Incorporating 3d Printing Techniques, As A Step Forward for Upgrading the Design Process in Architectural Education

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Introduction

The (3DPM) nowadays is spreading widely in many fields such as architecture, interior design, furniture manufacturing, education and many other industrial and medical fields, meanwhile the natural resource management is becoming more important and common strategy all around the world.

However, the last achievements in (3DPT) allowed reaching a full real model in its real scale with using a new sustainable material which enabled the engineers to understand their product in a direct way and in the same way it presented an effective design and production tool to the engineering students. Even now the common trend is using the Visualization improvements through representing designs using different techniques and technologies like Building information Modeling and rendering software.

Despite that the (3DPT) utilization still in its beginning in all fields. However, the return benefit driving these digital fabrication technologies more and more to the foreground. Also, there is a lot of views towards the depending on these technologies in a lot of fields. Among all those rushing developments in digital fabrication technologies, 3D printing is the most promising technology in achieving fast, accurate and highly efficient product with low cost. Karlgraad vision was that (3DPT) will obsesses the production processes in a lot of fields through 2015-2025 period. The wide spread of using 3D printers nowadays comes out from the availability and easy access to this kind of technology and its easy operations and requirements and the aim of improving the production chain of design, modeling and manufacturing processes.

3D modeling and digital fabrications techniques are considered as an essential core in industry and innovations developed through the widespread application of 3D technologies have led to breakthroughs in medical science and machinery automation, and even in education. Due to the huge growth in demand, designers, manufactures, and consumers are always looking for a way to fulfill that demand, 3D printing is considered the perfect solution to many and that’s for its flexibility and relative mobility of it, which recommended it to meet the growth in demand for the developing countries. It also would help students too, and since that all software which helps in modeling is all based on surfaces' underlying mathematics, which is also used in machines, thus making new technological outputs are possible such as 3D printing, milling and laser cutting. That’s being the case that this study focuses on the computer aided designs and 3D printing technology to check the students' comprehension, enlightenment and design intelligence. A two experiments were done using Google Sketch up as (3DVM) modeling software and a (3DPM) of it were compared to see the effects of the two methods on students' comprehension.

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The Research problem

Due to the fast and continuous development in technology , a lot of new technologies have come out to our world which offred a lot of facilities and capabilities in fabrication and production. However, those technologies are not used with the perfect way due to the lack in awearnes about how they work and how they could help in improving the educational field for architectural design and from this we could graduated a professional well updated architects with the last technologes in design and production process, so that the research disucsses the lack in the architectural educational system in using that technology, and how it will impact on the students and their production if it is applied to thier educational courses.

Hypothesis of the Research:

There is a lack in getting the maximum utilization from the latest development in the Digital Fabrictaion techniques , and to be more accurate ,that research foucses on the Additive Manufacturing Technology "(3DPT)" and that using it as a design and production tool in the architectural educational systms will improve the architectural students' spaitial and design cognition and enhancing their comprehension capabilities.

Aim of the Research

The research is focusing on showing the effective role of implementing the (3DPT) in the architectural education systems and showing its effect on improving the architectural students' spatial and design cognition and enhancing their comprehension capabilities.

Research Methodology

The research is built on an experiment to analyzing the impact of the (3DPT) utilization on a sample of architectural students to show how it will affect their design cognition and enhancing their comprehension capabilities, and that was through representation of a model with both methods (3DVM) and (3DPM), and present both for a random group of 30 students to make a survey for checking the impact on their spatial and design cognition.

Research Range

The research takes a limited scope, which is the effect of this technology on architecture students in the first educational stage for them in the study, which are the first and second academic years, where this stage represents a preliminary scope and the cornerstone of architectural education and the Design and Modeling and space perception of students.

Nomenclature:

Model General Form (MGF)- Details and Structure (DS)- Car park shade (CPS)- Students Number (S)- Wall Openings (WO)- Roof Details (RD)- Textures (T)- 3D Visual Model (3DVM)- 3D printed model (3DPM)- 3D Printing Technology (3DPT)- Computer Aided Design (CAD)- Computer Aided Manufacturing (CAM)- Computer Numerical Controls (CNC).

THE TRANSFORMATION FROM (3DVM) TO A (3DPM):

The 3D visual models on computers supplement the users' understanding of the project and its physical environments that shows the different interaction conditions. Later, most of the projects that was presented in 2D had limits. Moreover, the teaching methods through using 3D models with (CAD) programs guides the students to approach the construction comprehension. Even that, this method could not help the students to realize the needed result, especially for those kinds of projects which is complex and have a lot of details. And as a result of the development of digital fabrication technology, however, (3DPM) is considered the most accurate method for producing the design identically as its digital model source. This Additive

Manufacturing method is formed when the material melts and out from a printer nozzle to form layers placed over each other to build the model. Z Corporation company mentioned that the wide spread of using these technologies had made a gradual improvement on the engineering education fields. Also, Huang and Tien-Chi assert that common use of (CAD) and (CAM) and applying (CNC) technology and robotic arms have a remarkable change in the architectural education to be more intelligent and efficient to our era. From another point, these technologies become more common and widely spread and affordable. Thus, the digital fabrication and customization technologies got more attention and more focus to apply it in all fields.

Charles Hull was the first who developed the (3DPT) to print an object from a digital model in 1984.That was known as the stereo lithography technique and he got it patent in 1986. While in 1993 the Massachusetts Institute of Technology (MIT) received the patented for another type of 3D printing techniques that is similar to the used technology in inkjet 2D printers and it's named as "3-Dimensional printing techniques". In 2005 Z Corporation lunched an innovation product, called "Spectrum Z510". That was the first high-definition and colorful 3D printer in markets. Huang and Tien-Chi considered the deep and wide impact of (3DPT) on education has driven the need to help the students to develop their intelligent design.

3D printing is one of the leading technologies which can benefits from considering the design issues. Few studies in various research fields are based on (3DPT) but they have many limitations. In same time the artificial intelligence software and equipment are obviously a necessary resource for fabrication in architectural design. The digital evolution and fabrication are boosting the contemporary architectural design and offering it a noticeable potential for the deep understanding to the relation between the buildings' design concept, manufacturing and its development phases. Design and manufacturing processes become simpler when the structural parts can be directly assembled from its concept drawings, shipped to the site, and assemble it to form the entire building. the Digital fabrication techniques provides a different method, like product prototyping, decoration hoods, pipe welding, structural steel production, cladding panel design, and its manufacturing. Since 2005, 3D printers have been evaluated to enlarge its scale and printing dimensions to occupy (3DPM) and reach the real scale, in same time costs also have Significantly decreased, and that’s due to the competition between the 3D printing service providers. For example, a survey was done recently showed that there is a sharp rise in the last few years in manufacturing of components with additive manufacturing methods. Therefore, this study aims to put a description to a digital architectural design studio experiment which is developed to explore the Merging between using the computer visual modeling software and its (3DPM) for the same design to check the students' construction comprehension. The utilization of additive manufacturing and (3DPT) would introduce a wide range of new skills and opportunities for developing a new teaching method in the architectural education systems.

THE 3D PRINTING INTEGRATION WITH THE EDUCATIONAL CURRICULUM:

In 1990 the additive manufacturing technology was immerged in a large number of fields and markets, and that was through its best-known form which is the 3D printing, despite that Bio printing is also derived from that technology. So, allowing the development of materials which is affected by water, time, light, biological behavior, or any other energy activation to be an essential method for producing the desired forms. The combination between this technology with its various techniques and tools and education field would offer new opportunities and intelligent teaching methods in different subjects, and as a result of this, a lot of studies and researches have discussed these possibilities in various disciplines. However, many steps are still lacking to achieve the expected results. Berman referred that these technologies have received more care in the educational processes in aim to help student to learn. That wide spread

and growth popularization of (3DPT) have affected gradually the industrial hardware and software, which by sequence made a change to the educational processes as well. Using the (3DPT) for producing the (3DVM) would facilitate the learning process in different fields such as design, engineering, art and architecture, while these technologies are in continuous improvements, there are many concerns that the slow improvements in the education methods and skills would prevent that technology from being used on a large scale .

Some universities use the (3DPT) in sciences in which teaching process is supported by creating (3DPM) through the experiments which tests the materials' mechanical properties. Also, it's used in studding the special settings like visual comprehension and the spatial visualization .However, that's a great challenge for the educational researchers to improve the spatial visualization ability of architecture students. Researchers proved that using the computer generated design visualizations could help students with the sufficient experience to improve their spatial visualization. The students' spatial skills are the essential and effective signs of success in understanding complex objects and interacting with the (CAD). With proven that using the (3DPM) in testing the material in the educational experiments it was clear that it fits to that purpose. For that, many universities integrated those technical experiments to the undergraduate research courses. Katsioloudis recommended using the (3DPT) as a teaching tool for engineering and spatial skills, and he supposed that it could help the students to understand the modeling process. Moreover, it would drive the students for maximal understanding to their (3DVM) through the (3DPM) than the other visualization techniques. However, there is a few studies which investigated the effect of the (CAD) and 3D printing as teaching aids on the students' skills. Therefore, this research inspects the impact of the (3DPT) utilization with its related 3D modeling techniques on the architectural students' design intelligence and their production.

The survey Design and analysis

A group of 30 students from the architecture department in faculty of fine arts Helwan university in Egypt were randomly chosen to participate in answering the survey the students were in the first and second year. A study designed to carry out an analysis for their Spatial perception. The survey was designed according to the models' characteristics, openings in their walls, general form, structure, roof form, details resolution. The answers were ranged from "Very Clear" to "Partially Clear" to "Not Clear". The experiment was on two steps, the first was to show the student the project model on Google Sketch up software from different perspectives, then the students checked the (3DPM) for the project and they were able to hold the project and rotate it and examined it. Then, they answered the survey which consisted of six questions about their perception and spatial comprehension through using the (3DVM) and the (3DPM). The survey was created about the project as a whole and also its details such as structure, roof form, openings, the car park structure to specify the output improvements, which gave them the chance to the deep understanding of the project and to compare their perception from both kinds of models. Collected surveys were analyzed to consider how the 3D printing improved the spatial comprehension and to achieve an answer for the researcher question which is searching for a difference in spatial perception observed through using computer aided design and (3DPM), and does the 3D printing helps the students to have a better spatial comprehension than virtual models?

The Survey Results

Interestingly that the results showed some differences among using the (3DVM) and the (3DPM) to achieve the clear spatial comprehension. Which show that the (3DPM) is more effective for the students' perception the same was observed through understanding the comprehension complex details like opening and structure. However, using both of (3DVM)

and (3DPM) as Representation methods for perception for the project were almost close to each other. Which suggests that the continuous development for improving comprehension experience using (3DPM) is needed for understanding the complex details of spatial visualization. Furthermore, students will need that technology to help them interpret the projects' complex details. Especially through the design development stage. Another suggestion from the artistic point of view is that the integration of (3DPT) with the educational systems would improve the artistic and esthetic sense and strengthen the learning practicing like experiential learning and performance. Therefore, the architectural education system resulted from that integration of these technologies into teaching can be identified through a promoting learning, improved skills, and the students' participation, while also helping the teachers and instructors to strengthen their performance.

Concolusions

3D technology is one of the most important inventions of our time, meaning that it works in various fields that can help in achieving and facilitating educational processes. More Details (3DVM) (3DPM) can be very useful for interior architectural design, furniture design and even urban planning. Especially for what is necessary for spatial operation. That 3D printing uses the aid of architectural construction to derive and understand special and complex shapes. Which removes all barriers for students and unleash their creativity in design. We used both CAD and (CAM), furthermore, we learned through education techniques and architecture through experiential education with students. This study examines the assistance of 3D printing technology, and the results are the benefits that will be ensured by 3D printing, building an architectural building through the developed learning framework.

1- Developing curricula and educational programs for studying architecture in Egyptian universities to keep pace with the continuous development in technology and digital implementation technology in all its forms, through the integration of a scientific and academic curriculum that provides architecture students with knowledge and use of the techniques of that technology as a basic tool within the design steps.

2 – Organizations and institutions entrusted with the supervision and follow-up of the architectural field in Egypt, such as the Syndicate of Egyptian Engineers, educational programs and scientific and cultural tools to introduce architects and graduates of architecture to digital manufacturing technology and its importance to the architect.

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