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The Notion of "Building Information Modeling" and its Role in the Jordanian Architecture Practice and Education: The Case of The University of Jordan

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Abstract
The aim of this study is to discuss the reasons behind introducing Building Information Modeling into the Architecture domain, an in-depth investigation of its application effects on the design process in architecture pedagogy in Jordanian Architecture schools is carried out. Technology is the new spine of modern societies; architecture discipline is an interconnected sector in which computer programs have boosted, through multi-functioning capabilities. BIM (Building Information Modeling) is the new movement toward linking the Architectural Engineering and Construction (AEC) industry. Its effects on changing the conventional design process, presentation, and communication have altered the architecture profession in addition to education. Many Architecture schools adopted BIM in their curriculum, and many did not, therefore, the evaluation standards for student's work creativity have changed drastically. The research methodology consists of analyzing the fifth-year architecture student's work (at the Architecture Department/University of Jordan) in reference to their followed design process. The outcomes varied according to the followed design process (manual/Cad/BIM) revealing a pattern in the results. The students' work was evaluated by several accredited architects in addition to architecture educators from the university itself. The findings were also a huge indicator of the students' preference for using BIM in their designs. However, the students who adopted the manual method managed to achieve better.

Keywords: Architecture education, BIM, CAD, creativity, design process

INTRODUCTION

As known, it is the technology Era time; smartphones, computers, tablets, and many other home appliances are now in hand reach. Jordan is a small Middle Eastern country, it is going through this technological transformation very gradually, and the government has set a plan for making Jordan a county-run by collaborative electronic transactions in all the governmental departments by 2020 as well as for the Engineering sector. Many Engineering corporations and offices in the private sector started adopting BIM in

their offices for what it hosts of advantages from increased efficiency, accuracy, promptness, coordination, consistency, energy analysis, project cost reduction, and harmonization between engineers, contractors, and other built environment professionals. BIM has affected the design process greatly enforcing a collaborative and interdisciplinary way of working; it ensures that all parties involved record all modifications to the design and modeling process (Guney, 2015). As for the Architecture education in Jordan BIM started to find its way in the Jordanian Universities curricula for market-driven reasons, as BIM must be mastered entirely to have any hope of breaking into industry after graduation, tension arises when students concentrate on using BIM in their work thinking of it as the only mean to achieve creative designs (Kiviniemi, 2013). Although not all schools have adopted the BIM approach due to many reasons; misunderstanding of the BIM process was frequently the main one. Therefore, there is yet no guidance or a roadmap for architectural schools/institutions as to how they could adapt to the approaching challenges in the industry and educate the future architects accordingly (Kocaturk and Kiviniemi, 2013).

The structure of this study starts with the definition of BIM concerning its CAD derived nature. It analyses the BIM role in the engineering market and relation to different stakeholders. It Investigates the BIM introduction methods to Architecture schools in Jordan. Several related papers were reviewed to establish a proper methodology that examines BIM vs manual (as the traditional mean) approach impact on 5th-year architecture student work in terms of the achieved Academic excellence. It finally concludes by proposing the best practice model for integrating BIM in architecture pedagogy in Jordan.

The experimental study was conducted using the results of a structured Analysis for the 5th-year architecture student's work (Graduation projects) from the University of Jordan. The analysis relied on using the measuring criteria which are approved by the University of Jordan to assess the precept stage (A stage in design where the ideas and the concept evolve to be more mature) as the first milestone and the result as a second milestone.

BIM definitions: A very comprehensive approach was brought up by Chuck Eastman in 1976 when he suggested finding a new formula through which all engineering practice sectors would be included. Furthermore, any update would be inclusive for all future drawings on sections, plans, elevations, isometrics, etc., in addition to cost estimations and material quantities to be generated easily (Eastman, 1976).

The Concept of BIM has emerged from CAD, many obstacles have confronted the evolution process of the engineering practice and the interconnected and branched design process made the need for the change inevitable.

BIM was defined by several authors, scholars, and researchers; some define it as a process or a technology through which data is generated and managed (Smith, 2014; Davidson, 2009). Bormann defined BIM as a process in which digital building models are created and maintained through the whole lifespan of a building (Borrmann *et al*., 2018).

Others relate BIM to intelligence and define it as an Intelligent simulation of Architecture (Sacks *et al*., 2020).

BIM is also defined by Zuppa as a tool that assists the production and development of virtually intelligent models and is of great benefit to all stakeholders throughout the facility lifecycle (Zuppa *et al*., 2009).

Eastman in 2008 had a very comprehensive point of view, he clarified that BIM consists of many helpful tools through which building models are produced and not only technology or product (Eastman *et al*., 2008). Eastman's view is seen to be true when concentrating on the fact that there are data input and a final product used for construction, on the other hand, intelligence is also seen by Mandhar as a significant element that describes BIM (Mandhar and Mandhar, 2013).

BIM role in the Jordanian engineering market and the different confronted challenges: With the complexity of modern buildings and the scale of projects in Jordan, the difficulties of processing and executing the construction documents using two-dimensional CAD drawings from the private sector (offices, corporates, etc.) to the governmental departments made the private sector take the initiative to change.

BIM software programs provide major advantages in managing information, in addition to the ability to easily generate realistic three-dimensional views and even walkthroughs. The fusion of BIM with energy analysis programs provides crucial information and offers guidance for decision-makers on building materials and mechanical systems (Xu *et al*., 2019). Using BIM is also of great benefit for stakeholders and other parties; it reduces the conflict between all the involved members throughout the design process as the data becomes easily accessible to everyone.

BIM plays a fundamental role through revealing clashes, gaining client confidence, and post-completion operations as well as preventive maintenance.

Nevertheless, BIM brings countless benefits to the AEC industry and facilities management sector in Jordan, but the real issue that still residues, whether to adopt it completely in the profession's all sectors or not, more importantly, what are the ways to overcome any obstacles in its prevalent and efficient execution in both practices and across Schools of Architecture in Jordan?

In 2017, a survey was conducted by Rana Matarneh and Sadeq Hamed targeting the Key challenges that face BIM adoption and application process in AEC industry since only 5% of AEC companies and organizations are using BIM in Jordan. Matarneh and Hamed listed several challenges that face BIM implementation in the Jordanian market; one of the most important reasons is the absence of support from policymakers in the construction field in addition to the lack of any incentives from the government. Besides, researchers discussed how people still lack the awareness of BIM benefits. Another challenge that they pointed out is that clients do not have enough demand for BIM due to the previous point in resistance of change (Matarneh and Hamed, 2017).

BIM movement is still new to the Jordanian market; such essential changes are usually faced with many challenges and refusal from the people involved, this leads to the fact that actions need to be taken by the Jordanian government to take the advantage of BIM properly.

BIM in Jordanian architecture schools: The introduction of BIM in Jordan was through CAAD in the 1990s, the program was adopted by several design firms and construction companies. In 1994, CAAD software was added as an introductory course for undergraduates in a few architecture schools due to the lack of qualified instructors. A few years later, the course became compulsory and was taught during 2 semesters for second-year students (Abu Ghanimeh *et al*., 2006).

There is a clear gap between theoretical and design courses in schools of architecture in Jordan, for this reason, since 2014 several schools have been introducing courses related to Revit and BIM in their curricula for 3rd, 4th, and 5th-year students since 1st and 2nd-year students need to learn and understand the importance of manual drawings, sketches and building physical models (Matarneh and Hamed, 2017).

As a result, for the absence of BIM education in universities some students resort to self-learning or enrolling themselves in BIM-REVIT- paid courses given in training centers. Due to the difficulties and the expenses associated with architectural education, computers and complicated BIM software usage need in architectural education has increased dramatically. Using this software, an architecture student can perform his/her project design spending less energy, less time, and can create more realistic designs (Guney, 2015).

However, various methods can aid the process of introducing BIM in the architecture curricula but unfortunately, there is no clear approach to creating an adoption plan through which successful content delivery is achieved. Nevertheless, it's highly advisable to integrate the use of BIM in theoretical and design courses for architecture university students in Jordan to overcome the idea of using BIM only as a drafting tool.

METHODOLOGY

The purpose of this research is to identify the BIM notion and its role in both the Architectural practice and education in Jordan, to achieve this objective, the research started with an intensive literature review for the definition of BIM worldwide at first, and then an analysis of the BIM and its relation to the engineering work environment in Jordan was carried out. As for BIM effects on the educational aspect, a quantitative study was conducted first, using collected data for fifth-year architecture students' work from the University of Jordan to determine their design method preferences (computerized or manual). Afterward, a quantitative evaluation of the chosen design method was done on the precept design stage for what it holds of importance as a transitional phase to a more structured and mature design thinking. Furthermore, the results were analyzed concerning the chosen design method to assess the impact of the used method on the overall score. Data was collected for 65 students that have completed all the requirements to be evaluated according to the formal assessing standards for the architectural projects at the University of Jordan. The evaluation relied on specific indexes used by jurors to give grades to students in the precept design stage.

Those architectural evaluation indexes were established by the University of Jordan based on international recommendations concerning the evaluation of architecture projects. Five criteria were used to evaluate the student's ability to demonstrate their understanding of the aspects of the architectural process. Index 1 (design narrative) represents the

Table 1: Indexes used by jurors to grade students in the precept design stage

Grade	Poor (0)	Fair (1)	V. good (2)
Design narrative			
Wholeness and fundamental ideas			
Design precept, research and, theory			
Originality and challenges of the design concept			
Concept interpretation			
Functional zoning and organization			
Program understanding and structuring			
Basic functional relationship and zoning			
Architecture, language and style, form			
Composition, massing, and volumes			
Movement and experience			
Form and special qualities			
Identity and character			
Relationship and context (urbanity)			
Understanding of the site and the context			
Coherence and type of relation to the surrounding			
Entrance and accessibility			
Site and zoning			
Graphics and visual presentation			
Total 15/15			

concept stage of the project. Index 2 (Functional zoning and organization) demonstrates the special understanding and function relations comprehension. Index 3 (Architecture, language, and style, form) is related to the chosen matter in translating the concept description into physical masses, Index 4 (Relationship and context (urbanity)), index 5 (Graphics and visual presentation) are self-explanatory.

RESULTS AND DISCUSSION

Students' preference results: The collected data revealed a huge incline into using BIM (Revit) among students in all design stages (including the preliminary design stage). Furthermore, the number of students that relied on BIM (Revit) was 38 students (59%) out of the 65 while CAD users were 19 (29%) and the remaining 8 (12%) adapted the manual method (Fig. 1). The huge difference between the users of those methods can be a massive pointer to the student's preferences in their last year in Architecture school. Moreover, the high percentage of Revit users indicates the wide acceptance of this design thinking manner among students who are a few steps away from breaking into the labor market. However, the small percentage of manual users marks a huge, alarming problem that reveals the abandonment of such a fundamental method mainly in the early design stages.

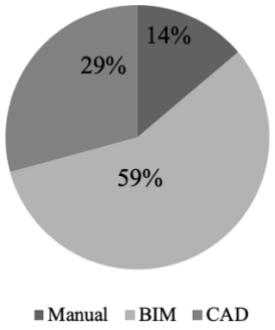

Fig. 1: Design methods used in the precept design stage

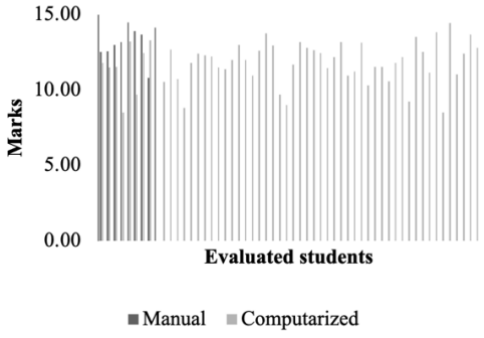

Fig. 2: Students' marks in the precept design stage

Assessment of precept design results: The students' assessment in the precept design stage was carried out by external Jurors (very well-known architecture practitioners in Jordan) in addition to the design instructors at the University of Jordan. Students' results in this design stage varied generally according to the used design manner, the average for all students was (12.58) out of 15 (Table 1). However, the results showed a noticeable difference between the results of

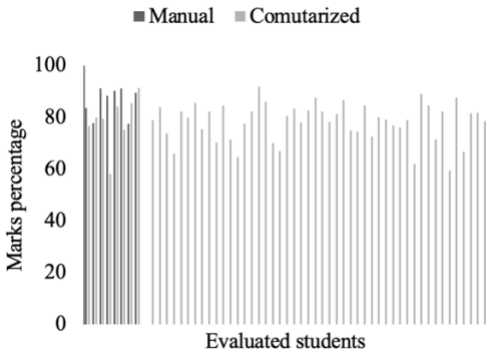

Fig. 3: Graduation projects results

students who adopted the manual method and those who adopted the computerized method (BIM/CAD) (Fig. 2).

The average for the computerized users' results is 11.59 while the manual users' results average is 13.15. This finding was supported by the fact that students who depended on using the manual method in this early design stage (precept stage) achieved better in most of the assessment categories. The adaptation of the manual method gave students more space and a window for creativity to come up with a more solid start for the other design stages.

Results: Furthermore, to dig deeper into the matter of the chosen design method and its effect on the student's scores, the results for architecture graduation projects at the University of Jordan were taken into consideration as an additional milestone in this study. As the results of graduation projects is an accumulating process; the result is the sum of the scores of the different evaluated design stages that are approved and agreed upon by the Architecture department at the university. The results of the same 65 students were analyzed to measure the overall effect of the chosen design technique (computerized/manual).

To cite the collected data (Fig. 3), the middle average for all students was 78.4% (the middle average for the computerized users' results is 76.9% while the manual users' results average is 86.17%).

The students' results indicate a significant difference as well, between the two student categories. The used design manner managed to reveal the gaps and holes in the design process and justify them; meaning the students who adopted the computerized method in the whole design process and never relied even on hand sketching missed crucial steps in the development process of their work.

The students' scores in the precept stage and the final mark signify a great alarming pattern with the outcomes of the design process. Although, Academic excellence was in favor of the manual users, who nearly achieved better in most of the evaluation categories especially the ones related to critical thinking such as (Concept finding phase, zoning, and special organization). At the other categories that are related to more mature three-dimensional (Form morphology) skills, for instance, a significant weakness was spotted. All in all, the two categories (computerized and manual) students' marks managed to demonstrate remarkable advantages and disadvantages of using each design method.

CONCLUSION

The study was conducted on a random sample of 65 students in their 5th year in Architecture school from the University of Jordan. The results of their work analysis showed that adapting one way (either Manual or Computerized (BIM)) in the different and varied design stages is limiting and impractical for many reasons, the weak adaptation for the BIM concept was obvious from the students' marks in most of the design stages; The lack of explicit guidelines to embrace such rich technology in the early design phases was the reason in this case. Despite the great achievement of the manual users especially in the precept stage, Students' over-dependence on the manual method during all design stages is also somehow problematic.

However, various methods can assess the process of BIM teaching in Jordanian Universities, a well-structured adoption plan should be followed to give students the ability to use BIM or other computer-aided programs in an approved manner to achieve successful content delivery.

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