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An Investigation into using Digital Games-Based Learning in Architecture Education

Abstract

Through the evolution of human life, the changes that happen in all fields, such as transportation, industry, communication, etc., are recognized, however the classroom and its education facilities are still as they have been for a long time, based on the concept of transforming information or knowledge from the mind of the instructor to the minds of students. Students, as a new generation, have evolving skills in dealing with digital technologies, having begun the process in their childhood; therefore, they cannot be educated via conventional methods. This study introduces digital gaming in education as a new, futuristic learning technique to be used in architectural education to attract students to learn, based on the common ground between the processes of designing and playing games, from exploring possibilities under certain constraints to emphasizing decision-making and activity-based collaborations. The research has originated from the lack of studies regarding this subject, especially in the architectural field, aiming to introduce a theoretical approach to investigating the use of digital game-based learning (DGBL) in architectural education as an integration between real and virtual educational environments particularly through the virtual worlds based on the 'Second Life'- digital platform. This study is significant in terms of making design learning fun and constructive, reaching new possibilities in architectural design.

Keywords

Architectural education; Digital game-based learning; Gamification; Serious games; Second Life

AN INVESTIGATION INTO USING DIGITAL GAMES-BASED LEARNING IN ARCHITECTURE EDUCATION

E.M.ELSAMAHY[1]

ABSTRACT

Through the evolution of human life, the changes that happen in all fields, such as transportation, industry, communication, etc., are recognized, however the classroom and its education facilities are still as they have been for a long time, based on the concept of transforming information or knowledge from the mind of the instructor to the minds of students. Students, as a new generation, have evolving skills in dealing with digital technologies, having begun the process in their childhood; therefore, they cannot be educated via conventional methods. This study introduces digital gaming in education as a new, futuristic learning technique to be used in architectural education to attract students to learn, based on the common ground between the processes of designing and playing games, from exploring possibilities under certain constraints to emphasizing decision-making and activity-based collaborations. The research has originated from the lack of studies regarding this subject, especially in the architectural field, aiming to introduce a theoretical approach to investigating the use of digital game-based learning (DGBL) in architectural education as an integration between real and virtual educational environments particularly through the virtual worlds based on the 'Second Life'- digital platform. This study is significant in terms of making design learning fun and constructive, reaching new possibilities in architectural design.

KEYWORDS

Architectural education; Digital game-based learning; Gamification; Serious games; Second Life.

1. INTRODUCTION

Years comes, and go, and everything changes in all life fields. If we went back in time 200 years ago, it would be found that the same education techniques hadn't changed, based on a classroom where the teacher is the main person in the system, responsible for the transfer of knowledge to students through different methods. Therefore, today's education system has become a boring process from the student's point of view, in comparison with what is outside the classroom, such as TV, tablets and other smart tools (Prensky, 2001).

The new generation of students has grown up in an evolving atmosphere, where digital technology affect all life aspects, through communication, social life and, especially, the learning process (Tang, Hanneghan, & El Rhalibi, 2009). These new technologies are growing fast, impacting on arts and humanities, and opening up new horizons of knowledge dimensions, especially in the learning and research fields (Champion, 2015). It has led to a new human intellectual structure, according to Ojeda & Guerra (1996). 'Every technological advance is accompanied by a new structure of thought' (Ojeda & Guerra, 1996), with an impact on the field of design thinking in the areas of architectural education and practice, through the design studio, which is considered to be the backbone of the architectural education.

The design studio has its origin in two important education models. The first design studio origin comes from the 'ateliers' model established at the Ecole Des Beaux Arts, emphasizing art as an

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approach to studying architecture. This approach is still at the core of most architectural education schools. The second was the workshop model in Bauhaus, which was established by Walter Gropius, this model emphasized practice and fabrication issues more than the art approach (Broadfoot & Bennett, 2003).

The architectural design studio has sat between art and practice for a long time, but today digital media plays an important role in changing the way in which we design and the way in which we learn how to design (Reffat, 2002). It has led to establishing new approaches in design education, such as the paperless studio, the virtual design studio and so on. One of these new techniques is the integration of digital gaming into architectural education.

This approach originates from the development of computer graphics and the increasing need of the new generation to play digital games. In addition, through the game design process, the connections between the designers of these different fields are becoming close, because the game production needs to have an architectural design to enable its virtual environment to be similar to a real one. A boom has been happening in game design studios, game courses are being brought into the education field by many academics, who agree that this field needs more links with digital technologies and architectural education (Champion, 2015).

The development of games for education promises great benefits; Marc Prensky agrees that digital games can have a massive impact on education (Prensky, 2001) because of the great pedagogical advantage of this approach, which has led to the increased use of game-based learning in many countries, from the first levels of education to higher education. Digital games allow users to simulate the real environment with all user experiences; this provides a chance for the learner or user to discover new concepts and ideas that could be difficult to practice in many fields. This has been tested in military, medical, business and physical training, using different types of game-based learning such as role-play, simulation and digital games; these tools give learners new possibilities such as the ability to imagine a real situation and recognize the feedback from the reaction base in this given virtual situation (Oo & Lim, 2016).

2. GAMIFICATION AND SERIOUS GAMES TERMINOLOGIES

Different terminologies have appeared from the interaction between games and education such as gamification and serious games; many studies show the difference between these terms .

The first term is ‘gamification’; it may seem like a new term but it has existed for many centuries as an idea or concept. It originated as a term in the digital games industry back in 2008, but the increasing use of this term can be traced back to the second half of 2010, when researchers and conferences popularized it. From its definition, gamification is the use of the elements of the designed game in non-game contexts (for example using Second Life as a virtual platform to apply education goals). This differs from serious games, which use the designed game as a whole game with goals related to non- entertainment purposes, and the design for playful interactions’ (Deterding, Khaled, Nacke, & Dixon, 2011), as shown in figure 1.

Fig.1. Difference between gamification, serious games and playful interactions. Reference: (Deterding, Khaled, Nacke, & Dixon, 2011)

Therefore, gamification and serious games are more related to using games for other targets rather than giving the user entertainment only, and aim to improve the user experience through different and interesting approaches that need interaction between users (Schnabel, Tian, & Aydin, 2014).

The increasing use of games in learning systems as an effective method to support the learning process, helps students to obtain knowledge and experience by themselves and to practice real experiments in a safe environment. It is more than just playing games. It can be defined as a game-based idea or game-based learning (GBL), which is applied to the education environment to reach the learning outcomes (Pandey, 2015).

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3. GAME BASED LEARNING-THEORETICAL BACKGROUND

Game-based learning (GBL) takes the benefits of games, as an interesting, interactive, attractive and non-boring activity to encourage the learning process through a virtual environment. Many studies have agreed that this approach can better motivate today's learners with an entertaining way in which to engage more in learning through different activities, defined through the game design and goals (Tang, Hanneghan, & El Rhalibi, 2009).

As a definition, game-based learning is 'a branch of digital games and education that deals with applications to reach the given learning outcomes'. It describes a method of learning, where students discover relevant aspects of their education field using an interactive game. Teachers and students collaborate in order to add depth and perspective to the experience of playing the game (EdTechReview, 2013).

Game-based learning is also about 'understanding users and creating value for them by providing a memorable journey in the game environment. It provides students a safe place to learn from their failures.' (Game-based-learning-Whitepaper, 2015).

Another approach to defining the use of games in the education field is; according to a study of Tang, Hanneghan, & El Rhalibi (2009), as shown in Figure 2. This approach is generally categorized using the term 'edutainment', which includes game-based learning, educational games and simulators, which are considered part of the serious games design (Tang, Hanneghan, & El Rhalibi, 2009).

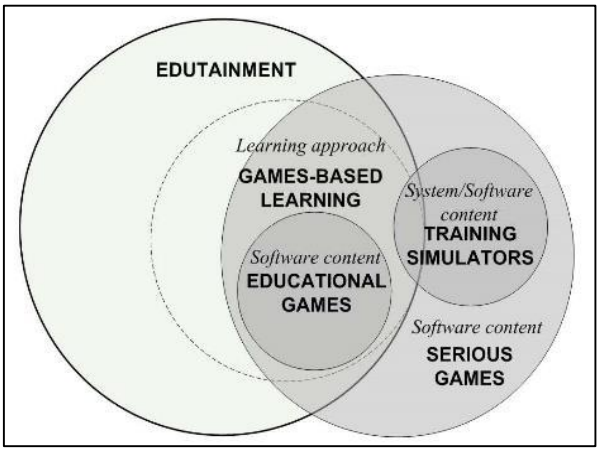

Fig.2. Relationship between and scope of edutainment, games-based learning, educational games, training simulators and serious games
Reference: (Tang, Hanneghan, & El Rhalibi, 2009)

There are many aspects that make games attractive and a non-stop activity for most of the new generation, according to Thomas Malone (1984). In his paper, entitled 'Heuristics for Designing Enjoyable User Interfaces: Lessons from Computer Games', he defines three categories that determine successful game experiences: challenge, fantasy and curiosity (Malone, 1984).

- Challenge: This should have a clear goal related to the necessary learning process when designing the education game, in addition to uncertain outcomes by providing different levels of difficulties, feedback on repeated action and random approaches related to the activity of the learner.
- Fantasy: This could be considered the most significant aspect when designing a game, relating it to the user interfaces to make it attractive and interesting, resulting in a relationship between mental images and physical objects and increasing the imagination of the user through two main factors, as follows:
  - Emotions: The power of imagination inside the digital game design gets its attractiveness from the emotional needs of the users based on the game situation, which differs from one user to another.
  - Metaphors: Linking the mental image of objects or events in the game design with familiar aspects of the real environment can help to make the game easy to learn and use.
- Curiosity: Building an attractive educational game can attract the user's interest in playing and learning. This can happen from the first step of writing the game story, with all its levels of complexity, surprise and unexpected reactions. In addition to evoking sensory curiosity, the use of audio and visual effects can decorate the virtual environment, increase the imagination of the user or serve as a representation technique (Malone, 1984).

'The more enjoyable these virtual environments are, the more likely users will learn and be interested in learning.' (Champion, 2015). Marc Prensky agrees that 'digital games are potentially the most engaging pastime in the history of mankind'. These benefits from games are due to a combination of twelve elements, as indicated in Table 1:

Table 1 A summary of games benefits and their outcomes. Ref. (Prensky, 2001)

Games	• a form of fun	**Give user**	• enjoyment
	• a form of play		• involvement
	• have rules		• structure
	• have goals		• motivation
	• are interactive		• doing
	• are adaptive		• flow
	• have outcomes and feedback		• learning
	• have win states		• ego gratification
	• have challenge		• adrenaline
	• have problem solving		• creativity
	• have interaction		• social groups
	• have a story		• emotion

Therefore, playing is considered the main and most important approach to learning and discovering things (Prensky, 2001). According to the cone of experience by Edgar Dale (Dale, 1969), shown in figure 3, the 'teach others' approach produces 90 % retention in terms of what learners remember after a period of time. Game-based learning tops this by 5% because it focuses on the application of knowledge in an experiential setting' (kipp-Report, 2012). Details of learning design approaches and their relationship to the retention of e-learning techniques are shown in figure 4.

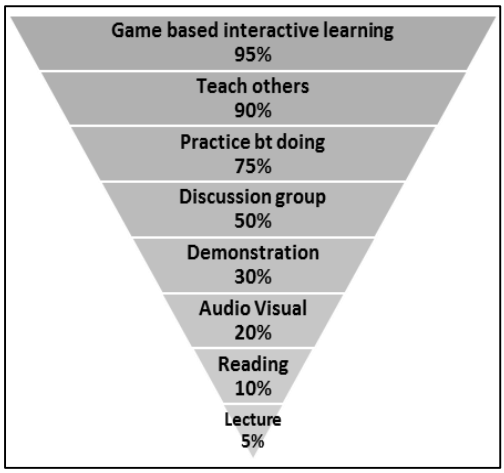

Fig.3. Game-based learning's rank in the learning pyramid
Ref: (kippreport, 2012)

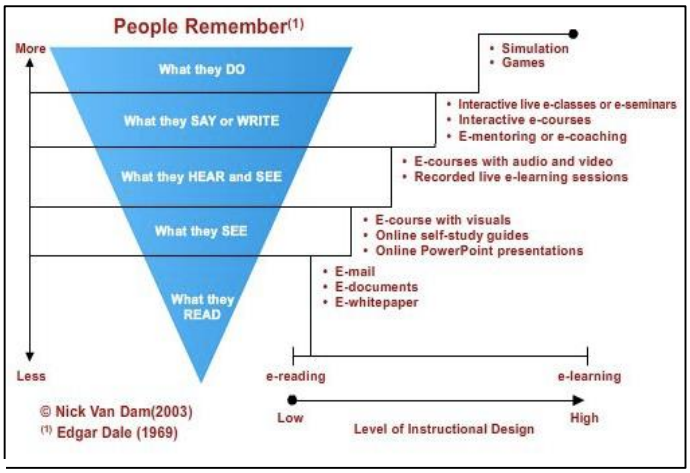

Fig.4. Learning design approaches and their relationship to retention of learning
Ref: (Pandey, 2015)

As noted from this, game-based learning can provide an effective approach to enhancing learning, through several benefits, to establish a learning situation that attract students' attention with challenge and entertainment (Pandey, 2015).

4. DIGITAL GAMING IN ARCHITECTURAL EDUCATION

In present times, digital gaming has been used in many architectural schools around the world, aiming to gain the benefits in developing the design skills and the acquired knowledge from the theoretical lectures (Taşçi, 2016). Using digital games in education gives students the skills of learning- by- doing and practical experience through the simulation of the real world (Oo & Lim, 2016).

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Through a literature review of the last ten years, , it can be seen that some attempts of academics and researchers to understand the benefits of the utilization of digital game-based learning in architecture education have appeared through two main approaches as follows:-

4.1 Investigating current digital games in related to architectural education

According to a study by Taşçi (2016) it can be seen that, through the field of the digital games industry, no single classification is followed. In spite of this, there are some classifications relating to the quality and content of games, the user age and how to play. One of these classification divides games based on their structure and subject, as the follows: simulation, role-playing, strategy, action and adventure games.

This study analyses a number of current digital games and their relevance to the different areas of architectural education, as indicated in Table 2, aiming to understand the integration between digital games and architectural education in relation to sub-disciplines and courses. As examples, historical strategy games can be used in learning the history of architecture, and simulation games can be used in learning various design skills (Taşçi, 2016).

Table 2 A summary of the integration between digital games examples and architectural education in relation to sub-disciplines and courses. Ref. (Taşçi, 2016) modified by author

Game classification	Current digital Games	Game based learning related to architecture sub-disciplines and courses						
		Learning history and culture aspects	Learning environmental aspects	collaborative work	Design education			
					Architectural design	Urban design	Interior design	Landscape
Strategy	Age of Empires	X		X		X		
	Civilization	X		X		X		
Simulation	Electro City		X	X		X		X
	Plant it Green		X			X		X
	Second Life	X		X	X	X	X	X
	SimCity			X		X		
	Sims				X		X	
	RCT 3		X		X	X		X

Another study of digital games analysis in relation to architectural education was carried out by Hosny, Abdel Mohsen, & Mahmoud (2006). This paper pointed out that there is great potential in digital games, represented by the Sims game, to be used as educational tools to make architectural designs, including interior design, and to simulate the experience through this virtual environment, as shown in Figure 5.

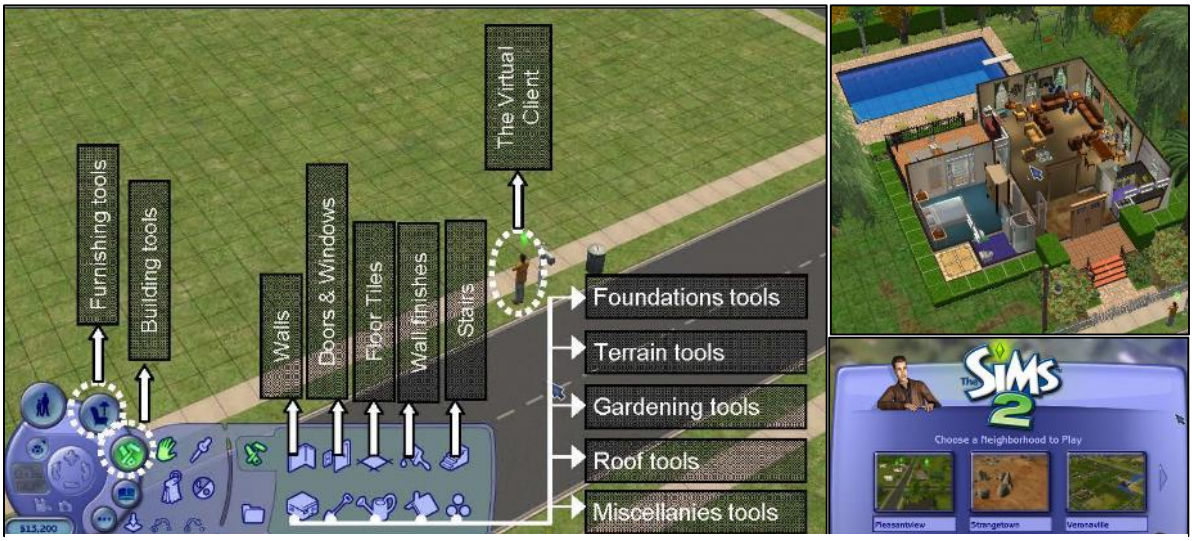

Fig.5. Analysis of Sims II game in relation to architectural education.
Reference: (Hosny, Abdel Mohsen, & Mahmoud, 2006)

4.1.1 ElectroCity : sustainability and environmental urban game

ElectroCity is a web game on the internet, established in New Zealand by Genesis Energy, a leading generator and retailer of energy, which allows players to manage their own virtual towns and cities. It's a game that teaches players all about energy, sustainability and environmental management, especially with regard to the following questions: How is energy generated? How much does it cost? How does it affect the environment? ElectroCity was developed to increase public awareness of the basic 'common knowledge' of these topics particularly among students through a game that is fun and educational- a game that gives students something different to do in class. The game includes: electricity generation, environmental impact, supply and demand, tourism, energy efficiency, budgeting and local body rates, coal and gas prospecting and extraction (ELectrocity, 2016), as shown in Figure 6.

'ElectroCity is all about balance and planning, balancing the city's growth with its environmental impact. City citizens need electricity and jobs, but they also love their clean green image. Making decisions will impact the growth of the virtual city.' (ELectrocity, 2016)

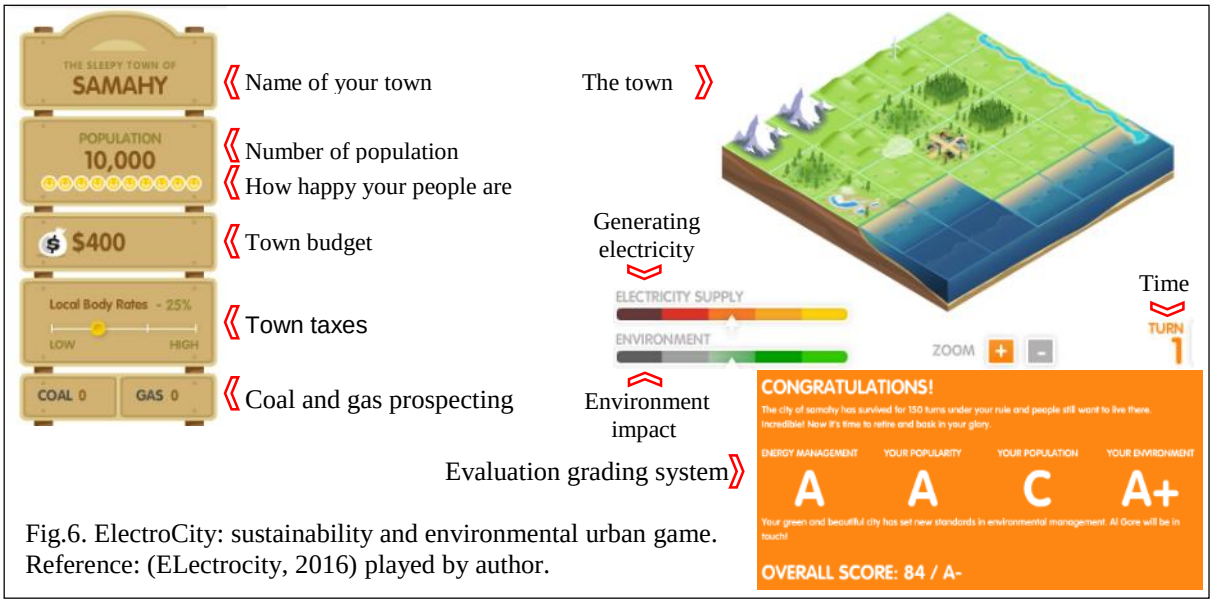

Fig.6. ElectroCity: sustainability and environmental urban game.
Reference: (ELectrocity, 2016) played by author.

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4.2 Using 3D game engines in architectural design education

'Today's 3D game engines have long been used by game developers to create dazzling worlds with the finest details, allowing users to immerse themselves in the alternate worlds provided.' (Haque & Dasgupta, 2008) As a definition, according to Wikipedia (2016), 'A game engine is a software framework designed for the creation and development of video games. Developers use them to create games for consoles, mobile devices and personal computers. The core functionality typically provided by a game engine includes a rendering engine-"renderer" for 2D or 3D , sound, scripting, animation, artificial intelligence, networking, streaming, memory management, threading, localization support, scene graph, and may include video support for cinematics.'

A study by Haque & Dasgupta (2008) described 'an approach for developing realistic 3D architectural walkthroughs using the 'Unreal Engine 2' to make the interior and exterior of a building model using a 3D game engine-based walkthrough, to allow users to navigate virtual environments from an ultra-realistic, first-person vantage point, creating the illusion of actually seeing the environment from the character's point of view, as shown in Figure 7. For architecture students the added realism of these models can enhance understanding of their own design in relation to time, space, environment, and scale. Interactive elements like lighting, sound, triggered events, animations, and artificial intelligence add to the realism of the 3D model.' This "Unreal Engine" gives architects an edge over the past traditional 3D pre-rendered and non-interactive visualization tools.' (Unrealengine, 2016)

Fig.7. Building model using a 3D game engine -"Unreal Engine 2"
Reference: (Haque & Dasgupta, 2008)

Therefore, 'a number of incredibly talented architects and engineers use the game engines to bring their blueprints to life and let their clients adjust the designs as they wish' (Hougaard, 2014). One of these tools is Unity3D, which has begun to be used as a new method of visualization and interactivity. Its useful features include the following: It can create any 2D or 3D game; this game engine allows the target of more multi-platform support more easily; it can link between games, virtual reality and augmented reality using VR glasses (as Oculus Rift, Gear VR); works on desktop and smart phones (Android and Apple Systems).

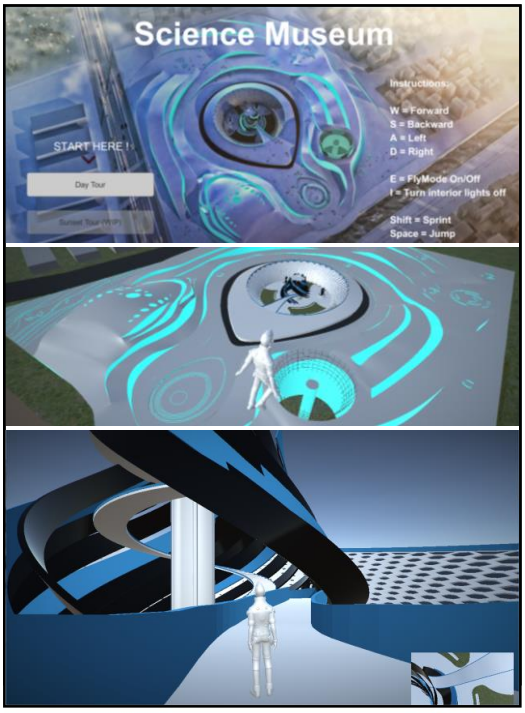

Fig.8. Walkthrough in museum design project using Unity3D game engine
Reference: Abd Elghani Safi, student work under the supervision of the author, 2017.

An example shown in figure 8 demonstrates the process that the students can use to interact with their design projects. This trial was through the course of Arch537 – Architectural design VII, Beirut Arab University, to present a walkthrough in a museum design project, as a new method of interactive design between the student and the teaching staff using Unity3D game-based learning.

5. IMPLEMENTING SECOND LIFE AS A DIGITAL GAME BASED LEARNING

'Second Life is an online virtual world, developed and owned by the Linden Lab in San Francisco, launched first in June 2003. It is similar to massively multiplayer online role-playing games.' It provides opportunities for contact, education and practice experience through virtual space parallel to the real world in all its elements as follows: (Second_Life, 2016)

Fig.9. S.L researcher avatar
Reference: www.secendlife.com

- Residents and avatars: 'Second Life enables a real user to create a virtual avatar of himself that can deal with other users in order to learn and share.' (Hodge. Elizabeth, 2011) See Figure 9.
- Economy in Second Life: This is based on the Linden dollar (L$), which can be used to sell, buy, rent or trade land and services with other residents.
- Land ownership: This virtual world poses a variety of small and large areas of land, starting from 512 m2. Residents can deal with dividing them and selling them, or create buildings and lease them. This work constitutes a real source of income for many of the virtual world users. A landowner can put laws on their land, which visitors must abide by. (Second_Life, 2016)

Many major institutions buy their own islands and have built their buildings to play a role in the goals of these institutions services, such as marketing, outreach and education for example. There are many universities who open their campus in this virtual world to apply their educational curricula, such as the Virtual University of Edinburgh, Scotland, UK. See Figure 10; and 11.

- Activates: Residents of this world can communicate or socially interact with the rest of the residents, as well as participate in group activities or work individually to produce virtual elements that can be exchanged in a trade. They can also travel from one place to another 'teleporting', and walk around and fly inside. Second Life supports several activities in the field of architectural design, including:
  - Architectural education: This particularly supports distance education, including: 'Classroom instruction, Group interaction, Office hours, Role playing, Peer review, Collaboration, Project development, Faculty and administrative meetings, Sharing videos and voice communication, Text chat, Interacting with the world, Creating interactive objects, and Participating in communities, meetings, and conferences' (Hodge. Elizabeth, 2011)
  - Collaborative design: Second Life is a virtual environment that support collaborative design activities and provides users with modelling tools that help in forming objects and design ideas. It can be used in solving real design problems through a teamwork from different times and places around the real world (Chase, 2008).
  - Design review: Supporting direct communication between students and instructors or between designer and client, with the

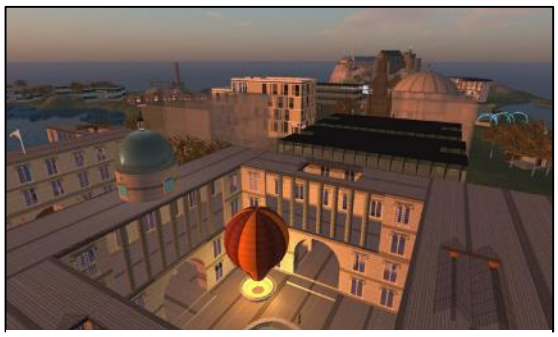

Fig.10. Virtual University of Edinburgh
Reference: http://secondlife.com/destination/virtual-university-of-edinburgh

Fig.11. Meeting area in virtual University of Edinburgh. Reference: http://blog.inf.ed.ac.uk/atate/2014/11/28/2014-virtual-university-of-edinburgh-graduation-school-of-education/

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possibility of interactive virtual display, walk through and living the design interaction experience aims to critique the design in order to attain the final product.

- Building in Second Life: Second Life is a 3-D virtual world built and designed by its residents (Hodge. Elizabeth, 2011) Using a build window which is divided into five different menus, as follows: shown in Figure 12.
  - Focus menu: allows user to edit his camera view.
  - Land menu: provides all the tools you need to modify your virtual land.
  - Create menu: vital to the building process where all objects in SL are built from virtual assets known as primitives. A primitive is commonly known by its shortened name, 'prim'. This menu provides you with 15 prim type choices.
  - Move menu: allows user to move the prim.
  - Edit menu: enables users to visually edit the position, size, and rotation of a prim.

Fig.12. Building in Second Life using build window
Reference: by author, 2016 in ARCHI21 sandbox SL location

5.1 The ARCHI21 experience - Second Life experiment in architectural education

ARCHI21 is an EU-funded project involving six institutional partners in four countries; France, United Kingdom, Slovenia and Denmark, aims to use the Second Life platform as a 3D virtual learning environment in architecture education where students can meet, discuss, learn, built, and etc. This virtual world designed and built by students and instructors to support learning-by-doing, experiential learning and professional development. (Escande, 2011)

In this experiment, there are several land uses which are dependent on the different activities and learning zones, especially in the field of architectural education as follows: shown in Figure 13:

1. Meeting zone (collaborative design and discussion)
2. Class room (E-learning lectures using interactive media)
3. Exhibition zone (design review)
4. Experimental zone (building in sandbox and dealing with designed projects in real time and real scale.

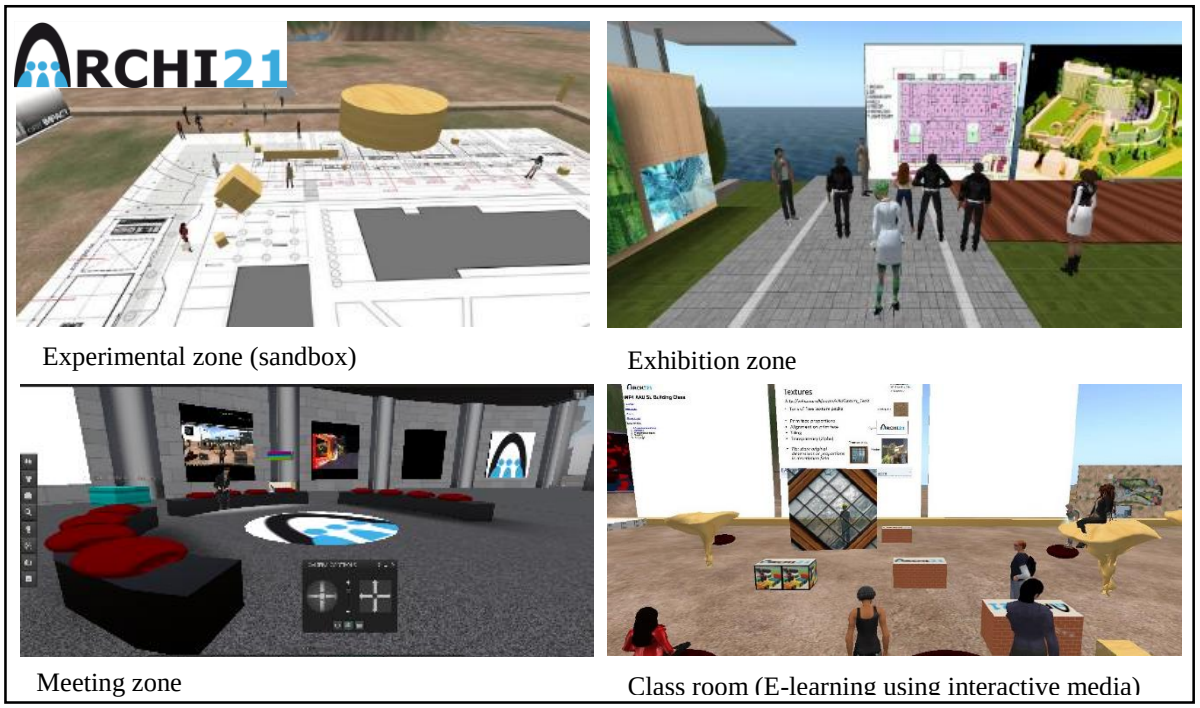

Fig.13. ARCHI21 based on Second Life Reference: ARCHI21 world on SL
http://secondlife.com/destination/archi21

6. THEORETICAL FRAMEWORK

Digital game-based learning in architectural education is considered to be an innovative approach to learning for the new generation of students, because of the nature of this evolving digital era. From the view of the researcher, digital game-based learning could be integrated in all fields of architectural education, which can be divided into the following: shown in Figure 14.

- Design courses;
- Construction courses;
- Professional practice courses;
- Different scientific courses related to architecture education.

This integration between digital game-based learning and architectural education as a parallel integration between real and virtual educational environments could work on two different levels, as follows:

- Gamification level (game elements designed to serve education purposes).
- Serious games level (whole game designed to serve education purposes).

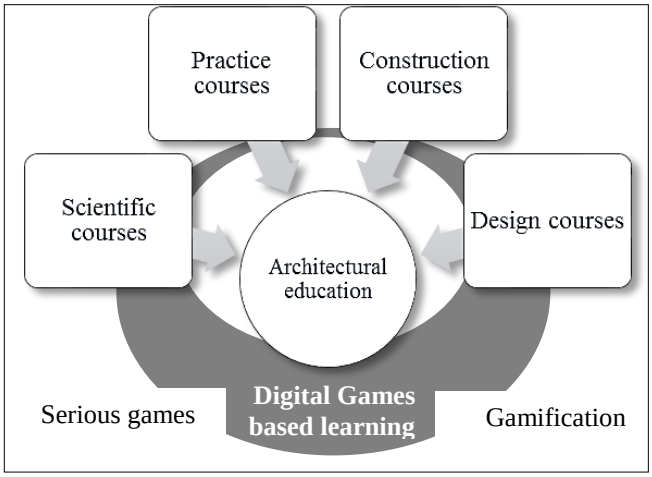

Fig.14. Integration between digital game-based learning and architectural education
Reference: Author, 2016

CONCLUSIONS

A. Today's students have high levels of technology skills, and digital games provide new tools for students with high efficiency which can help them in learning based on their interests.
B. Digital game-based learning environments are evolving rapidly to make a huge difference' in education because they are closer to simulating real-world experiences, and towards a new

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model of learning through meaningful activity in virtual worlds, to create personalized learning scenarios and intelligent tutoring environments.

C. Using 3D game engines in architectural design education as a real-time walkthrough, enables students to gain the experience of real dealing through virtual design.
D. For their promising future impact, virtual worlds have been used by many of architecture and design schools for education and practice. As an innovative platform, Second Life offers designers new and fascinating ways to experience architectural design and education.

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