The Role of Visualization Software in Architectural Education

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Abstract

The architectural profession is today confronted with an increasingly complex and challenging environment. From the local to global, the international to the vernacular, architects have to continually adjust and adapt their practice in a fast-changing milieu to engage with new shifting conditions both within the profession and externally. Schools of architecture are struggling to keep up with the current issues that are transforming architecture practice. From sketching and drafting to 3D rendering, to animation, and reaching to the Virtual Reality (VR), and Augmented Reality (AR), there is a rapid crazy change in the technology interfered informally in Architecture Education in the way that result in a bad effect on imagination and creativity skills of the architecture students.

The research aims to "Pave the way for architecture instructors and head of departments in using the visualization software in a better way in different courses and architecture programs". By using a descriptive, analytical, and inductive methodology (interviews & questionnaire). The research starts with the theoretical background to discuss the visualization programs, and techniques, their importance, and pros and cons, then, the research develops a questionnaire and some interviews with academics, practitioners, and information computer technology (ICTs) specialists to know their opinions in using the visualization techniques in the architecture education. Finally, the research ends up with a wider discussion and a road map to develop guidelines for using visualization techniques in architecture education and to draw a Model for plug-inn of digital visualizations and manuals techniques in different modules in architecture and urban design education.

Keywords:

Architecture Education, Manual, Digital, Visualization Techniques, Visualization Software.

الملخص:

تواجه مهنة العمارة اليوم بيئة معقدة وصعبة بشكل متزايد من المحلية الي العالمية ومن الدولي الي العامي و يتعين علي المهندسين المعماريين ضبط و تكييف ممارساتهم باستمرار في بيئة سريعة التغير للانخراط في ظروف تحول جديدة داخل المهنة و خارجها. تكافح المدارس الهندسة المعمارية لمواكبة القضايا الحالية التي التي تحول ممارسات الهندسة المعمارية من الرسم اليدوي الي العرض ثلاثي الابعاد، الي مجال الرسوم المتحركة وصولا الي الواقع الافتراضي و الواقع المعزز. هناك تغيرسريع في التكنولوجيا يتداخل بشكل عشوائي في تعليم الهندسة المعمارية بطريقة تؤدي الي تاثير سيئ علي مهارات التخيل والابداع لدي طلاب العمارة. يهدف البحث الي تمهيد الطريق لمدرسي و رؤساء اقسام العمارة في استخدام برامج التصور بشكل افضل بمختلف المقررات الدراسية والبرامج المعمارية. وذلك باستخدام المنهج الوصفي والتحليلي والاستقرائي باستخدام المقابلات الشخصية والاستبيان. يبدا البحث بالدراسة النظرية مناقشا المفاهيم العامة والخلفية التاريخية

لطرق وبرامج التصور واهميتهاومميزاتها وعيوبها، ثم يطور البحث استبيان وبعض المقابلات الشخصية مع اكاديمين وممارسين ومتخصصين في تكنولوجيا المعلومات والاتصالات للوقوف على ارائهم في استخدام طرق وتقنيات التصور المختلفة بالتعليم المعماري. ينتهي البحث بمناقشة لنتائج المقابلات والاستبيان ليستنتج بناءا عليها نموذج لتغذية تقنيات ووسائل الاظهار المختلفة يدوية ورقمية في مختلف المقررات الدراسية في التعليم المعماري.

اهداف البحث: يهدف البحث الي رسم مخطط تفصيلي وتمهيد الطريق لمدرسي العمارة ورؤساء اقسام العمارة كيف يمكنهم استخدام برامج التصور بشكل أفضل في مختلف المقررات الدراسية وبرامج العمارة. ولتحقيق ذلك يجب على البحث اولا تحقيق اهدافه الفرعية:

١. مناقشة تقنيات التصور المختلفة سواء كانت اليدوية او الرقمية.

٢. التحقيق في اراء الطلاب الجامعيين والخريجين الجدد والاكاديمين وممارسي المهنة و بعض خبراء تكنولوجيا المعلومات و الاتصالات في استخدام تكنولوجيا المعلومات والاتصالات في التعليم المعماري.

٣. لتطوير دليل ارشادي لكيفية استخدام برامج التصور في تعليم الهندسة المعمارية.

٤. لرسم نموذج للمكونات الاضافية لتقنيات التصور الرقمي واليدوي في وحدات مختلفة في تعليم الهندسة المعمارية.

الكلمات المفتاحية:

التعليم المعماري، يدوي، رقمي، تقنيات الاظها والتصوير، برامج الاظهار والتصوير.

1. Introduction

The use of technology is not a new occurrence in education. The popularization of low-cost home computers in the early 1990s and mass Internet access in the same decade greatly enhanced the possibilities of distance learning (e-learning concept), enabling access to all forms of digital content: simple documents, images and videos as interactive three-dimensional models, and computer graphics. At the end of the last century, a number of relevant studies were carried out that focused on how to incorporate new technologies in university teaching [1]. Based on the results of previous studies [2], it is important to identify the need to include technology as a tool to complement the work and teaching agenda, to monitor its proper use, and to allow teachers and students to prepare, taking the first step towards a paradigm shift in technological education: Passage from the "teaching" definition to "learning." Based on that, we will review, describe and address in the following sections the theoretical basis on which our analysis was based.

1.1. Problem identification:

Visualization software has been transferred from a tool " used to develop a skill in the students" to be a target for both instructors and students. Also, it became widely used and allowed to be used between young students and beginners that had a bad effect on the imagination and creativity skills of these students.

1.2. Aims of the research:

To draw an outline and pave the way for architecture instructors and head of departments, how they could use the visualization software in a better way in different courses and architecture programs. *And to achieve it, the research has first to achieve its objectives:*

1. To discuss the different techniques of visualization both manual and digital.

2. To investigate the opinions of the undergraduate students, fresh graduates, academics, ICT specialists in using ICT in Architecture Education.
3. To develop guidelines for using visualization techniques in architecture education.
4. To draw a Model for plug-inn of the digital and manual visualization techniques in different modules in architecture education.

1.3. Research Structure:

The research consists of 3 parts: the first part is about the theoretical approach to present the literature of the study. The second part is about the practical part where the research develops a questionnaire and interview guide to assess the different stakeholders' opinions in Visualization Techniques in Architecture Education. The third part is about the deductive approach where the research develops a Road Map to better understand and use of Visualization techniques both manual and digital in Architecture Curriculum.

2. Visualization Techniques: Definitions and Background.

Visualization has always been a painful process, with architects, artists and designers from all disciplines spending countless hours making their representations of the future as realistic and attractive as possible. Visualization has been democratized with new technologies, new techniques and cutting-edge software, allowing more accurate depictions to be made in hours or days rather than weeks or months than was possible only a few years ago. The ubiquity of visualization technologies and the subsequent capabilities of architectural firms have enabled constructors, designers, developers, realtors, contractors, management firms and all real estate professionals. Visualization is used to enhance the understanding of knowledge by reducing cognitive stimulation. People are often able to understand the information presented in a shorter period of time or to a greater depth by using visualization tools [3].

2.1. Historical perspective and Definition of 3D Visualization:

It is no wonder 3D visualization through visual imagery has been a significant way to communicate ideas from the dawn of man. Visualization is an ancient art, which traces its lineage back to some of the human race's earliest and most remarkable structures. Going back at least to the ancient Egyptians, imagination was revitalized in the Renaissance era as artists started to represent churches and homes not yet constructed in different styles.
3D visualization is defined as "any image or animation technique for communicating a message [4]. There are two connotations to the word "visualization." Visualization can refer to the practice people perform when creating an internal image of real-world or abstract entities. Visualization can also refer to the mapping process between abstract or real-world objects and their graphic representation; this process includes decisions regarding metaphors, setting, and interactivity [5]. What's interesting, though, is the pace at which advances are taking place in 3D modeling and 3D rendering technology, and how this affects the buildings we build and live in [4]. The art of creating two-dimensional and three-dimensional images showing the attributes of a proposed architectural design is architectural rendering or architectural visualization. New technology is changing the way we build it, in a way that just 15 years ago wasn't possible. The 3D rendering and architectural simulation software help architects and designers to determine "proportions" and "scales" using intuitive interactive 3D modeling and to simulate the effects of lighting, ventilation, and acoustics in internal environments. Today 3D artists are getting so

good at their craft that they can produce realistic 3D renderings of buildings, giving customers a precise 3D visualization of the proposed design. Such suggested architectural visualizations could represent everything that the client needs from the scale, textures, interior furnishings, etc. and are frequently depicted along with "architectural scenes" where daily activities are carried out.

2.2. Why Are Different 3D Rendering Styles Important for Architecture? [6]

The type of rendering style that you choose will depend on the design intent. You need to remember who the target audience is when designing architectural plans and what the layout will be used for. This will significantly affect what kind of rendering technique and style you like. For example, a photorealistic 3D exterior rendering service is a great choice if you're creating a design of a residential property that potential buyers will view. Potential buyers will have a clear visualization of the looks of the property. Alternatively, if you're creating a proposed design to exhibit a potential new type of architecture, you can choose a futuristic style of rendering. In short, architecture 3D rendering styles are needed to fill in a number of purposes. Analyze your design purpose and choose a style to suit and render.

2.3. From Manual Representation to 3D Rendering: [6]

3D modeling is a superb technique, which is commonly used in architecture. Architectural drawings were finished by hand in earlier ages. The phase was slow and it could take days. The findings were amazing, but it was inefficient for the time, cost and effort involved. Architects and designers can now use powerful computer software to create amazing 3D visuals. They are able to develop realistic and detailed architectural plans without putting a pencil on paper. It changed the cycle and gave the business an entirely new way of working. Most people believe 3D modeling should be used only to achieve photorealistic results. Although it is one of the most desirable kinds of rendering, there are most other types available.

Most views lean towards the perfect architectural rendering and 3D rendering images that we see today as the present and that we are going to move more into the field of Virtual Reality in future. Virtual reality or VR, which wasn't considered "science fiction" long ago, looks like the next big thing. Not just for the designers and architects, but for everyone. Architects and designers will be able to build 3D models of their work in full and use VR to bring their customers "into" the experience. We have had the opportunity to do this for quite some time now, but it will give viewers a completely different experience to actually put on a headset and let the senses feel the sounds and spaces. A truly "true" experience. Many people may call VR a game-changer [4].

3. Architectural Design Visualization List: [7]

3.1. Hand Drawing

Drafting and developing software is just a device in the architects ' hands to ease the workflow and reduce the precious drawing production time. Even in our technologically advanced world, there is no more basic and valuable skill than hand sketching. The initial idea should be clear and concise and easy for colleagues and customers to communicate. Different architectural manual rendering techniques like magic marker, colored pencil, charcoal, water-ink, linear rendering, dry/ fresh black marker, scrubber, pastel, normal pencil, match ink, tea, bleach, dry colored marker, correction fluid.

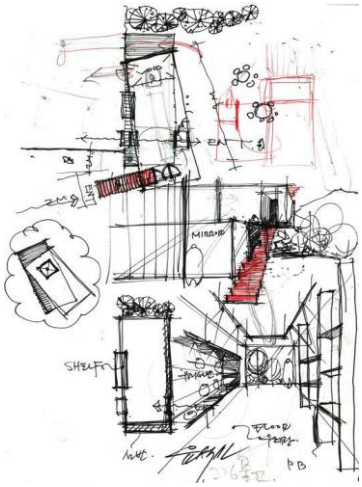

Fig. (1), hand writing technique https://www.arch2o.com/architectural-design-software/

3.2. SketchUp

We strongly believe that in 3D SketchUp, architects should start the conceptual phase, allowing the user to make 3D designs quickly and easily. However, many of its export features are disabled it can be downloaded for free. Since Google purchased its copyrights it has become extremely popular in terms of cost and usability. It's one of the easiest to understand programs but its simplicity also means it has limited rendering capabilities. Nonetheless, conveying first ideas is still a powerful program and it also offers a huge library of components particularly for domestic architecture. Object, surface, and material have their own unique texture that is definitely a plus. Its biggest advantage is still its user-friendly interface to date.

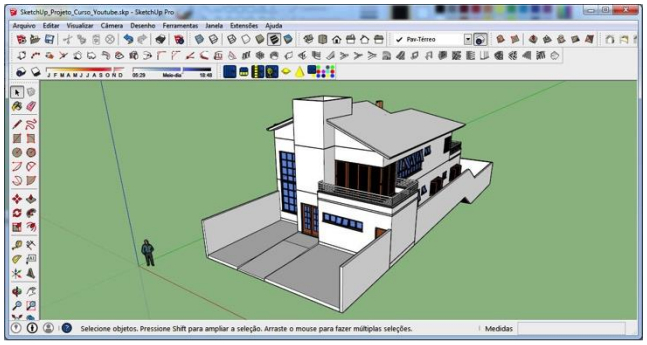

Fig. (2), SketchUp software https://www.arch2o.com/architectural-design-software/

3.3. AutoCAD

AutoCAD is the old dominant player in the software architecture market. It is so well known among students and professionals that, when moving files throughout the design process, it is unlikely to face any compatibility issues. This creates solely symbolic drawings and is typically the step-stone program for 3D modeling. The use of Auto CAD gives a decent draft with standard drawing conventions and measurable details of construction. AutoCAD Architecture is another version of AutoCAD, which is built specifically for architects. It has features that allow architects to create more efficient drafting, producing recognizable designs and documents.

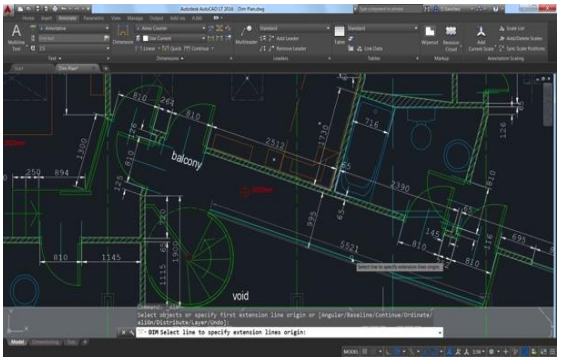

Fig. (3), AutoCAD software https://www.arch2o.com/architectural-design-software/

3.4. V-Ray

Fig. (4), V-Ray plug in https://www.arch2o.com/architectural-design-software/

For practical visualization, V-ray is simply the best. It is a plug-in that makes a nice rendering of Sketch Up and ArchiCAD. The cleanest textures, darkest darkness and brightest whites are the most accurate representation of the conditions of the real world. If the goal is to create a compelling style for the customers in the spaces, V-Ray will be the best option. The vast material library and services provide a variety of options for bringing the architecture design to the next level in lights, surfaces, and practical textures.

3.5. 3D Studio Max

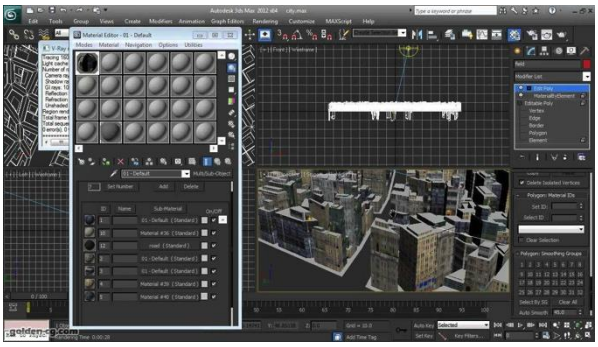

Fig. (5), 3D Studio Max software https://www.arch2o.com/architectural-design-software/

Though 3DRhino is spreading at an exponential rate, due to its parametric plugins and features of smooth modeling. And 3D Studio Max still remains the 3D market's most successful software. Things have changed since those primordial days of computer graphics and 3D Studio (the program running under DOS). 3D Studio Max applications have found their way into much more aspects of work-life in just the last half-decade than anyone would have expected. It has modeling capabilities and a modular plugin architecture that can be used on the Windows platform of Microsoft. It is frequently used by video game developers, many TV commercial studios, and studios for architectural visualization.

3.6. Revit

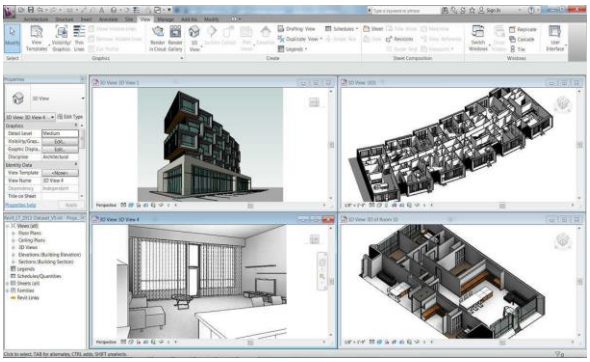

Fig. (6), Revit software https://www.arch2o.com/architectural-design-software/

Revit is the all-in-one 2D and 3D project program that delivers a complete project performance including modeling, rendering, and 2D building documents. We can use actual walls, floors, pillars, columns and other building components instead of lines and circles and also real-world features of the physical building such as windows and doors. It is compatible with AutoCAD, so inserting a DWG file and using it as a trace reference for starting to shape your model is pretty simple. One of its greatest advantages is that every change you make to the model, including plans and elevations, is updated in all perspectives. This significantly reduces coordination and drawing time.

3.7. Photoshop

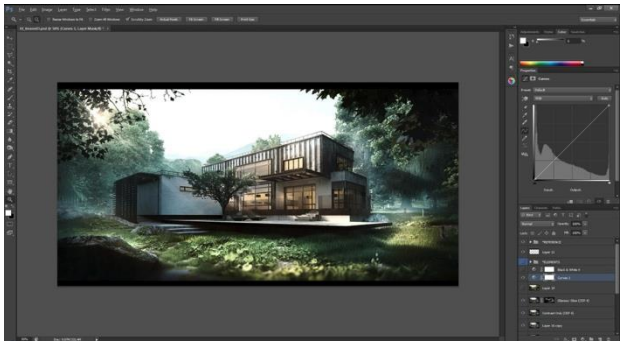

Fig. (7), Photoshop software https://www.arch2o.com/architectural-design-software/

Knowing how to use Photoshop is vital when creating renderings, whether it's a section, elevation or plan.

It is a program producing high-quality image, ideal for final renderings and touch-ups. You can give your rendering the atmosphere and style you want with very few alterations with its familiar layering method. It is used to process pictures, to add textures, environments, objects, a sky, etc. Fixing and editing scans of your work and making vignettes for the final presentation is also a great way.

2.8. InDesign

Fig. (8), InDesign software https://www.arch2o.com/architectural-design-software/

In Layout, a layout system is essentially ideal for creating large display sheets from booklets too. You can organize objects into presentable types including text, shapes and photographs and are also ideal for document production, such as resumes and portfolios. We can set up font types/ sizes, page master pages with page numbers, which helps increase productivity and consistency of documents. The app also gives us the ability to package and bring your files together with you so that you can work at school or at home without the hassle to make sure you copy and take and separate file with you.

4. Questionnaire and interviews.

4.1. Institutional Framework.

The purpose of this Inductive Study is to: identify the main effects and shortcomings in using visualization techniques in architecture education and; to identify how new architecture programs can overcome these shortcomings, and how it will facilitate achieving the intended learning outcomes. The research depends on the Inductive Methodology, using interviews, and an online questionnaire with different target groups to achieve the targeted objectives. The inductive analysis starts by identifying the study's target groups, which vary in age, experience, and backgrounds. Three distinct groups have been outlined:

- Academics (Egypt & Europe)
- Practitioners (Egypt & Europe)
- Senior Students &Fresh Graduates (Egypt & Europe)

Data Collection Tools

The research developed different data collection tools for different target groups. Separate interview guides were developed for academics, practitioners, and specialists of ICTs, while an online questionnaire for students and fresh graduates was launched on the IMPAQT website [8].

Data Collection Summary

Interview Guide for Academics and Practitioners: 25 interviews conducted.

Interview Guide for ICTs Specialists: 15 interviews conducted.

Online Questionnaire (through IMPAQT website): 100 participants.

4.2. Interview.

The interview guide consists of 3 main questions:

1. What do you think about the integration of Design-aid tools in Architecture Education (Parametric design tools/ Environmental simulation programs)? Advantages/ Disadvantages.
2. What do you think about design visualization tools (Drawing skills and 3D modeling skills/ Virtual reality…) in Architecture Education whether as design thinking tools or for the representation of the end-result? Advantages/ Disadvantages.
3. What are your recommendations to integrate ICT contributions in Architecture education?

4.3. The On-line Questionnaire.

The on-line questionnaire was designed to evaluate the opinions and satisfaction of the students and the architect fresh graduates. The questionnaire consists of the following questions:

1. Poor drawing skills and 3d modeling skills as design thinking tools (manual).
2. Poor drawing skills and 3d modeling skills as design thinking tools (digital)
3. The poor overall presentation of design concept skills.
4. Courses did not include utilizing computer programs and tools needed for an architecture graduate.
5. Poor visualization of the design end-result (lack of virtual reality, full-scale modeling).
6. Poor experience in user participation methods (participatory design).

4.4. Discussion and Analysis.

In this part, the research will compile and summarize the most common answers of the participants in the interview and also analyze the in-line questionnaire results.

4.4.1. The first question in the interview was about:

What do you think about the integration of Design-aid tools in Architecture Education (Parametric design tools/ Environmental simulation programs)? Advantages/ Disadvantages.

First: Advantages of integration DAT's in Architecture Education:

The majority of the participants agree that the integration of Design Aid Tools in architecture education is a very powerful tool, and has many advantages. As its influence in two levels first, in students' knowledge to achieve the software input and complete the simulation motion, second in the architecture product concept and form. We can summarize the common answers in the following points:

1. Decrease the gap between students and the labor market, and enable students to use contemporary and trending design approaches such as parametric and sustainable architecture.

2. Help students to express their ideas and show their creativity freely, it is also a good vision towards the future as the industry is going into these tools heavily these days, meaning that the students who learned how to use or already used these tools in their learning environment are more ready to smoothly get involved in the market and be better architects.
3. Parametric design tools make the design process a mathematical-based one, which mean the students have to think logically and mathematically in order to design their forms, which give them unparalleled customization options based on precise parameters, while in ordinary CAD process the form depends on morphing and sculpting which may give the same forms but with low precision and very hard construction methodologies.
4. Environmental simulation tools are now a core part of any design process worldwide, knowing the environmental performance of the design virtually is essential, not only to have a glimpse but to make alternation in the decision making so that such form can be more effective environmentally. This design thinking helps the students to know the constraints of the building's surroundings and how to use them to make the best of the proposed design.

Second: Dis-advantages of integration DAT's in Architecture Education:

The integration has no direct dis-advantages but of course, relying heavily on them without prior education to traditional design techniques can lead to students who know tools but have no sense of design, or no talent to feel good from the ugly within the design process, which is essential for architects aesthetically. Also, these tools often need a proper knowledge of programming and coding which is somehow out of architects' focus and maybe an obstacle against educators to master these tools and transfer their knowledge to the students. The participants agree on shifting the DAT's integration from a design aided by software to a design based on software. We can summarize the common answers in the following points:
1. Students may lack the knowledge to use as the right scientific way, which may lead to wrong misleading results if they haven't good supervising.
2. Students thought that they know if they go through the simulation programs for only some steps, which leads to neglect the physical and architecture knowledge.
3. The rapid production of soft wares leads to the random use of soft wares depending on the effective showing effect.

4.4.2. The second question in the interview was about:

What do you think about design visualization tools (Drawing skills and 3D modeling skills/ Virtual reality…) in Architecture Education whether as design thinking tools or for the representation of the end-result? Advantages/ Disadvantages.

First: Advantages of using Visualization Tools as design thinking tools in Architecture Education.

Design visualize tool is a very important tool on design processes, which Architects can't deny. In the past, it was the freehand perspective and evolved passing through 3d modeling, VR and 3d lazar cutter. Every step we take in this field helps students to imagine their models. We can summarize the common answers in the following points:
1. Enable students to clearly illustrate their ideas, evaluate their designs and explore different design possibilities.

2. Give a massive push for the imagination of students and help them to showcase their work to juries as well as creating proper user scenarios.
3. Help them get more involved in the market needs and fastly make good portfolios. As the industry heavily relies on visualization tools to market their properties, it is essential for students to master such tools himself and so that he can make their ideas come true from design to visualization.

Second: Dis-advantages of using Visualization Tools as design thinking tools in Architecture Education:

The participants agree that the visualization tools for 3D modeling can't replace the initial design thinking using a pencil and paper. The student should already have proper knowledge of aesthetics in architecture and can sense proportions, orders, etc. before he can rely on 3d modeling tools. Also, students should learn to use visualization tools that are BIM compatible so that they can integrate it into construction plans, environmental simulation, and other further processing tools. The main common answer is that visualization tools can:

1. Make the students' presentation-oriented caring only for impressive or good-looking projects while neglecting function and other assets.

4.4.3. The third question was about:

What are your recommendations to integrate ICT contributions in Architecture education?

All the participants agree that ICT integration is for sure an essential part of developing any educational criteria of architecture, but it should be integrated with careful planning so that the students don't get lost in the technological part of such tools. It should be balanced well with traditional topics in architecture such as freehand sketching and model making, as well as design theories and history. We can summarize the common answers in the following points:

1. Using programming and BIM
2. Integrating these tools in design and environmental courses, and not to be stand-alone courses.
3. ICT integration can't be applied properly without adequate facilities. Depending on the students' hardware or the tools they already have is no option in this matter. The following labs are needed to give the students a good experience regarding ICT in Architecture:

-Virtual reality lab: consists of large stereoscopic screens, VR ready computer hardware, VR glasses for both mobile and PC use. For software, licensed game engine tools are needed as well as programming interface. It is recommended to also have 3d scanning hardware tools and proper Point Cloud (Voxel conversion) software.

-Fab Lab: consists of CNC machines, proper PC hardware, 3D printers (medium or large scale), building materials (wood, plastic, light metals, glass or plexiglass), proper space for work in progress and workshops. For software, licensed mesh editing programs and parametric design tools.

-Environmental Design lab: Consists of heat sensing tools (infrared), user comfort measuring tools, powerful computers to do wind tunnel simulations, crowd simulation, and environmental form optimizations. Programs such as DIVA, Radiance, Ladybug, Revit, and Autodesk insights are a must for such a lab.

4.4.4. The On-line questionnaire:

The online questionnaire consists of 6 questions and was targeted undergraduate students in architecture departments and fresh graduates. The participants were around 100 persons. The questionnaire was assessing the answer from 1 to 5, as 1 is considered "No Problem", and 5 is considered "Major Problem", see figure (9).

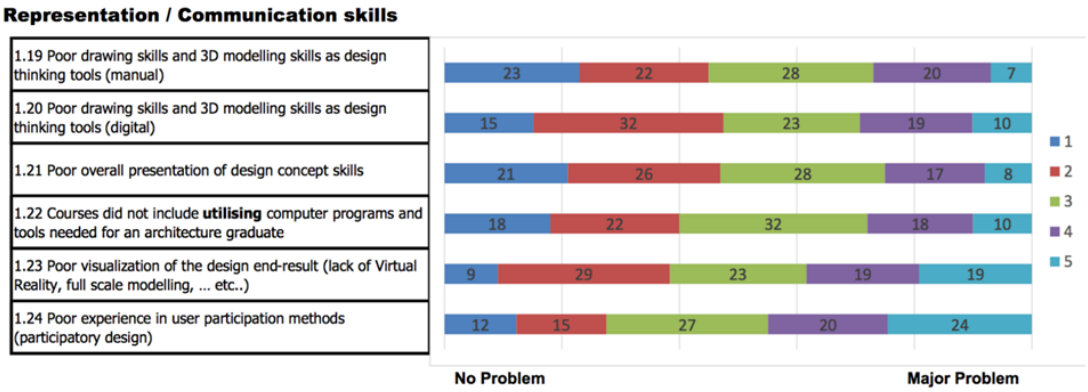

Fig. (9), the on-line questionnaire between participants
Source: https://impaqt.edu.eg

Poor visualization abilities seem to be a clear problem facing architectural students expressing their ideas, around 100 participants stated this as a major to a mild problem. To some extent, the same can be applied to the courses where computer programs were not included. With the technological advancements of visualization tools, the traditional techniques of drawing and 3d modeling seem to have less impact as a problem for students [8].

Table (1), Analysis of the online questionnaire
Source: the researcher

Poor drawing skills and 3d modeling skills as design thinking tools (manual).	It is noticeable that more than 50% of the participants see the poor drawing skills like design thinking tools (manual techniques) is a mild to a major problem they face in architectural education (55). On the other hand, 45 participants see that there is no problem.
Poor drawing skills and 3d modeling skills as design thinking tools (digital)	Topics like poor drawing skills and 3d modeling skills as design thinking tools (digital techniques) were mostly divided evenly between those who consider it as a major problem and those who don't. This is a clear indicator of the awareness of participants about the importance of design-aid tools and their role in the learning process and ideas expression, where the lack of these skills seems to develop a hardship for students to go forward with their design thinking.
Poor overall presentation of design concept skills.	The poor overall presentation of design concept skills account as a mild to a major problem to around 47 and 53 participants

Courses did not include utilizing computer programs and tools needed for an architecture graduate.	The majority of the participants see that there is a big problem if courses did not include utilizing computer programs and tools needed for an architecture graduate.
Poor visualization of the design end-result (lack of virtual reality, full scale modeling).	The majority of the participants see that poor visualization of the design end result is a major problem
Poor experience in user participation methods (participatory design).	Poor experience in user participation methods (participatory design) seems to be a clear problem facing architectural students expressing their ideas, around 71 participants stated this as a major to a mild problem.

5. Declaring the Road Map:

5.1. Developing guideline to integrate Visualization Skills in Architecture Education.

The belief is that the success of a technology-based education depends to a large extent on the technology is accessible, and easy to use by teachers and students. In this part, the research tries to draw sequential guidelines about integrating visualization soft wares to the students in the different levels of architecture education.

1. Teaching drawing skills and freehand sketching as a design thinking tool in the early years in architecture program is a must both in separate courses "like visual training courses, shade, and shadow, Basis for design …. etc) and integrated in different courses "like early courses of design studio, and early courses of building construction).
2. The first step in integrating the digital visualization skills is to provide the students of Architecture and Urban Design Departments access to free educational licenses of all Autodesk products, the leading company worldwide in the marketing of software related to CAD (Computer-Aided Design) and BIM (Building Information Modeling), two technologies closely linked to teaching and professional frameworks of architecture and construction.
3. In this first level the main objective is to provide students with spatial skills and the ability to represent 2D and basic 3D models using AutoCAD® and Sketch Up, which are the basic soft wares for all approaches and working as a guide tool for architecture students and beginners, see figure (10).
4. In the second level, the instructors should introduce different approaches to the students to improve their representation skills by using more advanced tools and classify the software approaches into two groups: Building Information Management Software or Revit®, and the Sketching & Modeling Software 3DStudio®. The decision now is to split the students into two groups depending on their passion and on a brainstorm with them, see figure (11).
5. In the third level, the students should focus on one of the software groups and use them in the studio application. Each one of the 2 software groups consists of three phases, and each consists of 3 stages, see figure (12).

- First Stage: Basic knowledge
- Second Stage: Tool Implementation
- Third Stage: Advanced Application

Fig. (10), Auto CAD Vs. SketchUp
Source: Amr Atef & Shimaa Ali "un published lecture presented at Smart Learn Conference in ASU 2018"

Fig. (11), introducing different approaches to the students
Source: Amr Atef & Shimaa Ali "un published lecture presented at Smart Learn Conference in ASU 2018"

Fig. (12), splitting up the students into two groups
Source: Amr Atef & Shimaa Ali "un published lecture presented at Smart Learn Conference in ASU 2018"

5.1.1. 1st Approach: Building Information Modeling, see figure (13).

1. REVIT	Software is specifically built for Building Information Modeling (BIM), empowering design and construction professionals to bring ideas from concept to construction with a coordinated and consistent model-based approach. It includes the functionality of all of the Revit disciplines (architecture, MEP, and structure) in one unified interface.
2. NAVISWORKS	Used primarily in construction industries to complement 3D design packages (such as Autodesk Revit, AutoCAD, and MicroStation) Navisworks allows users to open and combine 3D models, navigate around them in real-time and review the model using a set of tools including comments, redlining, viewpoint, and measurements. A selection of plug-ins enhances the package adding interference detection, 4D time simulation, photorealistic rendering, and PDF-like publishing.
3. DYNMO STUDIO	It is a programming environment for computational BIM design that enables you to use visual logic to design workflows and automate tasks.

5.1.2. 2nd Approach: Modeling & Visualization tools, see figure (14).

1. 3DS Max®	3D modeling and rendering software helps you create massive worlds in games, stunning scenes for design visualization and engaging virtual reality experiences.
2. V-Ray	It is a rendering engine that uses global illumination algorithms, including path tracing, photon mapping, and irradiance maps and directly computed global illumination.
3. Rhinoceros	(typically abbreviated **Rhino**, or **Rhino3D**) is a commercial 3D computer graphics and computer-aided design (CAD) application software developed by Robert McNeel & Associates, an American,

	privately held, an employee-owned company founded in 1980. Rhinoceros geometry is based on the NURBS mathematical model, which focuses on producing a mathematically precise representation of curves and freeform surfaces in computer graphics (as opposed to polygon mesh-based applications).
4. **Grasshopper**	Used in some of the most ambitious design projects of the past decade, Grasshopper, like Rhino, has become a robust development platform. Grasshopper provides the foundation for many third-party components ranging from environmental analysis to robotic control. The Grasshopper bundled with Rhino 6 is the same Grasshopper you have been using, plus many enhancements.

The two approaches are not parallel and no one of them can be an alternative instead of the other one. The two approaches are integrated with each other. The first approach, which concerns with the Building Information Modeling (Revit, NAVISWORK, Dynamo Studio), is mainly considered as a design thinking tool, simulation tool, also modeling and visualization tool. The second approach, which concerns with modeling and visualization tools (3d Max, V-Ray, Rhinoceros, Grasshopper), is mainly considered as modeling, visualization, and drafting tool.

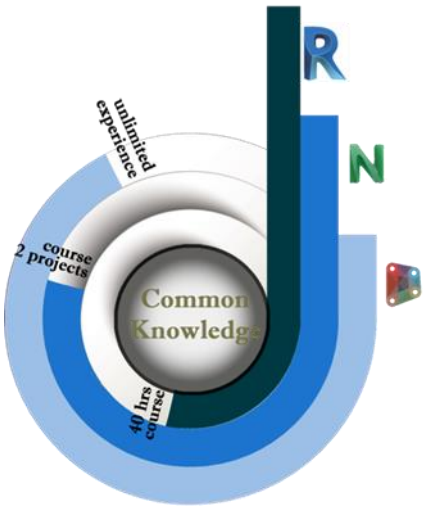

Fig. (13), the first approach of the BIM (Building Information Modeling)

- **Design thinking tool**
- **Simulation tool**
- **Modeling & Visualization tool**

Source: Amr Atef & Shimaa Ali "un published lecture presented at Smart Learn Conference in ASU 2018"

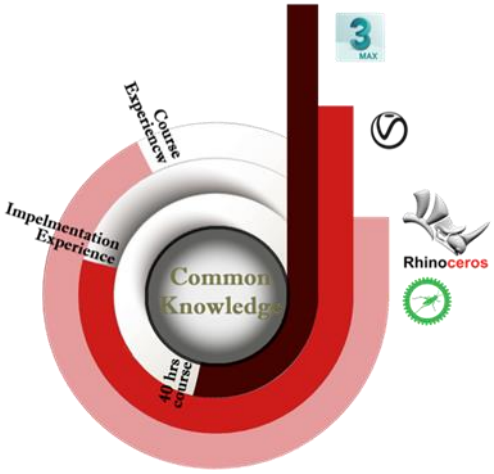

Fig. (14), the second approach of the Modeling and Visualization Tool

- **Visualization**
- **Drafting tool**
- **Modeling tool**
- **Animation tool**

Source: Amr Atef & Shimaa Ali "un published lecture presented at Smart Learn Conference in ASU 2018" [9]

5.2. Visualization Model to Plug-inn the Visualization Techniques in the Architecture Curriculum.

Skill is defined as an ability and capacity acquired through deliberate, systematic, and sustained effort to smoothly and adaptively carryout complex activities or job functions involving: Existence and presence of the software courses in the architecture curricula as separate course or not is depending on the program itself and the distribution of the credit hours between the courses and also the vision of the program creator and coordinator, some of that belongs to the vision of the institution itself. In this regard, we have 2 opinions: On one hand, some see that the presence of software and computer Aided courses in the curricula is a must. On the other hand, some see there is no room for software and computer courses and the students must learn it by themselves, with some advice from the instructors. Even we are with this or that, the point that all agree about this integration of the visual techniques even manual or digital software is a must and much more important to manage this from the first year of architecture to the graduation year. And the issue is how to manage the plug-inn of some or all these different visual techniques as a design thinking tool and where and when to achieve an integrative educational approach.

In this section, the research proposes Model to identify the different visualization techniques distributed on the different modules in Architecture Education. It could be easier if the research work on the exact program, but it is preferable to design the map, in general, to be applicable to any Architecture curriculum and flexible to any future technological updates. The Model starts with identifying the different modules and core courses in any architecture program, it could diver from program to another with the focus of the program and the percentage of the credit hour in each module, but it should be the same core modules.

1. **Visual Training and Basis for Design***:* Usually introductory course in the first and/ or second year of the program to introduce the students the basic elements in architecture and exercises on freehand drawing sketching.

2. **Theories of Architecture:** Usually in the earlier years (year 1, and two), to introduce the students with the basic theories of architecture, concepts, design methodology, design thinking, problem-solving, different building types, …etc. It is considered as the theoretical lectures for the design studio, and better to be integrated and coordinated with the design studios.

3. **History of Architecture***:* Usually in the earlier years (year 1, year2), to introduce the historical background of architecture to the 20^{th} century and shedding light on the current new trends in architecture.

4. **Environmental Analysis& Building Physics:** More in the intermediate to advanced levels. Introducing the environmental analysis, integrated building physics, and acoustics.

5. **Design Studios***:* Continuous sequential courses from the earlier year till the advanced years. Design studios are the integrated pool of all the courses in the architecture program.

6. **Building Construction:** In the earlier years (year 1, 2) to introduce the basics of the building construction methods, definitions, and techniques.

7. **Execution & Working Drawings;** In the advanced years (year 3,4) to introduce the detailed working and shop drawings with all specifications and tender documents.

8. **Urban Dimension***:* From the intermediate to the advanced level, starting with introducing the sense of the city, to design small clusters, neighborhood, district, and so on. In the advanced

years, the integration between this level and the design studio is a must even the perspective is designing in the existing urban areas or in the new cities.

9. **Graduation Project:** The integrative course, which compiles all the knowledge, skills, and experiences gained through the whole program. Always in the last year of the program, and the student should pass a minimum 75% of the total credits of the program to register in this course.

Table (2), the plug inn of visualization techniques
Source: the researcher

Module of Architecture Education	Level 1 / Year 1	Level 2 / Year 2	Level 3 / Year 3	Level 4 / Year 4	Proposing Visualization Techniques
Visual Training and Basis for Design					Manual
					Digital
					Soft ware
					VR
Theories of Architecture					Manual
					Digital
		Photoshop			Soft ware
					VR
History of Architecture					Manual
					Digital
					Soft ware
					VR
Environmental Analysis & Building Physics					Manual
					Digital
		Ecotect	Design Builder	Envi-met	Soft ware
					VR
Design Studios					Manual
					Digital
	AutoCAD/ sketch up	3DS Max®	V-Ray	Grasshopper	Soft ware
					VR
Building Construction					Manual
					Digital
		REVIT			Soft ware
					VR
Execution & Working Drawings					Manual
					Digital
			NAVISWORKS	DYNMO STUDIO	Soft ware
					VR
Urban Dimension					Manual
					Digital
		AutoCAD	GIS	GIS	Soft ware
					VR
					Manual

Graduation Project					Digital
					Soft ware
					VR
Key					
Not apply to this course	Not apply to this level	Manual techniques	Digital techniques	Indicating software	VR/ AR

5.3. Methodology of Software integration in Design Studio Courses:

Design Studios are continuous sequential courses from the earlier year till the advanced years, and the integrated pool of all the courses in the architecture program. In this part the research tries to propose the integration of the visualization techniques, which varied between "manual drawings, different digital software, and virtual reality" in Design Studio courses, from year one to year four.

Table (3), the plug inn of visualization techniques into Design Studio Courses
Source: the researcher

Courses	Year 1	Year 2	Year 3	Year 4	Visualization Techniques
Design Studios	✓	✓	✓	✓	Manual
	✓	✓	✓	✓	Digital
	✓	✓	✓	✓	Soft ware
	AutoCAD/ sketch up	3DS Max®	V-Ray	Grasshopper	
	✓	✓	✓	✓	VR

The proposal works on the integration between manual and digital techniques in the studio, considering the hierarchy of the software programs from year one to year four, and the importance of manual drawings in the first phase of design and sketching.

In year one:	The focus will be on manual drawings mainly, and some basic digital software like AutoCAD, which is the step-stone program for 3D modeling or Sketch up for easily and quickly 3D designs for first ideas.
In year two:	The focus will be on teaching 3DStudio Max to
In year three:	The focus will be on teaching V-Ray to achieve practical visualization. V-Ray is the vast material library and services provide a variety of options for bringing the architecture design to the next level in lights, surfaces, and practical textures.
In year four:	The focus will be on teaching Rhinoceros and Grasshopper to produce a mathematically precise representation of curves and freeform surfaces in computer graphics (as opposed to polygon mesh-based applications).

Conclusion

This study set out to investigate the integration of the different visualization techniques both manual and digital in Architecture Education and managing the rapid change in the different computer techniques and its effect on Architecture Education. The research depended on the inductive methodology using interviews with academics, practitioners, ICT specialists to investigate their opinions in the current education process and the facing challenges. Also, the researcher used the on-line questionnaire to be distributed online between architecture students and fresh graduates to build upon their needs. All the stakeholders agreed with the necessity of the integration between the manual and digital techniques both in architecture education, and the importance of keeping up the rapid technological improvements not only in the field of visualization but also in simulation programs, building physics and building technology. The research ended up with Road Map describing the way to inject the different types of visualization techniques between the different level/years of architecture education. Then divided the visualization soft wares into two groups: the first is the group of Building Information Modeling, which consists of (Revit, Naviswork, Dynamo studio), and considered as design thinking, simulation, modeling, and visualization tool, the second group is the group of Modeling, which consist of (3d Studio Max, V-Ray, Rhinoceros, Grasshopper), and considered as a modeling, drafting, presentation, animation tool. Finally, the research proposed a Model with different techniques and soft wares distributed between courses/ core modules in architecture education.

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