



RESEARCH ARTICLE

THE BENEFITS OF DIGITAL MULTIMEDIA AS A TEACHING AND LEARNING AID IN ARCHITECTURAL DESIGN STUDIOS

^{*,1,2}Ikenna Stephen Ezennia, ¹Patrick C. Uwajeh, ²Peter C. Agbonome and ¹Timothy O. Iyendo

¹Department of Architecture, Eastern Mediterranean University, Famagusta, North Cyprus via Mersin 10, Turkey

²Department of Architecture, Nnamdi Azikiwe University, PMB 5025, Awka, Anambra State, Nigeria

ARTICLE INFO

Article History:

Received 27th June, 2016
Received in revised form
23rd July, 2016
Accepted 15th August, 2016
Published online 30th September, 2016

Key words:

Design studio,
Learning,
Design process,
Architectural education
and Digitalmultimedia.

ABSTRACT

We live in a world characterized by the use of media and in the near future everything will be based on multimedia, and architectural pedagogy will not be an exception. Multimedia has a huge role to play in Architectural Education. Education is the knowledge and skill obtained or developed by a learning process; nothing is taught, unless it is learnt. It can be argued that architectural design process is driven by a method of communication between an instructor and students, which is part of a repetitive process where feedback, interventions, and reflections occur. This process is formed around the intentions to achieve multiple tasks or challenges: the communication and interaction between these tasks has not been adequately maximized over time. Projected texts are mainly used in design studios during lecture sessions. However, the ability to adopt the full packages of digital multimedia as a teaching and learning aid will create rich potential for students towards increasing their cognitive and perceptive capabilities in the learning and creative process. Therefore, this research seeks an understanding as to what year in the undergraduate program and the stage in the design process that would be most suitable for adopting digital multimedia as a teaching and learning aid in architectural education; with the pedagogic objectives of bringing to the fore the benefits of digital multimedia in the design process. The results of this study reveals that, introducing digital multimedia in architecture design studios would help instructors in giving a better understanding of their courses. Furthermore, the use of multimedia approach enhances teaching and learning experience in architecture design studios. This in turn has significant impact on the learning process, as instructors and students exchange ideas and information; as well as among fellow students.

Copyright©2016, Ikenna Stephen Ezennia et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Citation: Ikenna Stephen Ezennia, Patrick C. Uwajeh, Peter C. Agbonome and Timothy O. Iyendo, 2016. "The benefits of digital multimedia as a teaching and learning aid in architectural design studios", *International Journal of Current Research*, 8, (09), 39210-39217.

INTRODUCTION

Decades ago, the traditional method of learning in architectural education was described as didactic instruction, whereby information is given to students with little regards as to how the information is used. Bester & Brand (2013) elucidated that classroom teaching consists essentially of an instructor who teaches and students who learns. The simplicity of this relationship is influenced by several factors, which could have some effect on the excellence and the significance of teaching and learning. It also means that teachers must "establish a balance between sufficient organization to orient learners' actions and sufficient openness to allow for the varieties of experience, ability and interest represented in any classroom" (Davis, 2004). The common notion and practice in teaching design process in architectural design studios is such that it

encourages a general, imaginative and tentative methodology that improves the cognitive and learning abilities of student with regards to the fundamental design principles (Waks, 1999). However, in architecture education, there is a minimal pre-knowledge necessary for understanding without which the students cannot design (Snodgrass & Coyne, 2013). The design studio is supreme: it is the place where knowledge about buildings is theorized, and it is where the act of designing (developing, evaluating, generating and evolving alternatives) is learned and practiced. The design Studio provides the avenue to initiate creativity and hence, increase the interest in visual language. The studio is an ongoing research which creates a mark about spatial perception in the minds of students hence; it reveals the surplus possibilities that subsist in the world of space. It must be determined if Information and Communications Technologies (ICT) such as digital multimedia assists to unlock the students' creativity and enhance the spatial perception (Wang, 2012).

Corresponding author: ^{,1,2}Ikenna Stephen Ezennia,

¹Department of Architecture, Eastern Mediterranean University, Famagusta, North Cyprus via Mersin10, Turkey.

²Department of Architecture, Nnamdi Azikiwe University, PMB 5025, Awka, Anambra State, Nigeria.

Over the past few decades, the innovations in the information communication technology (I.C.T), has changed the interactive and learning possibilities among students and educators,

through the introduction of computer integrated presentation media, which includes software such as micro soft power point and projection technologies in lecture halls (Bester & Brand, 2013). Architecture education became more three dimensional in design representation and exploration at the start of the 20th Century. This transition to three dimensions made the design process more associated to digital multimedia (Abdelhameed, 2004; RabeeReffat, 2007). This research discusses the use of Interactive digital multimedia in the classroom for architecture students particularly for studio sessions where some students possess more imaginative power than others. This research is set in the context of usage of digital multimedia in the learning environment. The main focus of this research is on the level of effectiveness of digital multimedia as an aid that could support teaching and learning in architectural educational institutions. Architectural design education is barely flawless, the over reliance on the use of text and projectors in architecture design studios, hence, inadequate use of digital multimedia packages has contributed to the perceived low cognitive and perceptible abilities in students (RabeeReffat, 2007). It has been widely observed that there has not been maximum utilization of digital multimedia in the teaching approaches adopted in schools of architecture. It is also worthy of note that, the few schools where it is used were only limited to the use of Text and projectors, while in essence multimedia comprises the combined use of Text, Audio, Video footage, Animation and still images. Mintonogo (2004) maintained that there is need for further research on how multimedia and CAD technology really affect the design creativities in students.

Research question

1. Is digital multimedia an efficient tool for teachers in architectural design studios?
2. What difficulties could schools of architecture face in employing digital multimedia as a teaching tool?
3. Can studio sessions conducted with the aid of digital multimedia influence student's level of understanding in architectural education?

Research methodology

The qualitative research method was adopted. Data collection was through interviews which were conducted via email, telephone and face to face dialogue. The participants were research assistants and instructors assigned to design studios in the Department of Architecture, in some schools architecture in North Cyprus, as a field study. The interviews were scheduled between March 2016 and August 2016 depending on the convenience of the participants.

Multimedia

(Clark, 2001) stated that many definitions of multimedia have been postulated. Instructional media commonly describes as any tool for giving or conveying instruction. Some examples of these media are books, television, radio, computers, newspapers, people, movies etc (Clark & Feldon, 2005). In the actual sense; multimedia simply refers to "more than one medium." (Marmara University, 2003; Burke, 1972; Heath, 2000). It is the mixture of images, text, sounds and

movement (Vaughan, 2003; Mayer, 2009). The ability of computers to offer real-time illustrations of almost all kinds of media and sensory modes of instruction are generally referred to as Multimedia (Clark, 2005). Graham & Hussain (2006) stipulated that multimedia is incorporating sound, text, any form of graphics and a learning environment articulated in one digital information environment. Whenever multimedia is discussed, it commonly means computer multimedia. This terminology now represents the realm of video games, computer graphics, on-screen presentations, and a whole lot of many possibilities (Dede, 1994). Digital multimedia is a computer-generated presentation that employs at least basic animation or certain motion, sound-track or recording voice-sound and video to add impact (Newby *et al.*, 2000; Smith, 2002; Mintonogo, 2004) which allows students to receive feedbacks and make implementations (Heinich *et al.*, 2002).

The History of Multimedia

According to Solomon (2004) it is very difficult to identify the point at which multimedia began, but in 1972, Nolan Bushnell (who founded a then new company called Atari) developed a kind of multimedia called video game pong which was the earliest and best known example of multimedia (Burke, 1972). This game involved two blades which hit a square ball repeated in a to and fro manner across the screen, more like the tennis. It began as an arcade game, and eventually found its way in many homes (Dede, 1994). In 1976 came a new revolution, it was about to begin as associates, Steve Wozniak and Steve Jobs co-founded a small company called Apple Computer. The duo released the Apple II, the first computer system with color graphics that same year. In 1981 came IBM's first PC, and in 1984 Apple unveiled the Macintosh, the first version of computer with a (GUI) graphical user interface (Shuman, 2002). The Macintosh likewise came with the first mouse, which would forever revolutionize the manner of interaction between people and computers. In 1985, saw the release of the first version of its Windows operating system. Later that year, a machine which many experts described as the first ever multimedia computer largely because of its advanced innovative user interface and graphics processing power, called Amiga was released by Commodore. The Amiga popularity over the years dwindled unfortunately, and Windows has come to stay as the standard for desktop computing (Coorough, 2001). Macintosh operating systems and Windows summarily flagged off the lightning-fast advancements that were to be experienced in multimedia. Meanwhile both Mac OS and Windows handled sound and graphics which was something individual software applications had handled previously. Hence, developers were able to develop programs that use multimedia to more potent effect. By 1988, Macromedia unveiled its landmark Director program, which availed ardent computer users' opportunity to produce multimedia presentations that were stunning and interactive. Macromedia (formerly known as Macromind) from its very inception had played an essential part in the advancement of multimedia technology (Vaughan, 2001). Nowadays, Macromedia Flash powers most of the animation and multimedia that are available on the Internet, while high-end interactive productions are still crafted by Director Program. Every passing advancement of each successive year are immersed

into next year's technology, making the multimedia experience, faster, better and more interesting.

Issues Related to Multimedia Use in Higher Education

Studies have revealed that classrooms are still based on teachers' oral explanations, and they also present inadequate learning environments to learners for the learning process mainly of science in several developing countries, such as Taiwan, South Africa and Turkey (Bester & Brand, 2013; Koseoglu & Efendioglu, 2015) Recently, Instructors have expressed numerous concerns about our media-driven society and its role in learning. One of those is depicted here;

The basic significance of media literacy

For instance, Mergendollar (1997) cautions, that technology similar to multimedia are oblique gift. He exerts that, they may assists in communicating information more speedily. However, it does not assist to examine whether information is relevant, current and accurate or not. As the information available to us increases, the more essential it becomes to study visual literacy, critical analysis and information literacy skills.

Introducing Digital Multimedia in Design Studio

An approach which infuses audio, images and video in a more exciting manner is replacing the old text based approach to learning (Andrewartha & Wilmot, 2001). Technological advancements in building construction have had huge impact on architecture education and practice (Cavanagh & Allen, 2004). The introduction of digital multimedia in the design studio sessions has an intense impact on styles of learning and teaching; it is observed that when using digital multimedia, students were highly motivated and were learning co-operatively (Slack, 1999). The instructor then becomes a problem setter, facilitator and guide, instead of taking a central role. James & Nagasaka (2011) postulated that the introduction of digital multimedia in design studios requires a widened understanding of architectural concepts such as spatial and form composition. Exploring design concepts, through two dimensional and three dimensional forms, is the premise of design exploration and visual design thinking during the design process. The essence of visual design thinking is imagining how digital drawings and models will be presented in reality (Abdelhameed, 2004).

Visual perception, creativeness and conception, which students apply through depictions of digital multimedia advance their visual design thinking, and on the same hand, require diverse qualities than that of manual-media delineations (Abdelhameed, 2004). Digital multimedia, used as aid, ought to be slowly and steadily introduced to students of architecture in the early phase of the undergraduate stage, with the aim of creating and ensuring enough time for them to expand on the subjective parts of their visual design thinking as executed in these digital environments (Uwajeh *et al.*, 2016). Digital multimedia courses should at the same time progress with design courses, helping the process of visual design thinking to be shaped and stimulated at a same level.

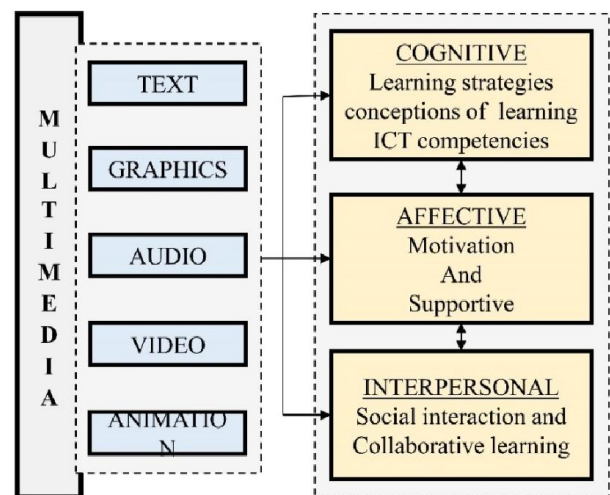


Fig. 1. Students Learning with Multimedia. (Adapted from: Slack, 1999)

Issues in Teaching Architectural Design Module

Design in architecture is an unpredictable and complex process. Students begin from something that is conceptual and has dynamically built up an issue that can be delivered in the form of products. Lawson (1997) stated that architectural design is a procedure in which architects make places, spaces, buildings and structures that majorly affect the nature and value of human life. For the purposes of this research, the design process is described as an efficient procedure that has many levels to deliver new products that could be evaluated physically and has numerous advantages. According to Kalisperis & Liakata (1998) the primary issues confronting students in the design process is the restricted capacity of conventional media to create a decent visual presentation of more intricate space. In addition, the conventional media likewise does not possess the capacity to appraise the performance of any design space in actual condition. Many researchers have pointed out to the absence of sensitivity of the students to control the elements, for example, scale, light, quality and scale in the design process. However, "digital multimedia poses the capacity to augment the experience of a physical space and afford innovative modes of architectonic function that invite broadened conceptions of architectural space" (James & Nagasaka, 2011). Another issue of the conventional media is that the design process depended vigorously on static illustrative diagrams without putting into consideration the impact of light in a space, the movement in space and the impact of finishing material in a space (Ismail *et al.*, 2012; Mintonogo, 2004) tried to address the difficult but interesting problem or phenomena using computer as a tool for design in a helpful way during the early stage of the design process, and visualization.

How digital multimedia can help students to imagine and view in architectural education

Multimedia Presentations and Learning

Milovanovic, *et al.* (2016) stated that multimedia learning helps to support a good understanding of how to foster

meaningful learning through the integration of words and pictures (printed or spoken text and illustrations, graphs, maps, animation or video). There are a number of different models of learning styles. One of the most popular identifies visual, auditory, and kinesthetic as the three ways in which people take in information

Confidence and Image

The impact of a good presentation in education cannot be over emphasized. Consequently, the quality of design and personality image of a student can be enhanced by studio works and assignments. A more dynamic and efficient learning is achieved when an instructor makes use of a combination of multimedia and content delivery. The materials must be in a format that will involve students, maintain their interest, and meet their learning needs (Buckley & Smith, 2007).

Flexibility

The computerized authoring multimedia tools are easily making changes and layout every minute to suit the presentation stories. Commonly, the visualization presentation has two types namely, Interactive presentations and Continuous-run presentations. Students have a lot of fun making multimedia presentations, some students either like making interactive presentations at CAD class and design studio, or like making continuous-run presentations. The multimedia learning platform allows students to suspend and revisit study materials at their convenience and within a flexible time frame (Hughes *et al.*, 2007). Heinich *et al.*, (2002) also summarized the significance of individuality and the advantages of flexibility and simulation, supporting the fact that users have a choice and are not forced to specific presentation materials and methods.

CAD/CAM Technology Built in Design

CAD now known as computer-aided design is a technology that can actually do more than just a sketch (Husain, 2007) and CAM stands for Computer Aided Manufacturing (Mikell & Emory, 1985). The combined CAD/CAM is the technology concerned with the use of computers to perform product designing and manufacturing operations. In the earlier days the CAD and CAM were considered to be two distinct technologies independent of each other, however, now there has been greater integration of CAD and CAM. CAD technology has also been able to produce a digital model of three dimensional objects. This digital model has a good visual impact and gives freedom to the architect to think about objects, space and form on the same screen. The fast development of CAD technology today has created a lot of software that can be used for drawing of two dimensional and three dimensional models. The digital model can be used easily for simulation activity. The development of CAD technology today has opened up new opportunities to assist the development of architectural education, especially in learning the design process.

In studying architecture one has to undergo courses such as Architectural Graphics, Descriptive Geometry where he must

have the power of imagination to answer the questions. It is important to enlist the different topics one has to study at this level these are; Projection of solids, Projection of planes, Section of Solids, Isometric views, Development of Solids, Assembly drawing, Perspective Views, Orthographic projection, Details drawing, etc. Let’s look at one issue of projection of hexagonal pyramid which is laying on its base and a corner which is made to be tilted in a way that its two base sides are parallel to vertical plane. Above issue while tackled with paper and pencil technique will resemble.

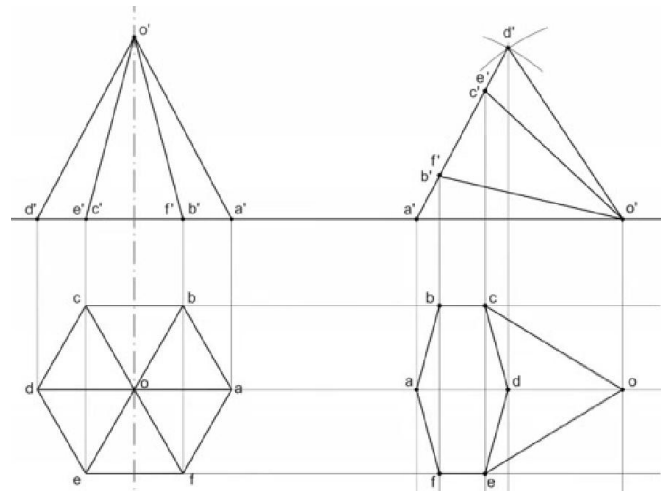
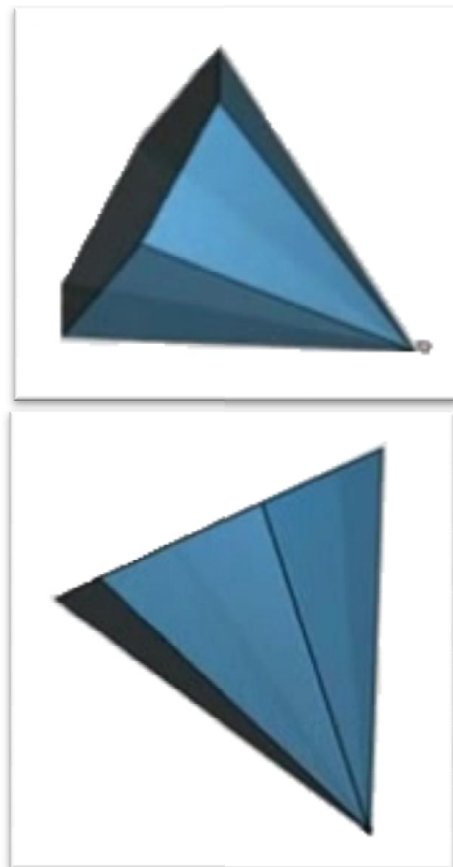


Fig. 1. A diagram of projection of the hexagonal pyramid

With the aid of digital multimedia, perspective and isometric views as below can be achieved as shown below;



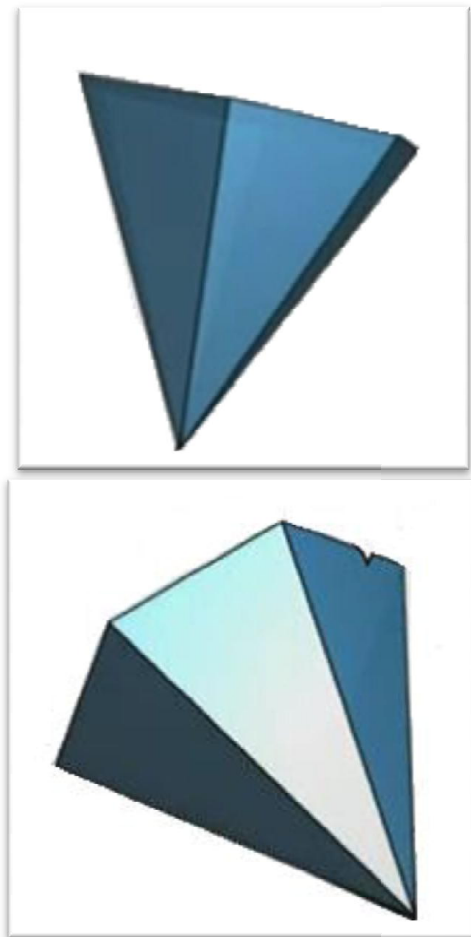


Fig. 2. A diagram of different views of Hexagonal pyramid

Computer Simulation

Simulation is a method to bring the actual situation in a process or activity during the learning process (Humphreys, 1990). Computer simulation can be described as a method involving the use of a computer to replicate events, processes or situations into learning activities (Michael, 2000). The integration of computer simulation in the architectural design process can help students to study the physical impact of building finishes and colors in the actual situation on the building designed using CAD software. Two methods based on CAD technology can be used to help students in simulation activities. Three dimensional digital models can help students to carry out static simulation to study the effects such as texture and finishes of finishing materials on the architectural design. The computer animation can be used in performing a dynamic computer simulation. Computer animation being integrated in the design process can also help students to assess the quality of space in terms of movement. The main advantage of using computer simulation in the design process is that it can help students to quickly assess the quality of the designed shape and space. If computer simulation is integrated into the design process students are expected to produce a creative design product. Integration of CAD technology in the design process can improve the quality of education in architecture, especially for learning architectural design process through design module. Integration of CAD

technology can help students create new ideas in architectural design process.

Visual thinking

The visual impacts by moving pictures can encourage and fascinate students to design inventive and effective designs. Digital stimulation can help students to understand interior spaces, taking into account the impact of light, shading, texture, colour and scale. The supreme benefit of digital multimedia is its capacity to comprehend the flaws of the design of structures and spaces before it is developed (Kalisperis&Liakata, 1998).

Current and Future Impact of Multimedia on Architecture Education

Multimedia technology has influenced modern society in many ways. Multimedia has evolved to applications in physical space, wherein media such as sound, visuals and interactive content have taken on spatial significance (James & Nagasaka, 2011). Interactive multimedia learning is a process, rather than just technology, that places new learning potential into the hands of users (Stemler, 1997). The current common pedagogical uses of multimedia packages portend a considerably heavier dependence on these systems in future classrooms. Instructors perceive and utilize these systems when they see the potent abilities they offer to improve the learning experience in classroom:

Motivation

Multimedia packages offer many diverse options that many individuals prefer utilizing them. Students who find it tasking to finish a project or term paper would enthusiastically handle a multimedia project. McCarthy (1989) in his submission argued that the most vital feature of multimedia is its capacity to inspire students to become proactive learners.

Flexibility

Multimedia packages borrow from the varied instruments that they actually offer something for students who exceed expectations in any of what Gardner (2006) refers to as "intelligences". For instance, students who have difficulty to comprehend written text but possess good visual ability can articulate learning with images, simulations or sound.

Enhanced critical and synthetic thinking skills

The remarkable access to multimedia packages opens up a host of imaginative channels for students and instructors. Marchionini (1988) alludes that multimedia creates a dynamic environment that regularly requires students to take decision and evaluate progress. Furthermore, he posits this process ensures that students put on a higher order thinking skills. According to Turner & Dipinto (1992), the multimedia environment enables students thinking techniques in form of metaphors, to be reflective and to offer direction to their imaginations. Ismail *et al.* (2012) submitted that integration of digital technology in the design process increases the number

of ideas in the synthesis activity and the number of simulation in the simulation activity.

Enhanced writing and process skills

In addition, Turner & Dipinto, (1992) observed that introducing students to multimedia packages helps in providing them with another and alternate point of view on the best way to arrange and present information and a refined insight in writing. Students now consider their writing to be lumps of information to be connected, rather than viewing it as one long stream of text. The general overwhelming dependence on multimedia packages to communicate information would likely multiply in the future. Connecting data with multimedia is an effective approach to present and increase the value of extensive body of information, the increasing number of World Wide Web pages on the Internet is a confirmation. A great number of individuals have published multimedia documents on the Information Superhighway with the expectation of drawing in readers, viewers, and listeners. Simonson & Thompson, (1994) also explained that multimedia packages likewise may allow sophisticated assessments of learning. While employing multimedia, many individuals were believed to "leave a track", this could allow instructors evaluate how students approach learning task. Multimedia packages in the future may apply pattern recognition technique from the areas of artificial intelligence to aid institutions of higher learning evaluate the level of higher order cognitive skills acquired by students. Dede, (1994) and Bagui (1998) stated that multimedia packages may have special capacities to encourage learning on account of the parallels that exists between the conventional way people learn and multimedia which is, by imagery and visual information.

Data analysis

The participants were interviewed from March 2016 to August 2016. Every question was geared towards gathering new information on the benefits of digital multimedia in teaching design process. Interviews were conducted with research assistants and instructors currently attached to studio classes. The following were the questions asked;

1. Can photographs, illustrations, videos, audio and images from digital multimedia used during studio sessions influence the design concepts and prowess of students in architecture?
2. At what stage in design process should the use of digital multimedia as a teaching aid be introduced in design studios for undergraduates in architecture?
3. At what level (year) should the use of digital multimedia as a teaching aid be introduced in design studios for undergraduates in architecture?
4. How can sessions taught with digital multimedia influence the design conception and creativity of students in architecture?
5. How can students represent what is seen in a digital multimedia into architectural designs?
6. What do you envision for the future of digital multimedia media in architecture studio?

The respondents were generally of the opinion that the introduction of multimedia packages in design studio, as pedagogical aid in the design process especially at the undergraduate level would be very helpful in enhancing cognitive and learning skills in students of architecture. As a summary of the interviews from their experience, the respondents were of the opinion that the following factors would aid students in developing creative design products in design studios;

1. Using visual communication tools is one of the most effective ways to explain complex concepts to students. Especially in the field of architecture education which is dependent on "graphic communication" using digital multimedia which can be accessed readily as a powerful means of teaching. It should be said that visual mediums should be used as complementary tool beside table critics because verbal communication with the studio instructor is necessary in architecture learning experience.
2. They also added that multimedia packages are useful throughout the entire design process but that it would be most beneficial at the early stages of the design process, that is, the "design information analysis". On the same hand, students become familiar with the ideas and concepts around the topic, and it encourages them to express and share their initial analysis and ideas through visual media. By exploring the proposed topic through digital multimedia packages, students becomes familiar with important building designs with similar functions, the idea is not to copy these works but learn the problem solving approach which shaped the project.
3. Now adays, it is impossible to separate the visual media from the process of teaching architecture. The concept of architecture studio is "learning by doing" therefore it is preferable to teach student how to use their hand for expressing their ideas (in the first year), but using visual media is inevitable as an aid even in these early stages. Consequently, Architecture is not a written or spoken phenomena, we as architects deals with physical or drawn entities, therefore the digital multimedia packages is an appropriate instrument for us.
4. That multimedia packages could provide more diversity for each individual students, digital multimedia as an aid for teaching and learning, if used properly can transfer and communicate more critical information to student, but on the other hand, if it is the only method used for this purpose information can easily be forgettable, as students would believe that they can access the information on demand and therefore pays less attention during studio sessions.
5. Students have to learn the necessary techniques and software to manipulate multimedia packages. In today's world they have to develop good quality visuals in order to score better grades and secure good commissions later during practice. For instance producing a three-dimensional drawing or an animation or simulation is not easy but it shows students ideas and design approaches extremely well.
6. Multimedia packages can help improve the quality of education, but face to face interaction will always be the

most effective way of learning. Digital multimedia by on its own can be only a tool of presentation, if the students could not produce these kind of materials by themselves it will be only disappointment, so we should focus in giving the opportunities of learning these new methods to our students.

7. In the future, a studio class will be involved in designing one project, and this project displayed for students in a huge screen in front of them, any one of them can add his ideas to this project and immediately those ideas appear in the screen. Hence, they can see visually the design process.

Conclusion

For a long time, it has been argued that the architecture design education is in crisis; yet in response, architecture education constantly reinvents itself over and over again in this societal context. Yet again, we should reconceive the roles and fundamentals of architectural design, as we discover new approaches to incorporate computation and multimedia packages in design teaching and learning. The architecture design studio is a hub of architectural education. Inarguably, architecture education and practice is changing fundamentally in light of the new technologies that enhance, if not substitute, the conventional pencil and paper drawings, chipboard and basswood models. This technology driven change, reflects changes in the public order as well as our civilization is taken over by digital age. Architecture educators must not just be users, but become pioneers, in developing design practice with digital multimedia, and anticipate not simply embrace technological changes. Schools of architecture, like architects in practice, should advance with technology and more so work to ensure that it becomes more helpful. Digital multimedia packages are not geared to substitute the instructors' role. However, it should be enhanced, well-designed and sophisticated enough to aid the instructor, by mixing in its design the various elements of the best quality of technology and cognitive processes. New and emerging digital design multimedia possesses incredible potentials; we should transform these potentials into reality. We are makers and shapers by trade. This tradition we should live up to, in the manner we teach design with digital multimedia packages.

REFERENCES

Abdelhameed, W. 2004. Visual design thinking in the design process as impacted by digital media. In *Architecture in the Network Society [22nd eCAADe Conference Proceedings]* (pp. 90 – 94).

Andrewartha, G., & Wilmot, S. 2001. Can multimedia meet tertiary educational needs better than the conventional lecture? A case study. *Australian Journal of Educational Technology*, 17(1), 1 – 20.

Bagui, S. 1998. Reasons for increased learning using multimedia. *Journal of Educational Multimedia and Hypermedia*, 7, 3-18.

Bester, G., & Brand, L. 2013. The effect of technology on learner attention and achievement in the classroom. *South African Journal of Education*, 33(2), 1 – 15.

Buckley, W., & Smith, A. 2007. Application of multimedia technologies to enhance distance learning. 39(2), 57.

Burke, L. K. 1972. A History of Multimedia. Retrieved April 16, 2013 <http://eric.ed.gov/?id=ED126889>

Cavanagh, T., & Allen, E. 2004. Introduction: Architecture, Technology, and Education. *Journal of Architectural Education*, 58(1), 3 – 3.

Clark, R. E. (Ed.). 2001. *Learning from Media: Arguments, Analysis and Evidence*. Greenwich, CT: Information Age Publishers.

Clark, R. E., & Feldon, D. F. 2005. Five common but questionable principles of multimedia learning. *The Cambridge handbook of multimedia learning*.

Coorrough, C. 2001. *Multimedia and the Web*. Orlando, FL: Harcourt, Inc.

Davis, B. 2004. *Inventions of Teaching: A Genealogy*. Mahwah, NJ: Lawrence Erlbaum Associates.

Dede, C. 1994. Making the most of multimedia. *Multimedia and learning: A school leader's guide*, Alexandria, VA: NSBA

Gardner, H. 2006. *Multiple intelligences: New horizons*. Basic books.

Graham, D., & Hussain, A. 2006. Multimedia, a course in the information technology programme. *Retrieved Mayis*, 23, 2007.

Heath, S. 2000. *Multimedia and communications technology* (2nd ed.). Boston: Focal Press.

Heinich R., Molenda M., Russell JD. & Smaldino, S. E. 2002. *Instructional media and technologies for learning*.

Hughes J.E, McLeod. S, Brown R., Maeda, Y & Choi, J. 2007. Academic achievements and perception of the learning environment in virtual and traditional secondary mathematics classrooms. *American Journal of Distant Education*, 21(4), 199 – 214

Ismail, M. A., Mahmud, R., & Hassan, I. S. 2012. Digital Studio vs. Conventional in Teaching Architectural Design Process. *Procedia-Social and Behavioral Sciences*, 64, 18 – 25.

James, A., & Nagasaka, D. 2011. Theoretical Connection Points between Multimedia and Architecture. *Journal of Asian Architecture and Building Engineering*, 10(1), 171 – 178.

Johnson, C. I., & Mayer, R. E. 2009. A testing effect with multimedia learning. *Journal of Educational Psychology*, 101(3), 621.

Kalisperis, L. N., & Pehlivanidou-Liakata, A. 1998. Architectural design studio: digital and traditional.

Koseoglu, P., & Efendioglu, A. 2015. Can a multimedia tool help students' learning performance in complex biology subjects? *South African Journal of Education*, 35(4), 01– 12.

Lake, S. E. & Bean, K. 2004. *Multimedia and Image Management*. Mason, OH: Thomson Southwestern. Washington: Merrill Prentice Hall.

Lawson, B. 2007. CAD and Creativity: Does the Computer Really Help? *ISAST*, Vol. 35(3), 327–331.

Marchionini, M. 1988. Hypermedia and learning: Freedom and chaos. *Educational Technology*, 28(11), 8–12.

Marmara University. 2003. Computer based multimedia applications. Retrieved May 24, 2007 from <http://iletisim.marmara.edu.tr/bilisim/BilDesMedUyg.htm>.

- Mayer, R. 2009. *Multimedia learning* (2nd ed.), Cambridge University Press, New York.
- McCarthy, R. 1989. *Multimedia: What the excitement's all about*. *Electronic Learning*, 8(8), 26–31.
- McCauley, G. 2000. The interactive multimedia software Project. A planning and development guide, Retrieved May 18, 2005 from http://home.earthlink.net/~gmmccauley/the_im_project.pdf
- Mergendollar, J. 1997. What research says about technology and learning? *Principal*, 76(3), 12–14.
- Milovanovic, M., Perisic, J., Vukotic, S., Bugarcic, M., Radovanovic, L., & Ristic, M. 2016. Learning Mathematics Using Multimedia in Engineering Education. *Acta Technica Corviniensis-Bulletin of Engineering*, 9(1), 45.
- Mintorogo, D. S. 2004. The Phenomena of Teaching CAAD and Multimedia in Architecture Education at Petra Christian University. *DIMENSI (Journal of Architecture and Built Environment)*, 29(2).
- Newby, T., Stepich, D., Lehman, J., & Russell, J. 2000. Instructional technology for teaching and learning: Designing instruction, integrating computers, and using media. *Educational Technology & Society*, 3(2).
- Patrick Chukwuemeke Uwajeh, Ikenna Stephen Ezennia, Peter Agbonome 2016. Impact of Photographs as a Visual Reference in Architecture Design Studio. *Contempart' 16, V. International Contemporary Conference on Urban Identities and Contemporary Arts. Istanbul; (Conference Proceedings)*, 32 – 42.
- RabeeReffat, K. F. U. P. M. 2007. Revitalizing architectural design studio teaching using ICT: Reflections on practical implementations. *International Journal of Education and Development using ICT*, 3(1).
- Shuman, J. 2002. *Multimedia Concepts*, Enhanced Edition— Illustrated Introductory. Boston, MA: Thomson Course Technology.
- Simonson, M. R., & Thompson, A. 1994. *Educational computing foundations*. New York: Merrill.
- Slack, R. 1999. *PEDACTICE: The use of multimedia in schools* (Vol. 17). Centre for Educational Sociology.
- Smith, L. 2002. Multimedia, what, why, how. *Multimedia and HCI*. Retrieved April 3, 2004 from http://www.cs.stir.ac.uk/courses/IT82/Handouts/Intro2004_color.pdf.
- Snodgrass, A., & Coyne, R. 2013. *Interpretation in architecture: design as way of thinking*. Routledge.
- Solomon, A.W. 2004. *Introduction to Multimedia*. Woodland Hills, CA: Glencoe/McGraw Hill.
- Stemler, L. K. 1997. Educational characteristics of multimedia: A literature review. *Journal of Educational Multimedia and hypermedia*, 6, 339 – 360.
- Turner, S. V., & Dipinto, V. M. 1992. Students as hypermedia authors: Themes emerging from a qualitative study. *Journal of Research on Computing in Education*, 25(2), 187–199.
- Vaughan, T. 2001. *Multimedia: Making it Work* (5th ed.). Berkley, CA: Osborne/McGraw- Hill.
- Vaughan, T. 2003. *Multimedia: Making it work* (6th ed.). Berkeley, CA: Osborne McGraw-Hill.
- Waks, L. J. 1999. Reflective practice in the design studio and teacher education. *Journal of curriculum studies*, 31(3), 303 – 316.
- Wang, J. (Ed.). 2012. *Challenging ICT Applications in Architecture, Engineering, and Industrial Design Education*. IGI Global.
