience showed differences in realizing the importance of building information modeling.

6. Conclusions and recommendations

This study showed a positive awareness of the concept of building information modeling among the various disciplines of civil engineering, which opens the way in the near future for making decisions that will develop educational programs in line with modern concepts, although there are many challenges facing the implementation of BIM, and it has been reached Formulate a general framework for integrating BIM with existing curricula that includes skills to be acquired, teaching approach, and implementation strategy. The outputs of this study can be used as a basis for improving education programs using a new methodology that gives the student the required basic skills and competencies and prepares him to deal with modern technologies. It qualifies him to work within the engineering digitization system required in the engineering labor market locally and regionally, and it is recommended to enhance awareness of BIM culture and its applications by providing specialized training courses for academics in the use of modern technical tools based on BIM as an effective educational tool that can be integrated into educational curricula while not underestimating the importance of the value of methods To provide students with a mixture of skills and knowledge that will enable them to face the challenges and developments of the construction industry in the future and to support the teaching staff and provide them with cadres specialized in teaching BIM. Also, the need to pay attention to holding workshops with industrial and engineering companies and lectures with specialists to connect students with the needs of the labor market and issues related to the construction industry, and thus increase students' motivation to learn the BIM method, in addition to the need to pay attention to developing computer laboratories and equipping them with the appropriate number of devices, providing Internet networks for remote cooperation with leading universities and benefiting from their expertise, which will develop research projects related to building information modeling. It is also necessary to work on finding an accreditation body that sets appropriate standards for the BIM education program in line with the objectives of the educational programs while identifying special requirements.

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