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USING MOBILE AUGMENTED REALITY TECHNOLOGIES IN ARCHITECTURAL EDUCATION

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Abstract

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Keywords

Augmented Reality, Architectural Education, Markers Based Technique, Augment

USING MOBILE AUGMENTED REALITY TECHNOLOGIES IN ARCHITECTURAL EDUCATION

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ABSTRACT

Effective applied research is based on close collaboration between research and industry. The teaching and learning methods used for decades in Architectural learning process should be reviewed taking into account habits of learning and the existing challenges provided by contemporary information technologies for a new generation of students. This paper introduces a pilot study based on using Augmented Reality (AR) as a new tool in architectural learning process. AR is an emerging technology which enables participants to interact with digital information embedded within the physical environment. Egyptian educational architectural institutions today are largely unaware of new concepts such as Augmented Reality opportunities for architectural practice, and the prototypes that are being developed by researchers worldwide. The paper goal is to present how it is very helpful to use such new advanced technology in architectural learning process. Testing its possibilities for graphical and spatial capabilities and recognition improvements for the first year architectural students in the Building Construction course, at the Department of Architecture, Menoufia University, Egypt. The case study was applied at the first semester of the academic year of 2015-2016.

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1. INTRODUCTION

Architectural learning process with its traditional methods, encounters a lot of issues regarding the imagination, especially for first year students who require more effort from the instructors to fully understand the architectural content. A lot of endeavors were made in this manner through introducing new technological methods and tools in the learning process like, using 3D computer applications, Web applications, and new presentation methods. In this context Smartphones or tablets with AR applications offer a conceivable worthy solution for a better understanding of the exchanged architectural information as they are more practical, interactive and easy to use with the end-user.

A traditional method of education was carried out through face-to-face instructions, where the knowledge and learning activities were all arranged and conveyed by the instructors, and the learning materials were also based on static material such as papers, in which static materials do

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not show any information in a dynamic way, such as motion or continuous movement. Although sometimes these existing methods work effectively, however there is an increasing interest of educators and researchers in introducing more useful methods to improve the teaching and learning experiences.(Nincarean, Alia, Halim, & Rahman, 2013, pp. p.p 657,658).

The fundamental inspirations and purposes behind the research are to make sense of the benefits of applying new methods of perceiving information in the architectural learning process by using AR technology, and to find its capabilities in increasing academic improvement and student's motivations toward this technology. AR is intended to change our thought as instructors about the way and endeavors that should be possible in conveying information to students.

2. BASIC AR DEFINITIONS AND TERMINOLOGIES

There are a lot of definitions that define and illustrate the meaning of AR, according to its applications and usage, some of these definitions are as follows:

- (AR) is an increasingly popular technology that supports the exploration of spatial information, it merges virtual and real spaces and offers new tools for exploring and navigating through space (R. T. Azuma, 1997).
- Azuma defined AR in 1997 as "it represents a computer system that allows the user to see the real world, with virtual objects overlaid, thus enhancing reality rather than replacing it", his definition indicates that there are three main attributes to AR; it combines real and virtual objects in a real environment; runs interactively, and in real time; and registers (aligns) real and virtual objects with each other (R. Azuma et al., 2001).

2.1 How Does AR Work?

(AR) uses computer-visualization techniques to add an additional layer of information to aid perceiving and interacting with the physical world around the user. This is commonly accomplished through emerging the real scene with additional rich digital information, which could be static images, video clips, even text or computer models that can be processed locally or online, then are displayed through some sort of visual output device.

2.2 Endeavors of Using Digital Technologies in Education.

Incorporating digital technologies in the educational processes is considered one of the challenges which confronts students and instructors, students feel strongly attracted to these technologies. From educational centers, there is a continuing insistence on maintaining traditional strategies, perhaps for fear to distort the contents of the fields due to the complexity that some traditional computer applications have. (Wang, 2013). AR technology allows collaborative experiences in a real scene. So, users can work with computer-generated objects as if they were real objects in a real environment simultaneously. It also allows a tangible interaction by superimposing virtual objects in a real environment, users can modify and manipulate the scale, position and location of virtual objects. So that AR technology, could promote active student participation in its own knowledge construction. Thus, it becomes a suitable medium to be used in the classroom (Redondo, Fonseca, Sánchez, & Navarro, 2013).

3. METHODOLOGY

The case study is about the viability of using AR technology as a tool in architectural learning process. The research outlined in this paper is qualitative and quantitative research, the case study has been designed and analyzed using the aforementioned grounded theory approach. The results of the case study have been analyzed through different tests, academic progress and a usability survey.

3.1 Designing the Questionnaire

The purpose of the questionnaire was to evaluate four main issues; students' identification and Smartphones possession (to be sure that possessing Smartphones would not be an obstacle for pursuing the case study), identifying students' background in the field of 3D

modeling (to know how many students use 3D modeling programs in their study), identifying students' cognition about AR technologies and their applications in Architecture, in addition to clarify if they already have explored one of AR applications and what are their feedbacks toward their experience. The last part aims to know the obstacles and suggestions that students proposed, and to what extent they are motivated to use AR in their learning process and architectural life style (appendix I). The researchers intended to start the case study with the first year students to be able to collect data from a large size sample community.

3.2 Objectives

The objectives of the study are to:

- Develop augmented exercises that may help architectural engineering students to perceive the contents of the Building Construction course easily, in an interactive way by, themselves and with less effort from the instructors, at anytime and anywhere with no prior knowledge with 3D applications.
- Evaluate the premises hypothesis stating that the new (ICT) tools used in web environment allow, at very low cost, improving learning processes and reducing their temporality, without prior technical experience.
- Encourage the first year students to be up to date with the latest technology in the field of architecture visualization techniques.

3.3 Case Study Questions

- What are the weakness points of the traditional methods of architectural learning processes?
- How can AR increase student's motivation and academic achievements and perception in the field of architectural learning process?
- To what extent, can we depend on AR technologies in learning processes?
- What are the maximum benefits of using AR in architectural learning processes and in which courses students are motivated to use such technology?

3.4 Stated Hypothesis

Based on the hypothesis stating that the new Information and Communication Technology (ICT) tools, used in web environment, allows at very low cost to improve learning processes and reduce their temporality, without prior technical experience, only with the help of using intuitive touch-screen interfaces of the latest generation of mobile devices.(Redondo et al., 2013) The utilization of AR in classroom has repeatedly been shown to increase students' motivation, it has likewise been shown to contribute to students' learning outcomes. Moreover, the use of an AR system had a positive effect on students' learning attitudes and their perception of the relevance of their learning to their everyday lives ("Augmented Reality in education – cases, places and potentials," 2014).

To facilitate students' perception of the studied materials in Building Construction course, the researchers prepared 3D models for the 2D manual drawing exercises into AR environment. The 3D AR scenes were created using a free academic version of AUGMENT application developed by (www.augmentedev.com). The virtual 3D models were overlaid on the real world environment after being recognized by rear mobile camera, the 3D model appears as a part of the surrounding environment. AUGMENT uses marker-based tracking system, (as shown as Fig. 1).

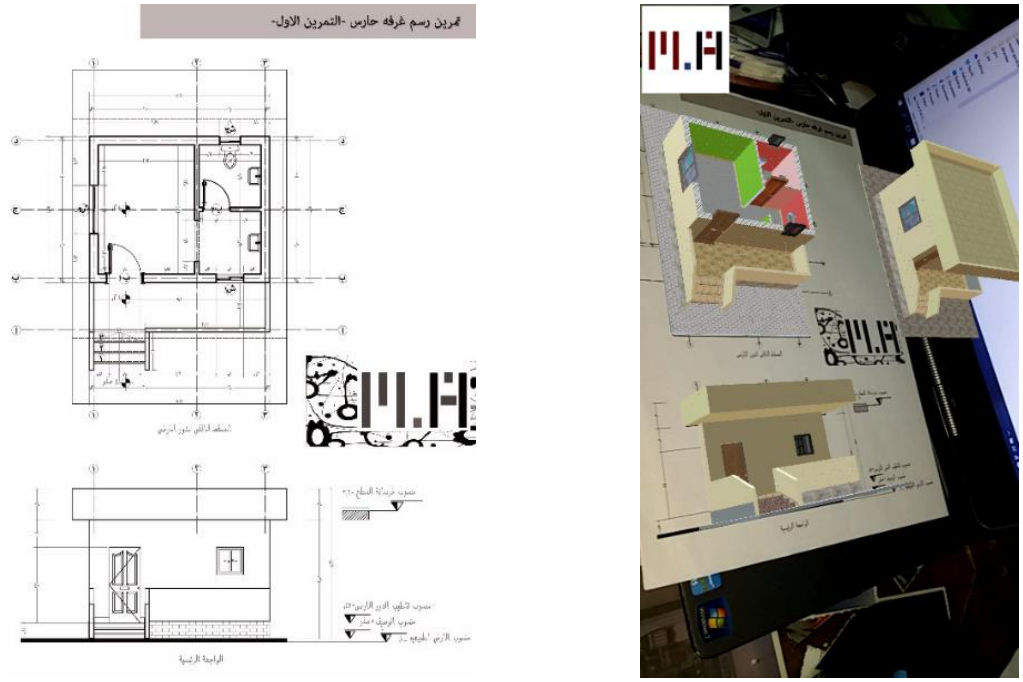


Fig. 1: Marker based tracking technique, used in the case study.
Source: Authors

3.5 Sample Determinants

- All students attended their preliminary year at the same faculty, so they all passed the same courses at their preliminary year.
- They all had no prior experiences with CAD programs.
- All the applications were made in the same place across the experiment.

This conditions made the first year students to be a suitable grounded sample for the experiment.

3.6 Course Content

Building Construction is a two semester course which informs and familiarizes students about types of construction, sequence of construction, how buildings are erected, different building materials and their uses and applications, general and also basic drawing skills for building construction, the course investigates different basic components of buildings and provides students with basic knowledge of building types, elements and foundations. Moreover, it introduces various construction techniques and emphasizes on architectural elements.

3.7 Selected AR Application

After evaluating a lot of AR applications like Junaio, Metaio, Aurasma, AR-plugin and Augment, and assessing their capabilities, software and hardware requirements. Researchers decided to use AUGMENT application. It is easy to use, has a good online support, does not need any previous programming experiences, and offers academic license for researchers and students. In addition to that, it is available in both the most well-known platforms; Android and IOS. Therefore Augment application requires only Smartphones or Tablet device working with Android or IOS system, connected to the internet and have a rear camera, as the camera would be able to capture the real scene and capture the marker through AUGMENT program that will help the program to recognize the marker and load the virtual objects connected with it.

4. FRAMEWORK IMPLEMENTATION

The case study was implemented over six weeks of the first semester of the 2015-2016 academic year, each task was meant to assist the different viability of using AR in the learning process; imagination, self-learning and motivation issues The researchers facilitated workshop for participants, the workshop introduced the program, provided a background overview of AR, demonstrated how to download the program, explore 3D AR content with traditional or custom tracker (appendix II).After that, five exercises were implemented over five weeks in class and the final exercise was a homework exercise.

4.1 The First Exercise (Basic Building Construction Drawing)

The first exercise was designed by the instructors and introduced to the students. They were asked to draw the plan view and derive the front elevation of the exercise. This was illustrated by the traditional way. The main problem was that, not all students were able to make the deduction of the elevation view. The 3D of the exercise was modeled with sketch up program and exported to Augment program. Then a custom tracker was created with Photoshop, to be used for augmentation and tracking. Smartphones and Tablets were used to explore the 3D content in AR. Students were able to explore the 3D content after scanning the markers by Smartphones or Tablet devices. (as shown as Fig. 2)

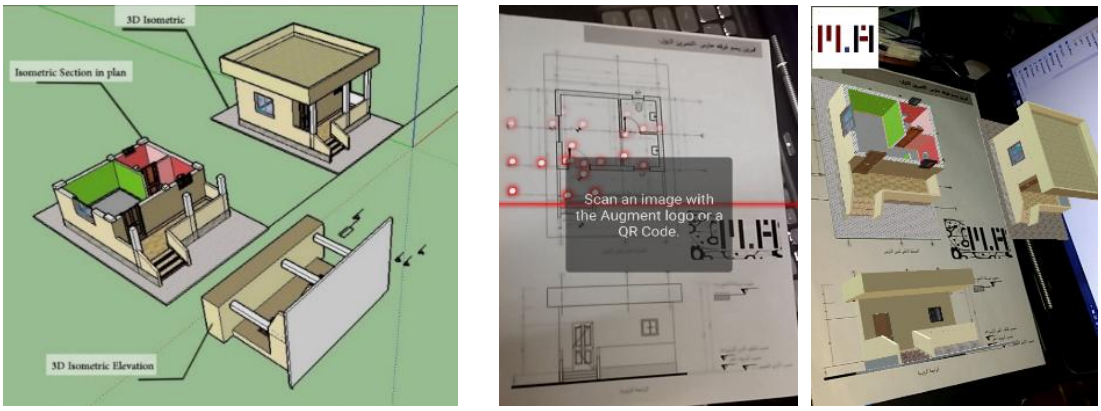


Fig. 2: The process used to explore the augmented content
Source: Authors

The main purposes of the first application in addition to the aforementioned problem, was to familiarize students with AUGMENT program and its main features. The following (Fig. 3) indicates how to use any image as a custom tracker, which can be any image. Taking into consideration light conditions, the clarity of the selected image, in addition to the resolution of the camera.

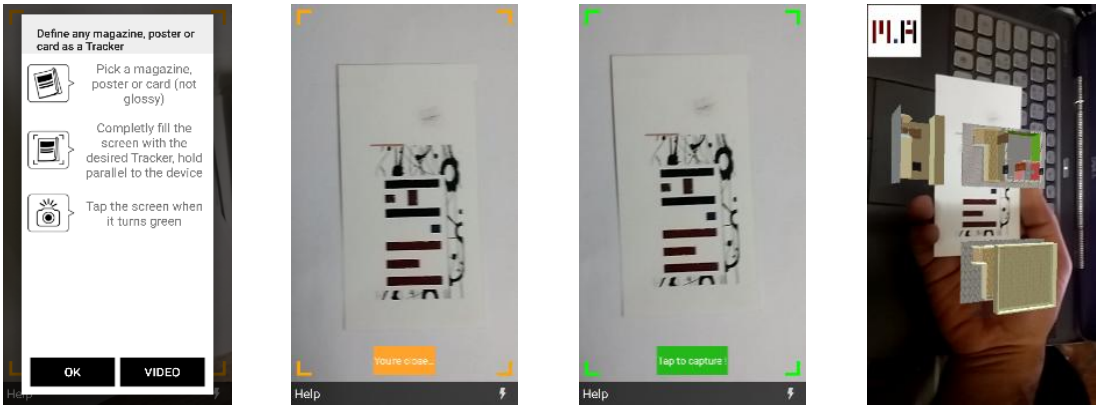


Fig. 3: The process of making new custom tracker for any 3D model
Source: Authors

4.1.1 Feedback collection after the first exercise

The primary means of the qualitative data collection were collected through a feedback from students who participated in this exercise. The feedback was collected from 44 students. Students' feedback emphasizes that, they are interested in using AR technology in class and they wanted to use AR technology in their future exercises (as shown as Fig. 4). This gave the researchers significant judgment about the benefits, and possibilities of using AR in architecture learning courses. As 98 percentage of students were motivated and wanted to embark on using AR in the building construction course.

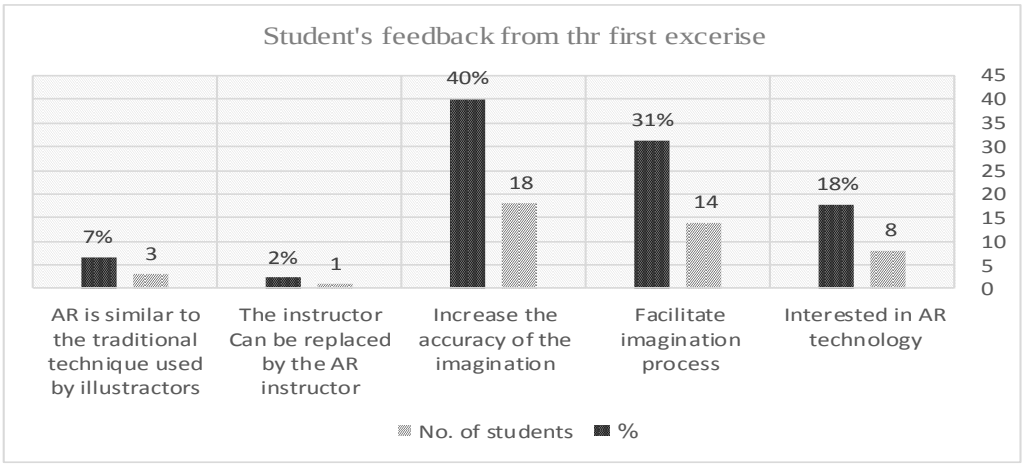


Fig. 4: The most notion of the students' feedback.
Source: Authors

4.2 The Second Exercise (Basic Building Construction Drawing-Building Types I)

During the following week, the students were given the second exercise, illustrators asked students to use skeleton structure system instead of load bearing wall system. Researchers observed that half of the students did not imagine the projection of the skeleton system at the façade elevation, this exercise was not made with AR until students had their exercises evaluated. So that, researchers were able to track their academic achievements through their evaluation grades. After that the exercise was prepared in AR, and students had the opportunity to explore it in AR, and they got the perception and the imagination of how to draw the front columns in the façade elevation view.

4.3 The Third Exercise (Basic Building Construction Drawing-Building Types II)

The third exercise was to draw a section in the previous exercise plan, instructors illustrated the exercise with the traditional way, and the purpose of this exercise was to emphasize the students' ability to draw sections for any building and imagine its different levels, the continuity in the building structure system, finishing material, and building damp-proofing. Students started drawing the task without AR. Nearly, all students were not able to finish the exercise properly. Students were asked to explore the exercise in AR at home, (as shown as Fig. 5).

Fig. 5: The third exercise (drawing section for guard house).
Source: Authors

4.4 The Fourth Exercise (Basic Building Construction Drawing-Building Types III)

The main purpose of this exercise is to evaluate the ability of students to draw another section view with the help of the AR implementation from the previous exercise, the foremost observation was that all students were able to finish the exercise properly. During the exercise evaluation, the researchers took into consideration two evaluation criterion; the ability of finishing the task within the exercise time properly, and with minimum inquiries about imagination issues. The general notice was that students made less inquires than the previous exercise.

4.5 The Fifth Exercise (Foundation System)

The following two weeks, exercises were about the foundation systems. The researchers managed to test the ability of using AR in the self-learning process. These exercises were divided into two sections; in the first one, the instructor illustrated the load bearing wall foundation system, its rules, dimensions and how it appears in the plan view, and then instructors asked students to draw a plan and a section of the exercise

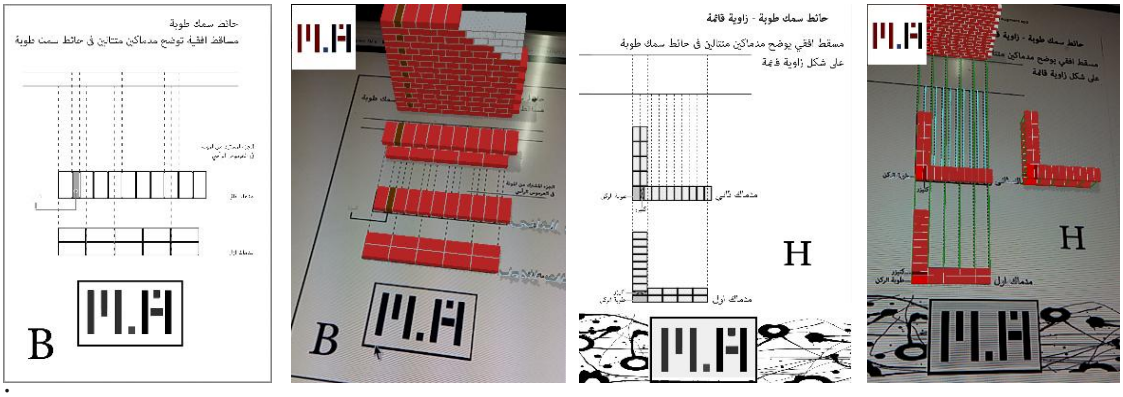
During the following week, Skelton structure system exercise was prepared in AR, students explored it during the exercise class (as shown as Fig. 6). About 90% of the students accomplished the exercise properly. This exercise was used as a base for the research hypotheses about the ability of using AR in the self-learning process, which was evaluated in the following two exercises.

Fig. 6: Foundations for skeleton structure system exercise - students explore the exercise in AR.

Source: Authors

4.6 The Last Exercise in This Semester (Masonry works)

In this exercise, the researchers managed to evaluate the accuracy of the hypothesis, stated from the previous exercises, about the ability of using AR as a self-learning method technique. The instructor introduced a brief about building with brick, and the rules that they have to consider, when using the English Bond with brick masonry in the building. Students took the exercise in AR (as shown as Fig. 7), they were asked to draw their task as a homework. Students were able to finish that task properly.



English Bond with brick masonry in AR (straight wall and L shape).

Source: Authors

Then students were asked to draw different shapes of walls in different width without any prior explanation, only with the help of AR. The researchers found that all students were able to complete the task properly, (as shown as Fig. 8).

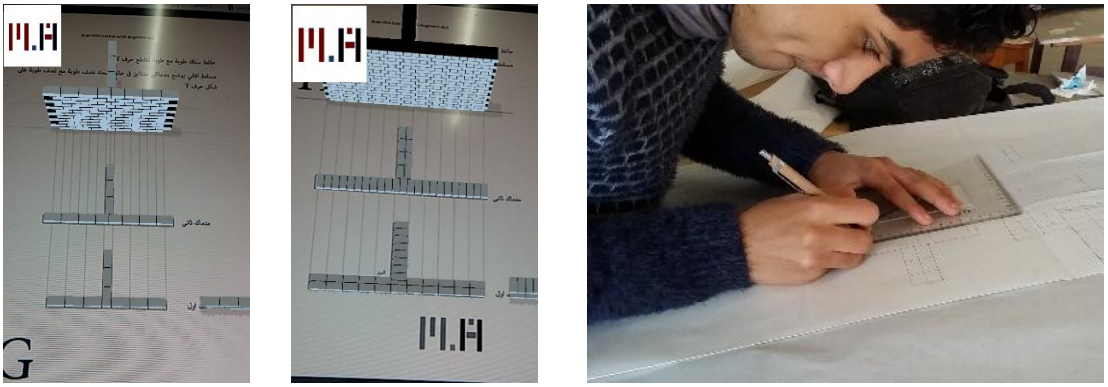


Fig. 8: Brick masonry exercise -Self learning implementation with AR (different shapes and width), Source: Authors

5. RESULTS ANALYSIS

It was clear from the students' first exercise feedback, and the questionnaires they filled after finishing the case study, in addition to their academic achievements that was recorded through their marks all over the semester, that the incorporation of AR in the field of architectural learning process, could make differences in the perception of the academic architectural content and can enhance students' academic progress improvement in an interactive way, without any additional cost. In our case, AR technology was helpful in clarifying the principles of projection in the Building Construction course, students were able to imagine the 3D of all the exercises accurately with less inquiries and without any prior knowledge of using computer applications that improve their ability to engage in self and lifelong learning, and which is considered one of the program objectives of the Department of Architecture at Menoufia University.

5.1 Questionnaire Analysis

The questionnaire was distributed among 43 students from a total of 51 students. As aforementioned the questionnaire asks four main criteria. The first part of the questionnaire was to make sure that all students are able to get suitable mobile device for the experiment, and use or share it with their colleagues to achieve the principle of equal opportunities for all students. Only two of the students didn't have Smartphones, however, they were able to share with their colleagues.

In the second part of the questionnaire, the researchers wanted to know if any of the students were able to use 3D programs in their studies, if anyone had any prior knowledge of AR applications, and whether they find the traditional methods of teaching, satisfying for their needs in getting and perceiving information or not, (as indicated in Table.1).

Table 1: Students' cognition of AR applications and 3D modeling App.
Reference: The authors

Q.N.	Students' cognition of AR applications and 3D modeling App.	YES		NO	
		%	No.	%.	No.
Q.4	Using 3D modeling programs	44%	15	56%	28
Q.5	Having prior knowledge about AR and its applications	21%	9	79%	34
Q.6	Facing difficulties in recognizing 3D models into real environments	47%	20	53%	23
Q.7	Satisfying with current methods used in learning Architecture to fully imagine Architectural drawings and 3D models	23%	10	77%	33

The following part was about the students' impression of using AR in the learning process. Some students had some applications on their cell phones run with AR technology, mostly were games. For all students who used AR in the case study, mostly all of them wanted to use AR in architectural learning process. Students admitted that these applications improved their cognition and perception. Students propose the courses they find mandatory to use AR in their learning processes, (as indicated in Table.2).

Table 2: In which courses students are motivated to use AR technology.
Reference: The authors

Course name	Building Construction	Architectural Design	Interior Design	Sciagraphy & Perspective
Number of students	34	19	16	20

5.2 Grades Analysis

All evaluation process for all the exercises, were remarked by the same lecturers, each task evaluated from ten grades, the main criteria are as illustrated at the following, (as shown as Fig. 9).

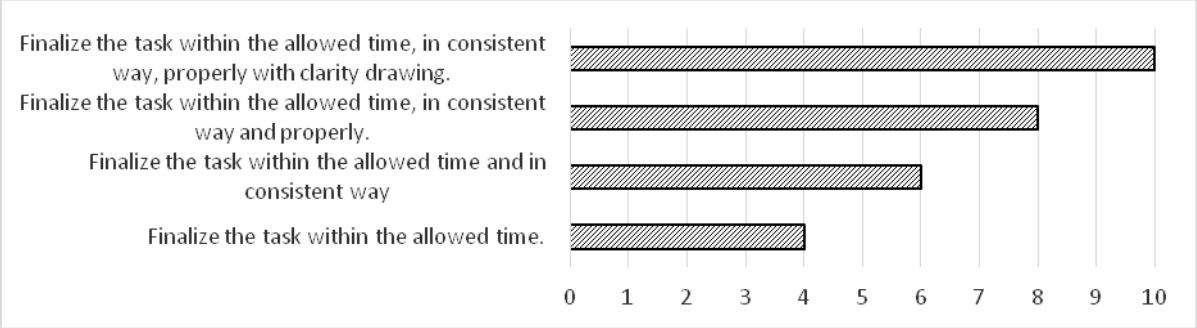


Fig. 9: Evaluation criteria used in evaluating the exercises.
Source: The Authors

Students' marks were used to evaluate the academic progress, the researchers considered the students' presence in each compared exercises, to be able to evaluate their marks before and after using AR.

5.2.1 First and second exercise

The researchers found the evaluation marks in the first exercise that uses AR, are higher than the second one which didn't use AR in the class, (as shown as Fig. 10).

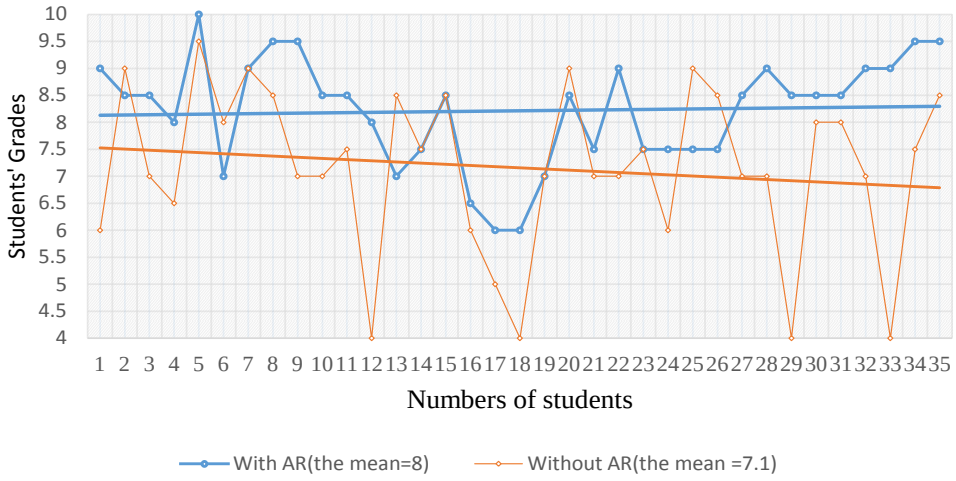


Fig. 10: Student's grades before and after using AR for the first and second exercise.
Source: Authors

5.2.2 The third and the fourth exercise

Students did not have the ability to explore the third exercise at section time, they started to draw the exercise depending only on the traditional way of teaching, after that they were able to explore the exercise in AR. They used the model answer and the AR model, to figure out the mistakes they made in their task, which they avoided in the homework assignment, (as shown as Fig. 11).

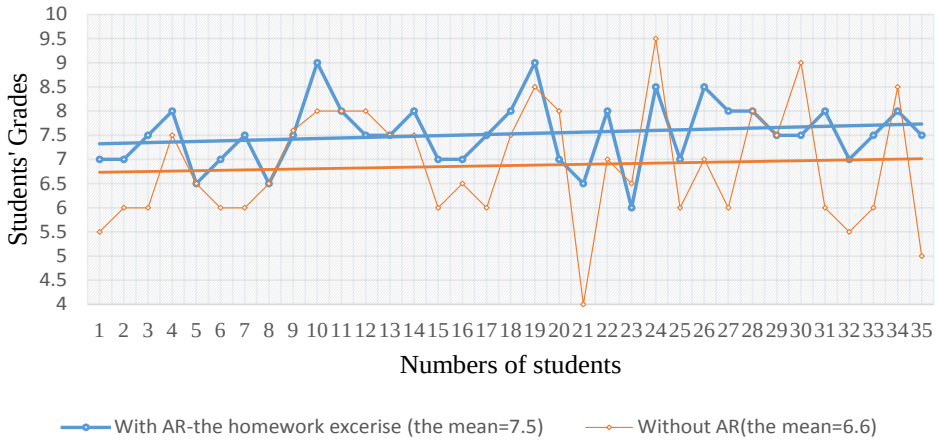


Fig. 11: Student's grades before and after using AR for section drawing exercises.
Source: Authors

5.2.3 The fifth exercise (foundation systems)

The fifth exercise was prepared for testing the ability of using AR for self-learning process, so that students could be able to improve their skills in the self - learning process. The researchers found that students got merely the same grades through both the exercise that was illustrated by the instructors and the exercise without illustration and both were in AR, (as shown as Fig. 12).

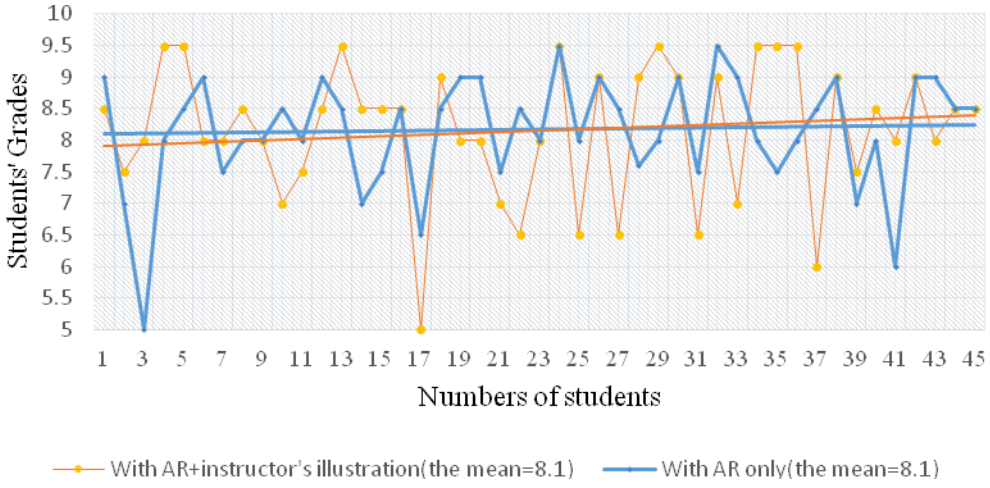


Fig. 12: Student's grades before and after using AR for foundation systems exercises.
Source: Authors

5.2.4 The last exercise (masonry works)

The last task was meant to emphasize the ability of using AR as a tool in the self - learning process, the researchers observed that all students were able to finish their task with the help of AR, gaining the highest grades across the semester, (as shown as Fig. 13).

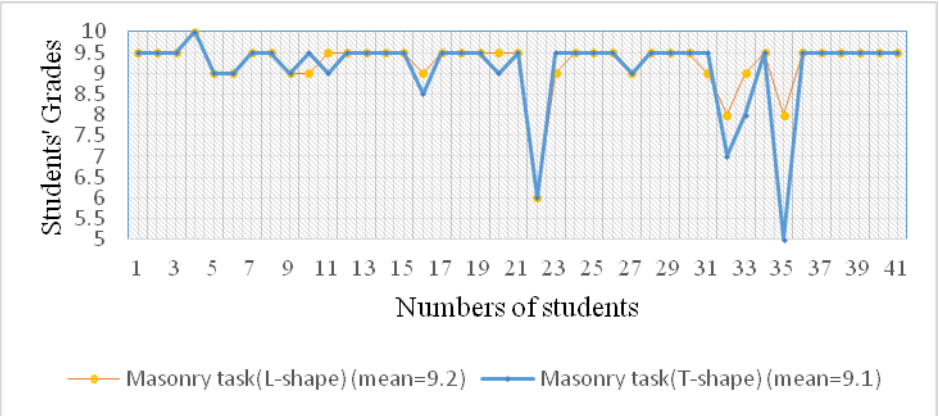


Fig. 13: Students' grades for the masonry works tasks. (Evaluating self-learning possibility).
Source: Authors

6. CONCLUSION

A. As 77% of the students, in the case study, are not satisfied with the traditional methods of learning architecture, the AR applications enable faster comprehension of complex spatial problems, and relationships which benefit the students greatly during their learning processes. Applying AR technology to support learning activities may become a trend in the future, not only for the Building Construction course but also many other subjects.

B. The questionnaire revealed students and lectures opinion's on the effectiveness, and the usability of using AR technology in the learning process. All the students considered this approach as being very useful in solving their imagination issues.

C. AR technology proved its values and benefits in the field of architectural learning process. It raises the students' motivation in academic learning process, increases their academic achievements and gives them inspiration about the way in which architecture can be presented. The overall response of the students about the AR model use in the Building Construction course was extremely positive.

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APPENDIX

I: The printed out questionnaire

Questionnaire about Augmented Reality technology and its applications in Architecture Learning process

Your opinion counts

This questionnaire is made within the procedures of master studies, entitled "Augmented Reality technology in Architecture", to evaluate the importance and necessity of using Augmented Reality technology in the field of Architectural learning process.

(Please, complete the questionnaire by yourself, by checking inside the box √ in front of each question.)

First section: Basic information about the student.

Name (optional):_____

1- Class First C. ☐ Second C. ☐ Third C. ☐ Fourth C. ☐

2- Do you have (Smart phone & Tablet & IPad) with Android or IOS

Yes ☐ No ☐

Incase No

3- Do you facing any difficulties in providing one to use in AR applications?

Yes ☐ No ☐

Second Section: Data about student's cognition of AR applications and computer modeling programs.

4- Do you use any of 3D modeling programs in your study?

Yes ☐ No ☐

5- Do you have any prior knowledge about AR technology and its applications in Architecture?

Yes ☐ No ☐

6- Do you facing any difficulties in recognize 3D drawings and models in one to one scale in real environment?

Yes ☐ No ☐

7- Do you find current methods in learning architecture, suitable for you to imagine 3D drawings and models?

Yes ☐ No ☐

Third Section: inquiries about the outcomes of exploring architecture content with AR applications.

8- Do you know the differences between Augmented Reality and Virtual Reality?

Yes ☐ No ☐

9- Have you already used any of its applications in your academic courses, till now?

Yes ☐ No ☐

In case of No, Please go to question 13

10- Do you find it is essential to use AR applications in the field of Architectural learning process?

Yes ☐ No ☐

11- Through your experience with AR, do you find any improvements in your recognition level and understanding 3D contents, rather than other traditional ways in teaching?

Yes ☐ No ☐

12- Have you faced any technical problems, through using any of AR applications?

Yes ☐ No ☐

The last Section: inquiries about the need of involving in workshops to learn more about AR applications, and suggested courses to use AR.

13- Would you like to participate in workshops to learn more about AR applications?

Yes ☐ No ☐

14- Specify percentage from (1 to 10), which represents your motivation toward learning AR applications in the field of Architecture, whether no 10 means very motivated?

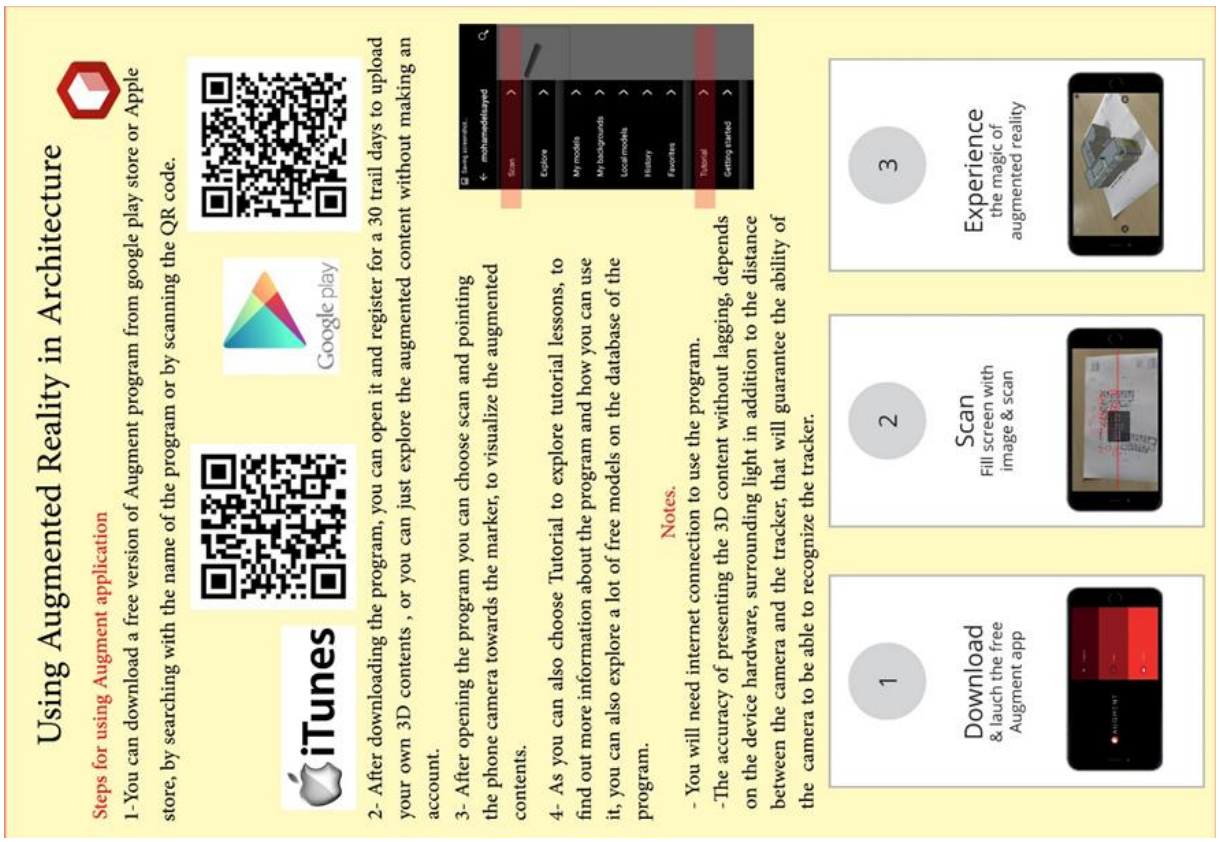
Yes ☐ No ☐

15- What are courses, you find it essential to use AR technology in learning process?

Building Construction ☐ Architectural Design ☐ Interior Design ☐ Sciagraphy and perspective ☐ others.....

Thank you for your time!

II: The workshop printed out instructions for using Augment application



Using Augmented Reality in Architecture

Steps for using Augment application

1-You can download a free version of Augment program from google play store or Apple store, by searching with the name of the program or by scanning the QR code.

iTunes

Google play

2- After downloading the program, you can open it and register for a 30 trail days to upload your own 3D contents , or you can just explore the augmented content without making an account.

3- After opening the program you can choose scan and pointing the phone camera towards the marker, to visualize the augmented contents.

4- As you can also choose Tutorial to explore tutorial lessons, to find out more information about the program and how you can use it, you can also explore a lot of free models on the database of the program.

Notes.

- You will need internet connection to use the program.
-The accuracy of presenting the 3D content without lagging, depends on the device hardware, surrounding light in addition to the distance between the camera and the tracker, that will guarantee the ability of the camera to be able to recognize the tracker.

1 Download & lauch the free Augment app

2 Scan Fill screen with image & scan

3 Experience the magic of augmented reality