3D VIRTUAL WORLDS AS NEW LEARNING ENVIRONMENTS FOR INDUSTRIAL DESIGN STUDIO COURSES

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ABSTRACT

3D VIRTUAL WORLDS AS NEW LEARNING ENVIRONMENTS FOR INDUSTRIAL DESIGN STUDIO COURSES

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Virtual worlds are 3D simulated environments which are shared with multi-users simultaneously via avatars. The primary purpose of this study is to discuss potentials and barriers of virtual worlds in terms of industrial design education.

For this purpose, firstly with an extensive literature review study, virtual world applications especially in higher education and for design education were scrutinized by means of the design process. This study showed that many areas including several design branches have already been benefiting from virtual worlds for their education, but there was no sufficient information in the literature about the virtual worlds applications for industrial design education. Therefore, interviews with professional industrial designers who are specialized in multi-media design were conducted for the purpose of gathering their ideas and suggestions about the possible use of virtual worlds in industrial design education considering the design processes experienced in the studio courses. The analysis of the examples found in the literature and the interview results comprise groundwork to determine the advantages and limitations of virtual worlds for industrial design education.

Consequently, it is obvious that the virtual worlds have potential to contribute to industrial design education in several means especially the stages performed together with the users such as user testing or with the educators such as critiques and presentations; however, by considering the current state of technology, it would be beneficial to debate integration of virtual worlds and traditional design education instead of complete transformation. This approach can help to eliminate deficiencies of both sides. This thesis study can be accepted as a starting work to think about industrial design education's possible future in the virtual world platforms.

Keywords: 3D virtual worlds, virtual learning environment, industrial design education, design process

ÖZ

ENDÜSTRİ ÜRÜNLERİ TASARIMI STÜDYO DERSLERİ İÇİN YENİ ÖĞRENME ORTAMLARI OLARAK 3 BOYUTLU SANAL DÜNYALAR

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Sanal dünyalar, birçok kullanıcının avatarları aracılığı ile aynı anda paylaşabildiği üç boyutlu simüle edilmiş ortamlardır. Bu çalışmanın birincil amacı sanal dünyaların sunduğu olanakları ve kısıtları endüstri ürünleri tasarımı eğitimi bağlamında tartışmaktır.

Bu amaçla, ilk önce etraflı bir literatür çalışması ile özellikle yükseköğrenimde ve tasarım eğitiminde yapılan *sanal dünya* uygulamaları ayrıntılı bir şekilde araştırılmış ve tasarım süreci göz önünde bulundurularak incelenmiştir. Bu çalışma, çeşitli tasarım alanları dahil pek çok alanın halihazırda eğitimleri için sanal dünyalardan faydalandığını göstermiştir. Ancak, endüstri ürünleri tasarımı eğitimi için kurgulanan sanal dünya uygulamalarıyla ilgili yeterli bilgiye ulaşılamamıştır. Bu nedenle, konuya bu aşamada en yakın olduğu belirlenen multimedya tasarımı alanında uzmanlaşmış endüstri ürünleri tasarımcılarıyla görüşmeler yapılmış ve stüdyo derslerinde deneyimlenen tasarım süreçleri göz önünde bulundurularak sanal dünyaların endüstri ürünleri tasarımı eğitiminde kullanımı konusunda görüş ve önerileri alınmıştır.

Sonuç olarak, sanal dünyaların endüstri ürünleri tasarımı eğitimine, kullanıcılarla bir araya gelinen kullanıcı testleri ya da eğitimcilerin önemli rol aldığı kritikler ve jüriler gibi aşamalara katkı potansiyeli olduğu; ancak, teknolojinin bugün gelebildiği seviye düşünüldüğünde, bütünüyle bir dönüşümdense, sanal dünyalar ile geleneksel tasarım eğitiminin birbirine uyumlu hale getirilmesinin tartışılmasının daha faydalı olacağı görülmektedir. Bu yaklaşım, her iki tarafın da eksikliklerinin giderilmesine yardımcı olacağı açıktır. Bu tez, endüstriyel tasarım eğitiminin sanal dünyalardaki olası geleceğinin tartışılması için bir başlangıç çalışması olarak kabul edilebilir.

Anahtar kelimeler: 3B sanal dünyalar, sanal öğretim ortamları, endüstri ürünleri tasarımı eğitimi, tasarım süreci

To Mom, Dad, Brother and Dear Husband

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CHAPTER 1

INTRODUCTION

Technology is developing through an ongoing and incremental process and it is becoming a key element of people's lives. One of the most effective technological developments is the Internet which is "a global computer network providing a variety of information and communication facilities, consisting of interconnected networks using standardized communication protocols" ("Internet", 2015). Technology has developed around the growth of the Internet; governments, economies, business, and even social relationships have all been affected in some way by this change (Neustadtl, Robinson & Kestnbaum, 2002). The Internet has started to become an indispensable part of human life.

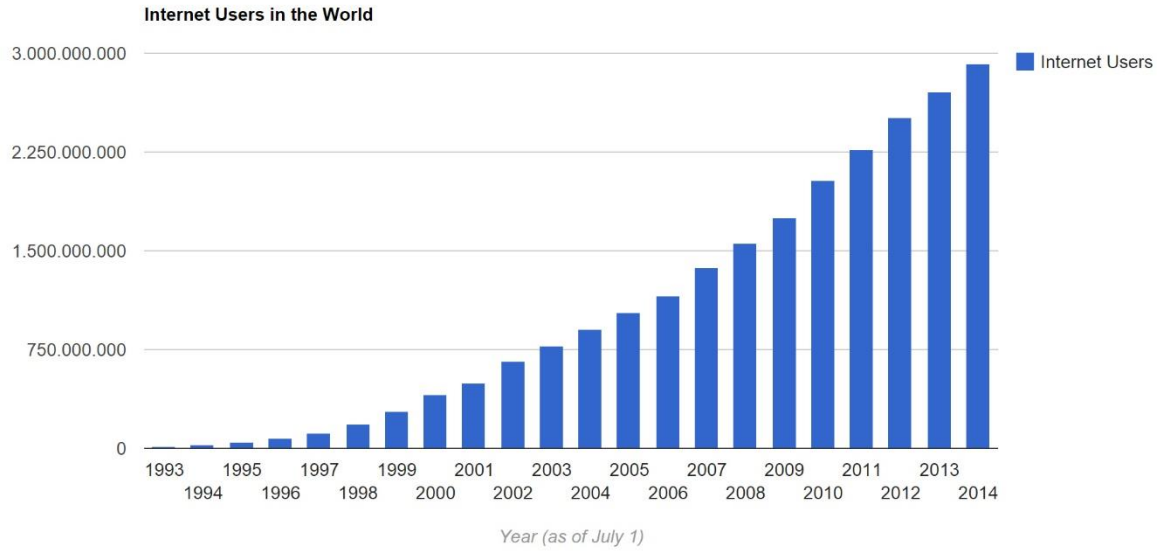


Figure1.1. Internet Users in the World

(retrieved July 4, 2015 from http://www.internetlivestats.com/internet-users/)

As seen from the above graph (Figure 1.1), as of July 2014, more than 3.1 billion people -which is about 40 percent of the world's population - have used Internet

services of some form. Internet usage started to become widespread after the invention of “the Mosaic” in 1993 which was the first global web browser. The Mosaic provided an interface for users instead of using computer commands, making it easier to connect to the Internet (Marson,1997). In 2005, the number of Internet users reached one billion, and further to two billion in 2010.

The number of people using the Internet daily has increased exponentially over the last twenty years. The way people perform their daily activities has been changing gradually. Instead of going out for daily activities, people have started to use online alternatives to carry them out. Therefore, spending a part of the day on the Internet is becoming quite a normal activity for many people.

Research shows that the internet is commonly used for social and entertainment purposes. Online searching, multimedia and social networking are the most popular online activities, and they require users to spend time on the Internet (Statista, 2013). Methods of communication, entertainment, the search for information, and the simplest daily activities have now taken on an online approach. The Internet has altered the concept of education and has become a new learning media. Neustadtl et al. (2002) state that the Internet can be seen as “the world’s largest library, albeit a library of inert, already-analyzed information” (p.186). Therefore, getting through to information is becoming easier via the Internet. As a result of this change, new terms have appeared in the field of education such as distance education, online distance education, e-learning and ubiquitous learning.

The Babson Survey Research Group, founded in 2005 in order to research the global impact of online learning, conducted a survey in 2013 to gather facts and figures about online education from more than 2,800 colleges and universities. According to Allen and Seaman (2014) who are the managers of this survey, the number of students attending online courses is increasing year after year. This increase is a sign of the transformation from traditional classroom environments to online platforms which has led to several changes in education. Internet-based education removes the

dependence of both students and educators on restricted course hours and physical places such as traditional classrooms. It can be assumed that students have greater control of course areas due to the physical absence of classrooms. This places greater responsibility on students to work independently and to organize schedules.

Internet-based learning or 'Distance learning' can be split into two categories in terms of the synchronization of the time that students and educators spend. Asynchronous distance learning usually provides weekly schedules and tasks and it allows students to work in their own spaces. On the other hand, synchronous distance learning provides live communication such as sitting in a classroom, chatting online, or teleconferencing. Students can communicate and interact with each other in real time just as they can in a physical classroom. Synchronous education can be held on different platforms such as web conferences (e.g. Adobe Connect, Saba, Vyew and so on), video conferences or interactive television programs that bring together students and educators at the same time (Beyth-Marom, Saporta and Capsi, 2005). *'Virtual world'*, which is the subject of this thesis, is another example of the platforms which contain many features and opportunities for synchronous education.

A virtual world presents a multi-user internet-based 3D environment. There are different virtual worlds, each tailored to their intended uses. For instance, *AvayaLive Engage* is a virtual world specialized for business purposes, which is utilized for meetings, product presentations, and business training; *Hyperfair* is a virtual fair field for online large-scale business trade fairs; and *Pharmatopia* is an interactive simulation platform for pharmacology. So, the use of virtual worlds can be diverse, from business purposes to medical purposes. Education is also a popular area for the virtual world. In contrast to the other online distance education platforms, the virtual world provides students with the opportunity to be part of the process in a similar way to the traditional classrooms, and to examine and work on educational materials outside of class hours. Students are represented by digital personas that interact and communicate with each other digitally.

A virtual world can be customized to accommodate different subjects. O'Connell and Groom (2010) explain that;

> Virtual worlds provide flexible learning spaces, simulations and alternative experiences, including creative, scientific, artistic and industrial immersive activities. Virtual worlds provide rich environments for scenario-based learning, allowing learners to interact with or construct places and environments, as well as objects of historical or scientific significance (p.7).

The main objective of the virtual worlds was originally entertainment and gaming but increasingly they started to be utilized for more "serious" purposes such as business meetings, project presentations, simulated training and for all means of education. The vast majority of educational applications are based on higher education and professional training. Various educational institutions adopt the advantages of virtual worlds into their curricula according to their specific requirements. For example, for medical courses, students can carry out their lessons in a hospital environment which has technical instruments and virtual patients. For banking education, students can role-play in a virtual bank to gain experience with virtual customers and their problems. For an art history course, a museum can be visited virtually by students under the guidance of educators. In other words, educators can customize these virtual environments according to their course topic, thus making their course more effective and interesting.

Whilst students and educators derive great benefits from the virtual world, design educators and students too can benefit from the virtual world as it enables them to collaborate and communicate with each other, especially during design projects in studio courses. For instance, in an architectural design studio, students can develop their projects in a virtual environment and can analyze their projects while walking around them as they would in the real world. While visiting, educators and students can discuss and analyze using the digital communication tools. As supported by Gu

et al, (2009) “the virtual world is a potential platform for collaborative design learning” (p.57).

Industrial Design Education aims to integrate theoretical knowledge with practical skills to generate a design. As Oztoprak (2004) explains,

> … in design education, the design process is mainly a problem based learning process. Students learn the process by living through it and instructors observe the students’ progress in the process. According to the observations, the outcomes of the process can be analyzed and further steps can be devised (p.12).

These interaction and communication networks continue throughout the duration of the course and throughout the process students try to develop their own projects for the next course based on the suggestions and feedback they receive. Therefore virtual worlds can provide multiple advantages for industrial design education; unrestricted course hours, full-time interaction and working areas for both students and educators are some of advantages of the virtual world that can contribute to design process and design education effectively. On the other hand, the question: “Is the quality of distance education as good as or better than face-to-face based pedagogy?” (Neustadtl et al., 2002, p.187) must be studied in depth.

This thesis can be accepted as groundwork for industrial design education’s possible transformation to virtual world platforms in the future. It includes detailed information about virtual world applications and their opportunities with specific regard to design education. In addition, it questions the advantages and disadvantages of virtual worlds as learning environments for industrial design education.

1.1. Aims and Objectives of the Study

The aims of this thesis are (i) to explore 3D virtual worlds in terms of their current state in the world, (ii) to examine educational applications in general and (iii) to discuss their potentials, possible advantages and disadvantages for industrial design education. The main purpose of this thesis is to provide groundwork to determine the advantages and limitations of virtual worlds for industrial design education. Therefore, virtual world applications especially in higher education will be examined. Studies around design education will be searched in detail. In addition, interviews with professional industrial designers who specialize in multimedia design will be conducted in order to gather their ideas and suggestions about the use of virtual worlds in industrial design education. This thesis study hopes to open a debate about industrial design education's possible future in the virtual world platforms.

1.2. Research Questions

The main research question of the thesis is:

- How do virtual worlds contribute to industrial design education in terms of design process?

The secondary research questions are:

- What is the virtual world?
- What are the educational virtual applications?
- What is the state of art of virtual worlds' contributions to the design process in terms of professional life and education?
- What is the current state of industrial design education and which of its features might be utilized in a virtual design education environment?

- What are the potential advantages and disadvantages of the virtual world for industrial design education?

1.3. Structure of the Thesis

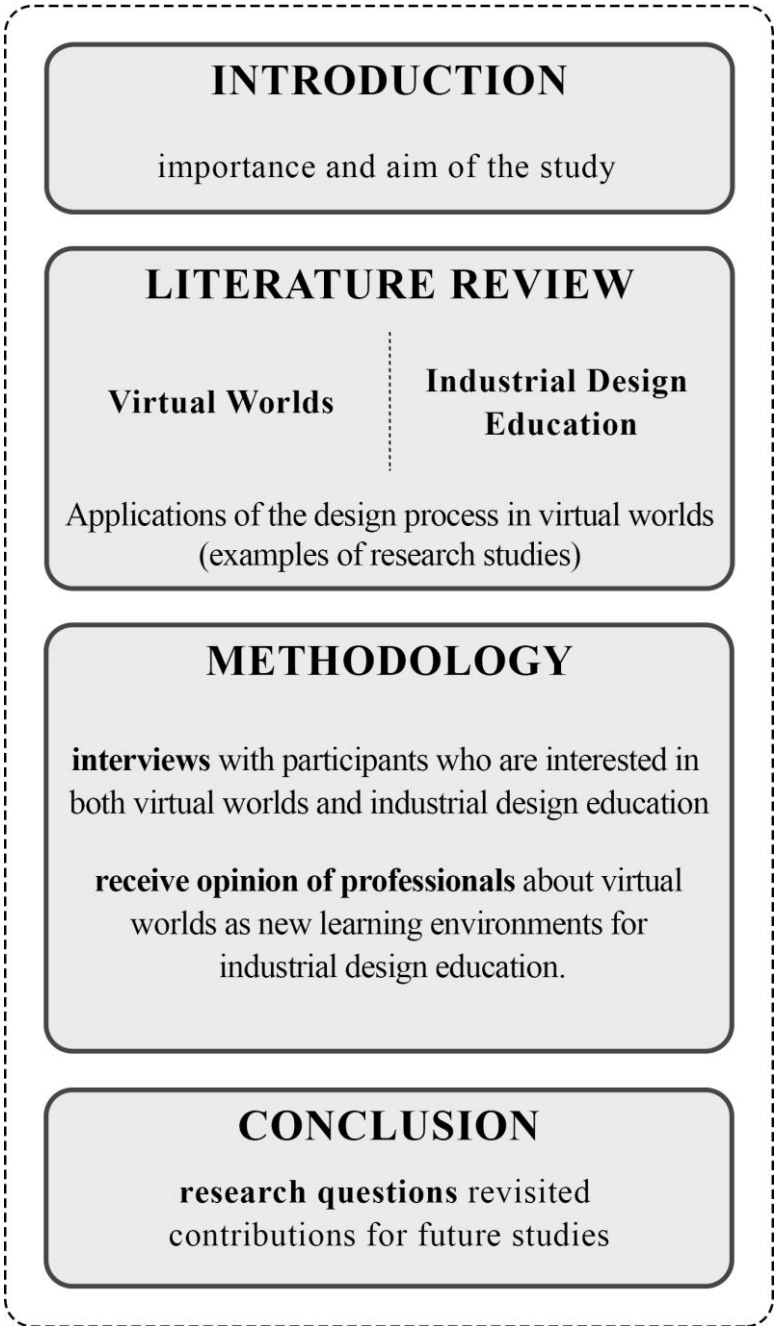
The thesis has been arranged into four chapters.
Chapter 1, *Introductio*n, includes the background, aim and objectives of the study, and determines the research questions.

Chapter 2, *Literature Research,* includes a review starting with the "Virtual World" which consists of the definition of the virtual world, its advantages, disadvantages and limitations plus examples. The chapter continues with the explanation of "Industrial Design Education". Essential definitions, the historical background of education, its current state and its future are examined. "Applications of design process in the virtual world" will form an important part of the chapter. Research studies on design education will be examined in order to evaluate the use of the virtual world for industrial design education. In the final section of the literature review chapter, the information presented will be discussed.

Chapter 3, *Methodology*, presents the research study which aims to enrich the theoretical background with information gathered by interviews with professional multi-media designers with industrial design background.

Chapter 4, *Conclusion*, includes inferences about the research with regard to the literature review and interview studies. The main and sub research questions of this thesis will be revisited. In the final part of the chapter, limitations of the study are discussed and some opportunities and implications for future studies are presented.

Table 1.1. Structure of the thesis



CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

The purpose of this literature review study is to provide a background to the foundations of the relationship between the virtual world and industrial design education. The first part of the review provides a detailed introduction of the concept of '*virtual world'*. Its definition, historical evolution, types of applications and its current situation will be explored. The second part of the review includes the essentials for 'Industrial Design Education', focusing on its origin and current situation. Traditional design education will be described and online education that is utilized for industrial design education will be detailed. Finally, applications of the design process in the virtual world will draw the literature review to a close.

For literature review, different sources which are mainly; METU Library, MIT Press Journals, ACM Digital Library, Science Direct, IEEE Xplore, Jstor and Google Academic search engines were reviewed. The keywords which are mainly "virtual worlds", "design education", "virtual worlds applications", "virtual worlds for design education" and their different versions were used while searching these databases. In fact, for each part of the literature review, keywords were arranged again in order to obtain more accurate information. These researches were focused on mainly the years between 2002 and 2015.

It is worth to mention here that the meanings of special terms used in this thesis are given in the Appendix A.

2.2. Virtual World

Before defining and explaining the concept of the virtual world, the term *virtual reality* must be explained to avoid misconceptions. As George Coates (1992) explains, virtual reality is "electronic simulations of environments experienced via head mounted, eye goggles and wired clothing enabling the end user to interact in realistic three-dimensional situations". So, not only use of a computer, but also special equipment is required for virtual reality applications to create and increase the essence of the reality.

In addition, Craig, Sherman and Will (2009) explain virtual reality as "a computer simulation that creates an image of a world that appears to our senses in much the same way we perceive the real world, or 'physical reality' " (p.1). Virtual reality introduces an artificial environment that affects the senses of the users in order to create a more realistic virtual environment. Wearable equipment enables the applications to check and respond to the users' motions and reactions. Therefore, responding to the senses increases the reality of this artificial environment.

Bartle (2003) focuses on the mechanisms such as visors and data gloves, by which users can interact with computer simulations when explaining virtual reality. By means of these mechanisms, some of the five main senses are controlled by the computer and the devices also monitor the user's actions, responding to them by sending new input. The definition and scope of the virtual reality differentiate with different technological developments such as the Kinect and Occulus Rift which are virtual reality technologies. The timeline below (Figure 2.1) demonstrates the evolution of virtual reality.

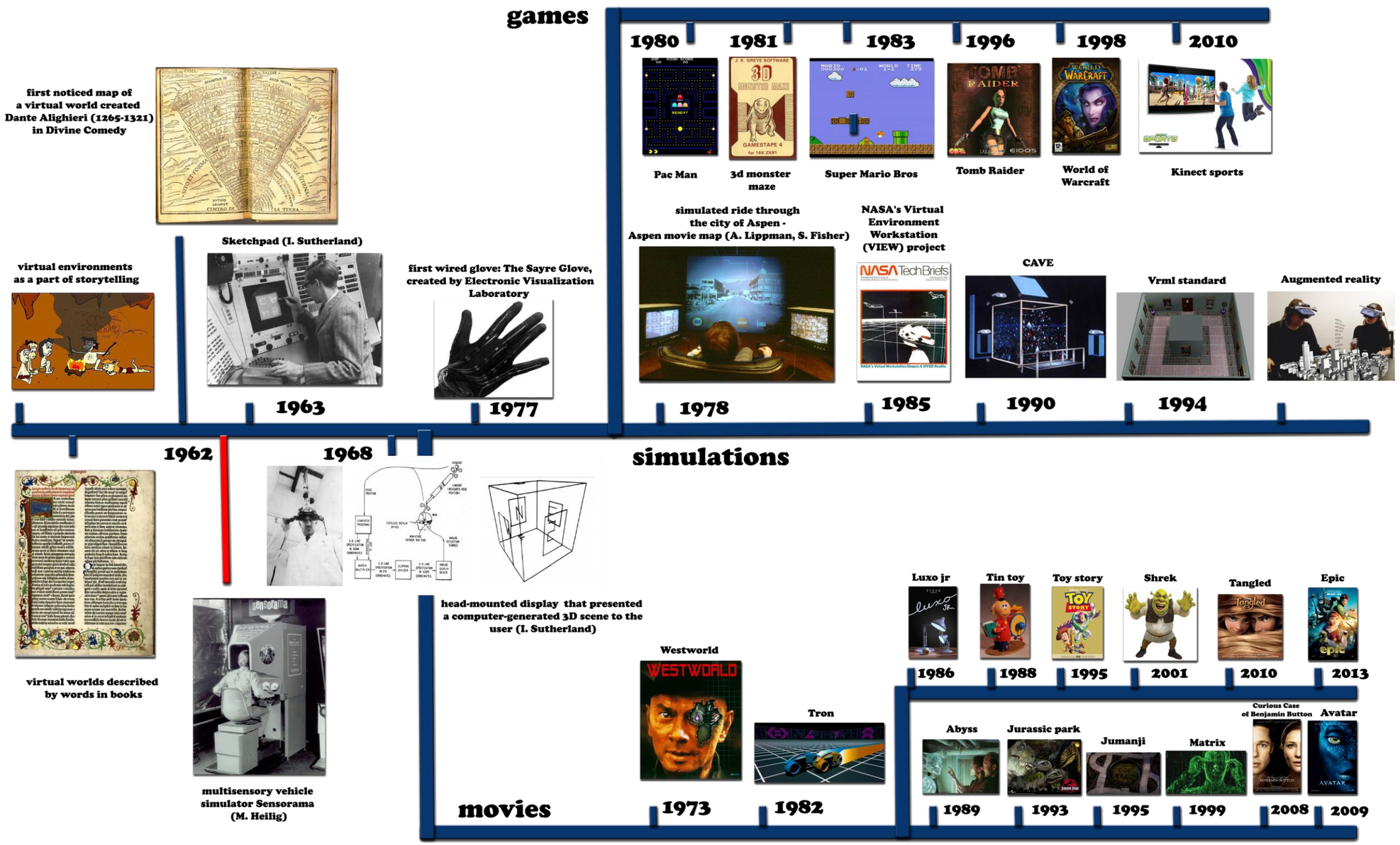


Figure 2.1. The history of virtual reality

(Retrieved 5 May from http://sccg.sk/~varhanikova/fmfi/apg/apg2.html)

As seen from the timeline (Figure 2.1), 'virtual environments' first appeared in the storytelling and books. Divine Comedy by Dante Alighieri (1265-1321) was accepted as the first fantastic book which narrates a virtual life. Until the 1900s there were no further improvements and the virtual environment existed only in books and stories. After 1962, with the development of technologies, virtual environments started to convert to digitalization. Multisensory vehicles, wired gloves, head mounted accessories and so on increased the effectiveness of the virtual reality and virtual environments became integrated with the users' movements. Movies and games are sectors most affected by these developments. As the most recent period of the timeline shows, virtual reality merged with augmented reality and motion capture cameras such as Kinect. By means of these technological developments, the effectiveness of applications has been increasing gradually.

Virtual reality provides its users with an experience in a virtual environment where they can interact with 'objects' which are 3D models and with the other users who share this environment simultaneously. Therefore, one of the important steps for creating virtual reality is to develop a virtual environment, in other words a *"virtual world"*. However, this does not mean that every virtual world requires virtual reality.

Edward Castronova (2005) explains the virtual world as "a world rendered by a computer" (p.294). Additionally, Raph Koster (2004) defines the virtual world as "a spatially based depiction of a persistent virtual environment, which can be experienced by numerous participants at once, who are represented within that space by avatars" (para.33). An avatar is a digitally created 3D character that is customized by the users according to their demands. Users interact and communicate with each other via these avatars. In addition, there are opportunities for communication which can be verbal such as voice chat, text chat and non-verbal such as gesture tools. These opportunities make users feel like themselves in the virtual environment in a similar way to the way they feel in the real world, as shown in Figure 2.3 in which users in the guise of their avatars visit 1920s Berlin.

Figure 2.2. Astronaut Rick Mastracchio practices shuttle mission tasks using virtual reality in NASA

(Craig et al., 2009, p.32)

Gonzalez, et al. (2013) offer a complete definition of the virtual world as a "persistent computer-simulated environment allowing large numbers of users, who are represented by avatars interacting in real-time with each other in a simulated environment" (p.331).

Judy O'Connell and Dean Groom (2010) emphasize the importance of the virtual world for human life;

> Virtual worlds - shared graphical spaces on the Internet - are an exciting new medium for the 21st century. They are the natural evolution of digital technologies that are defining the 21st century, just as telephone, radio, film, and TV helped to define life in the 20th century (p.1).

Therefore, it seems that virtual worlds will become an inevitable part of people's daily lives in the 21st century.

Figure 2.3. Role-play at the 1920s Berlin Project
(retrieved from http://en.wikipedia.org/wiki/Second_Life)

As stated previously, the first examples of virtual worlds were developed for the entertainment sector. However, they have started to be used for different reasons such as social, educational, commercial purposes and so on. By means of the various features and facilities which virtual worlds offer, users can determine their own goals and develop their own living environments; they can share these environments with the other users simultaneously.

Virtual worlds can be divided into two categories according to their development stages. One of them is in-house virtual worlds in which each aspect of the world is developed by the users themselves according to their needs and demands. The others are commercial which provide platforms to users in order to create their own virtual environments by using facilities provided by these platforms. For example, Second Life, OLIVE, Wonderland and Photosphere are some of these virtual worlds, which develop their own interface and language to guide and direct the users while using them.

2.2.1. History of the Virtual Worlds

The term '*virtual world*' came into people's lives initially in books and then latterly in some films of the last 20 years. Joe Sanchez (2009) categorizes the history of virtual worlds using five milestones:

- Multi-User Dungeons (MUDs)
- TinyMUDs
- MOOs (Multi-user dungeons Object Orientated)
- MMORPGs (Massively Multiplayer Online Role-Playing Games)
- 3D social virtual worlds (p.9).

The first MUDs were interactive, text-based virtual worlds in which users managed their interactions through text-based commands such as "walk" and "open". One of the earliest and most popular MUDs was Dungeons & Dragons created around 1980 by the students at the University of Essex in England.

Figure 2.4. A combat in The Shadow of Yserbius, an early graphical MUD (1991)

(retrieved form https://upload.wikimedia.org/wikipedia/en/e/e6/Yserbiusfight.JPG)

Unlike early MUDs (such as Figure 2.4.) that generally include adventure scenarios and battles, TinyMUDs offered much more creative and social virtual world experiences. Users could create new environments and objects which were static and non-interactive. However, Bartle (2003) points out that the weakness of the TinyMUD was that the "players spent most of their time creating things and talking about their creations" (p.9). Rather than a game, it turned into a social environment in which users could interact with each other, essentially a social virtual world. In addition, Sanchez (2009) indicates that the TinyMUD presented virtual worlds as social spaces where six to eight users could be online at the same time. In spite of the traditional elements, creativity and collaboration had started to appear in the game industry with the introduction of TinyMUDs.

MOOs provide users the opportunities of a virtual world with its own programming language. Users can create their own themes and objects and can share them with other users. In addition, these objects can be used and interacted with in comparison to the TinyMUDs. Stephan White published the first MOO in 1990 and many of them are still available twenty years later (Sanchez, 2009).

Massively Multiplayer Online Role-Playing Games (MMORPGs) began with Meridian 59 (Figure 2.5.) in 1996. MMORPGs provide users with an online graphical environment where they can interact with other users. MMORPGs present a scenario that users follow to achieve goals. By contrast, 3D social virtual worlds do not have scenarios; users create their own purposes and environment, and share this environment with others.

Figure 2.5. Meridian 59 Demo published in 1996, an MMORPG

(Retrieved from https://archive.org/download/mer59/mer59.jpge)

Sanchez (2009) explains "three developments from the use of MMORPGs created a ripe environment for the rise of 3-D social virtual worlds". The developments are detailed below:

- Collaboration creates a strong social system between users
- Users maintain this social system outside of the game
- The development of computer technology and the increase in the proliferation of the personal computers (p.11).

These developments accelerated the improvement of virtual worlds. Users in these virtual worlds can build and personalize their environment, and they can socialize and collaborate with other users. There is no goal or purpose for the interaction unless one is created or built because of the lack of a game scenario. In addition, these 3D virtual worlds remain flexible with spaces where each age group can participate for different purposes.

Sanchez (2009) also emphasizes the differences between MMORPGs and 3D social virtual worlds explaining that "while MMORPGs are still played more frequently than any social virtual world, social virtual worlds are rapidly expanding and are being adopted as a groupware technology" (p.12).

Accessibility to technology and applications became easier and more available day after day. This has encouraged the use of virtual worlds for a variety of purposes and in a range of areas.

2.2.2. How Virtual Worlds Work

While users are building their own world, they can create 3D objects digitally by using the virtual world' buildings tools which facilitate these creations. Systems begin with basic geometric shapes which are named as prims and users can create 3D objects from these prims with the aid of modification tools. At this point, users must have 3D modelling skills or if not, they can purchase objects from stores and import the system. In addition, the system provides a facility to import textures which are used to texturize objects in order to present more realistic appearance. Furthermore, the system offers an internal scripting language that can be used to assign interactions or missions to objects.

One of the attractive points of the virtual world is avatar customization. Users can choose character types which can be human or animal or other things. Gender, body type, hair, clothes, proportions and so on are optional and can be customized. Users can create an avatar that looks like themselves or just as they like. They can also create a fantastic character or model their avatar on their heroes. This diversity and freedom appeal to users.

As mentioned earlier, virtual worlds have options for communication. Basically, voice chat and text chat are the main communication tools; however, facial

expressions and body animations make communication more attractive and realistic. In addition, new technologies like webcams or augmented reality can be added to this environment to enhance the communication tools. For example, a video conference held between the same participants in real time allows not only speaking to the avatars but viewing the real person if there is a webcam available.

There are various options for movement of the users in a virtual environment. Users have the ability to walk, run and fly via their avatar. Users can control these options and walk or run on the terrain which is the ground of the virtual environment, or they can fly in the sky and adjust the height of the flight. In addition, there is a teleport option in the virtual world which can be used to change locations. Teleport icons which are placed at certain points in the virtual environment by the developers provide the opportunity to change location easily.

2.2.3. Application Areas of Virtual Worlds

Virtual worlds are developed to cater for different needs of different parties such as various businesses, educational institutions, and entertainment sectors. According to the Benchmark Report (2012), there are about 120 virtual environments, technological platforms and solution providers dedicated to building virtual worlds globally.

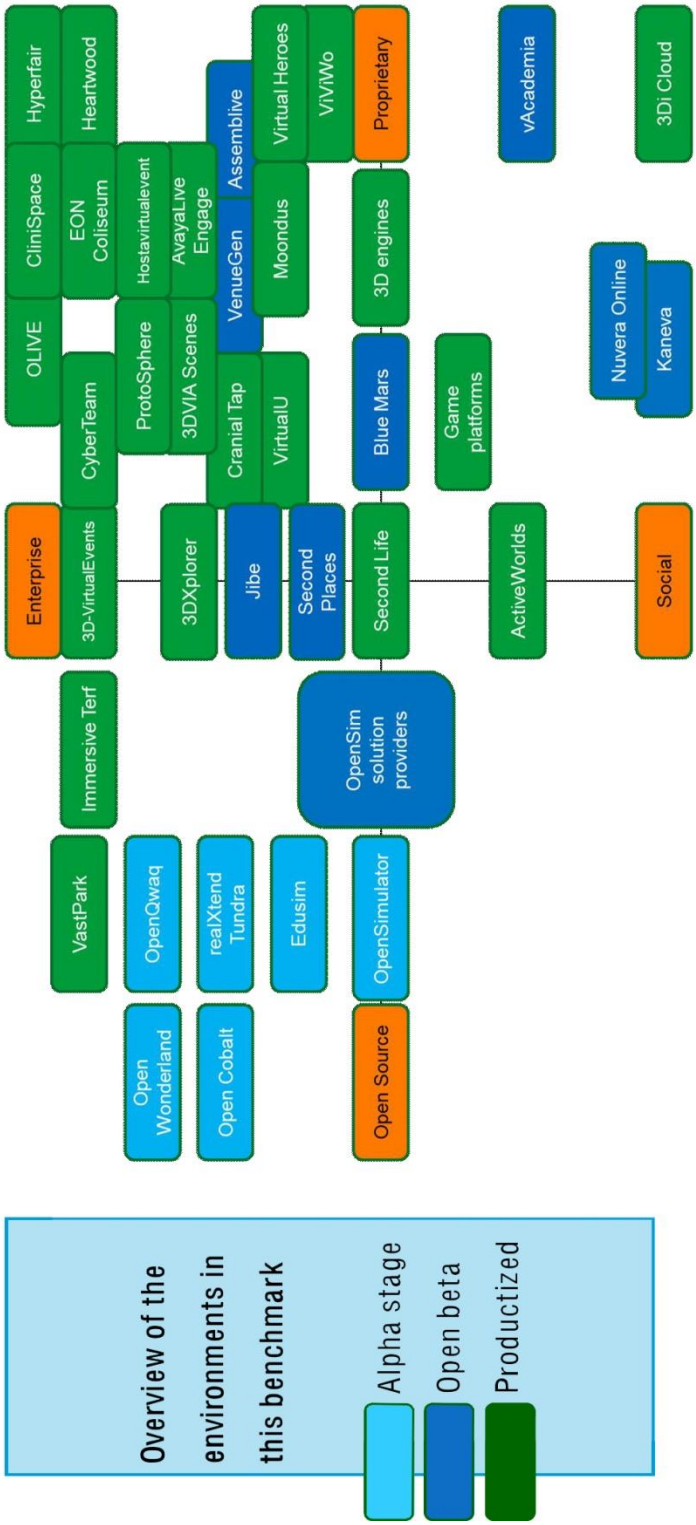


Figure 2.6. Categorization of 50 virtual environments

(Benchmark reports of virtual environments, 2012)

The report uses 50 of them which are the most popular ones as in Figure 2.6. They are divided into three according to their commercial use capacities in the above chart. Only 24 of them have been released, others have been in the development process, but seven of them are very close to the commercialization stage. In fact, in these three years, some of them such as OpenSim, Venuegen, vAcademia have been released.

One of the most popular virtual worlds is Second Life which was developed by Linden Lab in 2003 (Second Life, 2015). According to Linden Lab, it had about 15 million users in 2014. In Second Life, users collaborate with each other to develop their virtual environment and their creations range from single virtual items such as 3D buildings to virtual businesses and shopping malls. In addition, users create their avatars which can interact with other avatars, places or objects. They can explore their world, meet other users, socialize, participate in individual or group activities, build, create shops and trade virtual property and services with each other. It is a platform that principally consists of 3D-based user-generated content.

Figure 2.7. A snapshot of the METU Virtual Campus in Second Life
(retrieved from http://virtualcampus.metu.edu.tr)

> Education and training are the two most promising application fields for virtual worlds. Actually, there are more than 150 universities present at the Second Life virtual world although there are many educational institutions that opted for developing their own virtual world including private access for their students. (Gonzalez, et al, 2013, p.331)

Virtual worlds provide a lot of opportunities that make the learning process more appealing for educational institutions and they simplify interaction and collaboration between students and educators (Figure 2.7.). Without time and place restrictions, users meet and communicate with each other using only computers and Internet technologies. Moreover, accessing and sharing resources and information are becoming quicker and simpler. Also virtual worlds provide realistic and interactive multi-user environments for training and education.

Each area develops their own environment according to their purposes and needs. These areas will be examined in the following section.

2.2.3.1. Entertainment and Social Networking in Virtual Worlds

Entertainment and social networking were the most popular areas in the virtual world according to the number of users and market volume in 2011 (OECD, 2011). “More than 70% of virtual world users” used it for entertainment and social networking (p.4). This rate has been maintained today according to the Second Life website which presents the majority of virtual worlds utilized for entertainment and socializing purposes.

The entertainment industry, which includes virtual museums, exhibitions, theatres, theme parks and galleries, is one of the most attractive sectors for virtual worlds. For example, virtual worlds for museums are developed for remote access; also, applications are improved when integrated with the virtual worlds and placed in the

museums physically to enhance the effectiveness and reality of the museums. An art gallery can be visited without the need for travel. Users can view paintings and converse with other users via their avatars.

In fact, entertainment industry now goes hand in hand with the game industry. Massively Multiplayer Online Games (MMOGs) represent the most distinctive application of virtual worlds. The OECD report (2011) explains MMOGs as growing entertainment industry in a huge competition and "the total number of active users worldwide playing MMOGs was estimated to be more than 17.5 million at the end of 2008 (p.11).

Today, the development of the smart-phone and smart-tablet brings online applications and games to the fore; and, this facilitates access to the online entertainment industry. As a result, the number of users who spend time online for entertainment purposes is growing increasingly.

Social networking is another attractive area for the virtual world developers. Virtual social worlds mainly focus on users' creativity, collaboration and interaction. Users define their environment, rules and objectives.

A group of entertainment applications is about sports. Virtual worlds encourage users to partake in physical activities. For example, Online-Gym allows users to interact by using Kinect and to participate in online synchronized gymnastics sessions. The applications provide new opportunities for enhancing the physical and social well-being of people.

Users can build a social environment by participating in sports, playing games or participating in any of the available entertainment activities.

2.2.3.2. Medicine in Virtual Worlds

Medical virtual worlds generally are used in the field of education rather than professional practice. However, educational and working lives continue together in the health sector, so virtual applications for medical purposes are targeted by both professionals and students. Clinispace (Figure 2.8), for example and ClinicalCare focus on medical workers or students improving themselves and gaining experience. Apart from that there are virtual applications for patients (especially for cancer patients) which provide an environment in which they can support each other.

Virtual worlds have the potential to offer medical students social networking and learning opportunities through the use of collaborative and immersed learning. Medical students can experience emergency and disaster simulation training, or realistic and interactive role-playing simulations for improved doctor-patient interaction and communication and clinical diagnosis skills.

In traditional medical training, students trained with simulated or 'standardized patients'. According to the Association of Standardized Patient Educators (2010), standardized patients are actors trained to portray individuals with health issues in a standardized and repeatable way, which increases fidelity or realism (as cited in Fink, et al., 2014, p.560). These trainings allow students to develop their clinical skills and live experience. Conversely, virtual patients are computer-controlled avatars in virtual worlds. Compared to standardized patients, virtual patients are more affordable. They can be duplicated and modified to be made available for students. Although standardized patients are more real, they cannot be a part of surgical training at any time. Therefore in order to train basic doctor-patient interaction and clinical diagnosis skills, interaction with virtual patients is more efficient for medical education. Hence, virtual worlds provide an environment where students can learn by doing at any time.

Figure 2.8. A snapshot from Clinispace which is a virtual learning environment for healthcare

(retrieved from http://www.clinispace.com/)

One of the important points of health care education is inter-professional education (IPE) which aims to teach students, who are members of inter-professional teams, their role in these groups. They can share their knowledge and skills with each other and experience being a part of a health care team. However, time, space and location make it difficult for IPE to take place. Therefore, the use of technology can overcome these limitations, making inter-professional education more accessible for students. Students of pharmacy, nursing, physical therapy and medical assistance can use virtual worlds to experience collaboration between various professionals and practice the clinical diagnosis of virtual patients.

Nursing education includes some high-risk factors and situations that make practical training inappropriate for nursing students. Many important cases may not be convenient due to safety and ethical reasons. In contrast, virtual simulation may offer an opportunity to students to experience all types of clinical situations without the associated risks and challenges. In addition, all students can benefit from the opportunities presented by virtual world at the same level that standardization provides in education.

Furthermore, there are applications designed to help patients improve patient-clinician communication and to support and help each other in enhancing social skills, self-perception, empathy, psychosocial functioning and cognitive skills. Virtual worlds are effective learning environments for both patients and healthcare professionals.

2.2.3.3. Commercial Applications in Virtual Worlds

In 2011, the OECD foresaw the importance of the improvement of the virtual world in their digital economy papers, stating that;

> Increasingly, virtual worlds are becoming platforms for real economic transactions. This includes transactions between consumers as well as between businesses and consumers. Users create, sell and purchase virtual properties including land and objects which are 3D products in the virtual worlds (p.14).

Today, these forecasts are continuing to become reality. Some real-life firms are using virtual worlds - especially Second Life - actively. Many of these firms are well-known multi-national corporations such as IBM and Toyota; they build their virtual companies in locations where they hold meetings, conferences, and collaborative online activities. In addition, virtual worlds are now starting to be used as an additional marketing environment in which companies open virtual showrooms for their virtual products. Also, virtual worlds are used as an alternative advertising channel which is cheaper than conventional methods.

Gonzalez, et al. (2013) state that virtual worlds offer researchers, businessmen and users the opportunity to come together and work in a group. The development of the Toyota Scion prototype is given as a successful example. Toyota used Second Life to create an environment to bring together all the stakeholders during all the stages

of the design processes. Throughout the prototype creation, 3D visualization and close interaction opportunities were used effectively by the users via their own avatars.

Some firms and organizations are going further and are using virtual worlds for other activities related to their business such as hosting recruitment fares, virtual fairs, product promotion and training sessions.

Figure 2.9. A snapshot of VenueGen which is a virtual meeting room service (retrieved from http://www.hypergridbusiness.com/2011/02/arizona-school-goes-virtual-with-venuegen/)

VenueGen (Figure 2.9) is a kind of virtual world offering virtual meeting room services to their customers. Users can interact with each other by using realistic photo-generated 3D avatars. Firms can hold their meetings and gatherings by renting a space from VenueGen at any time. Customers experience almost face-to-face conservation.

OpenQwaq is another example of a virtual meeting environment, but it focuses on small meetings. It supports variable document formats including PDFs, JPGs, open office documents and some video formats which can be used during presentations.

In addition, as mentioned earlier, Hyperfair is an online platform that enables businesses to organize their own fairs. They can exhibit their 2D and 3D materials on these online platforms; their visitors can move around the fair and communicate with the company executives without spending time and money on travelling.

2.2.3.4. Educational Applications in Virtual Worlds

Virtual worlds are used to support education and training provided by private and public sectors such as the defense and aviation industries and educational institutions - especially higher education. One of the features of virtual worlds that makes this environment convenient for education is its interactive nature. Virtual worlds provide dynamic social interaction and collaboration between large numbers of users via the Internet. Therefore, it presents a new and innovative platform for education.

Virtual worlds provide an easier, safer and more cost efficient learning process than real world educational materials and physical learning environments. In addition, they provide realistic and interactive role-playing simulations in training situations. Multiple disciplines can easily come together and participants can experience being a part of group work. Also, there are several opportunities for educational institutions to adopt this kind of environment. They enable students and educators from all around the world to interact face-to-face, to access wide data and resources, to communicate by voice and to visualize a 3D environment (OECD, 2011).

As Guri-Rosenblit who works on the development of learning technologies at the Open University in Israel foresaw in 2009 that the use of electronic technologies has triggered a change in the way that students are taught, especially in universities. Technological developments have changed teaching methods and learning processes; in order to adapt the new technologies, universities have started to revise

their educational policies. Guri-Rosenblit (2009) emphasized that there was an assumption that;

> … the new technologies will transform teaching and learning processes from being highly teacher-dominated to student-centered, and this transformation will result in increased learning gains for students, creating and allowing for opportunities for learners to develop their creativity, problem-solving abilities, information reasoning skills, communication skills, and other higher order thinking skills (p.15).

Peter Drucker (1997), who is considered to be one of the most important management thinkers of our time, predicted in 1997 that "thirty years from now the big university campuses will be relics and universities won't survive" (as cited in Guri-Rosenblit, 2009, p.15). Currently, universities have both virtual and physical campuses. According to Second Life statistics, there were 150 university campuses in Second Life in 2013. For example Delft University of Technology is one of the universities that have both a virtual campus (Figure 2.10.) in Second Life and a physical campus.

Figure 2.10. A snapshot of Delft University of Technology's campus in Second Life (retrieved from http://www.tudelft.nl/en/current/university-magazines/delft-outlook/former-editions/delft-outlook-2007-2/kort-delfts/second-life/)

Language learning is a popular subject for education in virtual worlds. The best way to learn a foreign language is to live in or spend time in an area where the language is spoken. However, virtual worlds provide these environments for their users without the travel expenses. Students feel more relaxed and confident in the virtual environment compared to real life, so virtual worlds can be more appropriate for speaking practices.

Figure 2.11. Home page of Languagelab in Second Life

(retrieved from http://betatechnologies.info/blog/language-lab-registration-centre-and-branded-sl-client)

Sandler (2012) points out that "Languagelab" (Figure 2.11) is the most active virtual world language learning school. She explains that there are both traditional classes similar to a real life environment for basic conversations and pronunciation and special environments for topics such as Business English and Aviation English. (p.120). For example, they have created an airport in order to provide a realistic environment in which Aviation English can be learned. In this way, practicalities of real life and the comfort of the virtual world are actualized together.

The above examples show that virtual worlds provide important opportunities for multiple educational fields to make teaching and learning processes more effective.

2.2.4. Virtual Worlds in Higher Education

There has been an increase in the use of the 3D virtual worlds in higher education facilitating new and effective learning environments and experiences for students. These online platforms provide the opportunity to create specialized environments by using modeling and scripting tools for each department. In addition, they support various learning materials used to manage presentations and lessons. Various environments (such as virtual laboratories, design studios and simulated classroom) can be built according to needs and demands and they can be customized to accommodate multiple fields of study.

The Second Life database (2013) shows that the number of universities which use virtual worlds in the United States, is clearly more than the number of the European universities. MIT, Harvard University, Stanford University, University of Texas, University of Cincinnati and Ohio State University are some of the universities in the United States which have virtual campuses in Second Life. The reason for this dominance by the United States stems from the fact that the developer of the Second Life, Linden Lab, originates from the United States. However, universities in other countries such as the University of Warwick and the University of Sheffield in the United Kingdom, the University of Porto in Portugal, The Hong Kong Polytechnic University in China and the Monash University in Australia and some others have made studies on the use of virtual worlds in their curricula. Apart from that, there are in-house virtual worlds which have been developed by the universities according to their own needs.

Four of the main educational areas, engineering, medicine, teaching and architecture education, are prominent in the virtual world higher education applications, and will be examined in the coming sections. Virtual environments which were tested by universities for educational purposes will be explored. Special attention will be given to the research studies about architectural education since its educational

structure is based on the design studio approach similar to the common approach to industrial design education.

2.2.4.1. Engineering Education in Virtual Worlds

In the development of virtual university campuses, each department starts to build their own environment according to their discipline. They customize their virtual environments according to their different needs. Virtual worlds provide a distance student-based learning system for engineering education. Virtual laboratories and interactive systems are built to enhance the efficiency of the learning process. Also, standard classrooms are used for lessons and presentations. In addition, educators have the opportunity to give assignments and tasks to support the lessons.

One of the research studies on engineering education held in virtual worlds is about the Engineering Education Island of the University of Ulster (Figure 2.12) in Second Life. In 2006, the University of Ulster started to use Second Life to focus on distance collaborative education and to enhance the efficiency of their teaching and learning processes. Then the university developed a specific environment for engineering education where virtual laboratories and lecture halls were included. Callaghan et al. (2009) examine this environment and emphasize that "it is possible to successfully harness and integrate the relative strengths of each platform e.g. the course management features of virtual learning environments and the immersive/highly interactive nature of virtual worlds to create engaging learning experiences for students" (p.16). In addition, diversified and improved functionalities, interactions and movements are possible and are easily implemented using the features of the virtual world.

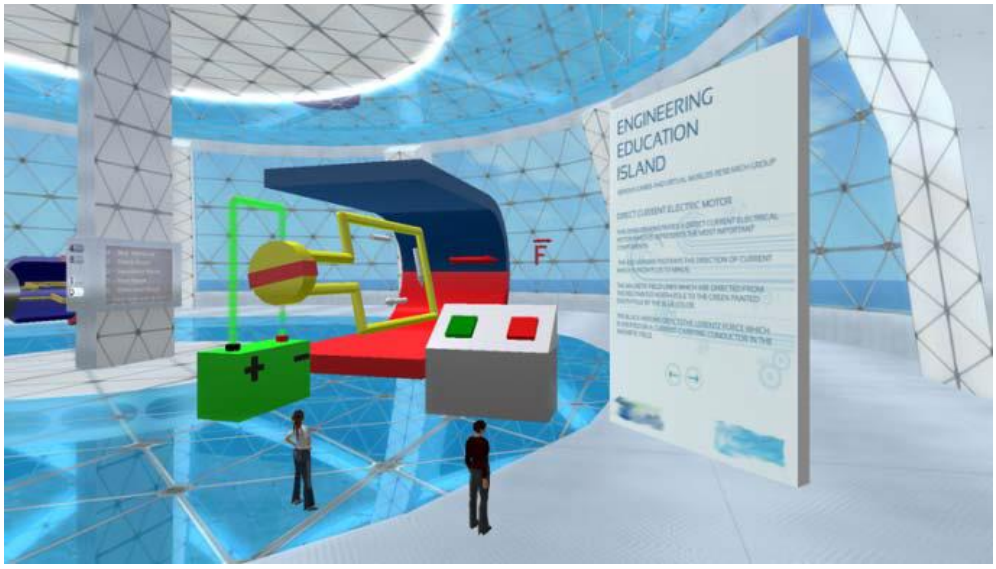


Figure 2.12. Direct Current Electric Motor Demo in Engineering Education Island (Callaghan, et al. 2009, p.6)

The island contains virtual laboratories which are interactive and simulated engineering aspects such as AC generators and DC motors. Students are given opportunity to examine these models in detail and simulate the system. In addition, "an interactive simulation which demonstrates the main functions and components of a direct current electric motor" (Figure 2.13) can be observed by the students and educators in a way that is barely possible in the real word (Callaghan, et al. 2009).

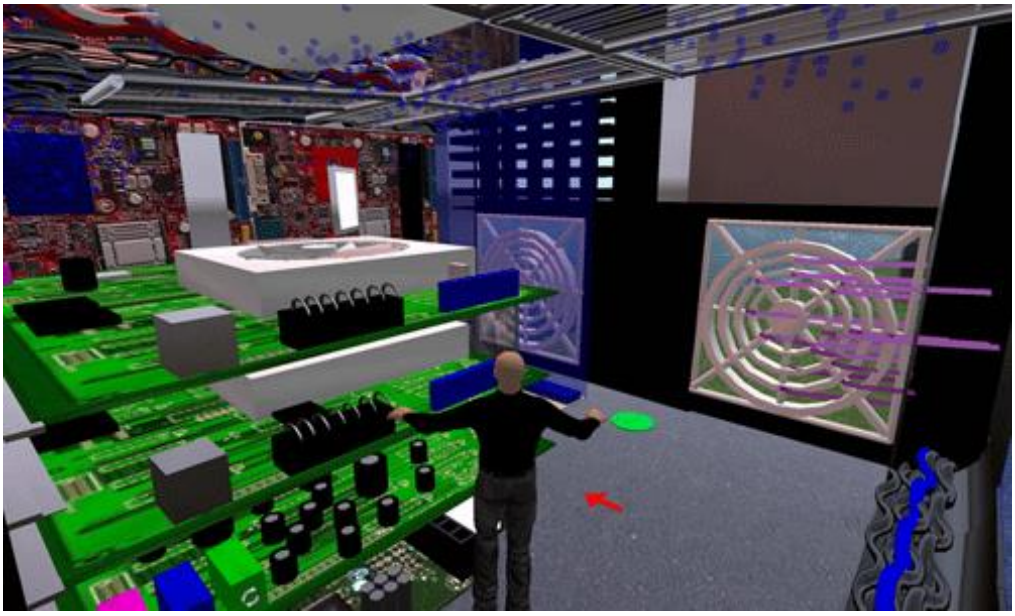


Figure 2.13. Inside the Giant PC in Engineering Education Island

(Callaghan, et al. 2009, p.16)

Another example is an in-house virtual world called Aeroquest (Figure 2.14) developed by Purdue University for an aerospace course. Okutsu, et al (2013) conducted a research study on this virtual world-based course which is actualized in Aeroquest by drawing a comparison with a control group in the real world and uses traditional educational methods. Exam scores revealed that the virtual world group was more successful than the real-world group. Therefore, they suggest that the application of virtual worlds especially in early engineering courses can be more effective for distance education.

Figure 2.14. Lessons in Aeroquest

(Okutsu, et al. 2013, p.292)

According to the study on Aeroquest, there are many advantages and positive impressions about the virtual course. The alternative options for communication methods, importing 3D models and uploading work such as posters and assignments to the virtual environment are appealing course factors for students (Okutsu, et al. 2013).

2.2.4.2. Medical Education in Virtual Worlds

There are several platforms for medical education, where medical students can practice and gain experience with virtual equipment and virtual patients in simulated hospitals or medical centers. For example, the School of Medicine at Imperial College London developed a virtual hospital in Second Life which utilized game-based learning activities. Students are given the opportunity to enhance their experiences with role-playing activities which include virtual patient diagnosis and treatment processes (Figure 2.15).

Figure 2.15. Imperial College London's Virtual Hospital in Second Life

(retrieved from https://secondhealth.wordpress.com/expect/)

Another example is the Neighborhood which is one of the popular medical education online platforms and specializes in nursing. Its aim is to enhance the quality of teaching and of the learning process. Fiedler, et al. (2014) who conducted a research study on the Neighborhood, highlight that with the development of technology in education, educators have started to search for new technologies that are customized for health care education and faculties have started to use these technologies in their learning systems in order to fulfill the needs and demands of health education.

San Jose State University developed the Heart Murmur Sim which is another medical educational application in Second Life. The aim of the project is to enable students to listen to various types of cardiac sounds and to experience the process of identifying them. As another example, MUVErs Medical Simulation which was built in 2009 by John Miller, is a nursing educative platform that involves a virtual patient who has pain symptoms; students are expected to interact with them, talk about their symptoms and treat the problem by using virtual equipment.

The number of these learning environments can be increased; universities are developing virtual applications not only for medical students but also for other users to increase consciousness about healthy life. For example the Ohio State University developed a nutrition game in Second Life to demonstrate the impact of fast food on health. The aim of the game is to show that the dietary choices of the users affect their health. When they make true and healthy choices, they score higher.

Moreover, there are virtual worlds which have been developed with the help of contributions from universities to support medical education. For example, CliniSpace, SIMCare Health and ClinicalCare are some of the platforms which provide healthcare education training applications and give users the opportunity to build specific training programs. Steps of medical interventions are carried out step-by-step in virtual worlds (Figure 2.16). Medical students and also professionals can enhance their experiences with the help of these platforms.

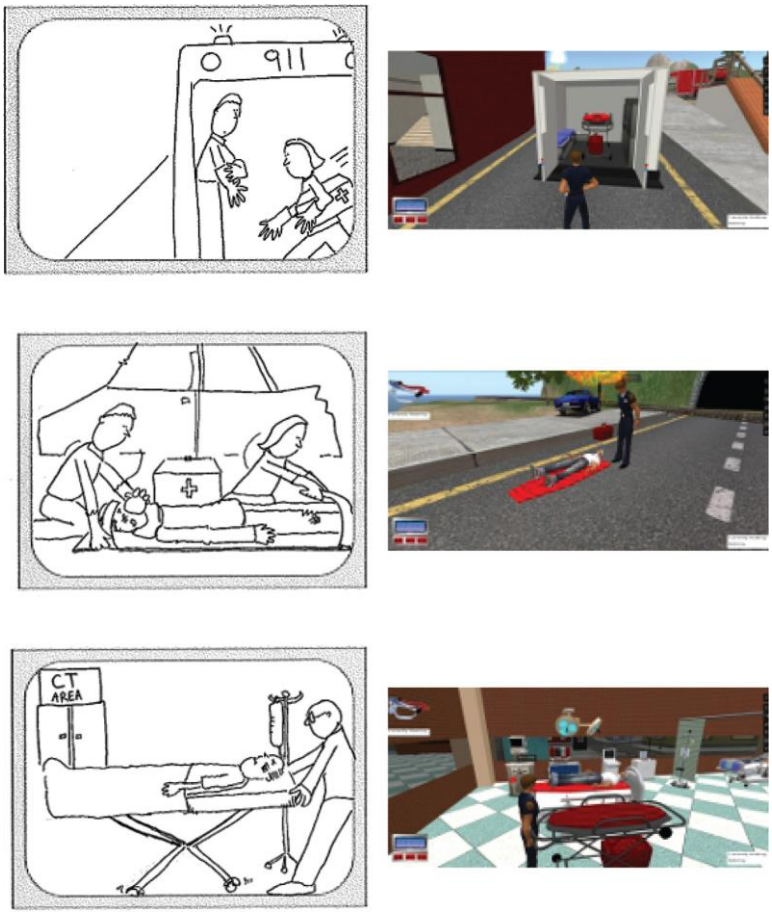


Figure 2.16. Storyboard scenes with their corresponding virtual world scenes.
(King, et al. 2012, p.5)

2.2.4.3. Teacher Training and Education in Virtual Worlds

Practicing teaching skills is an important part of many teacher education programs. This training provides students the experience of being a teacher in a class before their professional life starts. Traditionally, teacher education programs send their students to schools to spend a certain amount of time there observing the experienced teachers and practicing teaching. After they have observed how experienced teachers process the courses, they then have their very first experiences giving lectures in a real classroom environment based on their observations and theoretical knowledge.

Calandra and Puvirajah (2014) state that this practice is limited since the period spent in real school includes limitations and risks. Therefore, alternative and appropriate platforms are being started in an effort to enhance this training process. So, virtual environments provide important advantages for teacher education, too. Calandra and Puvirajah (2014) categorize these advantages as:

- "occupy a virtual persona within a near-real simulation of a give professional domain (e.g., acting as a teacher),
- work within a social, distributed environment,
- fail in a low stakes environment,
- repeat a given task many times,
- isolate a particular aspect of the experience for more careful examination and reflection" (p.32).

Figure 2.17. A science lab at the virtual school in Second Life.

(Mahon, et al. 2010, p.125)

Developers of Second Life created an educational simulation for teacher education in order to provide candidate teachers an environment to gain experience (as shown Figure 2.17. and Figure 2.18).

Figure 2.18. General classroom in a virtual school in Second Life.

(Mahon, et al. 2010, p.125)

The Department of Computer Education and Instructional Technology at the Middle East Technical University in Turkey experienced the use of virtual worlds in teacher education in 2013. They developed a virtual environment in Second Life in order to introduce and discuss teaching methods and techniques. Multiple virtual classrooms were designed for the application of various teaching techniques and students found opportunities to experience each of them thoroughly (Tokel and İşler, 2015). Students were divided into six groups to discuss teaching methods and techniques under the supervision of the educators. Each of the six groups worked on one of the teaching techniques to practice it through role-playing during the virtual course. Virtual classrooms which were specialized for each technique were prepared in order to demonstrate role-playing sessions and each group presented their techniques

to other students in these virtual classrooms simultaneously. Tokel and İşler (2015) state that this study emphasizes the importance of the acceptance and adoption of virtual worlds. They also highlighted that "if students see the usefulness of virtual worlds, they may adapt to the new technology more easily" (p.262). Therefore educators should keep this in mind and prepare students for adopting these new technologies. The Department of Computer Education and Instructional Technology at the Middle East Technical University continues to use virtual worlds as a part of their education program.

Similarly, the School of Education at Southern Cross University, Australia built a virtual environment in Second Life for the application of teaching experience in a visual arts 'methods' course. Wilks & Jacka (2013) state that students indicate the virtual world as a beneficial learning environment for their future profession as teachers. The environment provides the opportunity to students of teacher education in order to enhance their pedagogical aspects in teaching contexts and time management skills.

These examples of universities experiencing virtual worlds for teacher education purposes can be increased. Many educational institutions are starting to benefit from the opportunities of the virtual world especially for teacher training.

2.2.4.4. Architectural Education in Virtual Worlds

The applications of architectural education and of various design education in virtual worlds will be discussed broadly in the next chapter. Studies especially conducted for industrial design education, will be examined deeply to determine the advantages and disadvantages of virtual worlds for industrial design education. In addition, a literature review will be conducted for industrial design education's migration to virtual world platforms.

2.2.5. Significance and Opportunities of the Virtual World

> A virtual world like Second Life gives the promise of a world where anyone can be whoever they would like to be, and have the power of living vicariously through an avatar. At the same time, virtual worlds give people the opportunity to communicate and create a social network with others without leaving their own home, meeting other individuals with the same interests as their own, building relationships, learning new topics and even attending school. (Stendal, Balandin and Molka-Danielsen, 2011).

Different types of communication tools allow multiple users to get in contact with each other. Communication and discussion on the same topic or problem can be performed quickly and easily, so this environment is suitable for collaboration and multi-user activities. Role-playing exercises, problem-based group activities or case studies can be realized without experiencing real-world regulations. These activities bring people together from all over the world and provide opportunities to recognize different people and cultures.

Virtual world users can get rid of real world pressures such as appearance, financial situation and social status. It is becoming easier to meet someone, befriend and chat or talk with them. Users represent their virtual identity via avatars and this gives them the opportunity to create an alter ego which they can build new relationships with others.

Furthermore, virtual worlds offer people with disabilities a chance to explore new worlds without being limited by their disabilities. They can behave as they want, create and maintain friendships and do many things that they cannot do in their daily life. Virtual worlds can encourage people with disabilities to perform their requests virtually.

In addition, they make unwanted or uninteresting activities more attractive. For example, with the help of other technologies like Kinect, online virtual worlds are becoming more appealing for users; in a game scenario, users are encouraged to make a gym in front of a camera which has motion sensors that detect movement through the sports.

There are other opportunities in education and training. If designed effectively, virtual worlds can provide more stimulating teaching and learning environments where learning can be both challenging and fun. Also, it makes working together in a team or group easy and this improves interactive learning.

Eventually, virtual worlds present many opportunities for multiple areas. Users can develop and personalize their own space in accordance with their wishes and needs and can share them with the other users.

2.2.6. Barriers to the Virtual World

When the literature was reviewed, it was observed that there are some barriers to the virtual worlds. Steven Warburton (2009), who made comprehensive studies about the barriers of virtual worlds, categorizes them into eight main topics:

- Technical issues
- Identity issues
- Cultural issues
- Collaboration issues
- Time issues
- Economic issues
- Standard issues
- Scaffolding persistence and social discovery issues (p.422).

Technical issues include bandwidth, hardware, firewalls and downtime problems and also contain navigation object creation and avatar customization challenges. Technical components are important for a better virtual world experience. Green et al. (2013) described the effects of technical issues on education in virtual worlds that;

> Bandwidth or the speed of data transfer is important for virtual experience. A slow internet connection could affect situation such as the timely performance of a skill, and thus negatively impact student learning. The limitations of the technology can also potentially cause frustration and confident participants can become shy, inhibited and angry (p.5).

Identity issues faced by users are about the reliability, fluidity and playfulness of the identities and characters which are created in the virtual world by the users. There is no way to check the real identities of the users who visualize their imaginative characters generally. Furthermore, role-playing in a virtual world can lead to delusional and fake behavior.

Virtual worlds bring together different ages, social statuses, professions and cultures just like the real world. Therefore, these differences can cause cultural issues too. People want to become a participant of the communities. As Warburton (2009) emphasizes, users need to become comfortable and familiar with every element of the virtual world such as codes, norms and etiquette rules. These diversities and differences may cause some cultural problems.

Another issue concerns collaboration between users in a group activity. There are many communication alternatives in daily life that virtual worlds can also provide; however, their major shortcoming is the lack of face-to-face conservation. In addition, not all of them include all types of communication tools. This can present challenges in cooperation and co-instruction in the virtual world while doing group

work or role-playing exercises. Limited communication and social networking tools and functions can cause collaboration problems during virtual world experiences.

Especially in educational applications, users can encounter the time issues. Because of the new technologies, educators have to go through the learning process of operating and enhancing their applications and environments. In the early days, this learning process takes a lot of time and generates workload impositions educators. After the learning process they have to spend time on designing and developing their learning activities, environments and resources. In addition, the opportunities for the use of technology are only limited by the user's imagination in virtual worlds.

Another barrier is about economy. Although it can be variable according to the purpose of use, generally, virtual worlds require users to buy virtual land. For example, according to the Second Life official website, buying a private piece of land which is called an island from Second Life requires an initial price of 1000 USD and a monthly maintenance fee which is variable according to the size of the land. Although virtual worlds are often free for educational institutions to support learning, there are open source virtual worlds such as OpenSim. Developing and building the personal virtual environment requires time and incurs costs for the desired land objects and functions. In order to develop an application, the cost of purchasing land, buying in-world objects, importing textures and employing skilled people to perform building and scripting tasks bring a huge financial load (Warburton, 2009).

Warburton (2009) describes basic issues as the lack of open standards and interoperability between virtual world platforms (p.423). This restricts the users' abilities when transferring information and resources between platforms.

Ultimately, Warburton (2009) discusses the scaffolding persistence and social discovery issues as "although the virtual world itself is persistent, persistence for avatars only exists when their users are online" (p.423). Other social platforms like

Facebook allow users' profiles to be visible for other users even if they are not online. However, this barrier is not a major factor especially for educational applications in the virtual world.

Apart from these, user-based problems can be appeared because of the excessive use. According to Xing (2007) excessive use of virtual worlds increases the risk of online addiction. This addiction blurs the boundary between real and virtual worlds (as cited in OECD, 2011). The increasing adoption of virtual worlds raises some serious challenges. This may lead users to increase their time online, to extent that they may fail to devote enough time to other obligations like school, work, family, and even sleeping and eating. Another risk induced by excessive use is social isolation, in which the user of virtual world relies more on interactions that take place in the virtual world than on experiences in the real world, which could eventually cause depression, disassociation and other conditions.

2.2.7. The Future of Virtual Worlds

> Virtual worlds may still be at an early stage of their development and adoption, but both the opportunities and policy challenges that come along with them will increasingly require policy makers' attention and global co-operation, not only between OECD countries, but also major non-OECD countries (OECD, 2011, p.34).

The number of people creating new avatars increases every year. Technological advances such as increased broadband and mobile access will make it easier to access virtual world spaces on a daily basis. Visiting virtual worlds will increasingly become a part of everyday life. Virtual worlds will no longer be places one 'goes' to visit. It will become a part of daily routine which will affect all parts of life, including education.

Andrew Hughes, who is an instructor in University of Cincinnati which has virtual campus in Second Life, prepared a presentation concerns the future of virtual worlds in 2013. Hughes (2013) states that in recent time, virtual worlds will be adaptable to mobile phones and 3D virtual environments will replace 2D websites so that the concept of 3D environment will be included in our daily life. Augmented reality will be integrated virtual worlds for more interactive and real experience. Furthermore, Hughes foresees that educational institutions will be fully integrated to virtual environments as a distance learning way in the future.

Eric Johnson, who is an associate editor in Re/code which is a news website that focuses on technological developments, prepared an article with the CEOs of the considerable companies and asked them a question that where virtual reality will be in five years. According to the answers, Johnson (2015) mentions that there is a general opinion that virtual reality will become more easily accessible and virtual reality worlds will start appearing in our daily life.

Virtual environments will be enhanced with virtual reality technologies and it can be said that they will be a part of our daily life as the Internet.

2.3. Virtual Worlds and Industrial Design

According to the International Council of Societies of Industrial Design (ICSID) "Design is a creative activity whose aim is to establish multi-faceted qualities of objects, processes, services and their systems in whole life cycles. Therefore, design is the central factor of innovative humanization of technologies and the crucial factor of cultural and economic exchange" (ICSID website, retrieved 04 July 2015). Because of the transformation of the technology and information, ICSID launched an online campaign which encourages people to upload their ideas in order to redefine "design", known as the World Industrial Design Day 2015. Therefore, this

definition is expected to be renewed in the near future, when virtual worlds and related issues will possibly find a mention in the new definition.

Most interaction in our daily lives is an outcome of the design process. Therefore, design is a key element of our activities; it undertakes to fulfill the needs of users and increases the quality of life. Designer Richard Seymour during the Design Council's Design in Business Week 2002, states that design is ‘making things better for people’. He emphasizes that design activity is focused first and foremost on human behavior and quality of life, not factors like distributor preferences.

John Heskett (2005) describes design as “one of the basic characteristics of what it is to be human, and an essential determinant of the quality of human life. It affects everyone in every detail of every aspect of what they do throughout each day” (p.2).

The focus of daily life’s products and product design is closely associated with industrial design. So, what is industrial design? There are different definitions of Industrial Design (ID) in the literature. The Industrial Designers Society of America (IDSA) defines ID as the “professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer” (IDSA website, retrieved 4 July 2015).

Industrial design deals with a wide range of products that interact daily with users. So, what are the missions of the Industrial Designer in the Industrial Design profession?

IDSA defines Industrial designer as:

> Industrial designers develop products and systems through collection analysis and synthesis of data guided by the special requirements of their client and manufacturer. They prepare clear and concise recommendations

> through drawings, models, and descriptions. Industrial designers improve as well as create, and they often work within multi-disciplinary groups that include management, marketing, engineering and manufacturing specialists (IDSA website, 2015).

Industrial designers have responsibility for all stages of mass production which includes of developing the product, its production, packaging and distribution. Quality of life is connected to successful design. The designer's role holds an important key to the creation of difference and comfort. Therefore, educating designers comes into prominence.

Educators, who are interested in design education and virtual worlds, in fact conduct many design education applications in virtual worlds mention that technological developments are the integral part of the design anymore. This opinion supported by many researchers that;

> Today the information and communication technologies have brought both new opportunities and challenges to design and design education, requiring us to address the new pedagogical approaches that employ these emerging design medium (Gu et al. 2007). Innovative approaches to design education have demonstrated the impact of these new technologies in terms of creating new ways of designing (Kvan et al. 2004), new design contexts and possibilities (Gül et al. 2007, Kvan et al. 2004), as well as new core skill sets (Gül et al. 2008) (as cited in Gu, Gül, & Williams, 2010).

Therefore, definition of industrial design education will possibly be revised in the future.

2.3.1. Industrial Design Education

"The need for design in the production fields appeared in England, after the Industrial revolution towards the end of the 18th century. This then spread to the other "industrializing" countries of Europe and North America in a very short time" (Denel, 1981, p.9).

The need for design led to the requirement of design education. Therefore, the education of the industrial designer emerged during the second half of the 18th century in Europe and the United States. At first, education was based on the practical learning that took place in the workshops.

Britain is the pioneer of design education since the very first design school, the Central School of Arts and Crafts, was founded in London in 1896, with the emphasis on handwork and craftsmanship. Then, during the 19th century, arts and crafts schools were established throughout the world.

The Art and Crafts Movement in education changed with the establishment of Bauhaus by Walter Gropius in 1919 in Germany. Bauhaus has brought a new perspective to design and design education. Bauhaus promoted the combination of art with technology and encouraged students to attend different workshops, try different materials and methods and explore more possibilities (Wenwen and Zhuozuo, 2013). It became a pioneer in the idea of form and function and creating a style in design process. Bauhaus still has a crucial impact on the field of design and design education.

ICSID (2003) suggests that industrial design education programs should educate students in three categories of competence; generic attributes such as problem solving, communication skills and remaining adaptable to social changes; specific industrial design skills and knowledge including design thinking, the design process, design methodologies, manufacturing processes and materials, design management,

environmental awareness and prototyping skills; and knowledge integration through design and system implementation.

Typically but of course with certain exceptions, industrial design education throughout the world starts with the learning of basic design principles and then aims to develop students' creative thinking, 3D thinking, problem solving skills and so on. Er et al. (2003) categorize the competences which students gain at the end of industrial design education as follows:

- To analyze user/customer's needs and requests,
- To evaluate the developments of competitive products and the trends of the new products on the market,
- To produce new ideas for new products from these evaluations,
- To convert these ideas to tangible saleable product concept according to their working company's technologies,
- To work together with the experts and authorities in the company towards the realization of these product concepts (p.8).

Dorst & Reymen (2004) emphasize that design exercises are the core of design education and focus on the idea that learning design process can be done only by doing it. Therefore, studio-based teaching is the central pedagogy of design education (Sara, 2006; Shreeve, Wareing, & Drew, 2008). Studio courses are different from the classical lecture-based courses because the studio-based courses require both practical and theoretical knowledge. Generally, in a design studio course, students are under the control of the educators who define design problems and expect students to create design solutions. This design process integrates theoretical knowledge and practical skills. Students learn design process by doing and by analyzing their knowledge. During this process, instructors supervise and guide their students.

Through studio-based learning, students aim to receive critiques from their instructors and friends to help with the improvement of their design solutions.

During the critiques, students learn while discussing their works. Therefore, the learning process generally is based on communication and collaboration.

2.3.2. Traditional Design Studios

It is important here to explain how traditional design studios operate, because, in order to analyze the potential of virtual worlds as new learning environments for industrial design education, traditional design studios should be realized firstly. Lance Noel Green (2005) states that "the design studio is at the heart of most industrial design curricula and is a place where students learn to visualize and represent aspects of a problem graphically and to think as a designer" (p.11). In the design studio, students learn to think as a designer which requires creativity, drawing, model making, problem solving and communication skills. While students work on their design projects, they also learn the design process and absorb technical information from their educators.

Traditional studio-based design teaching and learning is usually student-centered and built around 'dialogical learning and teaching' (Danvers, 2003, p. 51). Danvers states that design education consists of dialogues between students and educators. During the dialogues which are named as critiques, students present their ideas to their educators and with their questions and comments educators aim to make students rethink and analyze their ideas further. Educators try to help students become aware of their shortcomings and mistakes individually or in a group. These critiques are evaluated in desk reviews, wall reviews or design juries.

Educators have critical and significant missions during the critiques. They have to encourage students to think deeply on their shortcomings without interrupting their ideas and creativity during the process. On the contrary, during the juries which are final step of the design process for the course, educators make comments

comfortably. Assessments of the students' projects are evaluated and judged in the final reviews according to the critiques.

Although technological developments and changes influence traditional design education in some degree, and although they bring some changes on educational system, industrial design education has sustained its traditional approach.

2.3.3. The Changing Face of Industrial Design Education

Industrial design is a profession that must be updatable according to the changing world and similarly industrial design education too. Every aspect of daily life has affected the development of technology and industrial design has been changing inevitably under these circumstances.

The Internet which is one of most important technological developments has affected people's daily activities quickly and radically. It also has influence on the educational process as much as daily life. Basically, the Internet has become the new research and communication medium for both students and educators. Industrial design education has started to be affected by this change too. The Internet provides huge information sources for design problems and solutions; moreover, critiques and reviews have started to appear in online platforms. Communication is quicker compared to the waiting time associated with studio courses.

Tauke, Story, and Ostroff (2004) state that "digital media, with the developing technologies, has affected the delivery of ID education in two important ways:

1. The role, value, and skills of the instructors have been changing;

    •Their role becomes facilitator and moderator to structure and organize the available online knowledge and to guide online collaboration and interaction

2. It is possible to study and make the instruction worldwide through the Internet and wireless technology;

•It brings freedom of movement by extinguishing the physical restrictions" (as cited in Ozturk, 2010, p.31).

Design education must keep up with the times even more than most other industries.

2.3.3.1. Online Design Education

"Technologies have always played an important part in revolutionizing design and design education" (Gu, Gül, & Williams, 2010).

Distance education occurs between a learner and an instructor, it actualizes at different times and/or places which is different from traditional education, and uses different types of instructional materials such as print and electronic media (Moore, Dickson-Deane, Galyen, 2011). Distance education become varied with the development of technologies such as online learning, e-Learning, technology mediated learning, online collaborative learning and so on. Online learning is described as accession to learning materials via the use of technologies. Park (2011) describes online learning as "an effective pedagogical method and tool, and is broadly integrated into various types of teaching and learning strategies in higher education".

Online education with the development of information and communication technologies has both advantages and disadvantages for design and design education. Vosinakis, & Panayiotis (2013) categorize the shortcomings of the traditional design studio approach as:

• In a traditional design studio, students produce paper prototypes and rough mock-ups. It is difficult to demonstrate and evaluate the functionality and interaction qualities of digital artifacts as well as to present and simulate usage scenarios in realistic contexts that are required for interaction design.

• The collaboration of student groups in the traditional design studio is constrained by space and time arrangements.

• Tutors in a traditional design studio need to devote a large amount of time with each student or group to track their progress. It is difficult to be aware of individual student efforts within group work.

• It is difficult for tutors to collaborate remotely with groups. Thus, support is limited to course hours.

These shortcomings emphasize that the online learning platforms which remove time and geographical constraints and enhance communication and learning materials can contribute to design education.

2.3.3.2. Virtual Design Studio

The term 'virtual design studio' was originated at MIT in 1993 and corresponds to "networked facilities that provide participants with access to the virtual organization's databases and computational resources, messaging and data exchange, and video conferencing, in a highly integrated fashion" (as cited in Chen, Frame and Maver, 1998, p.790).

A virtual design studio is a kind of distance education that is generally utilized for group activities. According to Maher and Simoff (2006), basically, using email for project communication can be a type of virtual design studio; and in addition, this range can be expanded by using virtual worlds. Various technologies and environments can be created as a virtual design studio for collaborative activities.
"Following the development of e-learning platforms, the virtual design studio has become an alternate method for implementing studio-based design education either in conjunction with traditional face-to-face studio teaching or as a standalone method" (Shao, Daley, Vaughan and Lin, 2009, p.1). The use of virtual design

studios is increasing gradually especially for the collaborative design projects. The aspects of design studios are satisfied effectively by virtual design studios.

There are a lot of opportunities presented by virtual design studios that Maher, et al. (2006) explain as:

- Bringing together of people from different locations,
- Computer-based communication tools,
- Electronic forms for documentation and lecture information.

The restriction of time and space is removed with the workspace of the design studio moved to the Internet. Users have the option of synchronous or asynchronous communication by using video conferences or e-mails. In addition, the knowledge which is taught in the design studio is gathered and documented for later use. Further, the virtual design studio enables collaboration between multiple parties. Maher, et al. (2006) state that "the design studio should be the real beneficiaries of this technology, where the development of the design models and documents is essential for communication of design ideas".

On the contrary, Thomas Kvan (2001) states that the advantages of the virtual design studio can create various dilemmas such as the need for basic communication which is necessary for the design review stages; however, because of the distance online educational environment, students do not attend their traditional courses. Therefore, he advocates that teaching methods must be reviewed in terms of these new technologies and their opportunities to adapt them to design studio programs. In this way, generated conflicts can be reduced with the adaptable design process.

2.4. Design Process and Virtual Worlds

The increase in the usage of the Internet technologies has brought about some changes in design collaboration and design process. Virtual worlds, especially

Second Life have become one of these technologies which can be utilized throughout the design process. Each design field (such as architectural design, interior design, industrial design and so on.) benefits from the virtual world in various ways. Design processes in virtual worlds will be discussed in the following sections referring to different design fields.

2.4.1. The Design Process

In order to discuss the stages of the design process that are more suitable for use in virtual worlds, first, the design process should be examined. Bruce Archer (1965) defines design as a systematic process for a problem-solving activity. Therefore the design process can be explained as a transformation of an idea inspired by the needs and demands of business and the consumer, to a product that fulfills these needs and demands. Throughout the problem solving process, designers focus on the product's function, visual attributes, usage, production and market placement. There are various categorizations and explanations within the design process. John Chris Jones (1980) who made significant works about design methods breaks down the design process into three stages which are:

- Analysis (preparation stage)
- Synthesis (development stage)
- Evaluation

The Analysis stage covers breaking the design problem into pieces and listing the requirements in order to understand the problem completely, thus allowing collection of all necessary information. The next stage, synthesis, requires creative thinking in order to find possible solutions and create a design by combining these solutions. The last stage of the process, evaluation, directs designers to make decisions. The design solution is tested before the_finalization. In addition, Jones offers many techniques for all these stages such as brainstorming, classification charts, morphological charts and so on. Later, he renames these stages by improving the process as:

- Divergence
- Transformation
- Convergence

Similarly, for the same purpose, Kevin Reeder (2001) compiles and summarizes the design process and divides it into five stages:

- Problem Definition,
- Design Research,
- Concept Development,
- Concept Refinement,
- Finalization (p.21).

In Reeder's categorization, during the problem definition stage, a problem which can be about a gap in the market or a product that does not perform effectively is determined and stated. After this initial statement, desirable goal states are identified according to the problem. Designers define the functions, user profiles and usage areas of the product. Reeder (2001) emphasizes that project timetables, design objectives, relevant materials and economic situations are identified in this stage.

In the design research stage, competitors' products and the market are researched and information about users, the market, technologies and materials are collected. Alternative specialties are explored in an effort to create a difference from existing and similar products. In addition, designers use research methods to improve their findings which become the inspiration for the initial ideas.

In the concept development stage, concept sketches are developed according to the design research stage to satisfy the design objectives. Potential ideas for the product or a part of the product are formed manually or by computer to find the best solution. The form, function and material of the product are evaluated using sketches and models. Reeder (2001) states that at the end of this stage, concept ideas are evaluated according to the design objectives and the most suitable one is selected to develop for better solution.

In the concept refinement stage, the selected concept idea is developed in detail. Each part of the product is revised and finalized. Product specifications which are size, material and so on are decided according to the required aspects of the design objectives. In addition, this stage includes manufacturing processes and a testing period. A concept model is tested by potential users in order to determine the shortcomings and to predict market success.

In the final part of the design process, the finalization stage, accurate details and decisions about the form, dimensions, materials and production methods of the designed product are concluded for the prototypes. Prototypes are tested in terms of the product evaluation criteria. Reeder (2001) expresses that the purpose of this stage is to "decrease production costs and increase function based on the consumer responses to the product" (p.22).

Design processes take place almost in the same way in an industrial design education program. Each process starts with the project outline and objectives which are determined by the educators. Of course there are some educational exercises/projects in which students define their own design problems, however in general, the first stage of the design process, problem definition, is accomplished by the educators and is expected to be continued by the students. Students perform research and start to reveal initial ideas and sketches according to their design objectives. During the concept development stages, students use sketching and computer rendering to express their ideas. After the critiques, they make 3D models of their designs using various materials. Students then test their ideas with their 3D models and finalize their projects. In the final presentation, students' design projects are juried by the educators or professionals. Oztoprak (2004) explains design education as "… somehow like learning swimming, no one can learn standing out of water. The novice swimmer might know the theoretical part, how to move his/her arms and feet; however without training in shallow water he/she cannot survive in open sea" (p.13).

Below, each of these design stages will be examined by considering the virtual world applications. Applications will be evaluated in terms of the stages of design process. The objective of the thesis will be to decide on the design stages in which virtual worlds might be more effective in order to constitute groundwork for possible applications of virtual worlds on industrial design education.

2.4.2. Applications of Design Process in Virtual Worlds

As noted above, the design process progresses through various stages. Börekçi (2013) categorizes this process basically into three in a similar manner with Jones (1980). The process starts with "defining a design problem", continues with "generating the design concept" and finalizes with "making the decision". This systematic process becomes a part of the transition from the real environment to the virtual environment due to the development of these Internet technologies. There are many studies about the use of virtual worlds in the design process which are reviewed through different sources, and it was realized that these studies were conducted mainly between 2007 and 2009. In addition, company studies and reports about the design process in virtual worlds became a guide for design education for the virtual world experience. However, there is not enough information about the company studies after 2010. This could be due to the avoidance of sharing information or companies may be in the midst of a new development process that where studies have not yet been able to detail enough in order to make inferences or they may choose to stay on hold in favor of following future developments and technologies. A similar situation is observed in the field of design education. After 2007, the number of studies based on design education increased annually; however, there was a decline after 2010.

Some specific design process examples in virtual worlds which were conducted by companies and educational institutions will be presented in the next sections. In the design education section, applications which were based on various design

education fields, such as interior design education, urban design education, fashion design education, will be examined in detail in order to determine important points for virtual world applications of industrial design education.

Although there are very few examples about applications of virtual worlds in industrial design education in the world and also there is no such study in Turkey, there are some research studies deal with social media platforms in order to examine their possible contributions to industrial design education. For example Gelmez and Bağlı (2014) conducted a project in order to explore the use of social network such as "Facebook" in terms of design education and state that the project increases the awareness of the potentials of different tools and media for industrial design education.

2.4.2.1. Design Related Virtual Worlds Applications in Business

The growth of technology and the Internet based applications stimulate companies to use and adapt these developments. Internet-based developments - especially virtual worlds - provide alternative platforms, on which companies can work, communicate and organize activities such as meetings and training courses. As they have become aware of the opportunities of the virtual world, especially Second Life, companies have started to purchase *virtual islands* and customize them according to their purposes. Especially virtual meetings held independently of a restricted time and place have attracted the attention of the companies who want to bring multiple stakeholders together easily.

Companies are gathering different parties together such as designers, engineers, customers and managers during product development stages in order to create an efficient manufacturing process. Virtual worlds can facilitate this product development process in terms of time and space. Companies can create an interactive product development platform to encourage customers to be involved in

the product development and testing stages. As a result, these developments emerged a new term that is an avatar based innovation. Kohler et al. (2009) explain this term as “an interactive new product development process, where manufacturers collaborate with virtual world avatars to generate value for their innovation activities” (p.396).

In general, these innovation activities which refer to stages of design process are examined in the literature and divided into three categories: idea generation, design and manufacturing, and testing processes. For idea generation, companies often organize competitions to encourage product innovation stages. Virtual worlds with modeling, scripting and multi-user opportunities foster creative sessions for users and prototyping. In addition, virtual worlds are an appropriate and excellent environment to discuss new ideas and to design with the involvement of prospective customers and manufacturers in order to receive their impressions and comments.

Idea Generation

One of the examples of companies which used virtual worlds, namely Second Life, for the idea generation stage is the Coca-Cola Company. In 2007, they organized a competition for a portable vending machine design in Second Life (Figure 2.19). The director of Coke’s Global Interactive Marketing, Michael Donnelly stated that they “ invited the world to use the Second Life platform to design and prototype the ultimate Coke machine, something that delivers an innovative, engaging experience in Second Life ” (as cited in Kohler et al, 2009, p.400).

Figure 2.19. A snapshot of the Coca-Cola vending machine competition in Second Life.

(Retrieved from http://www.secondlifeupdate.com/news-and-stuff/coke-returns-to-second-life-with-nestea-virtual-sim/)

The Coca-Cola Company concluded at the end of this study that Second Life enabled users to showcase their creativity and encouraged them to display their imagination. This provides a limitless opportunity to reach multiple users and to present various ideas for new products to companies.

After a while a furniture company, Steelcase, used Second Life for a competition to enhance innovative idea development for their new executive chair (Figure 2.20). The company invited users to showcase their creativity and develop ideas for a new chair in a virtual environment in 2008. Kohler et al (2009) highlight this competition as an excellent example for future product development opportunities by means of bringing together users in a virtual environment for brainstorming for a new product.

The ideas from the competitions became inspiring elements for the company's design staff.

Figure 2.20. Steelcase chair designs in Second Life

(Kohler et al. 2009, p.402)

Another example is the Philips Ideation Quest (Figure 2.21). The company gathered users to explore future sustainable living, under the topic of "Sustainable Habitat 2020" in Second Life. Avatars followed a road consisting of five creative steps. Scott Chase (2008) explains these steps as:

1) *Get informed:* Arrival (orientation to the project);

2) *Get inspired* (stimuli material);

3) *Get active*: Challenges (word association, answer questions, structured group brainstorming);

4) *Get creative*: Ideation (submission of individual ideas through text, drawings & models);

5) *Get critical*: Idea Review (voting and comments on submitted ideas) (p.3).

Figure 2.21. Various platforms from the Philips Ideation Quest.

(Kohler et al. 2011, p.163)

The project aimed to encourage people to make brainstorming and discussion about the potential scenarios for sustainable living. This activity provided a platform for customers and designers to merge in a discussion about the specific topic and the project directed users towards the goals through its schedule during all stages of the processes. The project collected customer-oriented ideas to create a vision for a future via a virtual world.

In addition, multinational lighting manufacturer, Osram invited users interested in lighting design to develop new ideas and design new products around the topic of lighting in Second Life.

Design

Scion is a brand of vehicles produced by Toyota who used virtual worlds to give the opportunity to customers to create their own car (Figure 2.22). They prepared a toolkit for users to customize their cars in Second Life. Users could change the colors and types of the parts of the cars. Furthermore, skilled users could change and customize all the pieces of the cars; the company gave limitless opportunity to users for change. In addition, the virtual environment gave an option to users to take a test drive and interact with the car. Steve Haag, Scion's corporate manager, states that the aim of this project was not to increase sales, but to raise awareness of the brand name, 'Toyota' (Chakravorty, 2007).

Figure 2.22. Mass customizing a Toyota Scion in Second Life.

(Kohler et al. 2009, p.403)

The Endemol Group which is a Dutch-based company dealing with entertainment content organized a furniture design competition to encourage avatar-based innovation in a virtual world. The project aimed to generate inspiration for real-life designs. The designs were evaluated by juries and users and the winner gained one million Linden Dollars which is currency unit of the Second Life. The company

organized its virtual environment by dividing it into multiple rooms which were based on "a holistic approach to create an open innovation experience within a virtual world" (Kohler et al, 2009, p.402). The main purpose of the company was to evaluate the users' attitudes toward virtual activities especially competitions. The result of the study showed that users' attitudes were exciting and good enough to warrant the continuation of work on virtual events for companies. Hence, this result encouraged the company in respect of potential future activities.

While the first example focused on the prospective customers in order to use their ideas for design enhancement, the second example's target group comprised solely of users. This shows that companies aimed to increase brand recognition by creating a fun environment rather than placing the emphasis on the design process. Consequently, the role of the company designers in the virtual world was to be inspired by the projects. Besides this, designers have started to use virtual worlds to examine their own production design prototypes in collaboration with their engineers. The opportunity of importing 3D models means that designers and engineers can evaluate the model and discuss it easily during the design stages. Also, designers can evaluate their prototypes along with their customers by using a virtual world to receive their initial opinions about the designs in order to decide the next stage of the process.

Test and market launch

Virtual worlds provide a significant opportunity for companies to prototype and test their projects; because, these processes are very expensive and time-consuming stages in real life. Dahan and Srinivasan stated in 2000 that "online prototype testing is as effective as more traditional offline physical prototype testing, with the difference that online methods can be conducted faster with less costs" (as cited in Kohler et al, 2009, p.403). The examples given at that time show that this vision still maintains its validity.

Starwood Hotels used Second Life for a new hotel concept ‘Aloft’ in 2007 (Figure 2.23). The company built their concept hotel in a virtual world and invited their customers to evaluate and comment on it while visiting the hotel via their avatars. The concept project was changed and developed according to feedback. After this virtual evaluation, the physical hotel was built. Architectural and interior design firms are now beginning to use virtual worlds to test their concept designs on their customers. In addition, virtual worlds provide the opportunity to both company and customers to discuss the design; the company can make suggested changes on a 3D concept model instantaneously and this design process can continue until the final decision is made. Interior design firms provide the opportunity to their customers of changing materials, colors, dimensions and objects on demand while describing their preferences using a 3D model via virtual worlds.

Figure 2.23. Aloft testing the virtual hotel.

(Kohler et al. 2009, p.403)

The other popular area which uses virtual worlds to ask customers to test their designs before production is the fashion industry. Jana (2006) highlights the ‘American Apparel’ brand as one of these fashion companies; virtual customers

have a chance to try their new jeans concept designs before the company's products hit the physical stores. Therefore Second Life is used as a "test-market" for the company's first line of jeans.

In addition, as opposed to customers, designers can check the concept models with the manufacturers to evaluate manufacturability and production stages. Virtual worlds can provide effective and cheap prototyping labs for private sectors as an alternative to expensive processes product development cycles in real life.

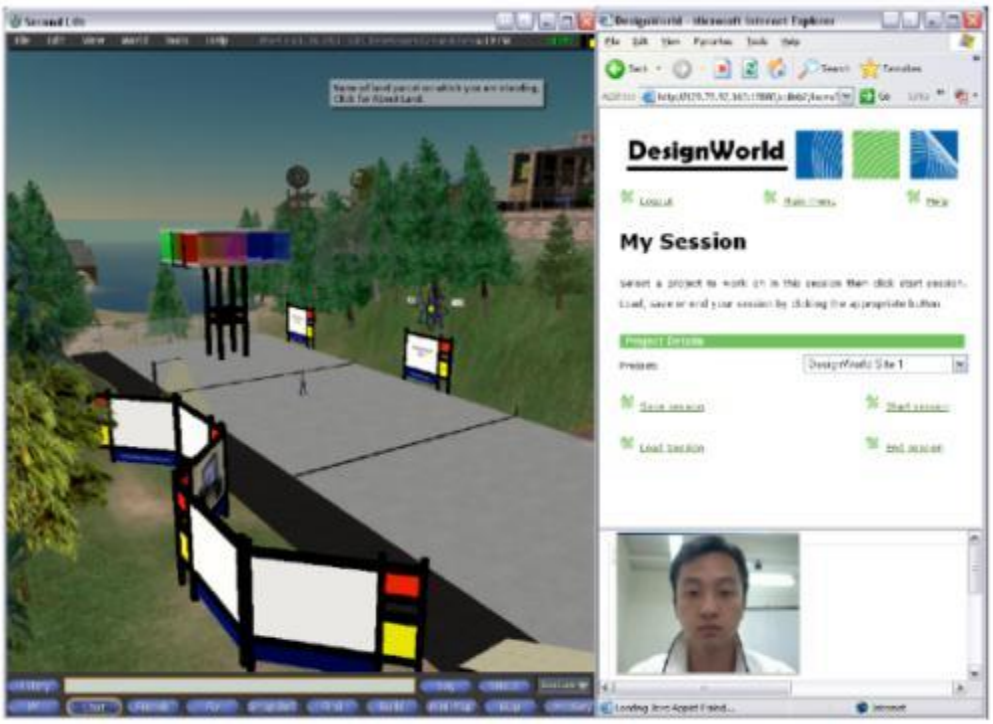


Figure 2.24. 3D virtual environment integrated with web-based communication and design tools are formed in DesignWorld

(Rosenman et al. 2006, p.2)

Apart from these examples, there are virtual environments and systems specializing in professional use of the design process. One of these systems is DesignWorld. Rosenman et al. (2006) describe DesignWorld (Figure 2.24) as;

> … a prototype system for enabling multidisciplinary, distributed design collaboration and consists of a 3D virtual world augmented with a number of web-based tools for the creation of different discipline views as well as the necessary relationships between these views to provide and maintain consistency (p.708).

The opportunity for collaboration between multiple disciplines simultaneously on a project attracts companies to the use of virtual worlds. The facility to create various 3D models of prototypes or to work on the same 3D model simplifies the project development process.

2.4.2.2. Design Education Applications in Virtual Worlds

This part comprises of examples of applications of design education in virtual worlds which include Architectural Design Education, Landscape Design Education, Interior Design Education, Urban Design Education, Fashion Design Education and Interaction Design Education. These examples are reviewed through different sources which are mainly; METU Library, MIT Press Journals, ACM Digital Library, Science Direct, IEEE Xplore, Jstor and Google Academic search engines. These databases were searched mainly with the keywords “design education” and “virtual world”; in fact, for each “design education” search special research was also conducted especially focusing on results dated between the years of 2002 and 2015. Considering the related literature, it seems that less research study about design education was conducted after 2010; studies generally took place between 2007 and 2010.

Contrary to this generalization, Koutsabasis, et al. (2012) examined three case studies in 2012 which are “(a) a design review session of the architectural design of a cottage focusing on the quality of communication among the designer and clients; (b) the collaborative design of the interior space of an academic laboratory with

focus on situation awareness of collaborating designers; (c) the collaboration of three design teams for the user interface design of a multimedia kiosk" (p.358) in order to evaluate the use of virtual worlds with respect to design processes.

The similarities and differences of these case studies focused on architecture, interior design and interface design were determined. These studies were conducted with the professional designers, graduate design students and clients in order to evaluate the effectiveness of the use of virtual worlds in different design processes. The results show that the virtual world is an effective development for design activities. Koutsabasis, et al. (2012) explain this effectiveness;

> … in a virtual world, users communicate in real time while being in the designed space, being able to point to specific attributes, objects or places, being able to instantly communicate an idea, restructure a solution, evaluate a concept. It all happens in the same space and therefore there is greater awareness and coordination of the collaborating design team (p.362).

2.4.2.2.1. Architectural Design Education

Gu, et al. in 2009, stated that "3D virtual worlds are the latest development of such technologies, which focus on the application and support of an integrated virtual learning environment for collaborative design, supporting synchronous communication, collaborative modeling and constructivist learning" (p.52) and this illustrated the rise of the virtual world at that time.

Nakapan from the Faculty of Architecture, Rangsit University, Thailand and Gu, Williams and Gül from the School of Architecture and Built Environment, and the University of Newcastle, Australia have conducted noteworthy studies on the use of virtual worlds in the field of architecture, developing a virtual collaborative architectural studio in August 2008. This virtual environment, "NU Genesis", was

modified in Second Life for an international collaborative project between both universities.

The main objective of the project was the evaluation of collaborative design in virtual worlds and to provide basic information and essential skills. In addition, Gu et al. (2009) determine the aim of this project for students as "(1) to understand and develop the essential skills of collaborative design and modeling using 3D virtual worlds; and (2) to develop the understanding and hands-on experience of 3D virtual worlds as an extension of conventional architectural design" (p.53).

The project was organized between the second year undergraduate architecture program of Newcastle University and the third year undergraduate program of the Rangsit University and took five weeks. Students came together in a virtual environment, NU Genesis (Figure 2.25) and collaborated on the design project which was named as "Virtual Home". They came together at least three hours per week under the supervision of the instructors. While conceiving the idea and developing the projects, students worked in group of three or four remotely. They explored different design possibilities and applications in ways that were not possible in the traditional architecture studio.

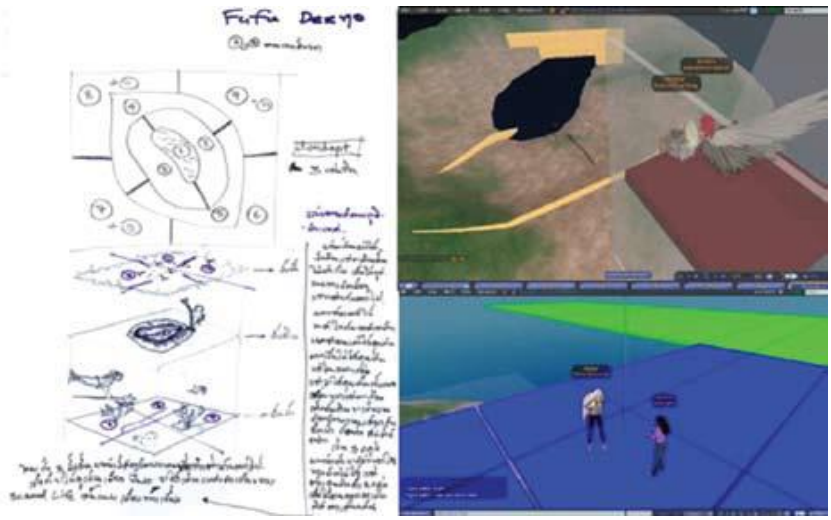


Figure 2.25. Three elements of NU Genesis

(Gül, 2011, p.258)

The virtual environment enabled the project to operate under the water, on the ground or in the sky. Therefore, six uniquely different and extraordinary design themes like Sky Garden (in the sky), Metamorphosis (under the water) and so on were developed utilizing these virtual aspects. The students were offered the opportunity to live different and interesting design experiences which enabled them to use their creativity without the constraints of the physical world.

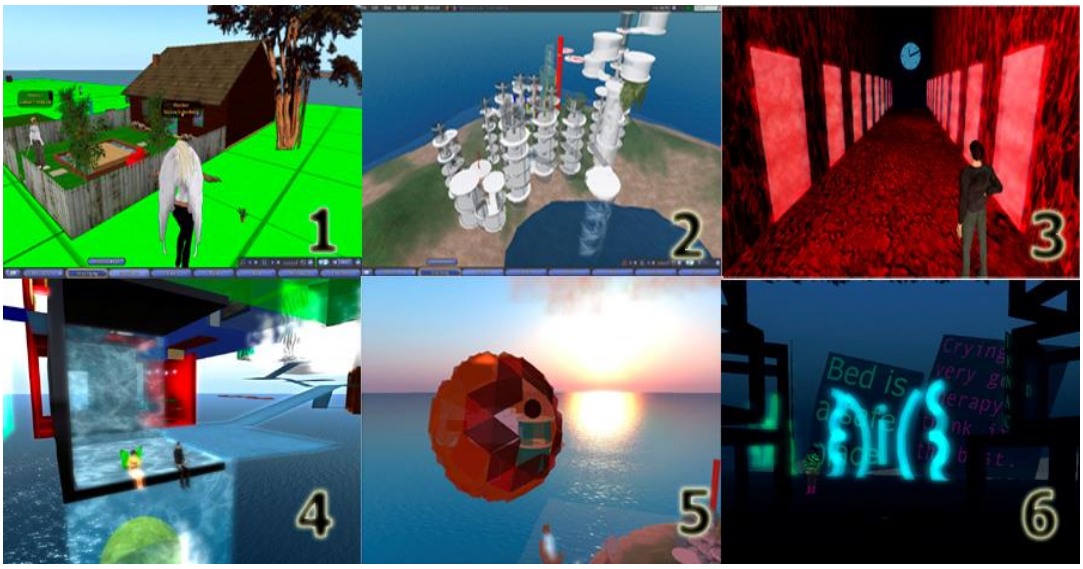


Figure 2.26. Selected student design projects in virtual worlds.

(Gu, et al. 2010, p.1265)

At the end of the projects, Gu, et al. (2009) state that "the virtual studio offers students unique opportunities for design collaboration in remote locations and for exploration of creative design" (p.61). In addition, the process was evaluated by the students through questionnaires. Gu et al. (2009) evaluate these results and conclude that virtual worlds offer many advantages for collaborative design learning activities; however, the system needs to be improved. "Lack of design support in 3D virtual worlds; inability in teamwork management; delay in responses from collaborators; language barriers; cultural differences; lack of shared design understanding and lack of common goal in collaboration" (Gu et al. 2009, p.57) are the issues that students faced during the project. In spite of this, project managers

noticed that the virtual environment provides a unique opportunity for design collaboration between remote locations and for exploration of creativity.

Another example study was conducted in the University of Huddersfield in England in 2008. The aim of the project was "to build an online 3D virtual Ramsden workshop (RW) game learning environment" (Unver et al. 2011. p.1). The students developed a virtual general workshop environment where art and design courses could be delivered. As a result of the study, educators state that the virtual world's effect on design education is valuable and it has the potential to be adaptable to the needs of all students, staffs and departments.

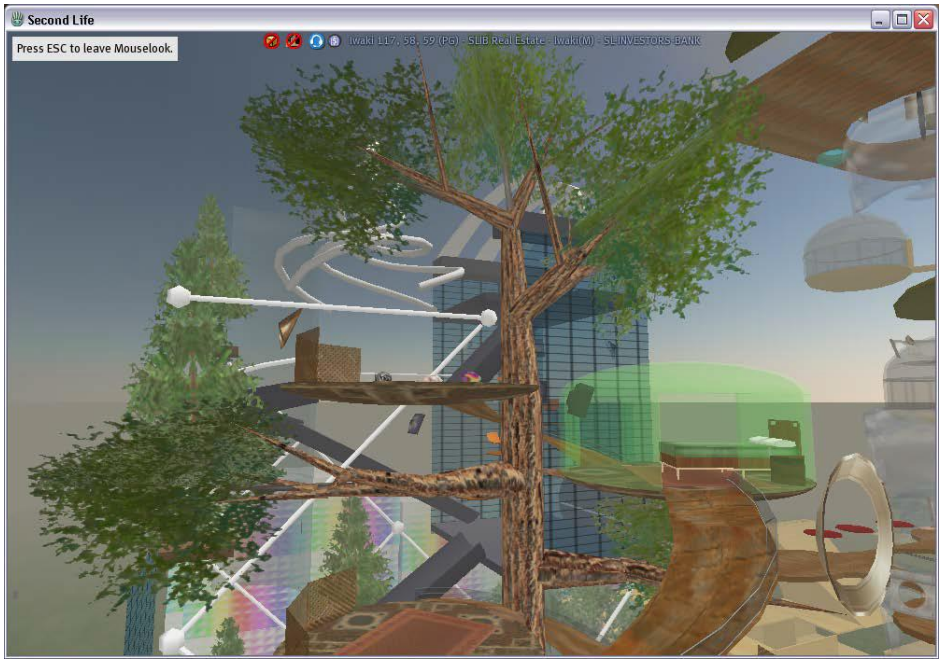


Figure 2.27. Tree House from Impossible Places

(Merrick et al. 2011, p.179)

Merrick et al. (2011) examined similar design activities which were conducted by universities in virtual worlds such as Second Life and Active Worlds. One of these activities was in the University of Sydney. Students developed their designs under the title of "Impossible Places" in 2007 (Figure 2.27). The project enabled them to design places that were impossible in the real world. Second Life enables the use of

various modeling alternatives such as in-world tools which includes modeling with primitives or importing 3D models which were developed in different modeling software. Students experienced various design processes and developed unrestricted projects using the capabilities of virtual worlds. After four case studies were conducted, Merrick et al. (2011) categorized the advantages of using virtual worlds as "design tools for modeling new artifacts, support for communication and the ability to incorporate artificial models of cognitive design processes" (p.185). In addition, it was foreseen that these advantages will increase with the development of the virtual worlds' attributes.

The Deakin Arts Education Centre which built a campus in Second Life as an art studio is the other example. The environment provides students with the opportunity to interact with virtual artifacts and attend the collaborative art learning sessions. Janette Grenfell (2013), who conducted research about the learning processes in the Deaken Arts Education Centre's campus, states that the artistic practice and work-based learning are developed during the creative processes of the virtual artifacts.

Rather than collaborating on architectural projects remotely, virtual buildings can be a subject of the courses in the departments of architecture. Students can wander among the architectural masterpieces via their avatars and review them. Especially, archeological buildings which were destroyed or which disappeared over time can be redeveloped in the virtual world, and students can get a chance to examine them instead of just looking at pictures. As a result, it can be said that virtual worlds can provide many contributions to architectural education.

2.4.2.2.2. Urban Design Education

Urban planning is one of the most popular topics for many virtual environments especially for games. For example, SimCity which is one of the most popular computer games is about city-planning. It was first published in 1989 and it has

enriched its user experience throughout in the 2000s. The aim of the game is based on building a city with an earned budget from an initial blank map. Thomas and Hollander (2010) emphasize that "although produced as a game it has been used widely to help teach physical planning and urban design for the past 20 years" (p.231). Through the popularity and success of SimCity, the number of similar games such as The Settlers, Cities XXL and Banished increased.

This popularity can also be seen in virtual education platforms. Thomas and Hollander (2010) state that many case studies about urban planning education are conducted in Second Life to experience virtual worlds and this study shows that virtual worlds provide "additional benefits to student learning and engagement through fun and intellectual simulation of play" (p.227).

During the 2006-2008 academic semesters, Professor Justin B. Hollander from the Department of Urban and Environmental Policy and Planning at Tufts University and doctoral candidate David Thomas from the College of Architecture and Planning at the University of Colorado, organized six courses about city planning and design in Second Life; it was accepted as a playground for learning urban design (Figure 2.28). These courses are 'Physical Planning & Design' in 2007 and 'Planning in the Gaming World: Urban Planning Concepts Using Games and Virtual Worlds' between 2006 and 2008. They state that both traditional and virtual courses were performed together and students used both studios throughout the semester.

> In Physical Planning & Design at Tufts University, students were tasked with managing a site development plan for roughly ten acres of vacant land adjacent to a mass transit station in a local neighborhood. In Planning in the Gaming World at the University of Colorado, students were assigned several projects where they experimented with land use through the assignment of three competing uses in a limited area of land (Hollander and Thomas, 2009, p.109).

At the end of the semester, students evaluated the study with special focus on virtual worlds. According to results, students stated that they get used to Second Life as a classroom easily. This combined education system provided many opportunities for students in terms of the methods of learning. Hollander and Thomas (2009) emphasize that students are more comfortable during the virtual courses compared with the traditional studio and face-to-face critiques. On the other hand, inconvenient situations were presented because of 'strangers' (as the authors called them). The access to this virtual environment was not restricted only to students; therefore, strangers disturbed the environment making it uncomfortable for students while working. However, Thomas and Hollander examined the same study in 2010 again and state that, at the end of the study, educators emphasize that virtual worlds, especially Second Life, are inspirational for future urban design education. Furthermore, students have the freedom of time and space while organizing design activities especially in the group projects.

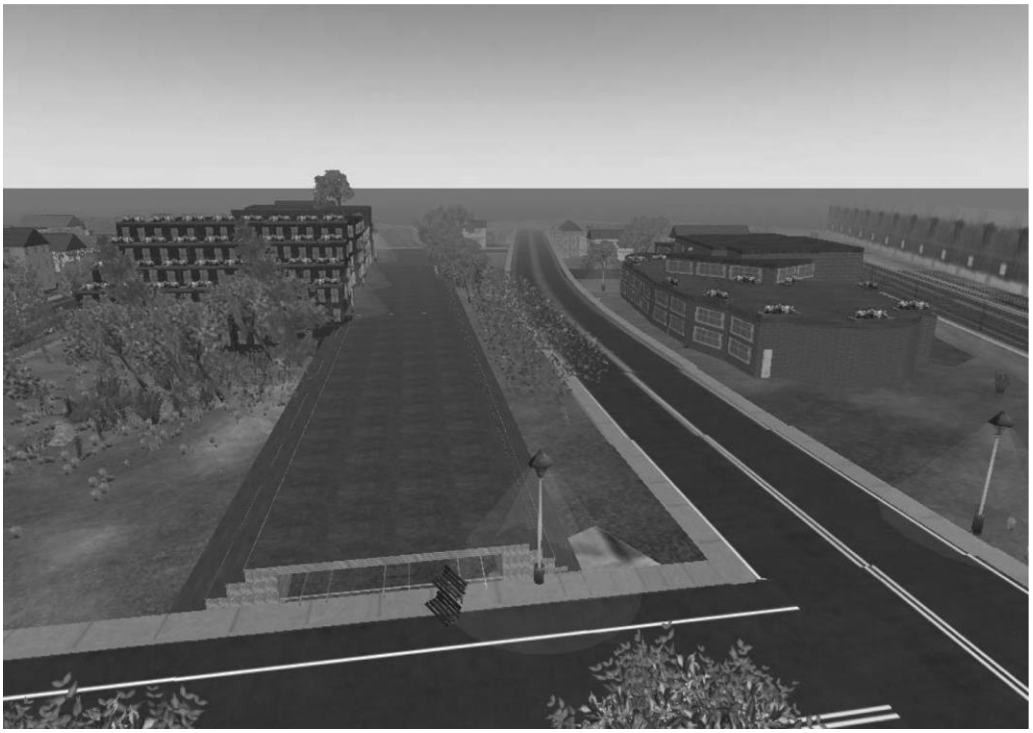


Figure 2.28. Urban design study from Tufts University, Medford, Massachusetts, USA

(Thomas and Hollander, 2010, p.234)

Furthermore, virtual worlds have been used not only for educational projects but also for collaborative urban design projects. One of them being the recreation of Lisbon which was destroyed by an earthquake in 1755 (Figure 2.29).

Figure 2.29. The Royal Opera House in Lisbon
(Da Cămara et al. 2009, p.343)

The project was a collaborative work and brought together researchers and experts in the area of art history, architecture, urban design and landscape design. The main purpose of the project was "to allow the recreation and understanding of the historic (urban, architectural and social) reality that disappeared with the earthquake" (Da Cămara et al. 2009, p.241). During the project, team members worked online simultaneously in Second Life. As a result of this collaboration, Lisbon lived again in Second Life. This study shows that the best way of representing of cultural heritage is a virtual benefit.

A similar project was performed under the leadership of Harvard University between professional architects, students and Boston citizens who are neighbors of the university in order to redesign their environment because of the new Harvard University science facilities. At the end of the project team members stated that using a virtual world was a reasonable way of enabling collaborative decisions on design problems (Knack, 2009).

These examples prove that urban design is an appropriate field for conducting a design process in a virtual world.

2.4.2.2.3. Interior Design Education

Inci Cantimur prepared a master thesis about the use of Second Life in interior architectural design education in 2009 at the Bilkent University, Ankara, Turkey. She prepared a seven-week research study as a part of an elective course. At the beginning of the study, students were informed about Second Life. For better results, the study was realized in two steps: the first stage was centered on a chair design; students studied individually and then they were divided into groups to design an "avatar cafe".

Students were responsible for designing the inside of the Avatar Cafe for avatars' virtual activities in Second Life (Figure 2.30). During the course, groups received feedback from their educators and from each other which was utilized to enhance their designs. These negotiations continued until the end of the process and groups finalized their designs according to these critiques in the interactive virtual environment.

Cantimur (2009) states that "the aim was to see to what extent Second Life would enhance students' skills in designing, by feeling more flexible and creative with the new possibilities" (p.39). Therefore, the project encouraged the students to enhance their creativity within interior architectural design projects in Second Life.

Figure 2.30. The Avatar Cafe project

(Cantimur, 2009, p.104)

At the end of the project, the design process was evaluated by the students and educators. Students reported that Second Life was user-friendly and provided an interactive and limitless platform while designing. Cantimur (2009) states that "the pilot study showed that students seemed to be satisfied, and perceived using Second Life in the design course as an enjoyable experience" (p.36).

Another project was conducted in East Carolina University, Greenville, United Sates in 2011 (Figure 2.31). The aim of the study was to design "an innovative curriculum for an introductory lab course in interior design" (Meggs et al. 2011, p.380). This course, Interior Design Fundamental Laboratory facilitates project-based learning for first year students in order to provide basic knowledge and skills for their professional life.

Figure 2.31. The East Carolina University campus in Second Life
(retrieved from http://virtualworlds.nmc.org/2012/10/01/educators-in-second-life-east-carolina-university/)

The project started in 2008 with the establishment of the university campus in Second Life. The department buildings and their interiors were designed in the virtual world. Interior designs were organized according to educators' needs and demands. The project was continued with different students each year. East Carolina University is still using Second Life actively in many departments.

Figure 2.32. A student is dealing with her work.

(Meggs et al. 2011, p.385)

Meggs et al. (2011) state that Second Life improves the communication, marketing and organizational skills of the interior design students. In addition, they point that at the end of the semester, "students are able to demonstrate professional skills in critiquing themselves and others, which provides evidence of summative outcomes… Second Life brings curricular strengths, which provide opportunities for peer feedback/review, visual examples, hands-on demonstrations" (p.390).

Furthermore, similar studies which are related to the use of virtual worlds in interior design education have been conducted at other schools such as Queensland University of Technology, Australia (McAuliffe, 2007) and the Florida State University, USA (Tan and Waxman, 2008).

2.4.2.2.4. Landscape Design

The School of Design, Queensland University of Technologies, (QUT) Australia performed a study to examine the effect of virtual worlds on design processes related

to landscape architecture. The study was conducted in Second Life which was used as a collaborative design environment by postgraduate students.

Gard & McAuliffe from the QUT (2009) state that virtual worlds like Second Life provide “an environment similar to the real world in terms of design activities and communication where users can create and manipulate objects in a shared workspace while being physically remote and they can communicate either by voice chat or text chat” (p.74). In addition, multiple departments are benefiting from Second Life increasingly for their educational projects and so the number of case studies based on design education is increasing. Because of these opportunities and examples, they organized a virtual study for their design activities and collaborations.

A part of the QUT Island which is virtual land belonging to Queensland University of Technologies in Second Life was designated for this study (Figure 2.33). Students were divided into groups of three or four and each group developed a design project according to their theme. Online meeting sessions were conducted between educators and students in Second Life to evaluate works and to give feedback via their avatars.

The process included a stage where students received feedback from guests, who were invited to visit the QUT Island via their avatars, in order to receive feedback, students made design project presentation. During the visit, students and guests evaluated the projects and determined the problems. According to these reviews, students continued to develop their designs and tried to find solutions to the problems while working on the island. At the end of the study, guests were invited again so that the students could introduce the final versions of the designs.

Figure 2.33. The Tropical Garden Section

(Gard & McAuliffe, 2009, p.78)

Gard & McAuliffe (2009) emphasis the reality of the Second Life for landscape design and explain that "the sun rises and sets, objects fall under the effect of gravity, trees and grass blow in the wind and clouds form and drift" (p.74-75). For this reason, virtual worlds can provide a realistic environment in which to present landscape design projects. During the study, the most critical limitation of Second Life for landscape design was the number of objects related to the number of prims for students (Gard & McAuliffe, 2009). Landscape design includes various objects, plants and so on, and students had difficulties creating and placing their objects. Therefore, educators planned to use alternative virtual worlds which provide more freedom for future projects.

2.4.2.2.5. Interaction Design Education

Interaction design is another design topic which uses virtual world for design process and education. Educators at the University of Aegean, Greece developed an interaction design studio in the virtual world in order to conduct a postgraduate interaction design studio course during the semester in 2012 (Figure 2.34). The aim of the project was to design a kiosk and its interface for a theater. Educators categorized all the stages of the design process and built special tools for these stages.

For the project, design stages which were classified as design brief, design research, design thinking, design practice, desk critique and design review and evaluation, were examined in detail in a conventional education scenario and an attempt at their equivalents was made in the virtual world. According to the results, appropriate environments and tools were developed for each stage. For example, during the design process there were special boards for presenting research, posting research results for examining whenever students want, sketching during the development of initial ideas and so on. The virtual world enabled students to stay in touch throughout all of the development stages and to communicate simultaneously; therefore, they evaluated each other frequently (Vosinakis, & Koutsabasis, 2013).

At the end of the process, a theater was built in the virtual world for presentation of the projects in order to generate a realistic environment. Students tested their designs while examining them thoroughly and tried to receive feedback in order to improve their designs.

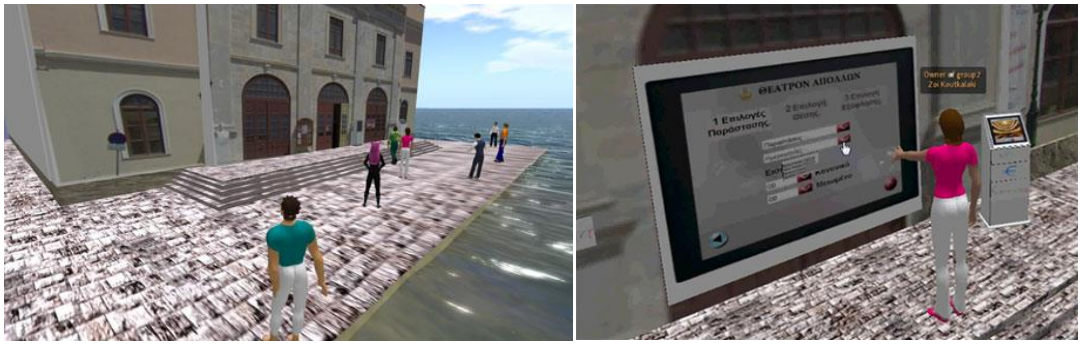


Figure 2.34. User evaluation of the kiosk prototypes in the virtual theatre model.
(Vosinakis, & Koutsabasis, 2013, p.71)

Vosinakis and Koutsabasis (2013) state that "virtual worlds have many unique advantages for supporting interaction design studio activities, provided that they are designed to include appropriate workplaces and interactive tools to foster collaboration and creativity" (p.59). This study shows that virtual worlds can be a supportive element of an interaction design studio in terms of many aspects such as online meeting, presentation and testing opportunities.

Similarly, another virtual studio was conducted in the undergraduate Human Computer Interaction course at Washington State University in order to explore new technologies for studio-based learning. Hundhausenm et al. (2010) explain the study thus: "in an undergraduate HCI course, we have been exploring a studio-based learning activity called the prototype walkthrough, in which a student project group simulates its evolving user interface prototype while a student audience member acts as a test user" (p.2). The audiences were invited in order to evaluate the projects and give feedback to students. This process continued throughout the design process and the prototype walkthrough resulted.

Prototype walkthroughs encourage students to attend the discussions about their user interface designs and evaluation sessions; they guide students in their efforts to improve designs. Educators state that this prototype walkthrough "should play a prominent role in the next generation of HCI education" (Hundhausenm et al. 2010,

p.2). Therefore, they provide a report about the current situation of the study and future tasks to be added.

Examples show that virtual worlds can be a key aspect of interaction design especially for user testing. They provide an opportunity to present the project to the users whenever the designers require during the development stages in order to receive feedback that will help to finalize the design.

2.4.2.2.6. Fashion Design Education

The Virtual Fashion Project was conducted by using Second Life in the Fashion Cad course, at Buffalo State College, New York in 2007 (Figure 2.35). The main objective of the course was to experience virtual worlds for fashion design and to provide a platform for students to create 3D models of their designs and examine them in a realistic concept.

Figure 2.35. Student (Katie O'Callaghan) collection in Second Life
(Polvinen, 2007, p.58)

The process started with the creation of students' own avatars and then with the help of the tutorials they started to learn the controls in order to create 3D models. After

the learning stage, they developed their own creations according to their own design concepts. During the seven-week project, they experienced fashion product development and at the end of the development stage, they started to prepare final presentation which included a video clip of their virtual collections. Although the development stage was conducted individually, some students collaborated for the final presentation development stages in Second Life. Polvinen (2007) states that especially during the presentation stage, students and educators had more difficulties especially for posing the avatars and creating the order of the presentation.

On the other hand Polvinen (2007) also states that during this project "students gained experience and introductory skills with: multiple techniques for virtual fashion garment development; presentation and product packaging; development of a virtual fashion exhibit; and virtual fashion show production and presentation" (p.59). However, according to the educators, virtual worlds should be improved for fashion design development. Even though students had a great time during the project, educators emphasized that they had difficulties organizing the students for exhibition purposes.

As a result, the system needs technical improvements especially for the posing and production stages in order to become a more appropriate tool for garment development (Polvinen, 2007). Up to now, there is no information about project's advancing processes, so we can conclude that the application of fashion design education in virtual worlds is more difficult than other design disciplines. In addition, Bardzell et al. (2009) reported that "in the vast majority of instances, fashion simply cannot be designed within Second Life" (p.9). As a result it can be said that virtual worlds do not provide an appropriate environment for fashion design education. Conversely, virtual worlds create their own separate comprehension of design. They provide unlimited worlds for fashion design; many alternatives and combinations can be arranged by the users free from the rules of the real world. There are many fashion blogs especially about Second Life and virtual fashion designers who work only for virtual worlds have emerged.

2.5. Summary

The examples mentioned in the above sections are generally from the time period between 2007 and 2010. Many of them use Second Life as a virtual world in order to conduct these studies. Second Life launched in June, 2003 and its mass media popularity rapidly increased between 2005 and 2006. Considering the development of the Second Life, and the time period (between 2007 and 2010) during which virtual world research studies began to intensify, the results were to be expected. Companies and educational institutions started to apply this new development according to their own purposes after 2006 when its popularity was growing.

Furthermore, a certain decrease in the number of the research studies is remarkable after 2010, and with respect to company operations, this situation can be derived from the privacy concerns of the companies. According to the Second Life database (2013), many popular brands such as Coca-Cola, Herman Miller, Adidas, and Mercedes have their own private islands in Second Life and they are active users continuing their work by utilizing virtual world opportunities. A similar situation is assumed for the universities, because there are many virtual university campuses in Second Life and they continue to deliver their courses virtually. In spite of this, the number of educational research studies (especially on design education) in virtual worlds is diminishing. One of the reasons might be based on the lack of active studies. The other reason might be the rapidly evolving and changing technology. Virtual reality technologies such as Kinect and Augmented Reality which are improving with each passing year may have reduced the popularity of the virtual world. Therefore, companies and educational institutions may be exploring these most advanced technologies rather than investigating only virtual worlds. These reasons may explain the current situation that indicates insufficient data.

The company projects were presented in terms of the design stages which are idea generation, design concept generation and evaluation (testing). For idea generation, companies intend to receive wide-ranging and inspirational ideas from their

customers by organizing competitions such as Coca-Cola's vending machine design competition and Steelcase's executive chair design competition (Kohler et al. 2009). Both of them preferred to use a virtual world in order to have their customers involved in design stages rather than carrying out their company's own design stages. A similar situation can be observed in the design concept generation stage; companies constitute a virtual environment for customers to create their own designs. For example, Scion came together with their customers in Second Life in order to customize their own car and create a test drive (Chakravorty, 2007). For both stages, the main objective of the companies was to increase brand recognition while satisfying and entertaining the customers; receiving inspirational ideas for future designs became as secondary objective for the companies. On the contrary, the testing stages of the studies achieved their main objective in that companies benefited from the virtual world in order to test their designs and receive feedback from the customers before the designs become real. For example, Starwood Hotels used a virtual world while designing their new hotel 'Aloft' (Kohler et al. 2009). Before the hotel's construction, customers were invited to the virtual hotel so that they could feed back to the company. As a result, it can be said that virtual worlds contribute to companies in different ways: by (i) increasing brand recognition, (ii) enabling companies to receive inspirational ideas, and (iii) testing designs and receive feedback for them.

Considering the virtual worlds applications in design education, when the examples reached in the literature were analyzed, it can be realized that virtual worlds were generally used for the transformation from an idea to a product, namely in generating the design concept and the decision-making stages. During the process of generating the design concept, virtual worlds provide a more comfortable environment for critiques; because, students feel more relaxed during online meetings compared to face-to-face critiques. In addition, ideas turn into three dimension quickly from the two dimensional sketches through the 3D environment of the virtual world. For the user testing stage, the accessibility of the online

platforms is better than the physical environment in terms of the participants who will attend the evaluation stages of the design process.

Presenting the finalized design projects is more fascinating in the virtual world for design educational projects; because, virtual worlds offer realistic environments for projects and give opportunities to visitors (juries) to examine designs in a similar way to a real environment. Therefore, feedback and opinions become more relevant to finalization of the design projects. For example, Gard and McAuliffe (2009) state that virtual worlds provide a realistic environment for landscape design project presentation rather than studying drawings and scale models. In addition, for interior design education projects, educators also have the opportunity to be a part of the designed environment via their avatars. Similarly, urban design educators have the opportunity to walk in the street as a part of an urban design project while evaluating the designed city. In the interaction design projects, virtual worlds provide a realistic atmosphere for design projects to be tested. Thus presentations become more real and the results of the user tests can be more reliable. For example, for a theater kiosk design, a theater was modeled for presentation (Vosinakis, & Koutsabasis, 2013). On the contrary, students and educators during the fashion design education encounter many problems, especially during the garment development and presentation of the fashion designs specifically posing the avatars (Polvinen, 2007). Therefore, it can be said that virtual worlds are not efficient environments for all the fields of design education. For industrial design education, no research study for virtual worlds could be found; however, companies conducted many industrial design related applications which covered all stages of the product design process.

Virtual worlds have both advantages and limitations for design education. One of these advantages can be to foster creativity by removing the constraints of the real world. Students have the opportunity to live a different and interesting design experience that cannot exist in the physical world's rules. "Virtual Home" (Gu et al. 2009) and "Impossible Places" (Merrick et al. 2011) are two of the virtual projects which were based on virtual architectural design. The project names indicate the

limitless virtual environment and they aim to foster creativity. The other advantage for design education concerns the interaction between students and educators. As mentioned in the examples, students feel more flexible and comfortable during the critiques in a virtual environment. Without the restriction of course hours and physical classrooms, online meetings and conversations become more appealing to students. In addition, virtual worlds provide realistic and easily accessible environments for both project testing and presentation as parts of design education.

However, these advantages are not enough to diminish completely the dominance of traditional design studios; because, virtual worlds also have limitations and problems. The limitations of virtual worlds are generally related with the technical issues such as bandwidth, hardware, firewalls, downtime problems, and identity issues which concern the reliability and fluidity of avatars' identities. The outcomes of the literature review study indicate that combined education which includes traditional and virtual design studios together can be more effective for design education. In addition, virtual worlds can become supportive for traditional design studios in order to facilitate the particular stages of design process.

Considering the examples mentioned in the previous sections, virtual worlds can become beneficial for industrial design education during critiques, user tests and project presentations. However, with the current condition of the related technology, for ergonomical, structural and mechanical properties, virtual worlds may not be efficient. To realize these features in the virtual world requires proficient knowledge and experience and also time. These results and the above examples can serve as groundwork or a starting point for the use of virtual worlds in industrial design education in the future. Therefore, this thesis will try to answer: at which stage of design process virtual worlds might be convenient and might be used possibly.

CHAPTER 3

METHODOLOGY

The previous sections concentrate on the detailed explanations of virtual worlds and industrial design education and the examples based on the applications of design processes in virtual worlds. There are very few examples about applications of virtual worlds in industrial design education in the world; furthermore, there is no such research study in Turkey on this subject. Therefore, this theoretical background is not adequate enough to generate groundwork for virtual worlds as new learning environments for industrial design education especially in Turkey; therefore, it would be valuable to enrich this theoretical background with opinions and suggestions gathered from related parties.

3.1. Background for Methodology

Due to the importance of the professionals' perspectives about the thesis topic, a qualitative research method is chosen rather than quantitative research methods which involves "describing 'reality' through numbers" (Tolmie et al, 2011, p.4). Because of the lack of awareness of virtual worlds and scarce number of applications focused on the use of virtual worlds in industrial design education; quantitative research might not be suitable. To obtain better quality information, a research study which includes a virtual environment for an industrial design project, for example, in the Industrial Design Department, METU, Ankara, could be conducted with students. Design project stages could be carried out in this virtual environment in order to evaluate the effectiveness of virtual worlds for education; however, the time limitations and financial constraints prevented its realization. In addition, another limitation is the lack of experienced people who could build the

environment for the design project; virtual worlds could be customized according to the needs of the design project but this preparation would also need time and the participation of professionals. Therefore, for a scientific examination, it was decided to conduct interviews as a type of qualitative research method which "seeks to understand a given research problem or topic from the perspective of the local population it involves" (Mack et al, 2005, p.1).

The most common qualitative research methods are: *participant observation* which is used generally "for collecting data on naturally occurring behaviors in their usual contexts", *in-depth interviews* which are effective for "collecting data on individuals' personal histories, perspectives and experiences, particularly when sensitive topics are being explored" and *focus groups* which are appropriate for "eliciting data on the cultural norms of a group and in generating broad overviews of issues of concern to the cultural groups or subgroups represented" (Mack et al, 2005, p.2). When these methods were examined, it was realized that in-depth interviews were the most appropriate method by means of gathering information about the application of design projects in virtual worlds. John Kuada (2012) states that in-depth interviews enable us to "gain an insight into the lived experiences of the person" (p.98). In addition, they also allow participants to express their ideas with their own words.

These interviews could be conducted with the educators of the Industrial Design Departments; however, it was foreseen that the number of industrial design educators interested in virtual worlds would be insufficient. Similarly, students could be interviewees; but students were considered to have insufficient information about industrial design education in general in order to evaluate new learning environments. Educators from the other departments, who have experience in virtual worlds, could be interviewees to express their predictions about applications on industrial design education. Due to the lack of information about design process in studio courses, their predictions would be more general for using virtual worlds. And also, there are sufficient research examples about applications of virtual worlds

on other departments in the literature review chapter in order to make a general comment.

The main objective of this research study is to gain insight about the professionals' perspectives on virtual worlds as new learning environments for industrial design education. The literature review holds the view that virtual worlds are active learning environments for many fields such as engineering education and architectural design education; however, industrial design education is not an active field which is currently benefiting from virtual worlds in their curricula. Therefore, conducting interviews with the professionals who are interested in and experienced about both virtual worlds and industrial design education would be complementary study for the literature review of this thesis.

Aforementioned limitations make in-depth interviews more suitable for this research study. In addition, considering that there are not enough example applications which can be informative in the world which use virtual worlds as learning environments for industrial design education, to form groundwork for the possible application of virtual worlds on industrial design education is a more reasonable goal at this stage. Therefore interviewees' perspectives will enrich and contribute to generation of this groundwork before its application.

3.2. Participants

The main aim of this research is to bring together the areas of industrial design education and virtual worlds and to gather predictions about virtual worlds as new learning environments for industrial design education. Metutech (Techno polis in the Middle East Technical University) consists of these types of firms and one of them is Reo-Tek which employs multi-media designers who are graduated from industrial design departments. Due to these reasons, designers of the Reo-Tek were thought to be as ideal interviewees.

Reo-tek (founded in 2005) is “a full service design and production company and developer of interactive technologies within Metutech, Ankara, Turkey” (retrieved 11 July from Reo-tek website). Reo-tek’s main field of interest is interactive applications in education, museums and exhibitions developed in collaboration with industrial designers, architects, computer engineers and graphic artists. This interdisciplinary structure develops creative projects which are significantly related to the technological developments. There are industrial designers who graduated from the industrial design department of METU in Reo-tek, working as multi-media designers. They are interested in new technologies (because of their working area) and experienced in industrial design education (as students).

There are six industrial designers in Reo-tek and four of them attended the interviews voluntarily. Voluntary participation is important for this study in order to get as much as possible viewpoints and suggestions. Each of the interviews was conducted in participants offices at the Metutech and audio recorded. Each interview session took approximately 45 minutes.

Table 3.1. Participants of the interviews

Participants	**Age**	**Graduation year**	**Experiences**	**Interests**
Participant A	27	2013	5	3D modelling Visualization
Participant B	28	2014	3	3D character modelling
Participant C	26	2012	3	3D modelling Graphic design
Participant D	25	2014	2	3D project development

3.3. The Interview Guide

Interviews can be categorized into three: (a) *structured interviews* which are used in quantitative research with standardized and close-ended questions and the results are coded using numbers or scales, (b) *semi-structured interviews* which are based on prepared questions that both encourage participants to use their own words and which also direct them to choose from specific answers, and (c) *unstructured interviews* which is like a conservation that is directed by the interviewer in terms of a set of specific question and topic (Garner and Scott, 2013). Therefore, unstructured interviews are seen as the most appropriate one for this research; because, there is no specific information or results about applications of virtual worlds on industrial design education to measure its accuracy and effectiveness.

A pilot study was conducted with two participants, a professional from Reo-Tek and an educator from the METU Dept. of Industrial Design in order to revise the interview questions and pre-test the process. By the pilot study, it was realized that the interview took longer than planned and continued out scope of the main topic. Therefore, it was decided to organize the interviews around one main question and to support it with some sub-questions during the conversation in order to control time and prevent to wander off from the main aim. There were five questions in the first version of the interview and then in order to conduct more successful process, the number of the questions was reduced to one with three sub-questions in the final version. In addition, grammar and vocabulary corrections were made also.

Purposefully, the main question (*What do you think about availability of virtual worlds in design studio courses in industrial design education?*) is a very general question and it emphasizes the aim of the research that is to get insight about professionals' perspectives about the virtual worlds as new learning environments for industrial design education. It encourages interviewees about their ideas. Sub-questions as probes are more specific as they are related with the advantages and limitations of virtual worlds (*Can you explain the potential benefits and possible*

limitations that virtual worlds may provide for industrial design education?), stages of the design process of a design studio project (*When you think about design projects conducted in the studio courses, which stages of this process could be more useful in the use of virtual words? How?*) and the convenience of the characteristics of the virtual worlds with the industrial design education (*In this context, what do you think about avatar-based education, group works in virtual worlds? and so on*). The interviews were carried out by talking about the process in design studio courses step by step; hence, during the progress of conversation three sub-questions were asked to the interviewees as probes while talking about the main question.

3.4. Data Analysis

For data analysis, firstly, audio recordings of four interviews were transcribed word by word and these raw data acquired were analyzed precisely. In order to identify codes, an open coding technique which "includes labeling concepts, defining and developing categories based on their properties and dimensions" was used (Khandkar, S. H., 2009, p.1). Ideas and meanings from the raw data were examined and grouped according to their similarities in order to determine categories and sub categories. Each relevant text from the raw data was marked by color coding while determining these categories. After this determination, relationships between categories were identified in order to determine themes. Each theme was named according to its content. After categorization was completed, raw data was compared with the categories for verification.

Raw data was divided into two themes under the title of design education. These themes (design process and general attributes) were categorized into sub-themes according to raw data and literature review. Content categories were grouped and named under these relevant sub-themes and relevant phrases were repeated in the analyzed structure of the interviews (given in Table 3.2). Opinions and suggestions

Table 3.2. The analyzed structure of the interviews

THEMES	INDUSTRIAL DESIGN EDUCATION (STUDIO COURSES)							
	DESIGN PROCESS					GENERAL ATTRIBUTES		
	ANALYSIS	SYNTHESIS	EVALUATION			RELATED TOPICS		
CONTENT CATEGORIES		Design Research	Concept Development	Concept Refinement	Presentations	Technological Developments	Avatar-based Education	Group Works
	Problem Definition	➢ Providing private space for students to store their research results ➢ Examining research results at any time ➢ Advancing research process through the process ➢ Monitoring project process ➢ Providing open source space for general information (material, anthropometry, technology and so on)	➢ Providing more appropriate environment for some stages such as ERM session ➢ Providing effective environment for product scenarios ➢ Providing to develop interactive 3D storyboards ➢ Enabling to advance virtual user scenarios ➢ Causing some difficulties for concept development **Critique Sessions** ➢ Comfortable environment for communication ➢ Opportunity to examine 3D models ➢ More educators and professionals ➢ Easy participation to critiques ➢ Preliminary preparation for educators before critiques ➢ Collaborative environment for universities ➢ Private space for following design process ➢ Inefficient communication way	**User Tests** ➢ Appropriate environment for visual attributes of designs (color and form) ➢ Effective way for testing basic human-product interaction ➢ Better way for testing interface design ➢ Easy access for more users ➢ Appropriate platform for big scale projects such as interior design ➢ Lack of physical interaction ➢ Unsuitable platform for testing physical properties (such as: weight, material, ergonomic, structure and etc.)	**Juries** ➢ Long-term juries ➢ More educators from different universities and departments ➢ More professionals ➢ Better relationship between universities ➢ Digital archive for projects ➢ Less cost and less time (compared to hard copies) ➢ More realistic environment ➢ Requirement of control mechanism in order to check students **Graduation Projects Exhibition** ➢ 3D interactive environment for exhibition ➢ Long-term exhibition ➢ More visitor and more comment for design projects ➢ Opportunity for every visitors to watch videos and animations and interacts with the designs ➢ Opportunity to experience the interface ➢ Integrated exhibition environment ➢ Different concept for exhibition environments	➢ Requiring to start computer courses earlier ➢ Providing thinking 3D better ➢ Following technological development (especially educators) ➢ Integrating technological developments with studio courses ➢ Revising course curriculum according to technological developments	➢ Non-essential for the concept analysis and synthesis stages ➢ Usable for user tests ➢ Effective use for animation and user scenarios ➢ Better way to show product scale	➢ Elimination of time and place problems ➢ Easy access ➢ Opportunity to work on the same model and drawing ➢ Easy communication ➢ Simultaneous comment and sharing ideas

of the interviewees about the use of virtual world in the relevant categories were kept in this table.

The data analysis stage is concluded in two main themes. The first one is ‘Design Process in Industrial Design Education’, which includes stages of design projects in studio courses. Each stage (except problem definition stage given by educators) is evaluated by the interviewees considering the use of virtual worlds. Its benefits and limitations were discussed. The second theme is ‘General Attributes of Studio Courses in Industrial Design Education’, which is formed by considering the general properties of the design projects in studio courses and general views of the interviewees.

3.5. Results of Data Analysis

In this section, each category will be explained briefly and the frequencies of mentioned categories will be indicated. Explanations regarding their categories will be presented in the relevant section.

3.5.1. Design Process of Design Projects in Studio Courses

Stages of the design process in studio courses were examined one by one during the interviews; hence, this theme was categorized according to design process as mentioned in the literature review.

Problem Definition

With some exceptions at the graduate level studio courses, the very first stage of the design process in studio courses is problem definition which is generally handled by educators and announced to students at the beginning of each project. So, there is no task to be completed by students; therefore, this stage was passed over during the

interviews. In order to give design process completely, this stage is only mentioned as a category. Although, problem definition can be announced to students in a virtual world designed as appropriate to the topic by educators, interviewees did not make any comments. In addition, there was not any example for problem definition stage in the applications mentioned in the literature review. This stage is missing in research studies about design education applications in virtual worlds.

Design Research

Design research is the first stage of the design process in studio courses for students. After problem definition, students have an extensive research period which consists of market research, similar products examination, material information and so on. Two of the interviewees mention *design research stage* when considering virtual worlds as learning environment for design process, others passed over this stage during the interviews.

Several inferences are formed regarding the statements of the interviewees about the *design research stage*. The first interviewee, who mentioned *design research* while talking about the virtual worlds as new learning environments for studio courses, explained that virtual worlds can provide private space for students in individual projects in order to store their research results and can revisit them at any time. The advantage of this situation is to resolve the deficiency of traditional design studio, all the students conduct research and present their findings to each other and they focus on particular points from these results and other information is forgotten during the projects; therefore, virtual worlds provide students an environment that does not disappear as time goes so that they can revisit and examine these research results at any time of the process. The interviewee resembled this situation to "Pinterest" which is a social platform to catalog visuals of users' interests. Each student can create his own 3D environment and check each other's area whenever they need. Moreover, he continued by stating that this environment can turn into a live-environment where students can add new information at any time through the

process. Therefore, the environment can be used as a control area where the design project process can be followed by students and educators to check students' progress.

On the contrary, the second interviewee, who mentioned *design research*, explained that because of competitions among students, there can be an open source environment, rather than individual areas, for general information about design projects such as material, anthropometry and technology. In this way, students can access this information whenever they need during the project process. Research results of the students can be easily forgotten during the later stages in the traditional design studio; therefore, virtual worlds can keep this information alive.

It can be said that virtual worlds can be used as a virtual gallery for students' research results about a specific design project and students can improve this information resource and check them throughout all design stages in studio courses.

Concept Development

Idea generation and critique sessions come into prominence while interviewees were talking about *concept development*. There is a general perception that virtual worlds are not beneficial for idea generation stage which consists of 2D sketching and 3D modelling sessions especially for individual projects; because there are much more advanced and proficient modeling or drawing programs for these creative stages.

Conversely, interviewees stated that virtual worlds can provide an effective environment in the concept development stage performed together with the users such as ERM (Experience Reflection Modelling) session which is "a design research method that is emerged from participatory and generative design approaches that encourage people's involvement in the early stages of design process, and connects design students and potential users through creating an effective medium for knowledge transfer" (Turhan, 2013, p.19). Interviewees told their experiences of the

ERM sessions from the third year design studio courses and indicated that to fulfill the requirements (such as development of toolkits) and to organize meetings with the users are very time consuming; instead of this, these types of sessions can be arranged virtually. ERM sessions with virtual users and virtual toolkits can be made more quickly and effectively. However, at this point, interviewees pointed out that users who participate in these virtual sessions must have computer abilities and know how to use virtual worlds. Therefore, an ordinary housewife (described as "Ayşe Teyze" by interviewees) can never take the role as user in virtual activities.

The other session of the *concept development stage* mentioned by the interviewees is scenario building method. In traditional design studios, scenarios are constructed by 2D drawings and talented students become more successful and effective in expressing their ideas. Therefore, interviewees explained that virtual worlds with scenario building tools can be very effective for students and rather than 2D drawings, virtual worlds can provide to present projects in a more realistic and 3D environment. In addition, they continued that projects can be presented with interactive scenarios in virtual worlds. Interactive design needs (such as product usage scenarios) can be built with training through role-playing by virtual users. In virtual worlds, projects can be expressed to educators and/or guests in a more realistic environment with interactive activities and virtual visitors can be parts of these scenarios as virtual users.

Another topic frequently discussed under this category is about *critique sessions*. As mentioned before, critiques are significant for the traditional design studios. Interviewees spent a lot of time while talking about critiques and they debated its advantages and limitations in terms of virtual worlds. Communication between students and educators during the critiques became a popular issue of the interviews. Interviewees stated that face-to-face communication in a traditional design studio between students and educators can cause some psychological issues such as discomfort and shyness of students; therefore, distance communication via virtual worlds can create more comfortable environments especially for students while

presenting their projects. However, they added that face-to-face communication is a more effective way to explain something. Otherwise, virtual worlds also give both students and educators the opportunity to examine 3D models of the design projects in detail via their virtual avatars. Moreover, interviewees added that educators can benefit from this virtual examination in order to be prepared for studio courses; they can check the students' projects before critique sessions and if they need, they have time to make researches to being more informed in order to make more precise comments.

All the interviewees stated that virtual worlds can create a collaborative environment for all the Industrial Design Departments of the universities to participate in critiques of each other, so that students can get feedback from the educators of other universities. Here, students can have private spaces to present their projects and educators or professionals can view the projects in those virtual environments and comment; it can be a more effective way of "critique" rather than with the limited course hours in a physical environment. Thus, virtual worlds can facilitate the participation of critiques for both educators and students; and also create a collaborative environment between different universities even from different countries.

Concept Refinement

User tests became the focus point of this category and interviewees evaluated the possibility of making user tests in virtual worlds with 3D avatars. There was a general opinion that industrial designers deal with products which are directly relevant with the human; therefore, virtual worlds are not an effective method while testing product properties about ergonomics, structure, weight, material and so on because of the lack of physical interaction. On the contrary, virtual worlds can be a good choice for testing visual attributes of designs such as making color and texture choices and deciding form alternatives.

In addition, two interviewees stated that virtual worlds can be a better way for testing basic human-product interaction (such as holding a refrigerator handle, opening its cover, the location of its interface etc.). One especially emphasized that virtual worlds can be a better way for testing interface designs. For example, the interface of a mini-oven or a tea-maker can be tested according to virtual users' ways of use. In addition, virtual worlds provide chance to reach more users for product testing.

It can be because of the examples provided by the author (some examples were given from the literature as probes), interviewees stated that virtual worlds are more appropriate for big scale projects such as interior and architectural designs to examine via avatars. For product design testing, physical-touch and a real environment is more critical and essential.

Presentation (Finalization)

The most popular topic among the interviewees was about presentations which can be divided into two parts: juries and graduation projects exhibition. There was a common point that virtual worlds contribute to industrial design education especially in presentation stage more effectively. The recommendations were mainly the same with the comments made for critique sessions.

According to three of the interviewees, if juries are organized in virtual worlds, long-term juries can be held instead of a single or two-day juries in order to invite more participants such as educators from different universities and professionals working in different cities. Students and educators from different universities can improve educational process by following and examining each other's' projects; hence, the relationship between universities can be improved.

All interviewees also stated that virtual worlds can provide more realistic environments for presentations. One gave an example that "if project is to design a

futuristic refrigerator, a futuristic kitchen compatible with this design project can be developed in order to make a better presentation and actually we are already doing these in order to prepare 2D boards; why shouldn't I use these things for a more effective presentation." In addition, they continued that the presentations in virtual environment consume less cost and less time and energy compared to hard copies of 2D presentations. A digital archive can be prepared automatically in virtual worlds. In addition to all these comments about juries, interviewees have reservation about the participation of students in these virtual juries. In traditional juries, all students follow each other and learn from the juries' comments and suggestions; therefore, it would be valuable to have a control mechanism to foster students to follow presentations in virtual worlds.

Similarly, all of the interviewees indicated that virtual worlds can be a good tool for a more effective graduation projects exhibition instead of traditional exhibitions. As mentioned for juries, exhibitions can be organized for longer periods and more visitors would have a chance to visit the virtual exhibition; thus more suggestions about design projects could be collected to evaluate design process and enhance projects. Virtual worlds also make possible to prepare 3D interactive presentations supported with videos and animations; thus, every visitor may have chance to examine all details of the projects. In addition, interviewees explained that if possible, visitors can also test the interfaces of them.

Another suggestion made by two interviewees was about exhibition environment. Constructing different concepts and themes for exhibition halls can be possible in digital environments. In addition, it is added that, this virtual exhibition can be a part of the traditional graduation projects exhibition. In other words, a technological structure for a virtual platform can be built in a physical exhibition hall in order to introduce projects in more detail to visitors.

3.5.2. General Attributes of Studio Courses

During the interviews, some important points emerged while interviewees were talking about the design studio courses. These points are about computer aided design courses and technological developments, and avatar-based education which are explained under the category of general attributes of studio courses.

Technological Developments

There was a common opinion between the interviewees that the computer aided design courses based on 3D modelling should be given to the students at earlier stages of their education (computer courses start in third year at METU). An interviewee stated that 3D modelling tools enable and facilitate 3D thinking and creativity. Students should be able to use 3D modelling and graphic design software effectively for a better design process.

The other thing interviewees put emphasis on is about technological developments and their contributions to industrial design education curriculum. They explained that educators in particular should follow these developments and integrate them into studio courses in order to be up-to-date and to prepare students for professional life better. In addition, they continued by stating that industrial designers have difficulties while designing innovative products without following technological developments. In order to design products for the future, industrial designers should be interested in these developments.

Avatar-based Education

To avoid misconceptions, at the beginning of the interviews, the definition of virtual worlds is given briefly and also brief information about virtual worlds' properties are explained to encourage interviewees to think without misconceptions during the interviews. They questioned the necessity of avatars (3D human characters) in virtual worlds for industrial design education and stated that avatar is not required

while visiting an exhibition or attending a jury or developing designs. A First person controller which indicates to look through the eyes of an invisible avatar in 3D environments such as simulations and games can be an option for these stages.

On the other hand, while preparing design scenarios and animation, avatars must be included in virtual worlds to symbolize user groups and to compare product scale. In addition, avatars should be used for the activities users belong to such as user test and ERM sessions.

Although “avatar” is in the description of virtual worlds, interviewees thought that it is not necessary in all stages of design process; the virtual environment controlled by the users can be enough for many cases.

Group Works

Throughout the studio courses, educators encourage students to learn to work in a group by giving constant group work. Therefore group work becomes one of the issues mentioned during the interviews by means of virtual worlds and if interviewees did not mention it, it was asked specifically as a question.

Interviewees stated that one of the big problems during the group work is arranging meeting dates, times and places; therefore virtual worlds can eliminate these problems. Access of virtual worlds is very simple and students can organize their meeting quite easily. Moreover they provide different communication alternatives so that interaction between students can get easier in comparison to other digital platforms.

The other advantage of virtual worlds for group works according to interviewees was about developing an idea simultaneously. Students can work on the same model thanks to the 3D modelling tools and can make suggestions and develop their ideas

simultaneously. Otherwise they can share their 2D works and receive feedback from each other.

3.5.3. Other Findings

It was realized that interviewees had doubts about the definition and scope of 'virtual worlds'. For example, they did not have exact information on the communication ways of virtual worlds or 3D modelling tools. Moreover, they were not aware of applications of virtual worlds which are used for design education. Therefore, throughout the interviews, interviewees were informed about these important points. Although interviewees do not have direct interest or experience to the main topic, due to their education and working background, they have qualities to express their opinions about the use of virtual worlds in design process in industrial design education and also their opinions and suggestions will be valuable. They have enough qualities to express opinion about the use of virtual worlds in design process in industrial design education. While deciding on interviewees, the important point was to have interests in these two areas.

In general, interviewees focused on the shortcomings of the industrial design education system and tried to find solutions in terms of virtual worlds.

As can be seen from the above section, interviewees gave positive suggestions about the presentation stage of the design process. 3D virtual environments can provide valuable advantages compared to 2D boards. There was a general opinion that the industrial design education system must be adaptable to the technological developments; because, one of the missions of industrial designers is related to new products improved via these developments. Therefore, industrial design students should be taught 3D modelling earlier.

CHAPTER 4

CONCLUSION

The aim of this thesis is to explore 3D virtual worlds and to discuss their potentials, possible advantages and limitations for future changes in industrial design education. For this reason, two phases of study were conducted. Firstly, two main related areas, virtual worlds and industrial design education, were reviewed in the literature; that comprises an important part of the thesis. In the first part of the literature review study, virtual worlds were investigated by focusing on the applications of virtual worlds in higher education. In the second part, industrial design education was explored by giving emphasis on its characteristic properties. In the last part of the literature review, researches about the use of virtual worlds in design education were examined in detail (Chapter 2).

Secondly, in order to complement the theoretical background based on the literature review study, interviews were conducted with professional industrial designers who specialize in multi-media design. The results of the interviews were analyzed by means of industrial design education and these findings can serve as background information or a starting point for a possible use of virtual worlds in industrial design education in the future (Chapter 3). Both literature review and interview~~s~~ became critical when drawing conclusions.

This final chapter revisits the research questions by focusing on the stages of design process in which virtual worlds can possibly be useful. The answers of the research questions are generated according to the literature review and interview studies. At the end of the chapter, the limitations of the study and implications for further research are presented.

4.1. Research Questions Revisited

The primary concern of this study was about the evaluation of virtual worlds as new learning environments for industrial design education. So as to make inferences, research questions will be reviewed.

The main research question of the thesis was as follows:
"How do virtual worlds contribute to industrial design education in terms of design process?"
Sub-questions were directed in order to answer this main research question; because, each of them creates a critical part of the main answer.

Virtual worlds can be explained with four main phrases: 3D simulated environment, multi-user, avatar representation and real-time interaction. Virtual worlds provide environments which are developed by integrating 3D models created and simulated with computer technologies. These environments are simultaneously shared with multi-users to enable users to interact with each other. Users are represented in this environment by avatars which are 3D characters in the form of human, hero or anything else created by the user (Chapter 1).

These computer-based environments offer many opportunities for different areas such as business, education and entertainment. Generally, virtual worlds are specialized for one area, but the most popular one, Second Life provides many alternatives for many areas. Furthermore, there are in-house virtual worlds which are developed by users considering their special demands and needs.

There are many ***educational virtual application examples*** as mentioned in the literature chapter. In general, virtual worlds provide distance, students-based learning environments for different educational organizations. For example, language learning and in-house training programs of companies are some of the areas which prefer to use virtual worlds for educational purpose.

For engineering education, virtual laboratories and interactive and simulated engineering aspects are developed in order to provide students environments to practice theoretical knowledge. Virtual worlds also give students the opportunity to experience their profession before they graduate.

Similarly, medical students benefit from virtual worlds on the purpose of gaining experience and making practice with virtual equipment and virtual patients in simulated medical centers. In fact, training programs including role-playing activities in virtual worlds enhance the quality of teaching and learning process of medical students and even professionals.

A similar application is seen in teacher training and education. Candidate teachers gain experience in simulated virtual classrooms with role-playing sessions. Virtual worlds contribute to students' pedagogical aspects in teaching contexts and time management skills for their future profession. Before actual experience, they have the opportunity to practice and self-development.

These three areas have a similar tendency to take advantages of virtual worlds. All of them prefer to develop simulated environments and/or equipment in order to support their educational systems. Theoretical knowledge converts to practical skills via virtual applications and students deal with interactive virtual systems or virtual people so as to gain experience.

On the contrary for design education, virtual worlds are used for the purpose of collaborative working environment. Collaborative modelling, synchronous communication and user-testing opportunities attract design students for a more effective design process for their design projects.

What is the state of art of virtual worlds' contributions to the design process in terms of professional life and education?

Companies mentioned in the literature review study about their experiences in virtual worlds -many of them are multicultural big companies- handle the design process generally in three stages; idea generation, design (refers to concept development) and test and market launch. Examples of the idea generation stage demonstrate that companies generally organize design competitions which bring together interested people in order to create new ideas, rather than benefit from virtual worlds for their own idea generation practices. Similarly, for design stage, companies give their customers an opportunity to create their own concepts in virtual worlds. Considering these two stages, companies prefer to use virtual worlds in order to increase their brand recognition by reaching more users rather than performing their own design practices virtually. On the other hand, applications for the test and market launch stage are developed to test new designs and receive feedback from customers. The main objectives of companies using virtual worlds are; (i) increasing brand recognition, (ii) obtaining inspirational ideas, and (iii) testing designs and receiving feedback from users. Briefly, virtual worlds mediate between companies and users.

Virtual worlds are used in different ways for design education. Considering the examples used in the literature, the main advantage of virtual worlds for design students and educators is to provide collaborative working environments especially for group projects conducted between different universities. In addition, for critiques and design testing sessions, virtual worlds offer a more accessible and comfortable platform for students. Besides these, virtual worlds provide more appropriate and realistic environments for design project presentations.

Due to the lack of research studies on industrial design education, this area is reviewed according to recommendations and predictions made by interviewees in order to evaluate which stages of design process are likely to be appropriate to benefit from virtual worlds. Results of the interviews demonstrate that virtual worlds can be supportive and beneficial to studio courses in terms of critiques and presentations and while testing visual attributes.

What is the current state of industrial design education and which of its features might be utilized in a virtual design education environment?

Industrial design education aims to teach students basic design principles and design methods, to develop their creative thinking abilities and to enhance their problem solving skills especially with the educational design projects conducted in the design studio courses. Studio-based teaching is the main approach of industrial design education, which combines practical and theoretical knowledge. Communication and collaboration are also significant elements for learning process of industrial design education.

The traditional studio-based design education approach is based on conversations between students and educators. The main objective of educators during these conversations is encouraging students to think deeply on their design solutions and foster their creativity. This traditional approach is one of the indispensable parts of industrial design education. During studio courses, students learn how to complete the stages of design process and eventually they bring out a design work and learn how to present it.

The findings of the literature review and interview studies show that industrial design education should follow technological developments constantly. However, it is critical that these developments should be integrated to traditional design education in the most appropriate way rather than changing it completely, so that they eliminate each other's deficiencies. Traditional design education has many positive contributions to students; these effects should be supported with these developments. If all the stages of the design process carry out in virtual environments, advantages of conventional design studios will begin to hinder. For example, "actual" presentation, freehand or technical hand drawing and 3D real model making are significant activities of industrial design education and professional life; it is difficult to have skills related with these activities improved with studio courses fully held in 3D virtual worlds. Therefore, technological developments should be used as complementary elements for traditional industrial

design education. Collaboration between technology and traditional education system may reveal more effective results.

What are the potential advantages and disadvantages of virtual worlds for industrial design education?

As mentioned in the previous questions, collaboration between traditional design education and virtual worlds in some stages of the design process may reveal effective results. Interviewees examined each stage of design process and especially focused on the presentation stage that the 3D environment can provide more effective atmosphere for design projects compared to 2D boards.

Virtual worlds may provide industrial design education to collaborate with other universities and professionals, and this brings many qualities such as awareness of cultural diversity and caring and valuing various opinions to students. Various disciplines and various views enable students to evaluate design solutions from different perspectives. In addition, learning to work with different disciplines improves students' social interaction abilities and advances their multidisciplinary knowledge and this allows them to be more prepared for professional life.

Furthermore, virtual worlds provide appropriate environments for "impossible" and futuristic project topics. For example, "Sustainable Habitat" which was conducted in 2008 by the Philips Ideation Quest to explore future sustainable living in Second Life, which is mentioned in previous sections, promotes users to build their ideas into the virtual world about sustainable living. In industrial design education, futuristic designs can be presented in more effective atmospheres compatible with project themes in virtual worlds.

On the contrary, some people believe that virtual worlds can damage interaction between students and educators due to digital communication ways in artificial environments. Some others add that the improvements of students' hand skills such

as hand drawing and model making, and presentation skills slow down because of the addiction to the virtual worlds.

If it comes to the main research question of the thesis:

How do virtual worlds contribute to industrial design education in terms of design process?

This question was also the main question of the interviews. Interviewees made interpretations about each stage of the design process considering the projects conducted in studio courses. Their first suggestions were about design research that virtual worlds can be used as a digital gallery for research results. This gallery can be updatable and students can examine these results during the each stage of the design projects. Briefly, virtual worlds are seen as a source of information generated and developed by students according to the interviewees.

The other stage of the design process mentioned by interviewees was concept development stage. Interviewees' first impression of concept development was negative due to advanced modelling and drawing programs. When considered in detail, it was concluded that virtual environments can be effective in the stage performed together with the users such as ERM session. In addition, design projects can be expressed in more effective environments interactively via virtual worlds and also virtual guests can be a part of these virtual design scenarios. Though face-to-face communication is effective in presenting ideas, virtual environments offer comfort to students.

The industrial design profession deals with products associated with humans; therefore, users should interact in reality for an effective testing process. For this reason, user testing in virtual environments does not give effective results in terms of the current condition of the developing technology; however, virtual worlds can be effective for testing visual attributes of designs. Additionally, it is possible to test interface designs and basic interactions between product and user effectively in virtual worlds.

Presentations and juries in industrial design education get positive interpretations from interviewees in terms of usage of virtual worlds. More realistic environments compatible with the design projects can be built in virtual worlds for more effective presentations. In addition, juries or exhibitions can be organized for longer periods via virtual worlds and more participants such as educators from different universities may have chance to view projects.

According to the research studies presented in the literature review and the results of the interview studies, virtual worlds can become a supportive element for industrial design education especially for concept development, user test and presentation stages. However, development of this collaboration with virtual worlds requires proficient knowledge, experience and also time.

4.3. Concluding Remarks

As a result of this thesis study, it can be concluded that collaboration between virtual worlds and traditional industrial design education can reveal beneficial results for students. The study focused on the design studio courses and virtual worlds were examined in this context. Industrial design education consists of various theoretical courses and the use of virtual worlds in some of them can reveal effective results. For example, structure and material of the designs can be analyzed in virtual worlds and a virtual gallery or a simulation platform can be developed for implementation of this theoretical knowledge.

It was seen that virtual worlds provide two types interaction. First is human-human interaction which includes interaction and communication between users via their avatars in virtual environment. The other is human-product interaction which refers interaction between avatars and virtual objects in virtual environments. These interactions form significant part of the design stages performed together with the users for industrial design projects. For user testing, human-product interactions

enable users to interact with design projects. In addition, for the stages performed together with the educators such as critiques and juries, human-human interaction simplifies the process.

On the other hand, virtual learning reduces physical interactions between students and design works; however, lack of interaction between students and models or prototypes of design works causes ineffectiveness in design studios. During the design studio courses, product features such as size, weight, form and material are analyzed by educators and students with physical interaction which helps in successful evaluation and decision making for better results. Since, experiencing whole the design learning in a virtual environment can cause misunderstandings for the physical characteristics of designed things.

Related literature indicates that virtual worlds can be beneficial and supportive for industrial design education in terms of virtual environments as learning environments. Virtual environments can be seen as a basis for emerging technologies which will increase reality of virtual worlds and also this process has already begun. For example, virtual environments can be seen more real by using different accessories such as Oculus Rift. In addition Augmented Reality technology can be combined with virtual environments so that users have an opportunity to interact with virtual designs by touching it in real world.

Technology and the Internet are developing at a great pace and becoming necessary parts of the human life. *Internet of Things (IoT)* which "refers to the networked interconnection of everyday objects, which are often equipped with ubiquitous intelligence" describes the future life in which every physical object in human daily life will be connected to the Internet and also each other (Xia et al., 2012, p.1101). In recent years, IoT has become most popular area for researchers and gained much attention from researchers and developers all around the world (Xia et al., 2012). This information is very significant for the industrial design education and profession; industrial designers will spend more time in designing smart products.

Students should be more integrated into technological developments in order to be aware of their professional life.

4.4. Limitations of the Study

The aim of this thesis is to evaluate the virtual worlds as a possible new learning environment for industrial design education by means of design process and to be able to identify the particular stages of the design process for which virtual worlds might be more effective. In order to achieve these aims, extensive literature search was completed and the opinions and suggestions of professionals were taken and analyzed.

In the literature review study, virtual worlds and industrial design education were searched and analyzed. This study was limited to the Turkish and English languages. Literature could not be reviewed with the other languages. In addition, keywords and years which were used for literature research were the other limiting factors for this thesis. As mentioned in previous sections, research studies about virtual worlds were generally conducted in USA between 2006 and 2009 due to the popularity of Second Life. There was very few research studies conducted in recent years. Design education applications in virtual worlds were searched and six different design education fields which had research studies about virtual worlds were found; however industrial design education was not one of them. At the beginning of the study it was predicted that similar research studies for industrial design education could be found. Other design education fields were examined in detail to constitute groundwork. Although the outcomes of the other research studies were satisfying, design disciplines are different from each other and therefore each should be examined in its own terms.

The decision making process of interviewees and the gathering of information from them is the other limitation of the thesis. There were many alternatives for

conducting interviews; however they were eliminated due to the lack of participants' knowledge about virtual worlds. If these interviews were conducted with students or educators, different results could have emerged. The results of the interviews are limited in terms of employees of Reo-Tek. They are industrial designers interested in multi-media design; nevertheless, they were not experts about virtual worlds and industrial design education; they only have sufficient knowledge to carry out the idea and make suggestions. The native language of the interviewees was Turkish, so that interviews were conducted in Turkish and then translated in English. The difficulty with translation is that it may not always be precise. Therefore, results of the interviews were limited to the author's English proficiency.

Although the outcomes of the literature review and interview studies were satisfying in terms of making inferences about using virtual worlds for industrial design education, a virtual world experience may produce more effective and reliable results. However, considering the examples which were mentioned in the literature review study, development of an application requires a considerable amount of time and effort and also more experienced people. The limitation of time for the thesis research meant that interviews with professionals would be more convenient.

4.5. Implications for Further Research

As stated before, it is important to provide collaboration between traditional design education and virtual platforms in order to make the design education more effective for students. Cooperative education can contribute to a student's learning process.

Interviews conducted were with professionals interested in multi-media design so results were limited to the participants' knowledge and perspectives. Therefore, if these interviews are conducted with industrial design students and educators who have enough knowledge about virtual worlds (the days of this theses written, there is no such student or educator with mentioned qualities at METU or at the other

industrial design departments in Turkey) results can be more comprehensive, accurate and applicable. All these three different participant groups' answers can be synthesized, analyzed or compared and results can contribute to practice in virtual worlds more.

In the literature review, there is not sufficient research study on the collaboration between virtual worlds and industrial design education. This directed this study to conduct interviews in order to get first impressions and suggestions after a deep literature search. Therefore, for further research, needs and deficiencies of the design stages of projects in studio courses need to be addressed. According to these needs, applications can be developed. Collaborative projects can possibly be conducted with other universities which have experience about applications in virtual worlds.

In addition other technologies such as Augmented Reality, and hardware components such as Oculus Rift and Google Glass can be integrated into this application for a more beneficial design process. The effectiveness of these developments should be analyzed as virtual worlds will unite with real world by means of these technologies in the future. Technological developments should be followed closely and integrated into the educational sphere in a most appropriate way.

To sum up, virtual worlds are new technological developments used in many areas, but there is lack of applications in industrial design education. Therefore, this thesis study tried to examine virtual worlds as new learning environments for industrial design education in terms of design process and also to determine the particular stages of the design process of which virtual worlds might be more beneficial. The findings of this study can serve as background information or a starting point for a possible use of virtual worlds in industrial design education in the future.

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APPENDIX A

GLOSSARY

Augmented Reality is an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device (as a smartphone camera) (Merriam-webster, 2015).

Avatar is a personalized graphical illustration that represents a computer user, or a character or alter ego that represents that user. An avatar can be represented either in three-dimensional form (for example, in games or virtual worlds) or in two-dimensional form as an icon in Internet forums (Techopedia, 2015).

Digital Technology is the branch of scientific or engineering knowledge that deals with the creation and practical use of digital or computerized devices, methods (Dictionary, 2015).

Distance learning is a type of education, typically college-level, where students work on their own at home or at the office and communicate with faculty and other students via e-mail, electronic forums, videoconferencing, chat rooms, bulletin boards, instant messaging and other forms of computer-based communication (Webopedia, 2015).

E-learning is the delivery of a learning, training or education program by electronic means. E-learning involves the use of a computer or electronic device (e.g. a mobile phone) in some way to provide training, educational or learning material (Derek Stockley, 2015).

Kinect is an add-on device for the Microsoft Xbox 360 gaming system that enables users to control games, movies and music with physical motion or voice commands

and without the need for a separate input controller like a joystick or keyboard (Webopedia, 2015).

Linden Dollar is the unit of currency for all monetary transactions in Second Life. Linden Dollars are a micro currency and can be traded for real world currencies (USD, EUR, GBP, JPY) on the official Lindex and on other third party exchanges (Second Life, 2013).

Multimedia is the combined use of several media, as sound and full-motion video in computer applications (Dictionary, 2015).

Oculus Rift is a set of virtual-reality goggles that will work with your computer or mobile device (Tom's guide, 2015).

Online education is defined as the creation and proliferation of the personal computer, the globalization of ideas and other human acts, and the use of technology in exchanging ideas and providing access to more people. Audio, video, computer, and networking technologies are often combined to create a multifaceted instructional delivery system (Bebawi, n.d.).

Primitive, or prim, is a single-part object (Second Life, 2015).

The Internet of Things (IoT) is a computing concept that describes a future where every day physical objects will be connected to the Internet and be able to identify themselves to other devices (Techopedia, 2015).

Virtual environment is a computer-generated, three-dimensional representation of a setting in which the user of the technology perceives themselves to be and within which interaction takes place (Dictionary, 2015).

Virtual Reality is an artificial world that consists of images and sounds created by a computer and that is affected by the actions of a person who is experiencing it (Merriam-webster, 2015).

Virtual world is a computer-based online community environment that is designed and shared by individuals so that they can interact in a custom-built, simulated world(Techopedia, 2015).

APPENDIX B

INTERVIEW GUIDE (ENGLISH VERSION)

The main aim of this interview is to get the interviewee's -who are the professional multimedia designers and/or instructors experienced and interested in these fields- opinions towards the possible use of virtual worlds in industrial design education.

"Virtual world is a persistent computer-simulated environment allowing large number of users, who are represented by avatars interacting in real-time with each other in a simulated environment" (Gonzalez, et al, 2013, p.331).

Main Question:

1- What do you think about availability of virtual worlds in design studio courses in industrial design education?

(Due to the fact that product-oriented design projects start with the second class studio courses, the basic design courses are off topic.)

Sub Questions as probes:

2- Can you explain the potential benefits and possible limitations that virtual worlds may provide for industrial design education?
3- When you think about design projects conducted in the studio courses, which stages of this process could be more useful in the use of virtual words? How?
4- In this context, what do you think about
    a. Avatar-based education
    b. Group works in virtual worlds.

APPENDIX C

INTERVIEW GUIDE (ORIGINAL _TURKISH VERSION)

Bu görüşmenin amacı, katılımcıların (bu alanda tecrübeli veya bu alana ilgisi olan profesyonel multimedia tasarımcılarının) sanal dünyaların endüstri ürünleri tasarımı eğitiminde olası kullanımı hakkındaki görüşlerini almaktır.

3B sanal dünyalar, kullanıcının avatar denilen 3B sanal karakter ile temsil edildiği etkileşimli sanal ortamlardır. Kullanıcılar sohbet araçları sayesinde birbirleriyle sesli veya yazılı iletişime geçebilirler; klavye ve fare ile avatarlarını kontrol ederek bu ortamda hareket edebilir, yürüyebilir, koşabilir ve hatta uçabilirler. Ayrıca, kullanıcılar avatarlarını kişiselleştirebilirler ve modelleme araçları sayesinde kendi ortamlarını yaratabilirler.

Ana soru:

1- Sanal dünyaların, Endüstri Ürünleri Tasarımı Eğitimi'ndeki tasarım stüdyosu derslerinde kullanılabilirliği hakkında ne düşünüyorsunuz?
(Ürün odaklı tasarım projeleri 2. sınıf stüdyo dersleri ile başladığı için temel tasarım dersi konu dışı bırakılmıştır)

İrdeleme soruları:

2- Sizce Endüstri Ürünleri Tasarımı Eğitimi'nde sanal dünyaların kullanımı ne gibi faydalar ve kısıtlamalar sunabilir?

3- Stüdyo derslerinde yürütülen tasarım projesi süreçlerini düşündüğümüzde, bu sürecin hangi aşamalarında sanal dünyaların kullanımı daha yararlı olabilir? Ne şekilde?

4- a. Avatar odaklı eğitim
   b. Sanal dünyada grup çalışmaları

Tasarım stüdyosundaki proje sürecinde sanal dünyalardan yararlanıldığını farzedersek, yukarıdaki konuları bu kapsamda değerlendirir misiniz?

APPENDIX D

CONSENT FORM (ENGLISH VERSION)

Dear Participant,

This interview will be used for Itır Güngör Boncukçu's master thesis in Middle East Technical University, Department of Industrial Design. The topic of the study is about *"the usability of 3D virtual worlds as new learning environments in Industrial Design Education".* The aims of the interviews are to get information and to obtain first impressions of the participants about the usability of virtual worlds in design process of studio courses for industrial design education. This interview will approximately take 60 minutes. In order to avoid data loss, -if you give permission- conversations will be recorded, but they will be listened only by the researcher. Your personal information will be kept confidential and your views will be used only within the scope of this thesis.

Thank you very much for your participation.

Researcher,
Itır Güngör Boncukçu
itirgungor@hotmail.com

Signature
....……..

APPENDIX E

CONSENT FORM (TURKISH VERSION)

Değerli Katılımcı,

Bu çalışma Orta Doğu Teknik Üniversitesi, Endüstri Ürünleri Tasarımı Bölümü yüksek lisans öğrencisi Itır Güngör Boncukçu'nun yüksek lisans tezi için bir araştırma niteliğindedir. Çalışmanın konusu "*Yeni Öğrenme Ortamları Olarak 3 Boyutlu Sanal Dünyaların Endüstri Ürünleri Tasarımı Eğitiminde Kullanılabilirliği"* hakkındadır. Görüşme genel olarak sanal dünyaların Endüstri Ürünleri Tasarım Eğitimindeki stüdyo derslerinde deneyimlenen tasarım süreçlerinde kullanılabilirliği hakkında bilgi edinmeyi ve katılımcıların bu konudaki öngörülerini almayı amaçlamaktadır. Yapılacak olan görüşmenin tahmini 60 dakika sürmesi beklenmektedir. Veri kaybı olmaması için -izniniz olursa- görüşmeler kayıt altına alınacaktır ama sadece araştırmacı tarafından dinlenecektir. Kimliğiniz ve görüşme sırasında vereceğiniz kişisel bilgileriniz saklı tutulacak, verilen bilgiler sadece bu tez kapsamında kullanılacaktır.

Bu çalışmaya katıldığınız için teşekkür ederim.

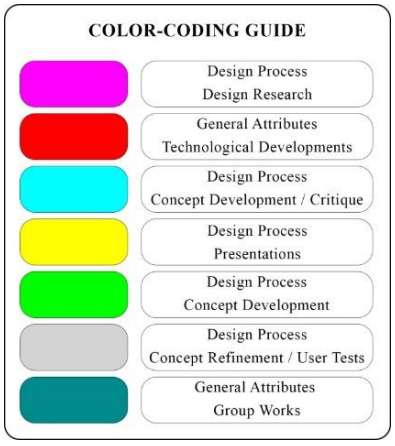
Araştırmayı yürüten kişi,
Itır Güngör Boncukçu
itirgungor@hotmail.com

Katılımcı İmza
.....

APPENDIX F

SAMPLE DATA ANALYSIS

(from the interview with Participant C)



Mesela öğrencilerin kendi alanları olabilir Pinterest gibi. Kendine ilham alabileceği alanlar, 3 boyutlu ürünlerin olduğu bir alan gibi.

Mesela stüdyo dersinde bize bir problem veriliyor ve bizim ilk yaptığımız şey başta oturuyoruz ve mesela bir ay boyunca bir şeyler araştırıyoruz. ... Bireysel projelerde, bulduklarımızı kendi alanımıza koyabiliriz daha sonra ilham almak için. Daha sonra dönüp oraları tekrar inceleyebiliriz. Hatta öğrenciler de birbirlerinin alanına istediği zaman gidip gezebilmeli. Orda olan şeyler, gezen herkese başka bir şey anlam ifade edecektir. O nedenle faydalı olabilir.

...

Yapılan araştırmalar sunumlar yapıldıktan sonra kayboluyor, unutuluyor. Sanal ortam bu bilgileri canlı tutmaya yardımcı olabilir. Sanal ortamda dokümente edilebilir araştırma sonuçları. Mesela 6 ay veya 1 yıl sonra o projeyi geliştireceğiniz veya onla ilgili bir şeye ulaşmak istediğiniz zaman bu alandan ulaşabiliriz. Kendi sürecini izleme ve takip etme aşamasında da yararlı olabilir.

...

3d modelleme programları hem ön plana çıkmalı hem de daha erken dönemde öğretilmeye başlanmalı. ... Form ortaya çıkarmakta modelleme programları cok yardımcı oluyor. Ordan başka bir noktaya ilerleyebiliyoruz.

...

Tasarımı 2 boyutlu incelemektense 3 boyutlu inceleyebilme sanal ortamda. Sen zaten 3 boyutlu modeli hazırlıyorsun neden onu direkt kullanmayasın. Ürünün tabiki güzel ve kötü açıları vardır bu tercih meselesi ama tasarımdan bahsediyoruz ürün bütündür o nedenle 2 boyutlu görselleri yerine 3 boyutlu modellerinin incelenebiliyor olması daha yararlı olur. Ürünün incelenmesi açısında yararlı.

Kritik aşamalarında çok başarılı olabilir 3 boyutlu incelenebiliyor olması. Belki sunumda en güzel açılarıyla süsleyip sunmak daha iyi olabilir ama geliştirme sürecinde tamamen inceleyebilmek mantıklı.

...

Ofis sandalyesi yaptığımızda, sandayenin yanında ofisi de modelliyoruz. ... Ergonomi açısından fiziksel modelle karşılaştırılamaz ama scale ve form açısından faydalı olabilir. Sandalyeyi sunarken bir de paftalara kullanıcılar ekliyoruz. Onlar yerine daha gerçek avatarlar kullanılabilir.

...

aklına gecenin bir yarısı bir şey gediğinde hemen ulaşabileceğin bir sanal ortamda onu yapabilir veya ekleyebilir olmalısın.

...

Avatarları farklı modellere getirebilirsin ellerini oynatabiliyorsun oturtabiliyorsun, böyle bir ortamda tam olmasa da ürünle ilişkisini görebilir inceleyebilirsin.

Var olan modelleri bir sanal ortamda birleştirip incelenebiliyor olması , bir sürü insandan kritik alabileceğin bir ortama dönüşebilir. ... Kullanıcı denetme kısmında ürünü denetmek zor olabilir. 3 boyutlu ortamda user testing ne kadar effective olabileceğinden emin değilim. Ama seneryo anlatımında güzel olabilir. Step step gösterebileğin bir ortam yaratılabilir. Oyun haline getirmek gibi. ... Anında tepki alabileceğin bir hale dönüştürmek. Maket de bir alternatif bunun için ama bu süreçte yetersiz kalabilir sanal ortamlara göre.

...

Sunumda, tasarlarken bir sürü insandan kritik almana ve fikir geliştirmede hemen modellemeyle fikrini yansıtmaya yarar sağlar.

…

Ürün ve ürünün ortamını da hazırlayıp zaman ve emek harcıyoruz. Bu hazır modeller sanal ortamda birleştirebilmeli.

...

Sanal ortamın içinde dolaşmak şöyle güzel olabilir. Buzdolabı yaptık diyelim, avatar gidip orda kapağı açıp içini inceleyebilecek. Arayüz denetmek açısından user test yapma aşamasında sanal dünya kullanımı çok mantıklı.