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Investigating the impact of teaching Building Information Modelling (BIM) in the early levels of Architectural Education

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ABSTRACT

Implementing Building Information Modelling BIM application with architectural education is one of the most challengeable cases facing colleges. Although, several schools have taught BIM as technology via CAD courses only, none of these cases were committed to implement though out courses. The aim of this paper is to investigate the benefit of teaching this technology in early stage and implementing it in projects then committing the implementation for the rest of the design studio. This was a three-year case study in the Architecture department in Al-Baha University. The paper reveals that creativity and productivity of the architecture students were positively affected by this implementation.

1. Introduction:

Nowadays, Building Information Modelling BIM has become one of the requirements for construction projects. Several governments such as United State of America, United Kingdom, Australia and United Arab Emirates have made it mandatory for their public projects [1-3]. It has been stated that BIM is one of the most promising developments in AEC industry [4].

However, there are some concerns in teaching BIM within architectural schools such as negative impact on imagination, no room for extra subject and lack of practice limited application period [5-9].

This article discovers the journey in teaching BIM based technology from early year of architectural education. In Al-Baha University, the architecture program starts in the third year, and the first two years are foundation level. This article concludes the effectiveness of BIM based technology on architecture students who were been taught Revit Software from year one and been supervised until their capstone projects.

2. Background

The future of building industry and the high demand on reducing cost and improving the efficiently for the facility management [10-12]. These benefits have driven governments around the world to make the implementation of BIM mandatory for all public projects; governments such as UK, USA, and UAE [13-16].

One of the main concerns facing BIM based technology to be taught in architecture school is that some of faculties assume that teaching this may have a negative impact on students creativity [17]. On the other hand, Morton (2012), said teachers failed to see the capability of BIM tools [18]. Also, students cannot see beyond the 3D model and expose other benefits of implementing BIM [19].

Hence, this research was designed to embed BIM based technology within architectural subjects. The first part of this research was to teach Revit Architecture software as BIM technology application though a computer subject, then implement it in a Design Studio and quantity surveying classes. This part was a three-year plan. The second plan will be a future research which will embed other BIM application within project management and sustainability subjects.

In Saudi Arabia, architectural education are taught in three different colleges; School of Built Environment, Architecture and Urban Design, and College of Engineering [20]. Some of the architectural

educations have been internationally accredited by professional bodies such as ABET and NAAB. The rest of the schools are planning to be internationally accredited. Although, most of these programs are taught in five years, there is a slight difference between them in how these years have been divided, some of them have two-years foundation and other have one-year foundation [20].

There is a high demand on qualified Saudi architects and engineers from building industry in Saudi Arabia [21, 22]. According to Eng. Nasser Abdul-Latif, the director of public relations at the Saudi Council of Engineers (2013), there are 175 thousand of architects and engineers working in building industry within Saudi Arabia; 11,500 of them were Saudis [20, 22] (figure 1).

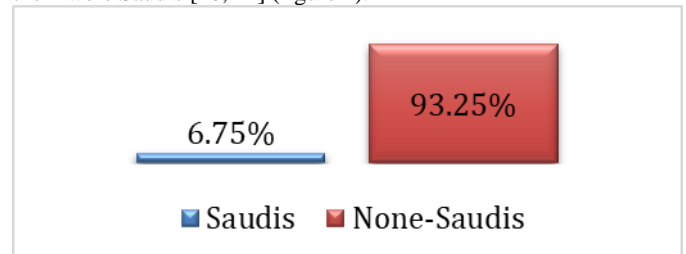


Figure 1: Engineers and Architects within KSA “developed by author”

Although, the, engineers and constructors in Saudi Arabia is increasing, the number of Saudi Architects and Engineers is very low comparing to the number of non-Saudis.

Besides that, several companies would not hire fresh graduate students because of their skills in computer and lack of experience, communication, understanding collaborative teamwork [23, 24]. Sadly, it has been stated that Architecture, Engineering and construction AEC Programs in Saudis' Universities are unsuitable for building industry in Saudi Arabia [24].

The University of Al-Baha is one of the Saudi Universities which undertaking development of their Programs periodically. The Architecture education in Al-Baha University has been developed four times during the last 10 years. The last change on the Program was to divide the five years Program into two years foundation and three years major in Architecture. In general, the embed of BIM with Architecture education in Al-Baha University had not mentioned during those developments at all.

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For the last few years, students were taught few CAD applications in order to be used to deliver their projects. They have been taught two levels of computer; AutoCAD and Graphic design via introducing Photoshop, then the second level aims to teach them 3Ds Max. However, most of them use CAD on the last level of their academic Program, and few of them present their skills in presenting their works using 3Ds max.

In this paper, Revit as BIM based technology was introduced to students via Computer Aided Design CAD and in other classes such as design studio. In term of CAD course, there are two CAD courses are taught to students. The first course starts in the first semester of the third academic year and the second starts in the second semester in the same year.

For Design Studio, students have the choice to decide the best tools to be used for doing their architecture presentation. The majority of the students are using AutoCAD to deliver their projects; and the rest of them prefer manual tools. Although, Photoshop and 3Ds Max were taught within the curriculum, the use of these two applications is almost rare among students.

3. Methods:

The method of this research is divided into two stages; 1) understand the students' current skills in architectural applications; 2) Teaching basic skills that helps students to utilize the application and build their projects, then implementing that on their projects during Design Studio.

First, there were two classrooms; each classroom has 14 students. Both were taught Revit. The Geographic Information questions was contained three questions. The first question was to clarify if students have taken this course before. In the last ten years, The Architecture department in The Al-Baha University taught AutoCAD software in this course.

Current Situation Skills

To understand students' skills and expectations, students were given a questionnaire to evaluate their level of skills in regards to the use BIM based technology and their general skills in term of Architecture. A printed copy was handed to students to feel it up. The questionnaire was divided into three groups of questions; geographic information, technical tools and evaluation questions.

4. Educational Level

The aim of this question is to make such of the level of knowledge in using Computer Aided Design/Draft. Students were asked a direct question if they have studied the Computer Aided Design class before. The question has got 28 responds. The figure 2 shows that 28.57% (n=8) of the total responds have studied this course, and it was AutoCAD. The 71.43% (n=20) have not studied before.

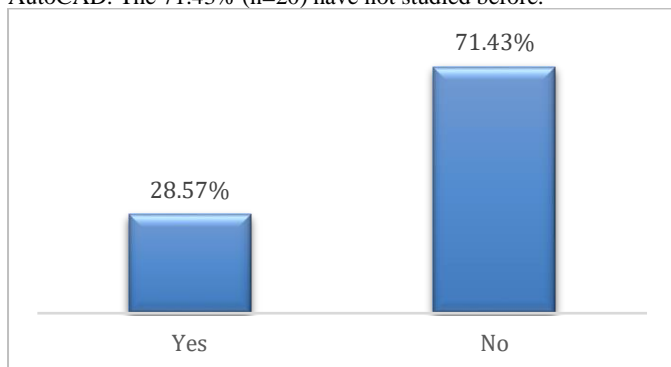


Figure 2: Have you studied this course before?

Second question aimed to see in which Design Studio they are taking now. In The Architecture Department, they are six design studios and the seven is a graduate level. It has been found that most of the students in Design Studio 4 with 60.72% (N=17) of participants. Moreover, Figure 3 shows that 39.28% (n=11) of the students in Design Studio 3.

In The Architecture Department, both studios (Design Studio 3 and 4) are taught in the same academic year, and this is a temporary situation. As The Architecture Department had developed a new curriculum and they are running the two curriculums parallel. Finally, 7.14% (N=2) of participant students were in the final year and they were in Design Studio 6.

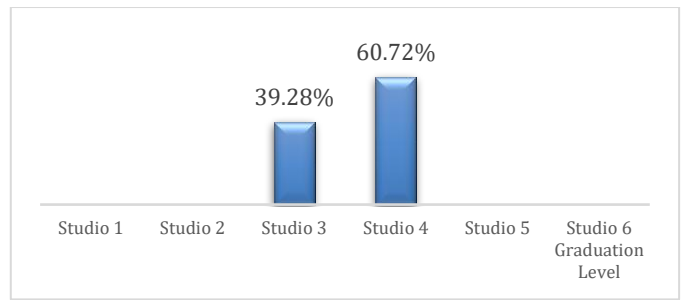


Figure 3: Which Design Studio are you taking now?

The third question shows in which academic year students were. Figure 4 shows that most of the students were from year three with 64.29% (n=18), and the rest from year four with 35.71% (n=10).

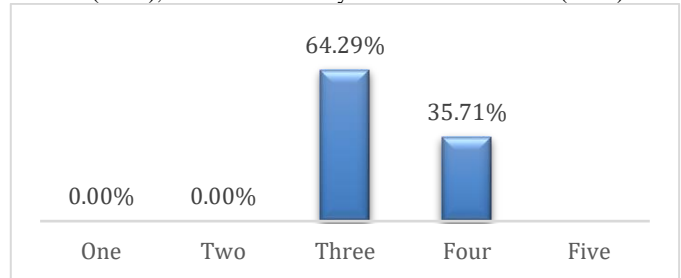


Figure 4: Students academic levels

Technical tools used to present their works:

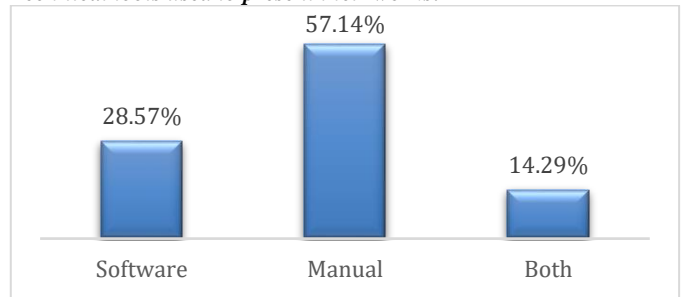


Figure 5: Technic used to deliver projects

This part of the questionnaire was aiming to understand how students present their projects during design studio. Figure 5 reveals that 57.14% (n=16) of the students were using manual tools. Figure 6 shows an example of the quality of the presentation for a project done on the third Design Studio for one of the students.

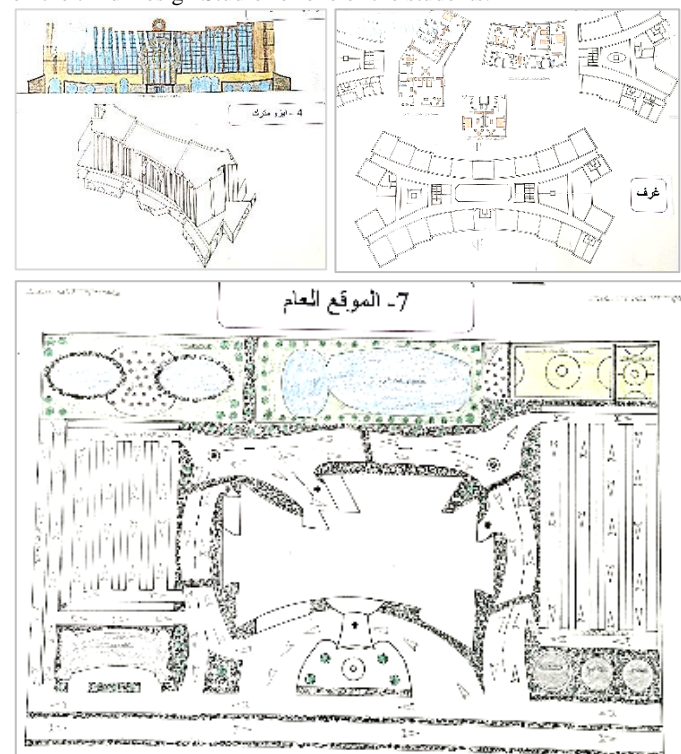


Figure 6: Manual Presentation for one of the students.

In term of using software as tool to present projects in design studio, 28.57% (n=8) of the students were used it as tools. Figure 7 shows that 48.65% of the students were no experience in using software. 32.43% of the students use AutoCAD, 13.51% use Sketch UP and 5.41% use 3Ds Max. The question presented in figure 7 was designed as multiple choices question.

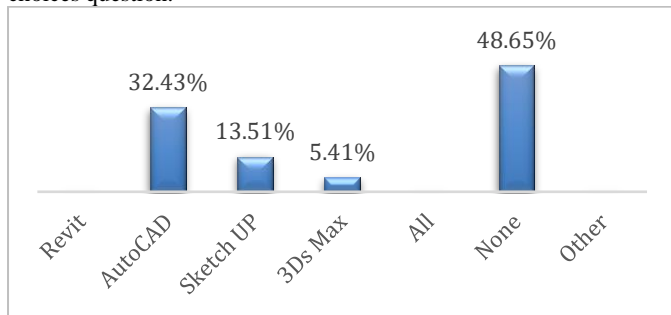


Figure 7: Applications used by students to present their works
Comparing their work with some random professional works.

In this part divided into two areas, the first area was to ask students to evaluate their previous work based on some random professional works. The second area focuses on their methods in how to design their projects.

First, students were asked to look at the provided pictures and to give from 1 to 5 if they are capable to provide the such quality. Also, faculty members were asked to evaluate if their students could produce such quality. The chosen projects were presented in figure 8, as each picture presents one of architecture typical views; plan, elevation, section, 3D model and perspective.

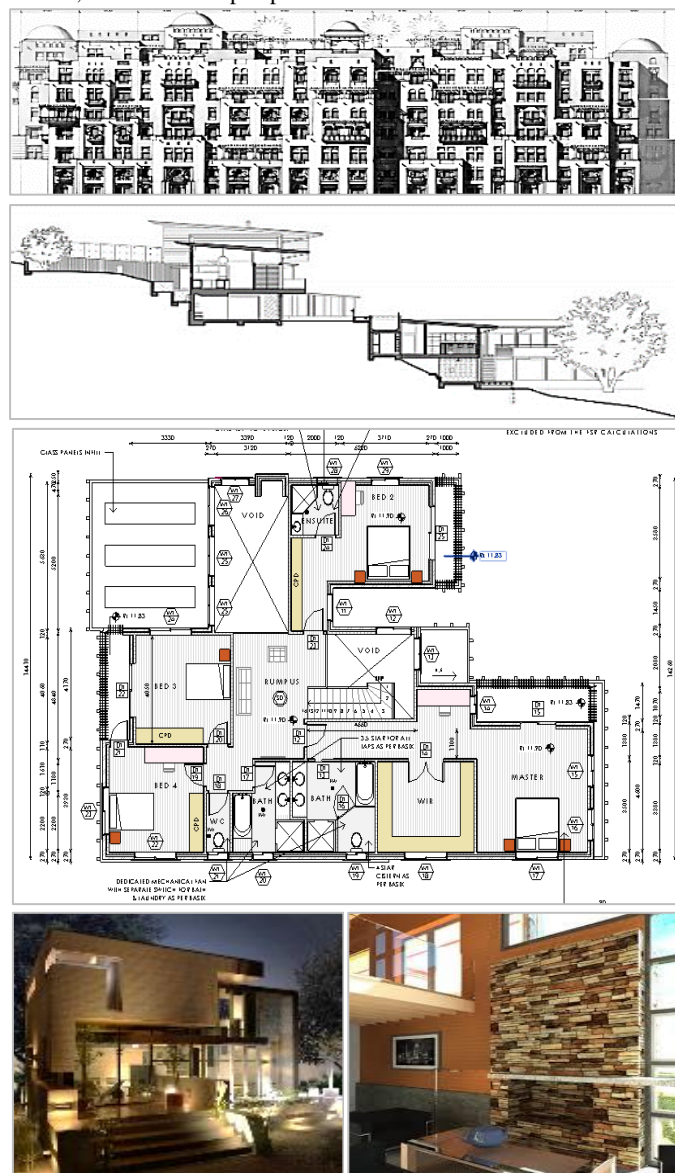


Figure 8: Random projects

Based on these pictures, figure 9 is the weighted average of the students' answers and faculties' answers. It reveals that all the results have got less than half of the weight which is 5 points. The floor plan sample was given the highest weight by students as they can do similar quality of better, which has got 2.43 points. On the other hand, faculty members have another perspective as they believe that students can do better quality in doing the elevation drawings; which has got 2.2 points. Generally, the results of this question shows that the students have lack of skills in presenting their projects.

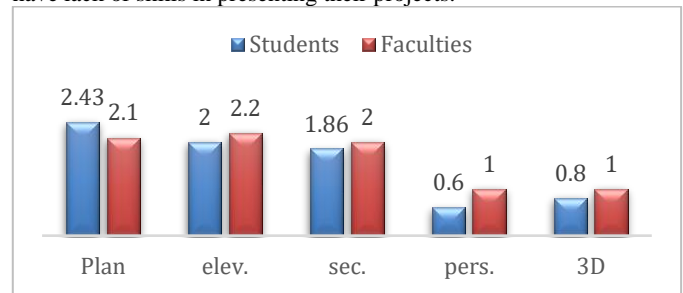


Figure 9: Comparing between faculty members answered and students on the quality can their produce.

The second area is helped to get deep understanding of how students are designing other views such as elevations and sections in their projects. According to some assistant professors in the same college, students begin with their plans first which will take them normally up to 10 weeks; then working through out sections, elevations, perspectives and 3D if they have time. In other words, students spend more than 65% of the semester developing one aspect of the design which is the plans then the rest of the time to develop other view plus presentation.

To get better understanding, students were asked when they are working in plans, at what time they will start designing and working in other views. They have been given three choices; parallel with the plan/s – After I finished 50% of the plan/s – after I finished the plan/s. Figure 10 reveals that none of the students develop other architecture views during the development of their plans. In fact, most of them wait until they finish their plans.

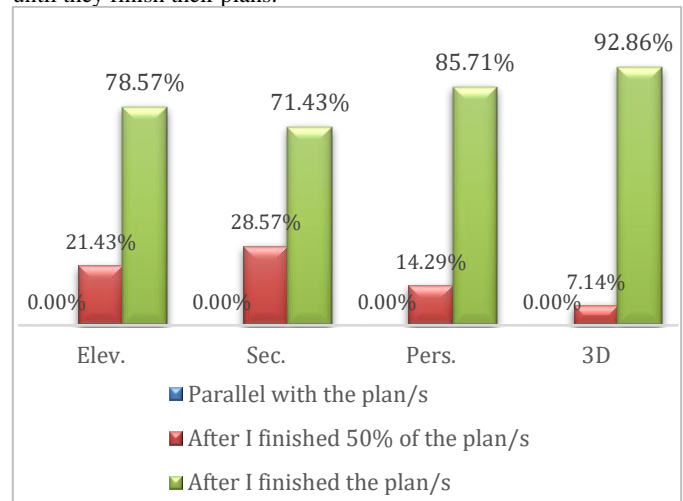


Figure 10: Students methods in working on other architecture views

In term of the speed in editing architecture views, figure 11 presents what is the easier job for students when they need to edit their work. It seems that 3D and perspectives drawings are categorized as the hardest job to edit comparing with the result of 2D drawings elevations, sections and plans.

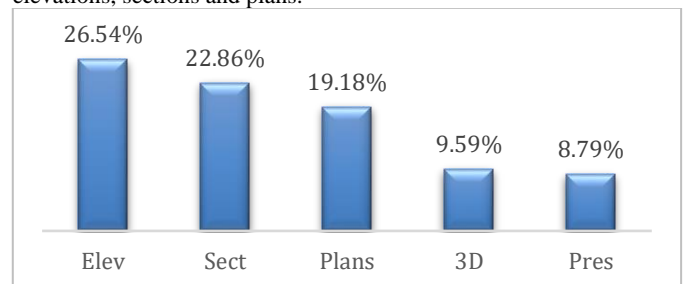


Figure 11: The ranking of the easy editing for students

Implementing BIM Based Technology

To implement BIM technology in Architecture education, the paper has proposed three stages; teaching, implementing and committing (TIC). These three stages were emerged in CAD course and design studio. Percentages in figure 12 present are just a proposal of time needed to implement BIM technology in architecture education. For example, if architecture education has 100 hours for teaching CAD class and studios, then 10 hours should determine to introduce BIM technology and 16 hours to implement it in a project and the rest of the time in their studios.

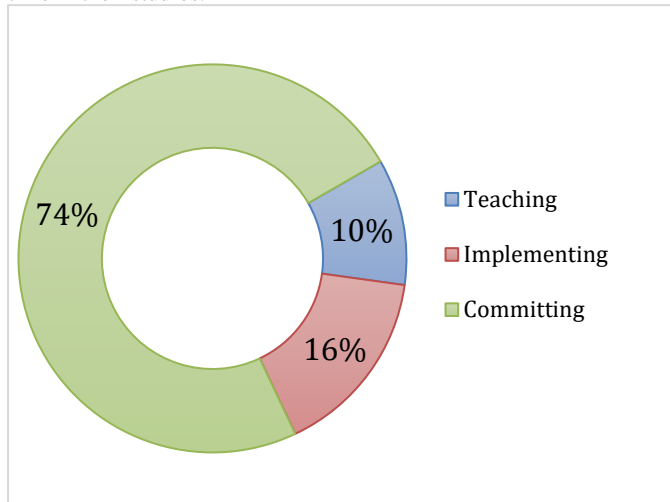


Figure 12: Determined time for Teaching, Implementing and Committing

CAD course was divided into two areas; 1) Teaching AutoCAD and Revit, 2) Implementing their acquired skills.

1- Teaching:

This stage is two sections; first section was to teach basic skills in AutoCAD. These skills will help students to produce basic 2D drawings with basic AutoCAD presentation using layers. These skills are using draw tools to create plans, elevations and sections; and accelerate that using modification tools such as move, copy, and other short-cuts.

On the second section, students were taught initial skills in how to model using the main tools in Revit. The initial skills must include the following:

5. How to navigate inside Revit:

Any model in Revit contains floor plans, elevations, sections, 3D views and schedules. Also, designer can add more views or duplicate from them. These will include introduction to Revit two interfaces; the opening interface and the workspace interface. The opening interface contains to areas: projects and families. In general, both interfaces have new file, open and recent files. Getting confident to browses these views and working with them is the aim of this part.

Students opened one of Revit sample projects; a small house. During this task, students created some views (Levels – Sections – Elevations – 3D views), edited (High – View Direction – Size – Scale – Level of Detail) and presented these view (Shading – Crop Regen – inserted in a sheet).

6. Setting up a project:

There are five things students had to do it before starting their projects; 1) Open architectural template, 2) Choose the unit, 3) Select the location using google map, 4) Build the TOPOSURFACE, 5) Draw the property line.

7. Learning architecture tools:

Tools under this ribbon can help students to build an architectural model as it contains the main elements. These elements can be categorized into three groups: vertical group “walls – Columns – Circulations”, horizontal group “Floors – Roof – Ceiling” and component group “Doors – Windows – Furniture”.

8. Understanding Parameters:

Students need to understand the power of parameter, that can be presented when students start using schedule in Revit and add parameter to this schedule. Frist, students started to add normal such as cost, name and date; then, created calculated parameter to calculate the value of the parameter.

9. Presenting the project

Finally, students learned how to add material for rendering purposes, then understanding how to use and modify artificial light and sun light. As an architect, these skills needed to present their work. After that, students designed their own TITLEBLOCK in Revit and prepare their sheets to print it out.

2- Implementation:

In order to master what they have learnt, students were given some of popular architecture building such as villa Savoye to rebuild it in Revit; figure 13 shows some of their outcomes. This task took them three weeks to be delivered, under supervision of their tutor. 85% of the students were able to deliver their task on time. Less than 25% of them have an outstanding deliverable, the rest were in level of satisfactory or less.

Student A



Student B



Student C



Student D

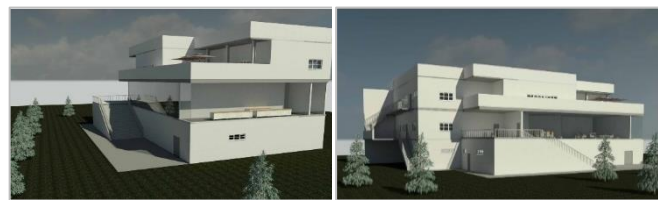


Figure 13: Example of Students' works during CAD Class

3- Committing:

This stage is a sharing responsibility between faculty members whom teaching other design studio. Faculty members at the Architecture department have made Revit compulsory to be used in their design studio classes. These design studio classes are the ones taught after or in the same year of the CAD Course. The number of these design studio is three classroom includes graduation design studio.

Lack of skills in utilizing Revit is one of the barriers facing faculty members. This was one of the drawbacks of this research. As students came from different studios, the tutor who had taught them Revit have dedicated one hour per day to support students in their projects. The fixed time was not suitable for some students, at the end, they have not got proper support. Therefore, Faculty members should get better understanding and start to utilize BIM application in order to support their students.

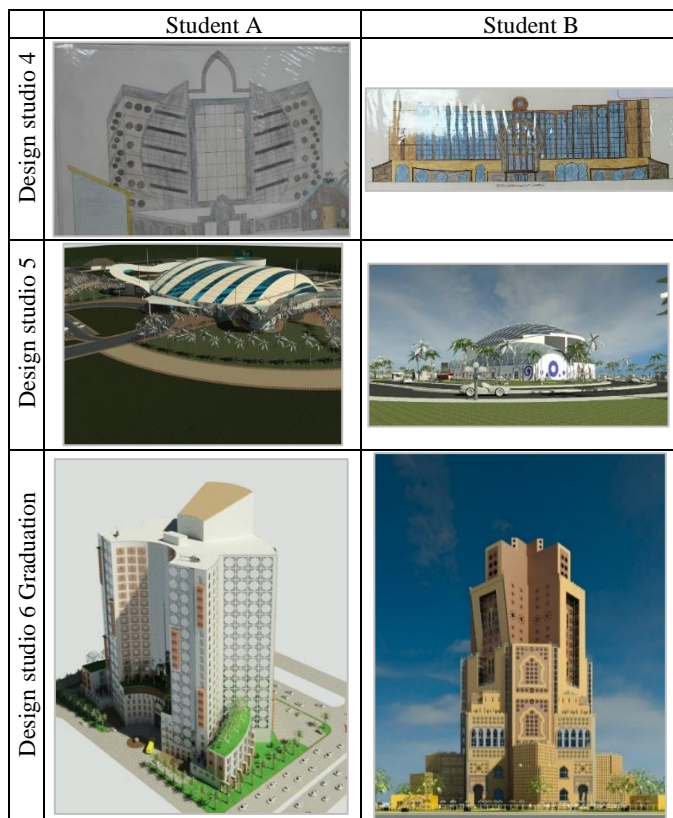


Figure 14: Samples of students' works during three design studio classrooms
Validation of the outcome

To evaluate the outcome, faculty members were asked few questions. Some of them have taught those students before this course and other have taught them before and after. Figure 15 shows that 60% of teachers who have interviewed have taught them before the course and the other 40% of them were working with them on Design Studio before the course and after it.

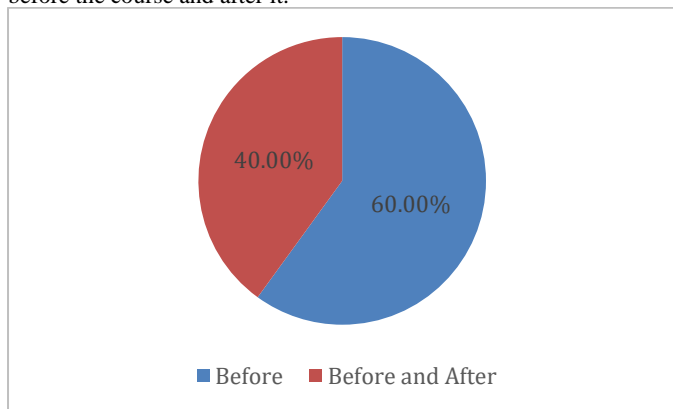


Figure 15: A comparison between who teach students before and after CAD course

Those faculty members were asked their opinions about: to what extent (from 5 Excellent to 1 Very Poor) do you think Teaching Revit as BIM based technology will:

- 1- Have positively effect on the students' works, in regards to form, composition and function
- 2- Enhance students' creativity
- 3- Improve their progress during design studio

Figure 16 shows a comparison between the answers of those who have taught the students after CAD course and who have taught them before and after. Overall, 40% of teachers believe that teaching BIM based technology such as Revit will have a great benefit on students' works. 70% of teachers who have got the chance to teach those students before the course and after the course have agreed that teaching Revit will have a positive impact on students' works.

The rest of them have some concerns in related to implementing BIM technology in early stage of architecture education. It has been stated that "Students spend a lot of time to master these tools instead of thinking in how to solve their design". On the other hand, one of the faculty members who sees the benefit in teaching Revit as BIM

technology has stated that "3D visualization has help number of students to be more creative as the technology help them to see other dimensions".

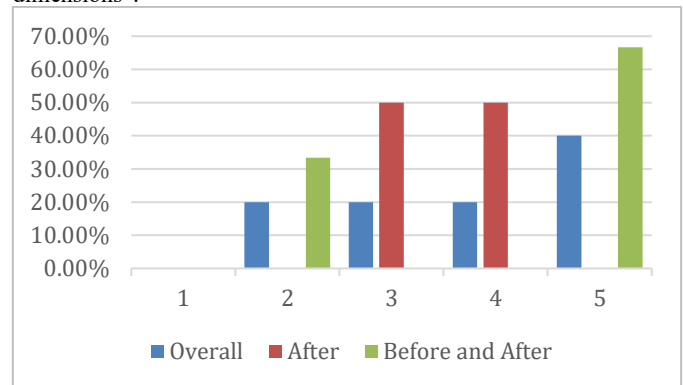


Figure 16: Comparison between faculty members' opinions in how teaching BIM technology would affect students' works.

In term of enhancing creativity through using BIM technology, most of participants agreed that the implementation of BIM based technology has helped students to be more creative. Figure 17 presents that professors who have taught students after CAD-course are having some concern in regards to the impact of these technology on students' creativity. One of them has stated "yes, BIM technology will benefit students, but I have some concern that students may become modelers than designers".

On the other hand, professors who have taught those students before the course and after are strongly believing that teaching Revit as BIM based technology for architecture students will enhance their creativity. Those professors have a bigger knowledge about the level of students before the course and they have seen the different after applying Revit. It has been said by one of faculty members "I was strongly believed that students need to present their works using manual tools to enhance their creativity, but with these outcomes, we should to be more supportive and open to encourage students and teachers to apply such technology".

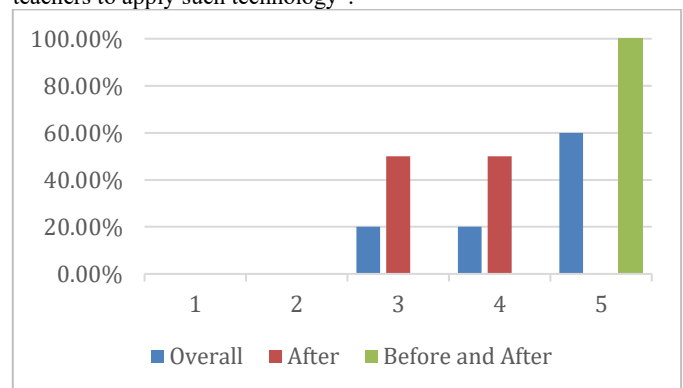


Figure 17: Comparison between faculty members' opinions in how teaching BIM technology would effect students' creativity.

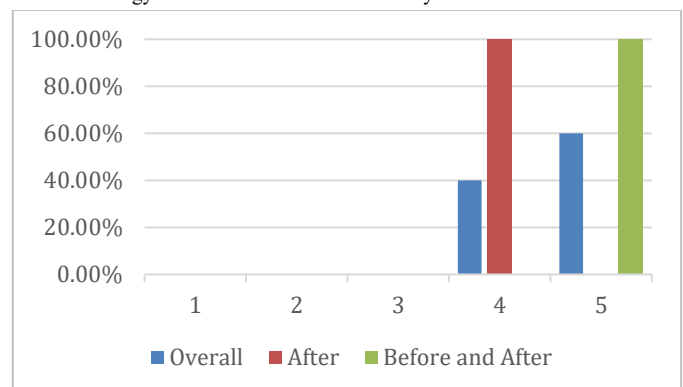


Figure 18: Improve their progress during design studio

According to professors and students (Figure 10), students need more time to edit their architecture views which will have a direct effect on the delivery time. Figure 18 shows that most of professors agreed on teaching Revit has improve students' progress during their design. As it has been said that "In the past, when we ask students to

make changes on their design, students spend times fixing and editing other architecture views, but now using such technology has reduced the waste time, we they made a chance in any view that will reflect in other views”.

10. Conclusion

Future architects must have skills to support themselves in real-life. Architectural firms and construction companies are looking for skilled architects and engineers. Mastering architectural technology like AutoCAD and Revit is one of skills need to be in future architects. Although, embedding Revit as BIM based technology within architecture educations may face some difficulties, there are huge benefits for students to utilize it. As it has been found in this paper that implementing BIM technology in early stage can help student's creativity, improve their progress and works during their study.

Recommendation

The benefit of teaching BIM technology can be more developed if the following points put in future consideration: 1) professors have to learn the fundamental tools of this technology in order to support their students and understand the capability of the software. 2) enhance inter-disciplinary classes to help students to work with students or professional in other trades in order to help them to understand collaboration.

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