AN EVALUATION OF VIRTUAL DESIGN STUDIO: A COURSE BETWEEN MIDDLE EAST TECHNICAL UNIVERSITY AND DELFT UNIVERSITY OF TECHNOLOGY

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Approval of the Graduate School of Natural and Applied Sciences

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ABSTRACT

AN EVALUATION OF VIRTUAL DESIGN STUDIO:
A COURSE BETWEEN MIDDLE EAST TECHNICAL UNIVERSITY
AND DELFT UNIVERSITY OF TECHNOLOGY

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This thesis analyzes the application of computer aided design tools and online collaboration environments in design education. The focus of this study is the utilization of online collaboration environments in design education in order to conduct an efficient and effective virtual design studio course. The requirements of design education and online collaboration environments will be identified and the coinciding and conflicting points will be discussed. The elements of design education; the concept generation phase of design process, peer learning in design studio and design juries will be evaluated with regard to the literature survey and the findings of the case study.

The findings of the case study indicated that in concept generation phase of design process the number of concepts created was not less than a similar project in a traditional design studio and publishing students' works to public via a shared online environment motivated students in a positive way to participate in studio activities in a positive way.

Keywords: Collaboration, virtual design studio, online design education,

ÖZ

BİR SANAL TASARIM STÜDYOSU DEĞERLENDİRMESİ:
ORTA DOĞU TEKNİK ÜNİVERSİTESİ VE
DELFT TEKNOLOJİ ÜNİVERSİTESİ ARASINDA BİR DERS

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Bu çalışma, bilgisayar destekli tasarım araçlarının ve çevrimiçi ortak çalışma çevrelerinin tasarım stüdyosu eğitiminde uygulanmalarını incelemektedir. Bu çalışmanın odak noktası verimli ve etkili bir sanal tasarım stüdyosu yürütmek için çevrimiçi ortak çalışma çevrelerinin tasarım eğitiminde kullanılmalarıdır. Tasarım eğitiminin ve çevrimiçi ortak çalışma çevrelerinin gerekleri belirlenecek, çakışan ve çatışan noktalar tartışılacaktır. Tasarım eğitiminin öğeleri; tasarım sürecinin kavram geliştirme aşaması, tasarım stüdyosunda sınıf arkadaşlarından öğrenme ve tasarım jürisi, literatür taramasına ve vaka çalışması sonuçlarına referanlar verilerek değerlendirilecektir.

Vaka çalışması sonuçları göstermiştir ki kavram geliştirme aşamasında geliştirilen kavramların sayısı, geleneksel tasarım stüdyosunda benzer bir projede geliştirilenden az değildir ve öğrencilerin işlerinin paylaşıma açılmış çevrimiçi bir çevrede yayımlanması stüdyo aktivitelerine katılım konusunda öğrencileri olumlu yönde teşvik etmiştir.

Anahtar Kelimeler: Ortak çalışma, sanal tasarım stüdyosu, çevrimiçi tasarım eğitimi

To my parents

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CHAPTER 1

INTRODUCTION

1.1 Problem Definition

With the decrease in the costs of silicon chip, in the late 80's and early 90's, computer technologies using these chips have become widely available for consumer market; and as a consequence, hardware tools and software packages have become affordable for both educational and professional institutions. Rapid evolution of hardware and software tools have been enabled those to spread in almost every branch of industry and education, including product design.

Utilization of computer technologies in design lead to the emergence of a new area named *Computer Aided Design (CAD)*. During early 90's, network technologies were also improved as well as CAD tools. *World Wide Web (www)* spread all over the world and *broadband-connection* became affordable for end-users. With the motivations of these improvements *distant education* and *online collaboration via www* concepts were introduced. Although at the beginning, distant education via www was utilized in lecture-based theoretical courses, after some time design studio courses which are semi theoretical, semi practical started to utilize distant education and collaboration technologies via www. These technologies brought out the opportunity to attend to a design studio course without time and place limits, at a much lower cost. Economical advantages and disappearance of geographical distances formed the main motivations behind establishing a Virtual Design Studio. Following the technological improvements and the implied advantages; by late 90's, a number of educational and professional institutions established virtual design studios. Today, with the help of video conference, online collaboration, e-mail, instant messaging, and video-phone technologies virtual design studios have become prevalent.

Design courses carried out in virtual environments have many advantages but it is needless to say that they are not perfect. It must be stated as well that there are many problematic areas in virtual design studios concerning the **design methodology**, **design education** and **technologies utilized**.

1.2 The Scope of the Study

This study aims to evaluate the utilization of online collaboration environments in design education in order to conduct an efficient and effective virtual design studio course. An online design studio course (ID 319-Virtual Design Studio) carried out in Middle East Technical University, Department of Industrial Design will be evaluated in detail as a case to reach conclusions on the subject.

To evaluate the design course, the study will use several methods such as literature survey on related contexts, questionnaires, interviews and personal observations.

1.3 Structure of the Thesis

The study will discuss online design-studio courses; named Virtual Design Studios, in three main parts (Figure 1.1);

- **What motivated the emergence of Virtual Design Studio (VDS)?** The background, the motivations and driving forces behind the phenomenon in relation to design education will be discussed.

- **What is VDS and what are the current debates on the subject?** VDS will be defined and current debates on the subject will be presented with reference to the literature review.

- **The evaluation of VDS course, the conflicts and concurrences with the literature survey.** Finally, a virtual design studio conducted at METU Department of Industrial Design will be evaluated giving special emphasis on its conflicts and concurrencies with the findings of literature survey.

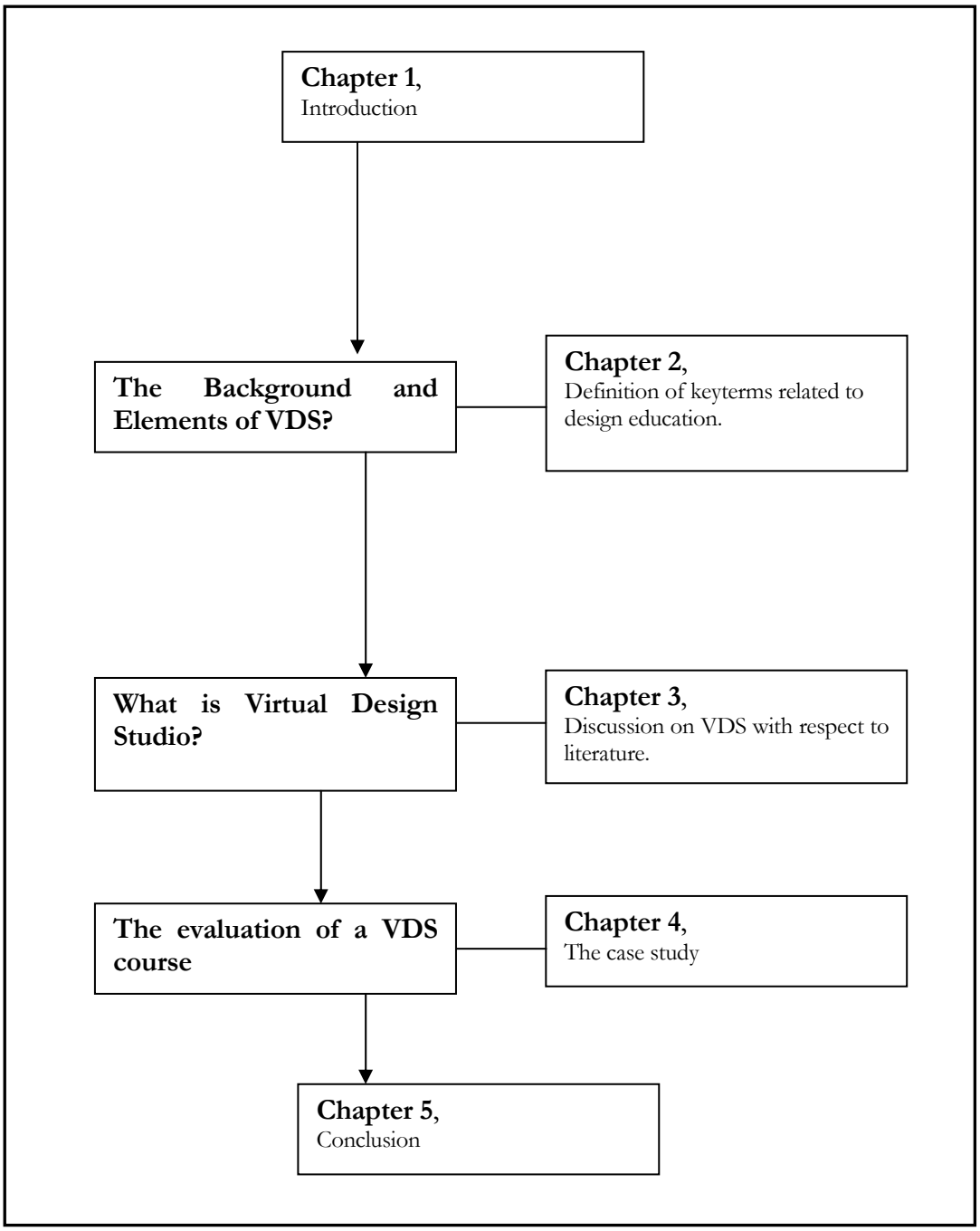

Figure 1.1 Structure of the thesis.

As shown in figure 1.1 all chapters are linked to the previous and next ones following a linear structure.

In chapter 2, the key concepts will be defined and their links to virtual design studio (VDS) will be revealed. The sub-concepts of VDS; traditional design studio, design education, design communication, design methods and design process will be discussed. The three main elements of VDS; information technologies, design education and design profession will also be covered in this chapter.

In the third chapter, current debates on VDS will be discussed based on the literature survey. This chapter will cover; the motivations behind VDS, in comparison with traditional design studio and the information technologies utilized.

In the fourth chapter, a VDS course carried out at Middle East Technical University, Department of Industrial Design in 2003- 2004 fall semester will be presented and discussed as a case study. The set-up, process and schedule of the course, problems observed during the course and further recommendations for the course, are going to be discussed.

In the last chapter, the conclusions of the study will be presented.

CHAPTER 2

INDUSTRIAL DESIGN

2.1 Definition of Industrial Design

Industrial design emerged as a discipline and a profession as the result of the industrial revolution at the beginning of the twentieth century. In early 1890s, companies producing the same products with the same production techniques and the same machinery in mass quantities realized the fact that they need industrial designers in order to differentiate their products in the market. Pioneers of industrial designers started the profession with *product styling*, which can be described as designing of outer shell of an available product in the market in order to differentiate it from its competitors. However, today an industrial designer is expected to take essential decisions concerning a range of aspects of a product including aesthetics, production technique, material, usability and ergonomics.

International council of Societies of Industrial Design (ICSID) defined industrial design as;

> *"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."*

Design is not limited to physical objects that occupy a space; processes, services and systems are also included in the field of design. The adjective "industrial" relates these products, processes, services and systems to industry and industrial ways of production. Architects, landscape architects, interior, industrial and graphic designers and engineers might be gathered under the term "designer".

Designers convert conceptual ideas to services or physical products as a solution of a problem. According to Reeder (2002), an industrial designer's main activity by developing alternative solutions to a design problem is to design innovative, new products that are

functional and aesthetic for the target market. Designers generate concepts as solutions to the given design problem or they extract problems from the needs of the society, then develop product ideas and finally turn the idea into a physical product. According to Schön (1983), designers gather things together in order to form new things, considering many variables and constraints, which were given or discovered while designing. While designing a product, an industrial designer has to deal with a huge number of variables such as the user group, the material, production technique, costs, aesthetics, functionality, user satisfaction and obsolescence.

In accordance with Reeder, Baker (1993) stated that designers are solution oriented; they solve a specific problem by creating alternative solutions to it. Designers' job is to find design problems as well as creating alternative solutions to it. Actually this is a two way process, at most of the time, the problem itself might be modified according to the alternative solutions proposed to it. For many design researchers; "designing" have been perceived as not only problem solving but also as a constant search for problems. According to Schön (1983), designing is a "conversation with the materials of the situation". Whenever a designer creates a solution he/she uses a meticulous medium and language in order to propose outcomes, which have not been projected before.

2.2 Design Methods

According to Gedenryd (1988), a design method is a sum of predefined steps that illustrate a certain procedure, the tasks to perform and the order of tasks to be carried out. A design method usually covers the whole design process in order to guide the designer or design group. The study of design methods was a hot topic in 1960s and 1970s. Writers on design methods in late 60s early 70s based design methods on logic, rationality, abstraction and exact principles. In 70s design methodologists tried to systematize design and tried to form a method that collects information, sets objectives and proposes a design solution following the principles of logic and mathematics. (cf. Alexander 1964, Asimow 1962, Jones 1970, Simon 1981)

Early theories and methods of design have been influenced by theories of technical systems and scientific method. In these theories, designing was defined as a rational problem solving process and design methodologists have tried to propose a method that might be used to solve any design problem. Problems of science which are solved by scientific method do not fit into same context with the problems of design. Science is mainly a "*descriptive activity whereas design is basically prescriptive"* and according to Lawson (1980) this is the most crucial difference between design and science.

> *"Designers do not aim to deal with questions of what is, how and why, but rather with what might be, could be and should be. While scientists may help us to understand the present and predict the future, designers may be seen to prescribe and to create the future."* (Lawson, 1980, pp 90)

Another set of theories were declared by Schön in 1983 describing designing as the experience of the designer. The experience of the designer clarifies when to follow which procedure or use which piece of knowledge under specific circumstances. Considering different circumstances, design method might change during the design process while new information is added to the process which is "*reflection in action"*.

Debates followed by a number of assertions through different perspectives and the negotiation was again a statement of Lawson (1980), there is no ultimate design method which automatically guides a designer to a good design solution. Each design problem has unique characteristics to be considered and covering these characteristics in a single, step-by-step method is not possible.

Although, methods of design is a debatable subject, it is evident that design has vague phases which are interrelated, and the course followed through these phases is called design process.

2.3 Design Process

After an extensive research on design methods in 1960s and 1970s, many models describing the design process were proposed. The process has been generally described with arrows and boxes. Most theories coincide in dividing the process in phases or steps. These steps are

mainly expansions of analysis of design problem and synthesis of a solution. Below, an early example of design process model, the RIBA plan of work map is given (Figure 2.1).

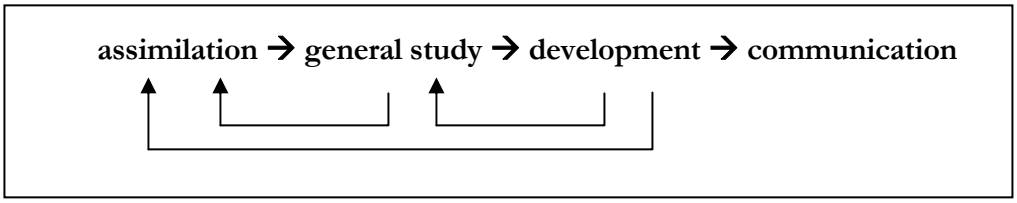

Figure 2.1, The RIBA plan of work map of the design process. (Lawson, 1980)

Regarding to the RIBA plan of work map, in *assimilation*, general information about the design problem is gathered and ordered. Then, in *general study* the problem is investigated and possible solutions to the problem are formed. In *development*, one or more solutions devised in general study phase are refined and developed. Finally, in *communication*, solution(s) of the design problem is shared with the design team through technical drawings, renderings, models and mock-ups. The depicted one way linear development of the plan where we see that the steps are clearly separated from each other, actually involves back and forth movements in design process. The information gathered or the solution devised in one step might change or modify the step before or after it. As it is seen in the RIBA plan of work map, the order of the steps might change according to the nature of the problem.

Another model which divides the process into four basic phases as: *Research / Definition, Concept Development, Concept Refinement* and *Finalization* have been proposed by Reeder (2002). In this model, the designer defines a problem or studies on a given problem during research and definition phase. He/she defines the factors that will influence the design solution, works on the user-group, target market and the environment that the product will be used. In the next phase, designer develops alternative concepts that might be a solution to the design problem. In this phase creativity and innovation are essential. In Concept Refinement, one or more concepts are selected for refinement that might end up with a solution to the design problem. Their details are defined and actual product gains a physical

body. In the last phase, the products are designed with all the aspects and they are prepared for the communication with other parties in terms of technical drawings, renderings and prototypes. In the following sections of this chapter phases of design process will be discussed in detail.

2.3.1 Definition of Problem and Research

In order to propose a solution, the designer has to define the design problem very clearly in research / definition phase. Any known attribute of the desired product narrows the solution set and helps the designer to reach a solution. Defining the user, the function, the cost, and the environment of the product, provides designer with the necessary information to narrow the solution set. However, defining these attributes so clearly and narrowly might limit the designer's creativity. Designer himself/herself must optimize the level of definition or detail in the problem. Another point is the hierarchy of these attributes in the design process. In some of the problems the cost is most important whereas in some other the user group or a different attribute gains importance. Reeder states that prioritization of basic attributes of the product would enable the designer to develop a product with the strongest qualities. (Reeder, 2002)

In this phase the designer carries an extensive research on the given problem or on a specific topic to devise a design problem. He/she observes the needs, the requirements of the user group and the target market. Examining the solutions of similar problems also helps in better understanding the given or devised problem. After creating a library of information about the problem, the designer is equipped with the necessary information to create innovative concepts for the problem.

2.3.2 Concept Development

In concept development, the designer identifies one or more ideas that have the potential to develop innovative products. He/she tests the concepts by working on them to reach a satisfying design solution. Proposing alternative products for a concept and considering all the aspects of those products in terms of user-group, target market and environment is

essential. Designer examines the concept by comparing the requirements of the problem with the concept. At this point, the first phase, research / definition of problem, is very important. If the requirements of the design problem are not understood and defined clearly, the proposed concepts will be useless for the problem. As mentioned in section 2.3 of this chapter, the phases of the design process are not fully separated from each other; the problem set in the first phase might change according to the concepts developed in the second phase. There has to be a feedback loop between the first two phases. Through operational diagrams and actual manipulation of feedbacks, defining a suitable problem and identifying the requirements of the problem leads designer to create to-the-point solutions, enabling him/her to focus his/her creativity and innovative thinking on the problem. According to Reeder, innovation, a critical and essential part of design process, can be reached through a design process that promotes the development of alternative solutions and selection, refinement and finalization of the most suitable concept. (Reeder, 2002)

2.3.3 Concept Refinement

In concept refinement, the designer starts to develop a product with the details required for its use and production. The conceptual product developed in phase two, is rationalized and interpolated according to the production, usage and budget constraints. The structure of the product is also redesigned for the possible physical loads on the product. If the concept cannot be refined in terms of these constraints, the designer has to return to the previous phase, modify the concept and refine the concept again. In this phase, collaboration with other disciplines is more important; cost of the product, manufacturing techniques, materials, ergonomics and structure of the product are all essential aspects that should be consulted to the experts in associated fields.

2.3.4 Finalization

In the last phase, the product must be ready to communicate with the production facilities, the marketing department or the design jury. That communication might be through technical drawings, color renderings, computer generated photorealistic images, CAD files and physical or virtual prototypes. To create those media for communication, the designer

produces the final solution physically in a workshop or virtually in CAD software, which clarifies every minute detail of the product. With those media, final tests can be applied to the product. These tests might cover 3D and tactile perception of the product, usability and mechanical properties. Carrying out the tests in physical environment by producing the actual product is time consuming and expensive. With the enormous rise in processing power of computers and the decreases in the cost of computer chips, "testing products through virtual prototypes" have become widely available since the 1990s.

After the product successfully passes through all above mentioned tests, the design process seems to be completed. However, design is an ever continuing process, as there is no ultimate solution for a design problem. The quest for better products will continue and new product solutions for the same problems will always be proposed.

It is evident that designing is a dynamic process in which the goal is hard to define (Reffat, Gero, 1999). Designer takes or creates a problem and looks for solutions; although the start and end of the design process are clear, the steps in between are not. Even the formulation of the problem might change the design process and lead to a different solution. While designing, the designer creates alternative solutions for the problem, he/she adds or removes objects to/from design solution. The interaction of newly added or removed objects with the design solution is totally unpredictable unless the designer proceeds. The design problem might be solved in moments or might be stuck with the new elements, foreseeing that without actually designing is not possible. (Reffat, Gero, 1999)

According to Lawson (1980) design problems often define a very wide area and the number of possible solutions is infinite. Unlike the problems of natural sciences, the goal of design is not clearly set and it changes according to the environment it is situated. A designer might ask how, what, and why while setting up the problem and gathering necessary information but they are not the questions that a designer would ask to solve a design problem. A designer seeks the answers of what and how might be, could be and should be for a design solution (Lawson, 1980). As a result, the ultimate design solution is vague and very difficult to achieve.

"The designer's job is never really done." Brian Lawson, 1980, pp 88

Finding the best solution among the countless elements of the solution set is generally not possible; therefore the design process never ends. The designer can always improve on his/her design or create alternatives; however there are practical limitations like time, money and information. Whether the designer is satisfied with the solution or not, he/she must somehow create a solution to the problem in a given time and budget. When the designer lacks one of the essential sources like time, money and information, the design process may end in an unexpected way.

Today, the information coming from other disciplines is a crucial input to the design process the design of some specific products and complex systems require the collaboration of engineers, sociologists, psychologists; the interaction of these professionals with the designer must be added to the design process. Failures in this flow of information also block the design process and cause unsatisfactory results.

2.4 Integration of Online Instruction to Design Education

2.4.1 Design Education

Apart from classical lecture-based courses, design studio courses require practical skills as well as theoretical knowledge. Design problems are given to the student, expecting him/her to create a physical object. In a design studio, the line between theoretical knowledge and practical skills is not clear. According to Maher and Simoff, (Maher and Simoff, 2000) design studio instruction is based on constructivist principles, in which the internal representation of knowledge is created by the student interacting with the material to be learned. In a traditional design studio students learn the design process by designing objects under the supervision of instructor(s); this instructional strategy have been widely accepted and applied since 1950s.

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. Learning how to design is 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.

2.4.1.1 Traditional Design Studio

Design studio has been the basic course of design education since mid 1940s. Students are gathered in a physical environment that allows them to create and present their designs. The communication and collaboration in this environment is the main difference that separates this environment from an ordinary lecture hall. According to Schön (1983), as there is no science of design, design related disciplines; architecture, industrial or graphic design involves studio traditions. In a design studio students are expected to solve manageable design problems that are derived from actual problems. Unlike a lecture based course there are traditional components of a design studio like;, desk reviews, wall reviews and design juries.

Apart from all those above, design studio has its own language; namely *language of designing*. This is a language that consists of both verbal and visual elements. In a desk review when an instructor says *"…you might think of emphasizing these functions, this part might be used for those functions, you can think of the interaction of the hand with the handle in another way…"* He/she not only says the words, but he/she may also draw the smooth edges and modify the handle in parallel with his/her speech. Presenting in visual form is much easier than using verbal language. As the products in a design studio are mainly three dimensional and physical objects, the communication in a design studio is based on two dimensional drawings or 3 dimensional models. Design reviews with the instructors and peers occur at student's desk or on the walls of the studio. According to Kvan (2001), students are engaged to studio projects not only to find solutions to design problems but also to learn the process under the watchful eye of the instructor. The instructor tries to guide students without interrupting their creativity and criticizing and evaluating projects are the main tools an instructor employs to trigger creativity in guidance.

2.4.1.2 Reviews and project evaluation

Reviews and evaluation are the most crucial elements of studio teaching. From problem definition phase to final presentation, students display their works to get useful criticism on their projects. Criticism is usually held as a review of the students' work on the project. Reviews can be held as private conversations or be public on a wall allowing everybody to see each other's work. According to Kvan (2001), the material brought to desk reviews is usually rough, multiple in intent and unresolved in many aspects. He also states that the participation of students to desk reviews was in two ways; by bringing their own work and observing other's reviews. That's why the physical environment in a design studio must allow the students to display their work and to observe others' work, due to the fact that observing other's review helps the student in understanding the problem better.

According to the author's experiences as a studio tutor, the quality of materials brought to desk reviews varies according to the phase of the design process. In problem definition and concept generation stages students tend to bring rough sketches, in which they express their ideas even with thumbnail sketches. In concept refinement, they usually bring scaled technical drawings and /or sections for review, while at this phase mechanisms, material and production techniques are also expected to be discussed.

Schön (1987) divided the design review into several parts. According to him, in the first phase the student presents his/her sketches and describes the problems he/she has encountered; in the second phase the tutor reconstructs the problems in his/her own terms and builds up possible design solutions. In the third phase *"there follows a brief interval of reflection on the demonstration so far"* (Schön, 1987 p 469). This is actually a feedback phase where the student sets his/her counter arguments as a reflection to the tutor and this feedback loop might be counted as the most important element of a design studio instruction. Following the feedback phase, the next stage is the one tutor again rephrases his/her arguments and defines the course of actions that the student should follow. This communication lasts about twenty minutes for each student.

Observing others' reviews helps students in the design problems by offering them different perspectives to approach through. Usually, all the students in the studio work on the same design problem, but the part of the problem they grasp might vary. Observing peers while taking specific actions to overcome design problems usually inspires other students and helps to create a library of actions to take. Nevertheless, Reeder (2002) states that, criticizing the student individually has some advantages, first it prevents the student from being embarrassed by peers' criticism, and second being criticized individually might drive competition among students.

Despite the fact that evaluation is present at any phase of the design process, evaluation is best conducted in terms of the design objectives and at the conclusion of the concept development and refinement phases (Reeder, 2002). Reeder (2002) states that prior to the concept development phase design ideas are not mature enough to be judged, and criticizing at that phase might result in inhibition of creativity of the students. He added that if ideas are criticized at the conceptual stages, students will concentrate more on the judging criteria and less on the generation of design ideas. Constraining student with cost, production techniques, material and usage, might result in the reapplication of existing solutions.

The conventional methods of teaching design have been well structured since 1940s, nevertheless, with the beginning of the use of information technologies in it since 1990s, the conventional methods have started to be integrated with the online materials which will be discussed in the next section.

2.4.2 Online Design Education

Distant education is still a hot debate in instruction. By the late 1980s, synchronous education technologies began to be applied as they became more affordable. Lecture-based courses became easy to conduct with synchronous education technologies. However, integration of online materials to courses like design which require practical skills as well as theoretical knowledge took more time. The differences between design and lecture based courses will be presented in the next section.

2.4.2.1 Difference of Industrial Design from Lecture-Based Courses

As mentioned in section 2.4.1 of this chapter, Industrial design courses have evolved their own language; "*the language of design"* therefore the tools and techniques that are useful for classical lecture-based courses might not work for industrial design. According to Tauke *et al.* (2003) industrial design involves "*highly visual products, hands-on activities and frequent interactions between faculty and students"*. The simulation of design activities in synchronous communication technologies demands high technology, high degree of computer skills and sophisticated hardware and software tools. For those reasons, designers employ sophisticated software packages that support the design process from concept generation to presentation and manufacturing on various operating systems using high-end hardware configurations. Utilizing all of these tools in a synchronous manner from distant locations imposes designers to be computer experts.

2.4.2.2 Use of Digital Media in Industrial Design

By the late 1990s the processing power of an ordinary personal computer became sufficient to run Computer Aided Design (CAD) and Computer Aided Industrial Design (CAID) packages, and as a result computers penetrated into almost every design office and school. Today digital media are used in almost every phase of the design process. Internet and online sources are used extensively in the research phase. The use of computer tools according to design phases is given in table 2.1. Bitmap and vector graphic editing packages, stylus and digitizers are utilized in concept generation phase. In concept refinement; 3D modeling, rendering and solid modeling packages are employed. Finally, in communication and presentation stages 3D rendering and rapid prototyping technologies are used. Although computer technologies seem to be well integrated in design process, many students and professionals use traditional and digital media together. Generating quick freehand sketches and then using them as backgrounds for creating computer-generated photorealistic images is very common in the field. Converting traditional media to digital media or vice versa requires a number of tools and technologies such as, imaging devices (scanners, cameras), printing devices (printers, plotters, rapid prototype machines) and

digitizers. Consequently, each student and professional has to comprehend an extensive literature on the tools and technologies utilized, in order to be able to create, edit and present digital media; and that requires a considerable effort.

Table 2.1, Use of computer tools at different design stages

	Research	Concept Generation	Concept Refinement	Presentation & Evaluation
WWW	X			
Online Databases	X			
Image Capture	X	X		
Image editing		X		X
3D Modeling		X	X	
3D Rendering			X	X
Solid Modeling			X	X
Rapid Prototyping				X

2.4.2.3 Reliance on Digital Media

Today, online databases and World Wide Web have begun to take the place of libraries. Tauke *et al.* (2003) stated that students would rely on online resources more and more to provide expert information. The reliance on digital media can be explained with the snowball effect. Every time the student uses a computer tool to do something, he/she needs more tools to develop or modify his/her work, and when a computer tool is introduced to students, they spend too much time to learn it. In digital media there is always a tool to employ; so if the student wants to utilize digital media in design process, he/she has to learn a significant amount of computer literacy, which may inhibit the design activity.

2.4.2.4 The Role of Internet in Design Education

As retrieving information from Internet is so easy and usual, many professional designers and students use it as the primary source of research and interaction environment. The most common utilization areas of internet or school intranet in design process are:

- To search on the design problem, for similar solutions and available tools and technologies that can be applied.

- To create virtual environments like forums or discussion boards to discuss a specific topic synchronously or asynchronously.

- To provide a communication medium for students, experts or instructors that can not physically attend to the design studio.

2.4.2.5 Online Design education

Design education that is carried out in an online environment, which might be a special web-site designed to enable the design studio participants to synchronously and/or asynchronously communicate and interact; can be named as "online". Online design education covers all the activities carried out in a traditional design studio, but they have to be reconstructed in order to integrate with the information technologies.

However, the integration of design studio with digital media in virtual environments has many problems. Many design schools around the world have been experimenting online design studio courses in order to reach a suitable instruction model. The most challenging point is simulating and supporting the interaction among the students and instructors, which is hard to achieve and relatively expensive. Tauke *et al.* (2003) listed some advantages and disadvantages of online teaching and learning of industrial design. According to her, one of the main disadvantages of online design education for studio instructors is the increased workload, as they have to respond to an overwhelming number of e-mail messages and feedback about the method, progress and problems concerning the utilization

of online materials. On the other hand, the advantages of online teaching of design studio for instructors and students can be listed as follows;

- Instructors might allocate their time in a flexible manner; they are not bound with fixed studio hours and physical space.
- Instructors can react to students at their convenience.
- Students are not bound with place and time, they work in higher privacy
- For some students online studio provides to work without the phobia of embarrassment.

However, the shortcomings of an online design course from the students' perspective might arise as the decrease in the face-to-face interactions between students and instructors, learning from others' work and social interaction in the studio. In a traditional design studio students comment on each other's work. Also they develop their 3D modeling, rendering, physical modeling and drawing skills by learning from each other during studio hours. Online teaching of industrial design also lacks these aspects.

Apart from the shortcomings, online design education provides opportunities for design students to reach distant experts and professionals easily. They can interact with a number of people at once. The one-to-one relationship of traditional design studio can easily be one-to-one, one-to-many and/or many-to-many in an online environment with the information technologies. As a result, collaboration and group work of physically distributed students become easier than ever.

Due to the need to develop complex products in less time with smaller budgets; collaboration and utilization of information technologies are heavily employed by professional designers. To prepare the design students for professional life, design schools must give emphasis on collaboration and group work. Collaboration and group work, in

design tasks and in virtual design studio in general will be discussed in the next chapter, as it is an extremely important aspect of virtual design studios.

CHAPTER 3

VIRTUAL DESIGN STUDIO (VDS)

3.1 Introduction

Distant learning which began with letters and continued with radio, television and information technologies has always been a challenge for educational institutions and students. With the introduction of computer networking and higher capacity network connections in the late 1980's and early 1990's, more courses have been conducted by utilizing information technologies. Information technologies have opened a new era in education by equipping the "act" of learning with the "fact" of technology. Jackson (2004) classifies distant learning as technology-enhanced learning and technology-delivered learning according to the utilization of technology in education. In technology-enhanced learning students have the opportunity to meet physically with each other and instructor; however in technology delivered learning, learning material is delivered via information technologies and learner audience never or rarely meets the instructor or the others physically.

In the early times of computer supported distant education, course notes were uploaded to a website for everyone to reach at their convenience. Then, mailing lists and discussion forums were utilized for asynchronous communication of course participants. Later, communication with instant messaging, audio and streaming video transfer were introduced to be used in distant education.

Online learning facilitates three basic functions of instruction which are;

- The delivery of course materials to students,
- Fostering the communication between students and instructors,
- Managing the students and appraisal of students' work and progress. (Simoff, Maher, 2000)

To begin with, "the delivery of course materials to students" was the most common and easy function of distant learning since the beginning. "The communication between students and instructors" improved apparently with the utilization of information technologies in distant education. As a result of the advanced networking technologies, students and instructors had the opportunity to have asynchronous communication and interaction with each other. Shared online databases, which can be accessed and modified from anywhere, give instructors and students the chance of following and evaluating the progress of the course work.

Distant education can also be categorized according to the format of learning. The categories might be (Jackson, 2004);

- Directed study (CD, audio, video tapes)
- Instructor led events (Synchronous, real-time learning)
- Small group collaboration (which corresponds to the informal gatherings of students, for ex. in library)

Sagun *et al.* (2001) identifies 5 models of distant education in which information technologies are utilized;

- *Individualized instruction model*, a text based system depending on the one-to-one interaction of learner and instructor.
- *Class Model*, which is a simulation of physical class on the web or in a virtual environment.
- *Integrated Class Model*, in which the simulation of physical class is enhanced with the research activities and participation of remote experts with audio and/or visual conferences.
- *Group model*, which is the simulation of group-work in computer environment.
- *Collaborative group model*, in which a number of instructors interact with a number of learners with the participation of remote experts in a simulation of physical class.

On the other hand, Minoli (1996) uses the term "interactive distance learning" (IDL) for the web-based distributed learning models. With IDL the sources are distributed evenly and the learner is able to customize his/her learning experience. IDL offers a self-scheduled, self-motivated and self-paced instruction model. In IDL the learning material is always available, there is a socially non-threatening learning environment and no travel time (Minoli, 1999).

As noted above, the use of information technologies in distant education has a history of approximately 25 years, but the utilization of those technologies in design education is relatively recent. Since design education is mainly a practical activity and depends more on visual elements instead of written texts, necessary technology to conduct a distant design studio course has not become possible until the late 1990's.

The nature of design education requires the interaction of students, instructors and remote experts as well as visual databases and libraries. Sagun *et al.* states that the *Collaborative Group Model* suits the design education best because design reviews, juries and consultation to remote experts could be achieved with this model in the best way.

Virtual design studio, which is a virtual collaborative environment for design education, is a category of distant education that is conducted by the collaborative group model. In the following chapter the background, the motivations and the driving forces behind VDS will be discussed.

3.2 Motivations of Virtual Design Studio

In a typical design process, the designer or the design student has to create concepts, choose an appropriate one, modify, test and present it. Furthermore, with the improvements in technology, the end-user testing and prototyping are also expected from the design process. It is evident that every phase of the design process requires sophisticated skills and knowledge over a broad range of information technologies. Friedman (2000) stated that;

> *"Design involves more skill and knowledge than one designer can provide. Most successful design solutions require several kinds of expertise. It is necessary to use expertise without being in each field.*

Organization theory suggests building teams or networks to engage the talent for each problem" (Friedman K., 2000, p9)

The complexity of design tasks and processes in contemporary design education and profession is the key motivation of virtual design studio. By the help of VDSs despite the fact that designers are geographically distributed, they are able to collaborate and interact seamlessly with each other as if they are in the same room. In addition, consultation to experts of other disciplines during design process can be achieved in a feasible way by utilizing information technologies.

In professional life, the pressure on the designer to design the whole life cycle of the product, from concept to end user testing, is increased with the arrival of new technologies in designing, presenting and testing phases considering the fact that the designer is now asked to be able to cope with the technology as well as the design. Moreover, with the communication and collaboration technologies, designers are able to reach expertise on a specific subject within minutes or hours. It is obvious that to satisfy the demanding requirements of design profession, design education has to conform to the new developments. The main motivation to initiate VDSs is to provide the design student with the necessary tools, techniques and skills for professional life. The motivations of VDSs might be listed in detail as follows;

- VDSs present different cultures, environments and ideas to the participants in a more direct way than traditional studios (Dave, Danahy, 2001). It is relatively easy to establish an international studio in a VDS. Students are able to interact in a foreign environment and gain different perspectives.

- Many students enroll in exchange programs to learn about different cultures and enrich their educational experience. With VDSs that is, to some extent, more cost effective and easy to establish. Moreover, both students and instructors have the opportunity to access the experience and knowledge of different faculties (Dave, Danahy 2001, Laiserin 2002). VDSs can also be used

to redistribute the intellectual resources of design education within different geographical and socio-economical divisions. (Laiserin, 2002)

- As design practice is a collaborative activity, many authors argue that VDSs can increase collaboration and develop students' collaborative skills (Cheng 2000, Larserin 2002, Zimring *et al* 2001 and Dave Danahy 2000).

- In a VDS, most of the communication and interaction is in digital format and can be stored and analyzed easily. That's why design researchers are concerned about the analysis of design process and design thinking which depends on the observations of design interactions (Chiu, 1998). The data provided by the recordings of VDS provides design researchers an enormous source for design research. With these data, the needs of collaborating groups and possible further forms of computational infrastructure of VDS can be studied more elaborately and new experiments on design teaching and analysis can be carried out which are not feasible in traditional settings (Dave, Danahy, 2000).

- The students have to be prepared to the design practice in which design firms compete in a more global market than ever. An "ever" global design ground might be considered as an "ever" global team for groupwork where the students will have to learn, "*how to use clear and precise language, delineate responsibilities and organizational structure and cultivate appropriate activities and responsibilities* (Middleton, M. 1967, p 268)*"*. At this fracture point, VDS improves students' skills to communicate in new media and prepare them with the necessary skills for the contemporary design practice (Cheng, 2000).

3.3 Distinguishing factors of VDS

Although the virtual design studio is a medium for teaching design practice just like a traditional design studio, there are many important differences between these studios. Maher, Simoff and Cicognani (2002) listed the main differences of VDS from traditional design studio as follows.

In VDS;

- The design group is geographically distributed,
- The design process and design communication is computer supported and mediated,
- The information is handled in electronic form
- The design documentation, sketches, technical drawings, renderings and final presentation, are in digital format.

Moreover, Chiu (1998) states that; although the design process, design collaboration, communication and decision making in a VDS are similar to those in a traditional design studio, in a VDS, all these aspects have to be restructured to meet the requirements of digital media and distributed setting of VDS.

Dave and Danahy (2000) identify 7 key points that characterize VDSs. They are;

- *Collaboration*
- *Media*
- *Tools*
- *Duration*
- *Distances*
- *Design brief*
- *Computing infrastructure* (Dave, Danahy, 2000, pp 59-60)

The two key points communication and documentation in VDS will be added to the ones identified above and will be discussed in the following sections.

3.3.1 Collaboration

3.3.1.1 Definition of Collaboration

Collaboration as a term has many meanings and defines various activities in different disciplines, as an example; a medical operation can be defined as collaborative as well as the construction of a building or the market research of a new product. All of these areas have their own definitions of collaboration. For problem based activities like design, Roschelle and Teasley (1995) defined collaboration as follows: *"... a coordinated, synchronous activity that is*

the result of a continued attempt to construct and maintain a shared conception of a problem" (p. 70). Activity here describes the sum of actions taken by two or more agents to reach a common goal.

Dillenbourg (1999) defines a situation or an activity as collaborative if the agents are more or less at the same level, able to perform the same actions, have a common goal and work together to reach that goal. He explains this with the symmetry in the collaborative interactions; and notes that the degree of symmetry in action, knowledge and status of agents are closely linked with the degree of collaboration between the agents. Symmetry of action is the available set of actions for each agent, symmetry of knowledge (or skill, or development) is the level of knowledge possessed by agents, and symmetry of status is the level of agents' status with respect to each other and their community.

The interaction between the agents is closely related with the effectiveness and efficiency of collaboration. Dillenbourg (1999) identifies three criteria that describe interactions as collaborative. These are *interactivity, synchronicity and negotiability*. By definition, collaboration must be interactive as it occurs with the presence of at least two or more agents. For an efficient collaboration not the frequency but the quality and content of interaction are important. Another criterion identified by Dillenbourg (1999) is the synchronicity of collaboration which stems from "doing something together". The third characteristic is the negotiability of collaborative interactions. Since the agents in collaborative interactions are more or less symmetric in status, they can negotiate in collaboration (Dillenbourg, 1999). Negotiation is an essential part in collaboration as agents divide the work into sub-tasks and then solve them. Any failure in negotiation might result in the failure of trust relations between partners as trust is a major condition for effective interaction (Andriessen, 2002).

Many interactions occurring between partners are named as collaboration in the literature. Miyake (1986) draws attention to the slight distinction between *collaboration* and *cooperation*. According to him the degree and the way of division of labor identifies the interaction between agents as cooperation or collaboration. According to Miyake (1986), in cooperation

agents solve sub-tasks and assemble their results to form the final output. On the other hand, in collaboration agents do the work 'together' to reach a common final goal.

To achieve the goal of learning, many educational institutions promote collaborative learning, which will be discussed in the following section.

3.3.1.2 Collaborative Learning

Collaborative learning has an extensive literature and many studies were carried out in the field (Hooper, 1992, Narayanan, Hmelo, Petrushin, Newsletter, Guzdial and Kolodner 1995). For example in Hooper's study (1992) it was found that students working in pairs learned more effectively than students working individually in ability groups. This finding was also supported by Kvan (2001) who states that students would be far more successful when they work together on a problem as they can cover more issues and as they discuss the problem in more detail and from many perspectives (Kvan, 2001).

There are quite a number of definitions of collaborative learning. Dillenbourg (1999) outlined the definitions of collaborative learning as follows;

- One of the broadest definitions outlines collaborative learning as any collaborative activity in educational context, such as studying course material or sharing course assignments.

- Another approach describes collaborative learning as a side effect of joint problem solving and learning is measured by the extraction of new knowledge and improvement in problem solving performance

- Another definition addressing the key terms of collaborative learning is that *"it is a situation in which two or more people learn or attempt to learn something together" (Dillenbourg P., 1999, p1).*

The final definition is quite generic and each term can be open to discussion and comment. Dillenbourg (1999) discussed this definition as follows; *two or more* may be interpreted as a

small group of 3 to 5 people or a classroom of students or a community or a society. The scale is so vague that the number varies from 2 to several thousands. Also to *learn something* might be anything from following a course, or studying course material, to performing activities of learning or learning from experiences. *Together* implies some sort of interaction, however it is not clear whether it is a face-to-face, computer supported, synchronous or asynchronous communication and whether it is collaboration or cooperation (Dillenbourg, 1999). The keywords; *two or more, learn something* and *together* draw an outline to the subject of collaborative learning, however the definition is apparently wide and encompasses many interactions. The definition covers all collaborative learning actions in general but fails in defining the branches of collaborative learning whether it is a problem solving activity of a team or the life-long experience of a community.

Dillenbourg (1999) explains the efficiency of peer learning, as a form of collaborative learning, with specific learning mechanisms that are triggered with the existence of another peer. Working in a group or with peers creates extra activities such as explanation, disagreement, negotiation which are absent in individual work. Those extra activities start extra cognitive mechanisms such as *"knowledge elicitation, internalization and reduced cognitive load" (Dillenbourg P. 1999 p 5).* Activation of those mechanisms is not guaranteed; but they are likely to be activated in collaborative learning, on the other hand they also may be activated in individual work.

> *In summary, the words 'collaborative learning' describes a situation in which particular forms of interaction among people are expected to occur, which would trigger learning mechanisms (Dillenbourg P. 1999 p 5).*

3.3.1.3 Collaboration and Interaction in Design

Design, which is mainly a practical activity and a problem defining and solving process, is a synthesis of a huge amount of information to reach a desired solution to the problem. In any design project (architectural, industrial, interior, graphic design), designer has to gather information to discover the problem and to define solution space. Furthermore, to bring the design into a physical object is sometimes a very complicated task which might require a number of different experts

In this context, collaboration and interaction have important effects on the design process. Although designers frequently collaborate with each other and/or with people from various disciplines in the design process, the patterns of collaboration and interaction might vary in design education and profession.

3.3.1.3.1 Collaboration in Design Education

In design education students are generally given individual projects to develop their design skills. At the first glace, one can think that there is little space for collaboration in design studio because of the individual projects. However during the design process, the project advances with the collaboration of all studio participants. This collaboration formally takes place as desk reviews, wall critiques and juries but may also continue or initiate at informal meetings during breaks. Collaboration may display different patterns according to the phase of design process and depends on the phase it takes place between students, students-instructors and students-remote experts. During collaboration the interaction among the participants might be one-to-one or one-to-many. As a result of these interactions, collaborative learning occurs in the design studio. For example, students discussing the design brief and explaining the design problem to each other are a common view from a design studio which is an instance of collaborative learning.

Student – student and student – instructor collaboration displays different patterns during the design process. Student-student collaboration occurs almost at every stage of the design process; they discuss the design problem, criticize each others work and help each other. Although students are expected to submit individual projects they share most of the design information and in a way work as a group. That might be the result of the synergy created in the studio.

Student – instructor interactions are one-to-one or one-to-many. In studio hours, student – instructor interaction might be in the form of desk reviews which might be privately held between student and instructor at students desk or might be in the form of juries which can be followed by other students. Students learn from instructors' comments on others' work, therefore they are expected not to make the same mistakes repeatedly.

Although many design schools place more emphasis on individual work, design profession demands groupwork (Cuff 1991, Middleton 1967, Cheng 2000). Considering the fact that students have to develop their communication and collaboration skills as well as their design skills to be ready for a demanding profession, they should practice with collaboration and communication tools and be a part of a design group. For this reason, design schools need to consider the new trends in design profession especially collaborative design area.

3.3.1.3.2 Design Studio versus Theoretical Courses

It is evident that design studio courses and theoretical courses are far apart from each other in many aspects. Fundamentally, the structure of a design course depends on the work of student; on the other hand theoretical courses depend on the transfer of knowledge from instructor to students.

The interaction between the instructor and the student in a theoretical course is mainly one way; from instructor to student, and the interaction between the students is limited to listening questions in the class and some group-work which is mostly "cooperation" outside the class. In recent years many theoretical courses have been supported with online group-ware tools which accommodate forums and discussion lists. These provide synchronous and asynchronous communication for students and instructors. Students can upload their assignments to a shared virtual space and see others' work. Therefore, theoretical courses are mainly text based and online collaboration needs relatively less infrastructure when compared to design studios.

Design studios are the places where knowledge gained in theoretical courses is synthesized. The work in design studios is visual and three dimensional, as a result; students use a wide variety of medium to express their ideas in design studio. For example, they use technical drawings, preliminary mock-ups, computer generated photorealistic renderings, freehand sketches, physical models or even models from rapid prototyping machines, etc… Unlike lecture based theoretical courses, in a design studio students and instructors might all comment on the students' projects; and that occurs not in a classroom based environment but in an atelier-like environment in which every student has his/her own desk. In a

theoretical course the interaction is mainly in a one-to-many setting, on the contrary in a design studio this is one-to-one and even many-to-many with the contributions of outside experts to the studio.

3.3.1.4 Collaboration Patterns in Traditional Design Studio

As it is already stated in section 3.2.1 many scholars argue that design schools give emphasis on individual work whereas design profession is carried out mainly as group-work. In order to learn group-work and efficient collaboration, it is efficient for students to experience teamwork. In a traditional design studio it is hard to ignore the existence of collaboration; however the pattern of collaboration does not match with the pattern of collaboration in design profession.

Participants in collaborative design, work together to solve some sub tasks to reach one final goal, on the other hand in a traditional design studio, students generally work individually and help each other to solve their design problems which might be named as cooperation. According to Vera *et al.* in collaborative design designers must decide when to carry out which tasks and what tasks to carry out. This requires division of tasks and labor in a design project.

3.3.1.4.1 Patterns of Collaboration

Maher, Simoff and Cicognani (2002) state that for a successful and effective collaboration in a VDS, collaborators must share *design tasks, communication, representation and documentation.* There is a continuing debate on patterns of collaboration in virtual design education. Early VDSs used to utilize real-time audio and video settings in order to simulate the traditional design environment. The view that, design practice can be learned through "reflection in action", dominated the early VDS settings. Schön (1987) and Fitzpatrick *et al.* (1996) assumed that the success of virtual design environments is tightly bond to the simulation of traditional design environment via the use of high-bandwidth networks, real-time audio and video connections. However, empirical studies (Dave and Danahy 2000, Vera *et al.* 1998, Briggs 1996, Kvan et.al 1999, Miller and Siegel 1996, Olson 1997) showed that this

approach had difficulties in application and in some cases low-bandwidth chat line communication was even better than high bandwidth communication regarding to design collaboration. On the other hand, Kvan (2001) and Dave and Danahy (2000) states that the atelier ambience of the traditional design studio, the informal interactions between studio participants, the non-verbal cues in design communication and the sharing of the design work, which are the key elements of a successful design studio, must be represented in VDSs. Moreover, according to Zimring *et al.* (2001) VDSs are better for providing the subjects with more sophisticated base of interaction letting them to collaborate more efficiently. According to him, the pre-structured, asynchronous and socially un-constrained interaction and the ability to interact with many people at one time are the key advantages of collaboration in VDSs.

3.3.1.4.2 Collaboration Patterns in Different Phases of Design Process

At the beginning of each design project, students are given a design brief and they are engaged to fulfil the requirements of the brief in a given period of time. The process is generally divided into 4 phases, which are;

- Analysis of the brief and research on the subject
- Concept generation
- Selection, refinement and detailing of one concept
- Presentation and evaluation

In analysis and research phase, students consult many experts from various disciplines in addition to making a literature review. However, there happen to be many times when the experts are not locally available. Utilizing information technologies is very helpful in consulting distant experts at their convenience, synchronously and/or asynchronously.

In concept generation phase, students are expected to create many alternatives rapidly using traditional media such as pen and paper. The interaction among the students is very

important in concept generation phase; as they share their ideas, discuss their projects and make brainstorming sessions. These may occur in informal conversations also when they meet each other at any time, any place apart from the studio hours. According to the observations of Bharat D. and Danahy J. (2000) the utilization of computer tools in concept generation phase does not support generation of multiple alternatives, and students engage in refinement of one alternative very early in the process. The lack of computer literacy may be one of the reasons for this. When the student is not experienced enough to create 3D computer models or 2D drawings with the digital media, he/she spends so much time and effort on one alternative and cannot abandon the work he/she does.

In the next phase, after creating concepts, students share their ideas with the instructors and select one of them, then refine the concept and design the details of the project. At this phase, the interaction among the student and instructor is at its highest level. Students regularly present their work to the instructors in a variety of media such as; freehand sketches, technical drawings, mock-ups, computer generated 3D models, clay or foam models etc… At this phase of the design process, students receive continuous feedback from the instructors. This feedback is mainly in the form of desk reviews where the students and teacher sit on a table and discuss the project one-to-one. The desk review is one of the main points which is very hard to simulate in a virtual environment. With the use of network video and a shared whiteboard desk reviews can be simulated to some extent but the communication and interaction are limited with the screen resolution and network bandwidth.

After the refinement and detailing of the project, students prepare to present their work to the jury for evaluation. At this stage, students use a number of computer tools such as 3D modelling and rendering packages to create photo realistic images and use bitmap or vector graphics editing packages to prepare printouts and/or multimedia authoring tools to prepare multimedia presentations.

Participants of a design studio are instructors, students and experts; therefore all the interaction takes place between these participants, where the interaction might be one-to-

one or one-to-many. The efficiency of interaction among these parties is crucial to conduct the studio. In addition to all, human-computer interaction is also very important in a design studio. In a traditional face-to-face design studio course, a wide variety of computer software and hardware, such as; bitmap, vector graphics and ergonomics software packages, solid and surface modelling tools, scanners, printers and graphics tablets are utilized as well as pen and paper. In a traditional environment, the student work created with computers can be presented to the instructor with print outs; however in virtual environments also the instructor needs to have the necessary tools in his/her computer and to know how to use them. As a result, if the participants' computer skills are limited, the design communication and collaboration among the studio participants may not be as efficient as it is in traditional design studio.

3.3.1.5 Collaboration patterns in Virtual Design Environments

Approximately two decades ago, virtual environments that accommodate virtual teams and organizations started to emerge. The arousal of virtual teams and groups can be explained by the following reasons (Hutchinson, 1999);

- Low-cost of virtual collaboration with respect to physical meeting
- Easy access to and low-cost of enabling technologies
- Globalization of products and services
- The need for flexibility in large global organizations
- The need for the manipulation of information in organizations
- Easy access to expertise and consultation in organization.
- Easier to reach people regardless of place.

The application of virtual collaborative environments in design profession and education has been a hot topic for the last 10 years. Asynchronous communication tools like e-mail and message boards as well as synchronous tools like instant messaging, audio and video conferencing have been used to facilitate virtual design environments. Many issues and question have aroused regarding the conduct and content of the environments. Although there were many groupware tools in the market early virtual design environments, later named as virtual design studios (VDSs) were World Wide Web (www)-based web sites. Those web-sites have enabled studio participants to collaborate and share information without time and distance limits. Application of virtual design environments is improving rapidly and constantly with the utilization of new technologies in computer tools and networking; however the theory of collaborative virtual environments have not been well defined. Collaboration patterns in virtual design environments will be discussed in detail in section 4.3.1 of the next section.

3.3.1.6 Design Collaboration and Interaction in Online (Virtual) Collaboration Environments

The design studio is the backbone of the design education curricula. During long studio hours, students discuss not only their individual projects but also each others' projects. Studio is a social place to share information and discuss the project both in formal and informal settings.

As Schön (1987) noted; tacit knowledge is an important part of design education and developing the skills and knowledge covering this tacit knowledge composes much of design education. Schön (1987) also explains "reflection-in-action" in which studio participants explore design solutions by being present through the design process.

As design studio depends much on tacit knowledge, the main argument is how it would be possible for a design studio carried out virtual environments. The transformation of face-to-face interaction to a setting in which students and instructors are separated with distances and time-zones are the main challenge of virtual design studios.

Many scholars argue that the social context of a design studio can only be represented in virtual environments by replicating traditional environment exactly with synchronous high bandwidth video connections (e.g. Fitzpatrick, Kaplan and Mansfield, 1996). However, a group of authors (e.g. Hollan and Stometta, 1993; Kvan, Yip, Vera 1999; Lawson, Loke 1997) argue that replication of physical environment is not necessary for successful virtual design education, furthermore, even they note that textual communication boosts students' creativity more than visual high quality sketches (Lawson, Loke 1997)

Kvan (1999) states that the final outcomes of both low bandwidth chat-line communication and high bandwidth video communication settings are similar. Explanation, disagreement, negotiation and evaluation were very similar in both settings which revealed that collaboration patterns are not affected by the bandwidth (Kvan, 1999).

Zimring (2001) having carried out a virtual design studio at Georgia Tech. (USA) states that online collaborative environment are better than traditional environment for certain reasons. Primarily, asynchronous communication allows students to review course material at any time; also the social interaction among the participants in virtual environment is better as they are less socially constrained. Finally, online environment allows students to interact one-to-many and many-to-many at the same time, which is quite hard to achieve in traditional setting (Zimring, 2001).

In an online collaborative environment, a wide variety of computer hardware and software to be utilized to conduct the studio properly and adequate computer skills of participants to allow them maintain the studio effectively is needed. Improvement of computer skills by means of peer learning, actually by means of sitting next to a peer, is a point where Kvan (2001) draws attention to. He also claims that when a novice user sits next to an experienced user having one common screen in front of them, learning of computer skills is much easier for the novice user. In addition to the benefits of working with peers and collaboration stated by different author so far, Vaitkus (1991) notes that groups do not work properly and efficiently if they are not formed well and anonymity is present. The development of trust relations in virtual groups is much harder than in traditional settings.

Students unfamiliar to each other, are reluctant to collaborate before building trust relations. To establish an efficient collaboration; the groups have to know and be able to interpret each other.

Table 3.1; Comparison of collaboration in traditional design studio and virtual design environments.

Collaboration in Traditional Design Studio (TDS)	Collaboration in Virtual Design Studios (VDS)
1) Design Brief	
Design Brief is introduced and discussed in the course.	Design brief is published in the web and discussed via computer media
Design brief in TDS generally encourages seeking of individual solutions to the design problem	Design brief in VDS is generally intended for group-work.
2) Design Process	
Face-to-face meetings of instructor(s) and students.	Meetings using high-bandwidth video conferencing or desktop video.
Variety of media used including computer tools	All media is converted to one digital medium
Informal gatherings of students to discuss the design problem during studio hours.	Asynchronous communication via e-mail, forums and discussion boards and informal chat-line instant messaging
Desk-reviews on rough freehand sketches which are usually multiple in intent.	A more structured communication on computer generated models and images, which are more concrete.
Learning from peers by helping each other	Learning from peers by observing the others' contributions.
Greater responsibility of instructor to guide the process and students.	Greater responsibility of student to make time and task plan.
3) Evaluation	
Juries on models, drawings and renderings	Online synchronous and/or asynchronous juries
Juries with the contributions of local experts and instructors	With the participation of distant experts and instructors.
Presentation medium is generally paper and models	Presentation medium is computer generated images and simulations

3.3.2 Media

In a VDS, students are free to use digital (3D computer models, renderings, virtual prototypes etc.) and traditional media (freehand sketches, marker pens etc.). However, students have to digitize the content created with the traditional media in order to share them in VDS (Dave and Danahy, 2000). The use of digital media cause problems as the early fixation, refinement and poor exploration of problem space as mentioned in section 4.7.3 of this chapter.

3.3.3 Tools

The tools used in a VDS can be classified as content creation, digitization, sharing, evaluation and communication tools. They can be either hardware and/or software tools. 3D modeling, rendering and rapid & virtual prototyping technologies can be used both in traditional and virtual studios; however communication technologies such as; file exchange protocols (FTP), asynchronous (e-mail, user forums) and synchronous (instant messaging, audio & video conferencing) communication, white-boarding, application sharing, shared databases, images, hyperlinked documents, world wide web and local intranet, are the key tools and technologies that maintain an effective and efficient virtual design studio. Although these tools and technologies are necessary for VDS, Dave and Danahy (2000) draw attention to an important fact that, regardless of the tools utilized, the final design solutions depend as much on the creative design skills of students as on the tools available to them.

3.3.4 Duration

The duration of a VDS can vary from a few days to a few months according to the design brief and the studio setting. In a case study (Kolarevic *et al.* 2000), students from Hong Kong, Zurich and Seattle seamlessly collaborated for a week. During that week, they worked in 8 hour long relays by using the 8 hour time difference between the physical locations. The actual project duration was three weeks but they were finished with it in one week with the help of the ingenious selection of geographical locations.

3.3.5 Distances

In a VDS, participants are separated by temporal, geographical, cultural, technological, and other distances (Dave and Danahy, 2000). The geographical and temporal distances can be neutralized by the help of communication technologies. However, when there are technological distances, the communication between VDS participants can be seriously blocked.

3.3.6 Design Brief

The design brief in a VDS is similar to the one in a traditional design studio. The design brief may vary from short term conceptual design problems to complex production oriented ones. In addition to traditional design briefs, VDS allows studio tutors try different settings of design studios in a more economical manner. The distances that separate the studio participants can be used to stimulate new settings of briefs that will allow the participants to design for or in or through the inheritance of different cultures.

3.3.7 Computing Infrastructure

Computing infrastructure is the key element in maintaining a VDS, and most problems are related to this element. Sophisticated computer tools are utilized and all the tools have to be compatible with each other throughout the VDS. Another point is the preparation in advance and the lead time that is required to efficiently run a VDS course (Dave and Danahy 2000). The studio instructors or technical staff must make sure that all devices are working, ready to use and will not make any surprise when they are needed.

3.3.8 Communication

Communication, which is an essential and crucial factor for any course, is also essential for a VDS, as expected. In a traditional design studio, all of the participants are in proximity with each other, and able to interact easily either in formal or informal manners. However; in a VDS, studio participants have to use computer tools to facilitate communication among themselves. The communication can be both in asynchronous and/or synchronous way. In

asynchronous mode, designers may work at different times, and simultaneous presence of all the team members is not required. On the other hand, in synchronous mode, team members simultaneously participate in the design process. To support synchronous mode, usually high bandwidth networks and common computer platforms at both ends of the line are required (Maher, Simoff, Cicognani, 2002). Moreover, students have to be prepared and they also have to plan the content and the form of interaction for an efficient synchronous interaction (Dave and Danahy, 2000). Chiu (1998) states that, as group decision making is different from individual decision making and requires critical design information, the synchronous interaction must be well structured to cover and share the information to provide decision makers with the necessary design information.

3.3.9 Documentation

In a traditional design studio the physical environment is the medium of storage and presentation for design works. Documents required for the design process and created in the design process are sometimes shared and available whenever they are needed in the physical studio, but these can also be individual works not shared by the group of students. On the other hand, in a VDS, all the information is created in and/or converted to digital media and stored in computers. The type and format of sharing makes the documents more accessible. Maher, Simoff, Cicognani (2002) identified two approaches to documentation in VDS; *Centralized Documentation* and *Distributed Documentation*. In centralized documentation, all design information is kept in one centralized server which is accessible online. In distributed documentation approach, different documents are stored in different places, which are accessible online. The changes and updates in design documentation create issues of consistency in this approach.

3.4 Pedagogical Aspects of VDS

The conversion of all the information and data into digital medium and the tools and technologies utilized in interaction raises pedagogical issues related to the student, instructor, time management, interaction and communication in virtual design studio.

Due to distributed setting and limited time of synchronous communication, students have to manage their time and work by setting their own schedule. Students must be aware of their own control over their education, their roles and responsibilities in digital medium. (Sagun, Demirkan, Göktepe, 2001). Kvan (2001) states that, in a VDS setting, the communication between the instructor and the students has to be more structured, planned and pre-prepared to maximize the efficiency of communication. In synchronous communication, the student has to prepare his/her work in a more conscious manner in order to explain design ideas to the instructor by means of the communication media. The communication channel might be a real time audio and video connection or just a chat-line. In an asynchronous communication, the presentation of the student and the review of the instructor must be clear, understandable and the presentation must explain itself to eliminate possible misunderstandings.

The instructor in a VDS has additional obligations and responsibilities because of the new medium and remote setting (Kvan 2001, Simoff and Maher 2000, Kalawsky 2000). First of all, the students have to be instructed to use the communication medium and the collaboration tools efficiently during design instruction. Secondly, the instructor must overcome the geographical distances and must give the students a sense of place and community. Thirdly, the instructor must respond to the student's design ideas and problems regarding to the course, as quick as possible to sustain his/her motivation in the course. Fourthly, the instructor has to make sure that the information received by him/her is the same with the information that the student has sent, that's why a feedback loop is required in a VDS to overcome the possible misunderstandings in communication. Finally, the instructor must interactively assess the work of students as the studio progresses. In a VDS, students usually send their work in digital format to somewhere in space with a click of mouse, and they have no evidence that their work is received and reviewed by an instructor. Students generally wish to know whether their ideas are accepted by the instructor before proceeding to the next phase of the design process.

Another point noted by Zimring *et al.* (2001) is the protective setting of a traditional studio in which the students solve simplified design problems set through predefined aspects,

under the watchful eye of the instructors. However, VDSs give extra responsibilities to the students and learning is more self-paced. Although, design practice can be simulated in a more realistic manner in a VDS, the pedagogical issues in design instruction are still subject to question.

3.5 Things to Consider in VDS from Pedagogical Perspective

To design and carry a virtual design studio, the instructors have to plan, establish and conduct many aspects.

> *"In order to design and manage a VDS, one has to make a systematic analysis of the objectives (why), objects (what), methodology (how) and management (who).* (Sagun, Demirkan, Göktepe, 2001, p 332)

In a VDS, considerable amount of data is created and shared. Organizing these data and the interrelations of these data with participants is the key component of a VDS. Engeli and Mueller (1999) identified 6 aspects that have to be considered while designing, conducting and assessing the outcomes of a VDS. These are;

- Information: The drawings, CAD models, presentation and design ideas are all converted to digital data which is a huge bunch of "ones and zeros". VDS has to be established in a way that this data can be converted to understandable and shareable information. Engeli and Mueller (1999) state that there must be upload of information in the system when a contribution is added to it, and basically information about by whom it was added, which knowledge it was based on and on what purpose it was created as well as the information about the contribution's generation process.

- Relations: The relations between the information and participants must be clearly visible and traceable in order to better understand and extract the information from the heap of data. Engeli and Mueller (1999) state that the data created with the contributions of studio participants might become more valuable by identifying the relations within them. These relations can be related to the time,

place or authorship and they help to place the information in the process at a certain place and discover why that information was created and added to the environment which enables us to estimate its value within the process.

- Context: The interpretation of information that is extracted from the data and its relations in the system might vary according to the participants working on different contexts. (Engeli and Mueller, 1999)

- Processes: The computer environment is the storage media for the work done in design studio. All the interactions, communications and contributions can be stored with specific information, for example; their time and creator would be attached to them in digital media. As a result, design process can be tracked in a better way. Engeli and Mueller (1999) state that the design decision will be well-grounded when the processes are better accessed. Moreover, "tracking of process" enables designers to reuse ideas according to the changing contexts in the process without reinventing the solutions.

- Views: In a VDS all the design information and data created during the process are documented in collaborative environment. The information must be organized in a way that it is easily accessible. Engeli and Mueller (1999) identified three points to organize the information in design environment. 1) Individual views; that a participant reviews and modifies his/her own contributions. 2) Work and product oriented views; so that everybody can track the design process. 3) System oriented views; by which one can see the interactions and relations between participants and their works.

- Interaction: the environment must be usable to provide an efficient medium of communication and interaction. The navigation in the system, the process of submitting contributions and modifying them must be user friendly and as simple as possible.

3.6 Communication in VDS

One of the main differences between a virtual design studio and a traditional design studio is the communication channels that are employed. In a traditional design studio the communication is mainly face to face, in addition to the mentioned, there might be the works of students on the walls creating a kind of asynchronous communication. In the last decade, traditional studios have started to utilize e-mail groups and discussion boards as a computer support to the studio. On the other hand, in a virtual design studio, the main communication channels are computer mediated. Studio participants rarely or never have the opportunity to meet face-to-face during the design process. The lack of face-to-face interaction in VDS contradicts with the widely accepted theory of D.A. Schön (1987), which justifies that students' learning mainly occurs in *reflection-in-action* by interacting face-to-face at desk reviews by sitting next to a tutor. However, increasing number of scholars (Dave and Danahy 2000, Vera *et al.* 1998, Briggs 1996, Kvan *et al.* 1999, Miller and Siegel 1996, Olson 1997) argue that simulation of face-to-face environment does not necessarily lead to better design work and does not provide a better communication than low-bandwidth channels.

Chiu (1998) states that, due to the nature of the online environment, in most cases the content of the communication concentrate on the technical problems and on learning the new media. To utilize the communication medium efficiently, the main content of the communication should be directly related to the design problem. In addition to what's been asserted by Chiu, Maher, Simoff and Cicognani (2002) state three key issues concerning the representation and communication of shared information, which are;

1) The degree of sharing required,

2) The kind of information being shared,

3) The organizational structure for shared information.

The degree of sharing information in a studio might range from private to public. The student may either want to share his/her design ideas with the instructor or with the whole

world. This degree of sharing might be analogized by a private desk review, a drawing table drawer or a wall in studio in virtual environment.

3.6.1 Types of Communication in VDS

In a VDS or even in a traditional design studio, a wide variety of media is utilized. Scanned freehand drawings, 3D CAD models in various file formats, digital photographs, spreadsheets, texts in various formats, textual, verbal and visual communications, are sent and received by participants. In order to integrate all of these media efficiently, all agents participating in a VDS have to have platforms that recognize different file formats. Even if the platforms are the same, there might be connection and quality problems on the network which may block the synchronous interactions occasionally (See Section 4.4.3 of Chapter 4). On the other hand, asynchronous interactions are more easy to use and participants are more familiar with them. The accessibility and quality of network is a minor thing for asynchronous communication, as the connection of one agent to the network is sufficient.

3.6.1.1 Synchronous Communication in VDS

In a VDS a variety of communication channels are used according to the availability of tools, participants and the requirements of the design process. Synchronous communication, which requires the simultaneous participation of agents, has categories of channels, ranging from video-conferencing sessions to chat-line communications depending on the tools utilized.

In a video conference session, the traditional setting can be simulated to some extent, through the real-time exchange of audio and video. However, conducting a video conference session requires expensive hardware, a high-bandwidth network connection and a considerable amount of planning. Even if the requirements of high bandwidth network connections are fulfilled, the deficiencies in the resolution of the transferred video may cause problems in simulating a physical class environment in a video conference session (See Section 4.4.3 of Chapter 4). In a design interaction, students and/or instructors need a shared screen to discuss the design problem. As designers work on visual materials, those visual materials also have to be transferred for collaboration. In these cases, another camera

is needed to shoot the drawing surface or a shared digital whiteboard can be added to the video conferencing hardware.

Another synchronous communication tool is application sharing. By using two workstations connected to a network, an application can be shared to collaborate by working on the same file (shared applications can run on different networked computers at the same time). Audio transmission and/or a chat line may accompany to this kind of collaboration. Dave and Danahy (2000) reported that network video was the least important source when they had a shared real-time CAD model running with a robust full-duplex sound.

One commonly and easily used synchronous communication tool is VoIP (Voice over IP) or Internet Telephony. In this kind of communication, participants have audio communication as if they are on the phone. Participants can open a shared application or the same document or the same image as they are in front of one single screen and they are able to collaborate.

The most easy and widely available synchronous communication technique is the chat-line or text-based communication. In this type of communication participants use one of the chat-client software, for ex. MSN Messenger, Yahoo Messenger or ICQ (I seek you). These software packages enable users to operate with file transfers, VoIP, audio and video conferences if the necessary hardware and software are installed on the computer. Kvan, Yip and Vera (1999) argued that chat line collaboration reduces fixation in problem space exploration by encouraging students to explore design ideas in a different manner than graphical or video based communication and interaction. That view is in line with Lawson and Loke (1997), who argued that words or textual communication better support the ambiguity and parallel lines of thought in exploring design ideas. The role of textual communication in conceptual design will be discussed in detail in section 4.7.1.3 of this chapter.

3.6.1.2 Asynchronous Communication in VDS

Asynchronous communication is a type of computer mediated communication, in which a piece of information is sent to a shared database for others to review at any time. In

asynchronous communication, the participants do not have to be online at the same time. This gives them the opportunity to work in their convenience and review their work better before they submit it to the shared workspace. In this type of communication, mainly, e-mail, FTP (file transfer protocol) and discussion forums are employed.

Asynchronous communication gives extra responsibilities to students like managing their learning experience and time-plan. The organization of the collaboration taken into account, being not online at the same time may cause some problems, especially when task sharing is required; the schedule has to be carefully planned. Besides, if there are tight deadlines, students might spend meaningless spare time waiting their teammates to send their part of the file to work on.

Table 3.2, Tools utilized in Synchronous and asynchronous communication in VDS.

Asynchronous Communication	Synchronous Communication
E-mail	Video conferencing
FTP	Application Sharing
Discussion Forums	VoIP
WWW	Chat-line
	Instant Messaging

Another issue regarding the asynchronous interaction is "building trust relations" between the participants. The lack of face-to-face interaction and synchronous interaction prevents or slows down the development of trust within the group (Andriessen, 2001, p 117). For building trust relations, asynchronous communication must be supported with synchronous communication in which participants interact face to face as if they are sharing the same physical environment. Mac Gregor and Ion (2004) reported that in a short term empirical study, to make sure that the design moved in the desired direction and the groups worked between the desired time-limits; considerable amount of synchronous communication was required.

Engeli and Mueller (1999) observed that in synchronous interaction, casual and task related discussions are merged when students are in private communication. They observed that in

informal communications students discussed school issues and other things they have to do, as well as the things they want to do.

The casual interactions in synchronous communication show that the synchronous communication in digital environment is easily accepted by VDS participants (See Section 4.4.1 of Chapter 4). On the other hand, apart from arranging virtual meeting schedules and sending files, students rarely used asynchronous communication.

3.6.2 Technological Constraints in VDS

In this section the technological constraints in VDS will be discussed under two headings.

3.6.2.1 The role of Bandwidth in VDS

As discussed above, synchronous and asynchronous communications have different bandwidth requirements. Also the need for bandwidth varies according to the type of asynchronous and synchronous communication. For example, for sending and receiving an e-mail message; a 56Kbps (Kilobyte per second) *modem* connection is enough; however when the user wants to attach a file more than one megabyte in size, it takes at least 10 to 20 minutes of time to upload with a 56Kbps modem, which might be 1or 2 minutes through *cable* or *ISDN* connection. In a synchronous communication; there is no doubt that to establish a real time face-to-face connection, the user needs at least a cable or ISDN connection, however; chat line communication has been used for 30 years as a synchronous communication tool and even a 14.4 Kbps modem connection would be enough for this type of communication.

Considering the last assertion about the chat-line communication, the first question to raise is; "Why do we need high bandwidth connection if we can use chat-line for synchronous communication in VDS?" There are many answers to this question in the literature;

- Engeli and Mueller (1999) states that the chance of misunderstanding is very high when the communication is limited to text, and that as a consequence the communication

must be enriched with different channels (e.g. video conferences, white boarding) to reduce the chance for misunderstanding.

- Andriessen (2003, p117) states that the information exchange shouldn't be restricted and the quality of communication shouldn't be distorted, when this happens collaborating partners feel mistrust.

- Fitzpatrick (1996) states that traditional design studio should be simulated in online environment. As design learning is mainly reflection in action and desk reviews; the key elements of traditional studio education must be simulated by video conferences, which require high bandwidth networks.

On the other hand a group of authors state that the simulation of traditional design studio provided by high-bandwidth network connections in online environment does not lead to a better work (Kvan 2000, Vera *et. al.* 1998, Briggs 1996, Miller, Siegel 1996, Olson 1997). Ambiguous and restricted nature of text-only environment encourages the students to explore the problem space in a more creative manner than students that have a shared drawing surface during collaboration (Kvan, Yip, Vera, 1999). Kvan, Yip and Vera (1999) also concluded that the percentage of design exchanges for the collaborative problem solving steps of meta-planning, negotiation and evaluation are very similar under high and low-bandwidth conditions. Therefore, it is possible to say that collaboration is not affected by the communication bandwidth. Moreover, Vera, Kvan, West and Lai (1998) state that students adapt to the available communication bandwidth and omit the irrelevant exchanges and focus on the design task, which means that the communication bandwidth has minor effects on the collaboration..

Communication bandwidth is important for the motivation of the participants. When the bandwidth is as low as 56Kbps modem connection, participants have to wait too long to view and to download the mainly graphical content of the online medium. Also submitting a contribution is problematic when the bandwidth is low, as 3D CAD files or high quality presentation renderings are too large to manage through a modem connection. The cumbersome and problematic environment due to the quality of the bandwidth creates

barriers to the motivation of participants. As an outcome of the all above, students with low-bandwidth connection have to make a trade off between low quality work and wasting time in front of computers.

3.6.2.2 Design, Communication and Computer Tools in VDS

Computer tools greatly enhance the communication between designers and also aid them in the design process. However; to use computer tools effectively in design and communication, the nature of design and the nature of interpersonal communication must be carefully taken into account (Latch and Zimring, 2000). A successful design process is the main goal of a virtual design studio and the VDS should be designed to establish and sustain that goal. As VDS is generally a virtual environment composed of linked websites and shared databases on one or more computers, the infrastructure and minimum requirements to use this environment should be set in a way which enables all participants to access and use every aspect of the VDS efficiently. Design is a highly visual discipline and a considerable amount of sketches, drawings and renderings are created during the design process. Consequently, the online environment must have an infrastructure that efficiently supports the sharing of this visual information. Communication with or without visual information (application sharing, video conferencing, white-boarding) in a virtual environment is the key element for collaboration.

Besides the enhancing effects of accommodation of visual elements in communication channels, "communication" itself prepares an environment for participants that help them to see beyond the so called "visual", by letting them to know each other better within a group and by creating the possibility to feel attachment.

3.6.3 Requirements of Design Process

The nature of design (See Chapter 2), by definition, demand some additional aspects from online design education to conduct an efficient VDS. In the following sections the type of communication required in different stages of design process and the role of remote experts in design will be discussed.

3.6.3.1 Identifying Stages of Design Process and Communication

To integrate communication effectively into VDS, identifying different design stages might be helpful (Engeli, Mueller, 1999). At different design stages the needs of the designers, the tools they employ, and the information they need and produce might vary. As a consequence, the content, the duration of their communication and the people they communicate in VDS might change.

"Definition of problem space" is the first phase of the design process, where designers use libraries, online databases and contact the people that have experienced the problem or who are expert on the problem. This phase mainly requires access to WWW, and simple asynchronous and synchronous tools (chat-line and e-mail) to communicate with experts, users and studio participants.

In "concept development" stage, designers generate ideas within the problem space which might be solutions to the design problem. At this stage, the design ideas are mainly represented through freehand sketches, renderings and mock-ups. VDS participants need to convert these freehand sketches and renderings to formats of digital environment with image capturing devices such as scanners, digital cameras and digitizers. This stage requires file sharing capabilities in addition to the tools listed in the first stage and the network bandwidth must be high enough to share the images without too much time delay.

In “concept refinement" stage, students interact with studio tutors and experts. The interaction is mainly synchronous; instructors, experts and students communicate synchronously on the works of students. The most problematic and complex interaction and communication takes place at this stage; the student and the instructor are in interaction with each other with the work in front of them. This interaction requires a high bandwidth network, video conferencing equipment, white-boarding software and careful planning of the interaction.

In the final stage, namely the "finalization" stage, students refine their concepts and present them to the instructors and experts for evaluation. This stage also requires synchronous interaction and communication of participants. During the evaluation, the works of the

students presented to the instructors and experts must be consistent with each other so that participants can easily follow the evaluation.

3.6.3.2 Communication with Remote Experts

Communicating through internet is more convenient than face-to-face communication when the communicating partners are geographically distributed (Sagun, Demirkan, Göktepe, 2001). With the internet, students are not constrained with local experts when they need suggestions , and they can consult remote experts and practitioners, as "reaching" is not a matter of more than a few seconds long waiting on the internet grounds. (Kvan, 2001).

Collaboration with remote experts provide students with views from different geographic locations, cultures and contexts, so that students do not fixate at one alternative but become aware of competing issues and possible solutions from a number of perspectives (Dave and Danahy, 2000).

3.7 Information Technologies and Virtual Design Studio

In this section information technologies (IT) and virtual design studio will be discussed from 3 main perspectives; (1) utilization of IT in design (2) Computer literacy and (3) Issues raised with the utilization of IT in design.

3.7.1 Utilization of Information Technologies

Information technologies are widely utilized even in a traditional design studio, where students work at their desks and instructors review their work by visiting their desks. The concepts are visualized by computer generated 3D renderings and design solutions are reviewed through computer screens. However, the debate on the utilization of computers in the design process still continues. Many authors (Scwartz R. 19.., Bjerklie, 1992, Lawson and Loke 1997, Latch and Zimring 2000, Dave and Danahy 2000, Wang *et al.* 2002) argue that utilizing computers in the early stages of design process causes early fixation and the

extensive need for computer literacy diverts time and effort of designers to information technologies instead of design skills and practice (See section 3.7.2 of this section).

Although the debate about the utilization of information technologies in design studio continues, it is a fact that computer tools have penetrated into every stage of design process. Velasco and Clayton (1998) identify two perspectives of utilization of computer tools in design studio;

- To increase the efficiency and the productivity of designer in design process by utilizing CAD/CAM tools.

- To satisfy the needs of a global market by utilizing communication and collaboration tools.

In the first perspective, computer tools are generally used at the later stages of design process to create design presentations. The "glossy" photorealistic renderings from a number of perspectives, and design presentations created for juries are generally products of the main utilization of computer tools. Image manipulation tools give students the opportunity to blend various media in designing their presentations. Marx (2000) notes that studio instructors must make sure that students look beneath the "glossy" presentations and grasp the conceptual depth of graphic design in the computer generated presentations. Although computer tools are very effective in creating presentations, they may be accused of limiting the exploration of problem space and inhibiting the alternative generation when they are utilized in the early stages of design process (See section 3.8.1 of this Chapter).

In the second perspective, CAD tools are used with the communication technologies to support the collaboration of geographically separated studio participants, which can be achieved by VDSs. One of the main motivations of virtual design studios is to prepare the design students for a global market where designers are expected to be engaged in design projects that arose anywhere in the world and they are asked for working with smaller budgets in shorter periods of time (See Chapter 3.2).

Computer tools have changed and will continue to change the design practice and process. The tools and design process are evolving in interaction with each other. Marx (2000) identified 6 points that need to be focused on in architectural design process with the introduction of digital design tools, which are;

- *Digital-based design will replace traditional modes of architectural design.*
- *Students must learn to design "on screen", initially without hand sketching.*
- *Instruction should be "Creatively-based" rather than "Skill-based".*
- *Instruction should be taught independently of design studio courses.*
- *Instruction should be comprehensive, beginning with initial massing studies and finishing with high resolution graphics.*
- *Digital-based graphic design will raise expectations for presentation quality, both in terms of content and imagery.* (Marx J. 2000, p 20)

3.7.2 Computer Literacy for a VDS

A wide range of computer tools are utilized in VDS. The degree of computer literacy required to utilize these tools and ways of learning the required literacy will be discussed in the following sections.

3.7.2.1 Degree of computer literacy required for a VDS

Velasco and Clayton (1998) state that utilizing computer tools in communication and in design process require students to acquire an impressive range of computer knowledge, which would be quite hard to achieve during the design course; and noted that courses that utilized computer tools extensively would be in danger of being only a software training course. However, they noted that, the solution of design problems generally required the use of many software packages and hardware tools; consequently, students must obtain an ability to choose the right tools at the right time for the right job and to transfer the information from one tool to another. Dave and Danahy (2000) noted that without learning to be selective in utilizing the right tools in the process, students' design skills alone would not meet the demands of computer supported design studios. They also pointed out that, in

such a studio technical and design skills both are equally weighted in the evaluation of design projects.

Many authors argue that a prerequisite or an introductory computer aided design course is necessary to get the maximum effectiveness from a computer supported design course (Chiu 1998, Velasco and Clayton 1998, Marx 2000). In an empirical study carried out by Marx (2000), it was observed that students enrolled in an introductory digital design course were differentiated by the level of detail in their models and the degree of sophistication in their architectural designs, also one third of the class maximized their potentials as designers and their use of computers. Chiu (1998) states that, technical sessions prior or parallel to the studio sessions are critical for the performance. He adds that the performance of computer supported design studio is associated with the learning curve of the technology, but the technology does not directly affect the quality of design. CAD and communication tools contribute to the design process by increasing the effectiveness of decision making, consultation, negotiation, evaluation, and confirmation.

Both in a computer supported design studio and/or in a virtual design studio, the computer tools utilized require extensive computer knowledge. Students have to be familiar with the software and hardware utilized in the studio. They have to be able to use a wide variety of software packages and hardware tools to select and utilize the appropriate ones according to their needs. Another point noted by Velasco and Clayton (1998) is the "adeptness". In their point of view, being able to use the tools is not enough for a digital-based design studio participant. The students have to be proficient in utilizing the needed tools, not just only as being professional at one particular but as becoming expertise in all of them. Moreover, they have to know the limitations of the tools and the ways to transfer data from one to the other

On the other hand; Kalawsky (2000) reports that the computer literacy required to efficiently utilize computer tools in design progress sets barriers to the designers who wish just to use the tools without becoming computer experts. He adds that some designers do want to be IT skilled but the majority consider computer as a major barrier to their creativity and progress.

3.7.2.2 Teaching the Required Computer Literacy for VDS

Many designers and design students want to enjoy the wide capabilities of CAD applications. There are many 3D design packages that can build, manipulate and visualize complex products; however they are difficult to learn (Kalawsky, 2000). As students are expected to know at least a bunch of applications to build a 3D computer generated model of a product when they are hired by a firm, they have to learn to use computer applications before they graduate from design schools.

> *"In terms of instructional objectives students must be offered learning opportunities that provide remedial knowledge, breadth of knowledge, effective use of computers and skills in learning computing"* (Velasco, Clayton, 1998, p8)

The design process taken as a framework, students have to actually practice how all the tools are utilized in designing in an effective manner. In essence, the design process requires the utilization of different applications and the transfer of data from one application to another. As a matter of fact, knowing the limits and capabilities of application becomes as important as using it to create the design solution.

It is certain that students have to be taught to use digital design tools but the question is; how? The aim of a design studio is the creation of possible design solutions, the content, but the computer itself is not the creator of content, it just facilitates design ideas (Marx, 2000).

> *"It is the implementation of theory and critical analysis which should be the core concern of studio instruction. Given the limited time students are exposed to design studio it would seem appropriate, then, the digital tools, which facilitate the design process, be taught separately, so as not to dilute the design studios importance."*(Marx J. 2000, p 19)

Also Velasco and Clayton (1998) added that a design studio utilizing computer tools must avoid becoming merely a computer tools training course; therefore, information technologies must be taught separately at the foundation level of design curriculum.

Marx (2000) identified 2 models of teaching digital design at university level; a course as an attachment to the design studio or a course independent from the design studio. In the first approach, students learn designing with computers during the design studio. Students try to create, modify and visualize their designs with their limited knowledge of digital design tools. This is like trying to write a meaningful text without knowing the entire alphabet and the relations of the letters. However in the second approach, students focus solely on learning the "tools" instead of learning both to design and to utilize information technologies.

Marx (2000) made a further classification in the second approach; creativity or skill based teaching of digital design as a course independent from design studio. In creativity based approach, students are asked to design without hand sketching and entirely on computer screen. However; he observed that the habit of hand sketching is quite strong and students design by hand and prepare the final presentation with computers. In skill-based approach students are asked to complete a series of tutorials or examples from simple shapes to complex objects in an incremental manner (Marx, 2000).

Kalawsky (2000) states that generating tutorials for each application speed up the learning process very much, by means of giving students hands-on experience on predefined exercises. Besides the help of all of the tutorials and examples that are supplied during the course, there is one other issue referring to Kvan (2001), which is the ease of acquiring computer skills with peer learning.

After taking the digital design course students know that what they can do and what they can not do with computer tools. Moreover, they will be able to decide on which tool to utilize in the design process.

Before starting to teach digital design, Marx (2000) listed the goals of digital design course as follows;

- *To teach students to design "on screen", as an alternative to the traditional plan and elevation process. To understand the value of a digital-based evaluation and prediction process.*
- *To encourage students to design more in 3D, using a variety of complex, organic and/or compound curve-based shapes.*
- *To encourage students to use digital design in their studio courses.*
- *To teach students a comprehensive digital design process. One beginning with initial massing studies and ending with high resolution presentation drawings.*
- *To expose students to the image making opportunities of realistic rendering techniques.*
- *To expose students to the opportunities of graphic design via the computer, and to explore presentation methodologies beyond the painterly approaches of architectural tradition.* (Marx J. 2000, p 22,23)

After teaching the digital design course Marx (2000) observed that the works of students were more three dimensional than the ones produced in the traditional process and students created their designs from a 3D view-port by exploring the form from its axonometric or perspective views. Moreover, the shapes were more complex and dynamic and there was a motivation to experiment with forms, which were difficult to rationalize with traditional tools.

3.7.3 Issues Raised with the Application of Information Technologies in Design

Information technologies are heavily utilized in design education and profession. The software packages and hardware tools diversify and improve every day. It is very hard to track every change and improvement in the tools and technologies. Rowe (1997) states that designers do not want to learn everything that a computer application can do, they just want to learn that part of the application which they need. However, the part that they need to learn is not very simple.

> *Industrial designers want to be designers first, not system or software experts.* (Rowe J. 1997, p3)

Whatever the designers may have felt about the computers, exploring the user's limits of design on computer screen, it is widely seen that computer tools are generally applied in the later phases of design process and they are utilized for presentation purposes. Marx (2000) noted that the time and effort involved in the setup and manipulation of tools made them

crude methods to be utilized in the earlier phases of design process. Although many studies are carried out and a number of tools are introduced to support the initial phases of design, designing completely on computer screen seems not practical in the near future.

Before contemplating a design process "fully" carried out on a computer, it should be taken into account that the participants of the computer supported studio would have different levels of computer knowledge. Actually, a computer supported design studio assumes that all the students enrolled are familiar with computer tools; however this happens to be not the fact. Without a prerequisite basic computer tools course, students with a variety of computer knowledge enroll to the design studio. In such a studio it is obvious that students with little computer knowledge will retard and students with a breadth of knowledge will advance more. Velasco and Clayton (1998) stated that to give the opportunity to succeed to the relatively computer illiterate students their computer skills must be improved with a separate course.

The gap between computer illiterate and literate students increases more in a virtual design studio in which the communication is also computer mediated. To carry a complete design process in a VDS, VDS must integrate, *"designers' goals, descriptions, reasoning paths in their design steps, partial solutions to design task, design communications and information exchange"* but there is no such a single computer system that supports all the information, as a result, a VDS employs a wide variety of different tools such as, hypertexts, tables, images, 3D models, animations, linked web sites etc. (Laiserin J. 2002). The need to create and edit the content in all these media requires specific knowledge on each medium. Cheng (2000) stated that since 3D modeling; photorealistic rendering or web authoring takes time from design; a balance must be setup in between. The risk of becoming a computer training course is always apparent, when the balance is not made properly.

3.8 Issues raised in Virtual Design Studio

The literature of virtual design is being supported by sufficient empirical studies. When the findings of those studies are scanned, six common issues are identified:

- Utilization of CAD tools in the early stages of design
- Costs of computer tools
- Technical support
- Peer Learning
- Desk reviews, virtual juries and evaluation of design projects
- General issues regarding computer aided design tools.

3.8.1 Utilization of Computer Tools in the Early Stages of Design

The analysis of problem space and concept generation forms the initial or early stages of design process (See Chapter 2.3). Concept generation is very important as design alternatives created in this stage constrains the later stages of design. Latch and Zimring (2000) state that initial concepts play a constraining role as objects of fixation; however, in an ideal design process the concepts would be flexible enough to be developed and modified easily when new information becomes available for input in the later stages of design process. Wang *et al.* (2002) notes that the result of concept generation phase affects the basic shape and material selection for the product, that's why it becomes extremely difficult to compensate the shortcomings of a poor design concept. Designers mainly use hand sketching in their search for concepts and initial forms. Although, pencil and paper have been the primary tools for designers to "sketch", computer tools began to be utilized for concept generation in the last decade.

3.8.1.1 The Role of Sketching in Design Process

Sketching plays an important role in design process. Won (2001) states that drawing is the most effective and fastest way for designers to express their ideas. Sketching is a versatile tool for exploratory design and "*the representations of mental images on paper often adds clarity to a design* (Schweikardt E. Gross M.D., 2000, p109). However, sketching does not have a worldwide standard convention, like technical drawing. Lawson and Loke (1997)acclaim that sketches do not have to explain themselves, as they are not a tool for design communication, but they are for the designer him/herself and as they are designers'

personal tools for exploring design space. At the early stages of design process, designers are not concerned with a finished or totally resolved design; and consequently there is a great uncertainty in the sketches or works of designers during concept generation phase (Lawson and Loke 1997). The unresolved and rough drawings provide multiple representations for designers. Gero and Reffat (2001) state that multiple representations provided opportunities for designers to conceptualize and interpret the possible design solutions from different views; moreover, multiple representations allowed the coexistence of several descriptions of the same design.

Sketching may also be used for stimulating the idea generation of design groups. Lugt (2000) states that visual expressions, especially sketching, were key activities to originate new product ideas for industrial designers and enabling designers to sketch in "creative problem solving meetings" might make these sessions more suitable for product design context.

3.8.1.2 Issues Raised with the Application of Computer Tools in Concept Generation Phase

Traditional design studio teaching is based on the notion that successful design solutions and design learning is directly related to which extent the problem space of the design is explored (Schön, 1987). This states that studio environment should foster better exploration of problem space and avoid fixation on early phases of design process (Kvan, Yip, Vera, 1999). At the early phases of design process, designers analyze more than one concept or design idea in parallel without criticizing the concepts in detail. Many authors (Lawson B., Loke S. 1997, Kvan T., Yip W. H., Vera A. 1999, Won P. H. 2001, Kalawsky R. S. 2000, Schweikardt E., Gross M. D. 2000) state that the main drawback of computer tools lies in their deficiency in supporting the ambiguous, uncertain and ill-defined nature of the concept generation stages of design process. Dave B, Danahy J, (2000) state that due to the modeling applications, design representations lack the ambiguous nature of traditional drawings and moreover they argue that computer generated design representations appear more concrete and decisive than its author may have intended. Computers can produce an immediate and precise visual feedback and designer might easily be influenced by the finished look of computer graphics to form some imaging in his/her mind, which plays an

inhibiting role when the designer uses computer to generate concepts (Won P. H., 2000). Rowe (1997) states that utilizing computers in design studio forces students to do too much too soon. Rowe J.(1997, p4) observed that "*students using computers methods have a tendency to commit to a design as "final" too early in the process without exploring an optimal solution to a design problem."* In addition, Dave B, Danahy J, (2000) state that the use of digital media does not support generation of multiple alternatives; they go further with the fact that students could create separate CAD files but they are the versions of the same design idea; and they tend to get drawn by one proposal and finalize it very early in the design process. Bjerklie D. (1992) added that, CAD systems allowed designers to record and present design ideas but they hardly generate multiple alternatives.

In a VDS students have the opportunity to use both traditional and computer tools. The sketches and drawings created with pencil and paper are converted to digital media by means of imaging devices for further work on computer.

Since existing CAD systems focus on the detail and generation of one single precise computer model, most designers use computers for generating presentation drawings, but not for designing. (Lawson B., Loke S., 1997). According to Scweikardt E., Gross M. D. (2000) designer's frustration of the initial design exploration tools provided by current CAD tools, forms the basis for designers to start the design process with hand sketches and only after then to convert them into digital media to go further with the design. At the initial stages of design the information about the intended solution is ambiguous, fuzzy and incomplete; as a result, current CAD packages that work with tight tolerances and exact dimensions become useless at the early stages of design. Kalawsky (2000) states that there are very few design tools that support the conversion of conceptual ideas to the virtual mock-ups, which can visualize design solution without exact dimensions and final look. There are many sketching software that utilize a graphic tablet and a stylus, however hand-eye relationship changes when using them. Designer has to learn to look at the screen while drawing on the tablet. Also, there are sketching applications which supports graphic tablets and stylus or mouse, but they are mostly 2D systems. CAD tools such as 3D Max, Alias Studio Tools, FormZ are quite capable of supporting initial stages of design; nevertheless

they require a high degree of computer literacy before the users can express themselves clearly (Kalawsky, 2000).

Won P. H. (2001) carried out a study to compare the concepts generated with CAD tools and with traditional methods; pencil and paper. He found out that; (1) more concepts are generated in unit time when pencil and paper are utilized; (2) The representation of initial concepts is concrete with CAD tools, while they are rough and open to interpretation with pencil and paper; (3) On the aspect of shading and rendering CAD tools generate renderings immediately, whereas it takes more time to do the same with conventional media.

3.8.1.3 The role of Textual Communication in Virtual Design Studio

The shortcoming of current CAD tools in initial stages of design resulted in the search for alternative methods to support design process. Latch D., Zimring C. (2000) states that focusing more on the textual discussions between participants and less on visual presentations might support the concept generation phase in a better way. *"Textual discussions and other open-ended representation schemes may enable participants to express their concepts even if they are difficult to pin down at the start* (Latch D., Zimring C. 2000 p 202). The advantage of words over pictures in expressing early design ideas is explained by Lawson and Loke (1997) with the possibility of interpretation that words are able to sustain.

> *It is what they (words) leave out rather than what they say is important* (Lawson and Loke 1997, p176)

In a VDS, participants have the opportunity to communicate through many channels, including audio/video conferencing and chat-line (See chapter 3.6). In contrast with the view that virtual design studio must be a simulation of traditional design studio and must utilize tools to mimic the physical environment of traditional design studio, which basically favors a video/audio connection; Kvan, Yip and Vera (1999) observed that VDS participants using a chat line to communicate, explored more ideas than those using video/audio; thus chat line enable a richer exploration of problem space than video/audio condition.

3.8.2 Costs of Computer Tools

For a VDS to work efficiently all the software and hardware must be compatible with each other. Before initiating the design course, careful planning must be made to ensure the compatibility. In many software packages, files created with a later version cannot be opened or modified with the earlier versions. Following that, all of the software packages must be up to date or at least compatible with each other. In addition, computer hardware must be capable of running the latest software, since software updates usually require faster and more powerful PCs. Information technology is a frequently improving industry and generally in every 3 months new versions of hardware and in every 6 months new versions of software are introduced to the market. To sustain the quality of the computer tools systematic upgrade is necessary. Kalawsky (2000) states that there is a risk of obsolescence of the tools if the educational institution does not continually invest on the tools. However; he also notes that selecting the optimum hardware is extremely important, as the most expensive facility is not always the best facility. Furthermore, he claims that if everything is working, it is not necessarily needed to upgrade the utilized tools to newer versions in order not to get caught to "upgrade trap". He also acclaims to keep the old adage in mind; "if it isn't broke then don't fix it"

3.8.3 Technical Support

VDS participants are more computer literate than an average person but when it comes to solving technical problems related to hardware and software, professional support is necessary. Chiu (1998) states that, effective technological support is an essential factor for a successful virtual design studio. Technical support is necessary not only before the studio sessions but also during the studio sessions. VDS place heavy demands on network, communication tools (audio/video conferencing equipment, web cams, microphones) and software, so; any problem occurring during a studio session must be fixed as soon as possible in order to finish the session within the planned time. Users who are not that much familiar with computer literacy will need a higher degree of support for ordinary work like modeling, rendering and setting up a conversation, as well as for extraordinary situations when software and hardware bugs takes place. Kalawsky (2000) noted that hardware and

software bugs apart from being tedious, are extremely time consuming to debug and in many cases the solution to these problems exceeds the time scale of the studio.

When students use the school workstations, it is relatively easier to solve technical problems than it is at their own PCs at home. Any failure of a device or software might cause the design work to be late, as processes are interconnected. To ensure that everything is compatible with each other and will perform as expected, technical staff must check the tools in advance.

3.8.4 Peer Learning in VDS

Students learn better when they work together on a problem (See Section 3.3.1.2 of Chapter 3). By dividing up the tasks, they are able to examine more issues and by discussing the issues between themselves they test their ideas through different perspectives (Kvan, 2001). To motivate students to do so, virtual environment must have certain kind of characteristics and Kvan (2001) identifies 4 reasons to motivate students to provide contributions and accomplish something:

- Need to complete, to find the shortest way to the end.
- Engaging in an intellectual quest, to diverge from others.
- The activity of others, peer pressure, competition
- To satisfy the examiner.

With the contributions motivated by the above reasons, students create a virtual environment like a traditional design studio in which the contributions of all of them can be seen on the walls. Students learn from each other's work by seeing a large number of alternatives for the same design problem, which helps them to increase their design experience and form a background for future design tasks (Engeli M, Mueller A, 1999).

In a traditional design studio, instructors build studio communities through group work and reviews, to make them informally learn from each other. To go further, physical studio setting allows students to observe each others work and reviews, which plays an important

role in peer learning (Zimring C *et al.*, 2001). On the other hand, working with peers is a problematic issue in VDS. Vaitkus (1991) draws attention to the fact that effective groups are not likely to be formed if "anonymity" is present. He acclaims that trust relationships are essential to be built if groups are to be established and it is needed that group members know each other if they are to shape a group. Peer learning, as being dependent on the above mentioned factors might be held back if any deficiencies occur regarding to that events. As mentioned before in section 4.5.3 of this chapter, textual communication might be better for exchanging of design ideas; however, to motivate peer learning it is urgent to build trust relationships between the participants and it is might be possible when audio/video conferencing, allowing the participants to have a facial contact is provided.

Another problematic issue of peer learning in VDS is commenting on each others' work. Latch, Zimring (2000) and Zimring *et al.* (2001) state that, although students are encouraged to post comments on each other's work no one appears to post a comment on the other student's project. The same results were observed in Delft-Metu case (See chapter 4).

3.8.5 Desk Reviews, Evaluation of Design Process and Virtual Juries

3.8.5.1 Desk Reviews

The distributed nature of virtual design studio does not allow instructors to walk into the studio and have an opinion about the progress of the students. In a VDS, instructors can examine the shared database in which all the contributions are visible; however, they do not have the opportunity to see the discarded alternatives as opposed to the chance of seeing them all in traditional studio. In an asynchronous review in VDS, student posts the finished or final idea sketches or drawings to the instructor, but in traditional desk review instructor has the opportunity to see the discarded alternatives or the sketches instantly.

In a synchronous review, students have to make pre-planning in order to use the time efficiently and they must organize the content and form of the interaction (Sagun, Demirkan, Göktepe, 2001). Zimring *et al.* (2001), notes that, the unstructured dialogue in synchronous criticism was not achieved due to the limitations of both hardware and human interest; however; the structured criticism proved to be effective considering the fact that it

sustained the interaction between the students and instructors despite the geographical distances.

Feedback; a form of which appears to be "desk review", is very important for creative work since the quality of the contribution can only then be evaluated when human judgments are available (Engeli, Mueller, 1999). In a VDS, feedback can be supplied through design reviews and comments on the contributions. The first is a more structured and formal method, however the latter is cumbersome and raises some psychological aspects. Contemplating the need for privacy, it has to be taken into account that some participants may want some of the comments they have received, not to be seen by everyone and instead may want them to be kept in secret (Engeli, Mueller, 1999).

In a VDS, the instructors, reviewers or remote experts have some advantages over traditional setting; (1) they are free to prepare their comments according to their schedule in a certain time period of course, (2) they can consult relevant material, colleagues or partners (3) they can organize and review their comments before posting (4) they are able to scroll back to the previous contributions of students and (5) they can compare the works of multiple students at once (Zimring *et al.* 2001).

The main problems regarding the criticism in VDS occur during posting of comments and reviews. Latch and Zimring (2000) report that, reviewers commented that they were not sure about whether their comments have been taken into account or even have been read by students. Latch and Zimring (2000) note that in some cases critiques were totally disregarded by the students. On the other hand, students reported that sometimes comments were not addressing the problems that they were dealing with. Since there was a time gap between the posting of design work and comments, students moved to a further step or changed their design in the mean time (Zimring *et al.* 2001).

3.8.5.2 Evaluation of Design Process

During the design process students create a wide variety of work including, sketches, drawings, 3D models and renderings. In a conventional design studio, instructors can keep track of students by having a look on their sketchbooks or file of works during the project.

However, in a VDS instructors do not have this opportunity. Students might be asked to keep a history of their digital files to track their progress but the computer software today is not likely to convey clear messages about the development stages of design to someone who's been outside the creative process in that digital medium (Bharat, Danahy, 2000). In a VDS, Zimring *et al.* (2001) asked students to create an individual online journal, which consisted of initial ideas, discussions, considerations, evaluations, concepts, sketches, drawing etc. However, the final journal became too long, scattered, and hard to browse, where it's been also observed that some students refused to put their initial ideas to public environment.

In another study, Kolarevic *et al.* (2000) utilized a shared database in which students submitted their work by linking to another contribution which was the older version or a version of the newer one. With this database, a hierarchical structure, a genetic tree was created and the design development process was recorded in the database in which students were able to see the parent-child relationship of the contributions in each phase.

3.8.5.3 Virtual Juries

The open juries of conventional design studios are simulated in VDS courses; however, many difficulties were encountered in such juries (Kvan, 2001). There appeared to be technological problems as well as problems arising because of social and cultural communication gaps.

In a VDS review LCD projectors and/or computer monitors are utilized as presentation media. Being constrained with the technological limitations of the display media, students have to be more careful with the design of their presentations. Kvan (2001) notes that presentation is also a part of the learning and gains more importance in a VDS jury than it actually has in a traditional design studio.

Bharat and Danahy (2000) identified 3 important drawbacks of synchronous virtual juries, which are;

- Unlike traditional design studio juries, reviewers do not have the chance to see all the work of a student in an electronic jury. The documents arrive in squence avoiding the simultaneous cross referencing (Bharat and Danahy, 2000).

- Compared to the high resolution print-outs, the presentation area is quite small in electronic juries (Bharat and Danahy, 2000).

- If an LCD projection is used the space is dimmed out, the people at the other side of the video conference cannot see the broadcasting side, particularly who is talking and how many people are participating (Bharat and Danahy, 2000).

Kvan (2001) noted that some schools attempted to avoid the problems of synchronous juries by arranging meetings where participants review the material on-line and leave the comments according to their wish. In this kind of setting, all reviewers download the students' work to their local computer and comment synchronously online. This setting minimizes the bandwidth and presentation area requirements, however, the differences in the download speed of reviewers make it difficult to examine large quantity of work synchronously.

3.8.6 General Issues

There are some general issues raised in conduct of a VDS. These issues tend to be in larger scale and require the setting of new standards or conventions. The general issues can be classified under 5 main titles which are;

- Learning the tools and technologies

- File formats and sharing the CAD files

- Insufficient computer hardware

- Reliability of information on WWW

- Continuous learning of computer tools

3.8.6.1 Learning the tools and technologies

For an efficient VDS the tools and technologies must be introduced to the participants in advance. During the initial stages of design process, students still try to learn the environment and cannot focus on the design task (Latch, Zimring 2000). (See also section 3.7.2 of this chapter)

3.8.6.2 File formats and Sharing CAD files

In a VDS quite many different file formats are used and every format cannot be opened by all participants. Especially in 3D modeling and graphical content creation applications the versions and types of files are extremely important. Although translators for different CAD files are available but when the number of translators exceeds 2, it is probable that serious data will be lost (Kalawsky, 2000). As a result, instructors must make a careful forward planning about the file formats and standards.

3.8.6.3 Insufficient Computer Hardware

Today there are many hardware tools for different applications; however there are insufficient hardware tools to be utilized in design process. The lack of 3D input tools, like digitizers and/or laser scanners requires the 3D modeling of every object to be used in computer environment including mock-ups. Mock-ups made for form seeking and conceptual thinking become concrete and look finished when modeled with highly precise computer modeling tools.

3.8.6.4 Reliability of Information on WWW

The reliability of the information in WWW is an important issue, since students tend to use WWW more than they apply to traditional databases like libraries and local experts. As there is no refereeing mechanism for the information in WWW and much of the information is anonymous, it is a very much likely that the information gathered from the Internet is unreliable.

3.8.6.5 Continuous Learning of Computer Tools

Computer tools improve in a continuing manner and it is extremely important for design students to be equipped with self education skills in order to improve their computer skills in the future (Velasco, Clayton, 1998). Much of the information regarding to the computer skills is technical and might be gained through online tutorials, students should be accustomed to utilize tutorials for self-paced learning.

C H A P T E R 4

CASE STUDY

ID 319 – Virtual Design Studio

4.1 Introduction

In order to observe and test the previously discussed subjects throughout the research, a virtual design studio course was carried out with the cooperation of Middle East Technical University (METU), Department of Industrial Design (Ankara) and Delft University of Technology (TUD), Faculty of Architecture (Delft) was studied as a case.

The course was conducted in 2003-2004 Fall Semester and its duration was 12 weeks. Apart from the last three weeks, 9 weeks of the course were conducted with the participation of both schools.

4.2 Methodology

Methods utilized during the case study are questionnaires, interviews, video recordings and personal observations of the researcher. Before the course, a questionnaire of 14 questions was given to the students to collect data on the accessibility of computer tools and network resources at their own environment. During the course, studio progress and motivation were analyzed by the help of video recordings and personal observations. After the course, interviews were conducted with students and a questionnaire was asked to be filled to collect data on satisfaction of students from the course.

4.2.1 Context of the Case Study

ID 319 – Virtual Design Studio, which is the focus of the case study, was an elective course offered in the undergraduate curriculum of Department of Industrial Design. The course aimed to carry out a design project in collaboration with a geographically distant partner by utilizing synchronous and asynchronous communication channels and digital media. The course was organized once a week and distant partners got familiar with each other by IT tools.

In 2003-2004 fall-semester the course was carried out with Delft University of Technology (TUD). The exchange and broadcast of the contributions were achieved through a virtual environment, called Infobase. Participants were able to log-in to the environment and they were allowed to browse, upload, download, comment and rate the contributions. Also they were able to see the history of a contribution, its parent and child, through a java applet.

Because of the mismatch between the academic calendars of the two universities, students at METU started the semester 3 weeks earlier than the official date announced in the academic calendar. Students were informed about the course during their summer holiday and the course was started with 12 third year industrial design students from METU and 6 architecture students from TUD.

4.2.2 Participants of the Case Study

Participants of the case study were the students who had enrolled in the ID 319 - Virtual Design Studio (METU) and BKMVK05 – Mediated Discourse (TUD). Although 12 students registered for ID 319, one student dropped the course after two weeks as it overlapped with another course. 12 students enrolled to BKMVK05 and 7 students dropped the course because of their academic workload.

The studio started with 11 students from Turkey and 5 students from the Netherlands. None of the students were native speakers of English and both universities were English-medium institutions.

4.2.3 Physical Environment

VDS participants met weekly in Turkey and the Netherlands for synchronous interaction. Participants in Turkey met in the video conferencing room of Faculty of Architecture. Video conferencing room was 7.6 meters in length and 9.3 meters in width (approx. 63 m^2), which provided a comfortable working area for 11 students. Multi media PCs and video conferencing equipment were available in the room for students' needs. In the Netherlands participants used seperate rooms for weekly meetings and video conferencing sessions.

The room in Turkey was equipped with;

- 7 PCs, with Intel Pentium4 processors, 256 MBs of memory, 60 GBs of disk storage and 17 inch displays. Computers had a permanent broadband internet connection through LAN. All computers had an USB web-cam and a head-set including microphone and earphones.

- Video conferencing equipment (Polycom) employed a camera mounted on the equipment and connected to 2 ISDN (128x2 kbps) lines. The camera on the device could move in 2 axes, could zoom and had a voice tracking function.

- An image scanner in A3 size

- LCD projector with a maximum image resolution of 1152x864 pixels.

- All computers ran on Windows XP Professional Edition as operating systems. Microsoft Office XP, Adobe Photoshop 7.0, Rhinoceros 3.0 and Alias Wavefront MAYA 5.0 were installed on computers.

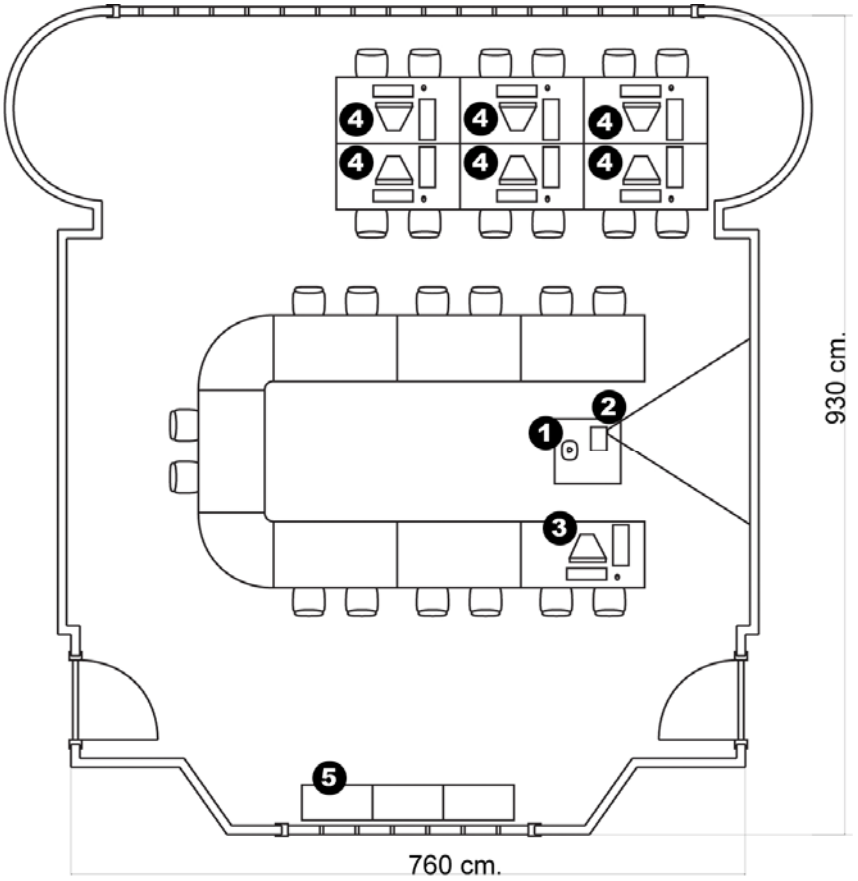

Figure 4.1 Layout of video conferencing room at METU, Faculty of Architecture

In figure 4.1, the equipment is marked by numbers;

(1) Videoconferencing equipment,

(2) LCD projector,

(3) Instructor's computer (the scanner was connected to this computer),

(4) Computers for students' use,

(5) Cupboards for students' belongings,

Meetings, video conferencing sessions and short tutorials on the software packages were carried out at the U-shaped table. The environment had to be dimmed to use the LCD projector efficiently as there were two big windows in the room. The room got very hot during the meetings and created a cumbersome environment to work in.

4.2.4 Virtual Environment; Infobase

In ID-319 virtual design studio, "Infobase" was used as the collaborative virtual learning environment (CVLE). Infobase has been developed by Delft University of Technology to provide necessary medium for students to share their design thoughts in the form of sketches, computer drawings, CAD files and digital animation. A java applet embedded into Infobase enables students to link their contributions to another contribution or create a new thread. The graphical representation of the hierarchy of contributions reveals the history of a design idea or concept through parent-child relation (Akar *et al.* 2003).

Students could use "Guides" and "Browse" pages to navigate through the environment. At "Guides" page (See Figure 4.2), the contributions and authors are listed in three rows according to various criteria. At this page students could see the latest, best rated, most commented and most accessed contributions, as well as all contributors. After clicking on the thumbnail of a contribution or the "browse" button, the second page, "Browse" opens. At this page, students are able to locate the contribution in the process with the graphically represented history of the contributions in the java applet (See Figure 4.3).

The java applet automatically creates a tree structure according to the contributions' parent. Students are able to associate their contributions to thumbnails and keywords in order to track the threads and organize their contributions. With this tree structure students and instructors have the opportunity to track the design process of a concept from beginning to final stage.

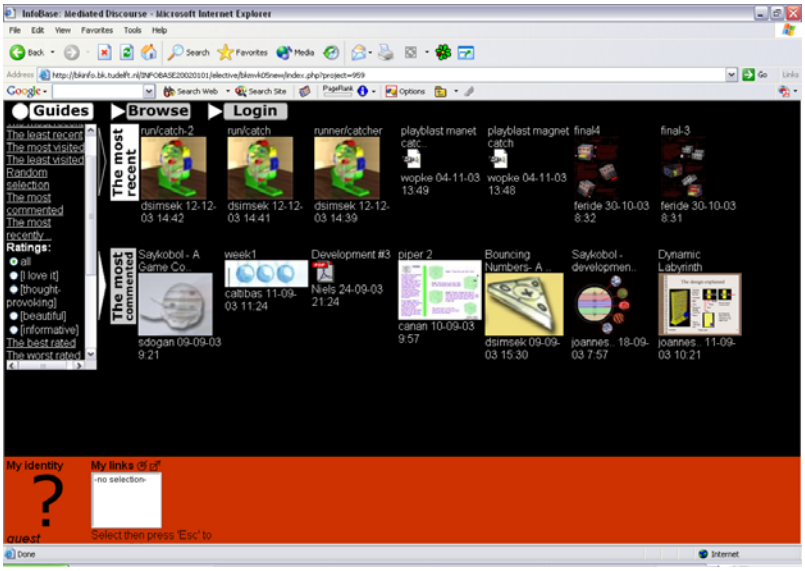

Figure 4.2 Guides view of Infobase

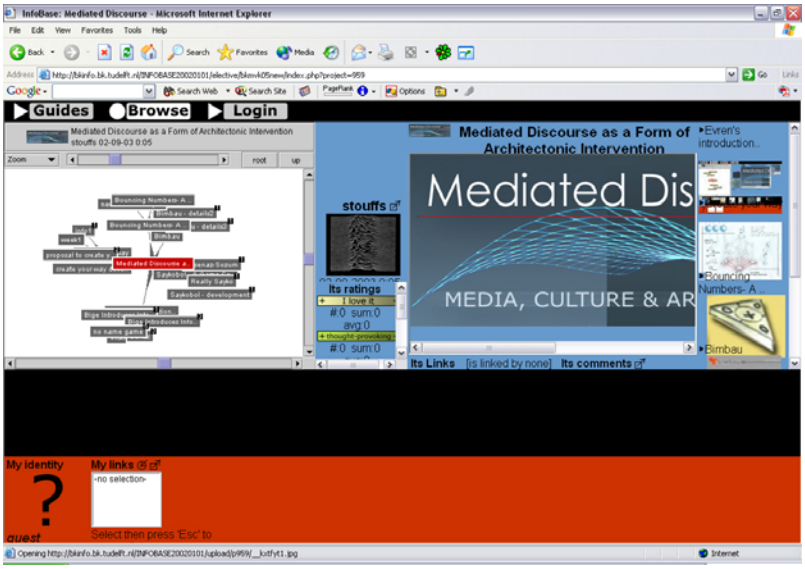

Figure 4.3 Browse view of Infobase

4.2.5 Design Project and Course Schedule

Students were asked to design a game played by either 2 or 3 balls for children aged between 4 and 12. The balls had to move with gravity; and gravity should be considered as a design element while creating concepts. Another constraint was the volume of the game; according to the design brief; the dimensions couldn't exceed 20x20x25 cm. The design brief (See Appendix D) was announced in the first week of the course, and students were expected to create and upload their initial concept-drawings to Infobase before the second week.

Due to the difference in the number of students in the Netherlands and Turkey, students in Turkey formed groups of two. In the first four weeks Turkish groups and Dutch students created concepts individually. After 4th week they formed international groups (one Dutch, two Turkish students in 4 groups and one Dutch, three Turkish students in one group) and collaborated on the refinement and presentation of the design idea they have selected from the previously developed concepts.

The first 4 weeks of the studio were reserved for concept generation, every group or student had to generate a new concept for the first week and upload it to the Infobase. In the following week students or groups had to select a concept from the concepts submitted to Infobase and generate a new concept from it. This iteration repeated for three times. After selecting a concept intentions, groups worked for three weeks to refine the concept and the last 2 weeks were reserved for the preparation of their presentations. The final presentation and jury was held in the 9th week (See table 4.1). For the final presentations students were required to create a simulation of the game by utilizing Alias MAYA 5.0 dynamics feature, as well as renderings of the product and its packaging.

After 9th week post course questionnaire was distributed and one-to-one interviews were held with the students. The data collection method and the interpretation of the data will be discussed in the next section.

Table 4.1 VDS schedule

		Mon	Tue	Wed	Thu	Fri
Concept Development	Week 1	8-Sep	9-Sep **First meeting**	10-Sep	11-Sep	12-Sep
	W - 2	15-Sep	16-Sep **Pre-course questionnaire**	17-Sep	18-Sep	19-Sep
	W - 3	22-Sep	23-Sep	24-Sep	25-Sep	26-Sep
	W - 4	29-Sep	30-Sep **Formation of international groups**	1-Oct	2-Oct	3-Oct
Concept Refinement	W - 5	6-Oct	7-Oct	8-Oct	9-Oct	10-Oct
	W - 6	11-Oct	12-Oct	13-Oct	14-Oct	15-Oct
	W - 7	18-Oct	19-Oct	20-Oct	21-Oct	22-Oct
Presentation	W - 8	25-Oct	26-Oct **No meeting**	27-Oct	28-Oct	29-Oct
	W - 9	1-Nov	2-Nov **Final jury - End of VDS**	3-Nov	4-Nov	5-Nov
	W - 10	8-Nov	9-Nov **Satisfaction questionnaire**	10-Nov	11-Nov	12-Nov

4.2.6 Data Collection

As it is stated before three different data sources were utilized during the course; interviews, questionnaires, and personal observations. Open and close ended questions in the questionnaire and interviews as well as observations provided qualitative and quantitative data. Descriptive statistics were utilized to calculate the means and standard deviations of quantitative data. The qualitative data collected from the interviews, observations and open ended questionnaires were grouped under common responses and used to reach conclusions on students' opinions about the course. The results of the interviews, questionnaires and personal observations will be discussed in the next sections.

4.3 Pre-course Questionnaire

The aim of the pre-course questionnaire (See Appendix A) was to assess the degree of computer literacy of students. Also the accessibility of computer tools and computer hardware ownership were assessed with open and close ended questions. In order to give local pre-course lectures about computer tools, the questionnaire was distributed only to Turkish students, and the language of the questionnaire was Turkish. The questionnaire was distributed to 11 Turkish students and the return percentage was 100%. The questionnaire consisted of demographic information about the users; accessibility of hardware and network connection and, knowledge about software packages.

4.3.1 Demographic Information

The gender ratio of the students was 8 female to 3 male and the average age was 21. They were all 3rd year industrial design students.

4.3.2 Accessibility of Hardware and Network connection

Three of the 11 students (27.3%) reported that they didn't have any access to a network connection. Among the students that had access, 7 (87.5%) of them had 56Kbps modem lines and one of the students had access to a permanent broadband LAN connection.

All of the students had a computers at home and 3 (27.3%) of them owned a computer for more than 2 years, 7 (63.6%) of them for 1 or 2 years and 1 (9.1%) of them for less than 1 year.

Of the hardware tools; which were printer, scanner, digital camera, digital video camera, graphic tablet, plotter, 3D scanner, 7 (63.6%) of 11 students reported that they had quick and easy access to a printer and 4 (36.4%) had quick and easy access to digital cameras. None of them had access to a scanner which was an essential item for the conversion of freehand sketches to digital environment.

Students reported their knowledge about the hardware as; low with a frequency of 45.5%, medium with a frequency of 36.4% and good or very good with a frequency of 18.2%. 4 (36.4%) of them had never installed a hardware component, 5 (45.5) of them had at least once and 1 (%9.1) of them had assembled a system.

4.3.3 Knowledge about software packages

This section of the questionnaire was composed of 3 parts. In the first part the usage frequency of software packages, in the second part familiarity with collaboration tools and finally students' knowledge about software packages were asked.

In the first part, students were asked to mark their frequency of usage of software packages. Software packages were grouped under the headings of; 3D modeling (Maya, Rhino, 3D

Max, Studio Tools, Solid Works), 2d drafting (AutoCAD), graphic design (Adobe Photoshop, Adobe Illustrator, Corel Draw, Freehand), multimedia presentation (Macromedia Flash, Macromedia Director, Dreamweaver, PowerPoint) and office applications (Microsoft Word, Excel, Internet Explorer, Netscape Navigator). The results are presented at Table 4.2.

Table 4.2 Frequencies of use of software packages

	Once a Day	Once a Week	Once a Month	Once a Year	No response
3D Modeling	3 students (27.3%)	8 students (72.8%)			
2D Drafting			1 student (9.1%)	5 students (45.5%)	5 students (45.5%)
Graphic Design	2 students (18.2%)	4 students (36.4%)	5 students (45.5%)		
Multimedia Presentation		1 student (9.1%)		5 students (45.5%)	5 students (45.5%)
Office Applications	3 students (27.3%)	2 students (18.2%)	3 students (27.3%)	2 students (18.2%)	1 student (9.1%)

The next part of this section of the questionnaire was about students' familiarity with online collaboration tools. The results indicated that 4 (36.4%) of 11 students had used an online collaboration tool. 3 of these 4 students reported that they had used Yahoo Groups as an online collaborative tool.

In the final part the software packages were grouped under 5 main titles; office applications (MS Word, MS Excel, MS Access, Adobe Acrobat), messaging applications (Outlook Express, Netscape Messenger, Eudora, MS Messenger, Yahoo Messenger, ICQ), graphic editing applications (Adobe Photoshop, Adobe Illustrator, Corel Draw, Corel Photopaint, MS Photo editor, ACDSee), 3D modeling and animation applications (3D Studio MAX, AutoCAD, CADKey, Alias Studio Tools, Alias MAYA, Pro Engineer, I-DEAS, CATHIA, ArchiCAD, Rhinoceros) and web publishing applications (MS Frontpage, MS Publisher, Netscape Composer, Macromedia Dreamweaver, Macromedia Flash, Macromedia Director). The results of this part are given in Table 5.3.

Table 4.3 Turkish students' knowledge of software packages

		Never Used	Beginner Level	Medium	Good	No Response
Office Applications	MS Word			4 (36.4%)	7 (63.7%)	
	MS Excel	1 (9.1%)	6 (54.6%)	3 (27.3%)	1 (9.1%)	
	MS PowerPoint		1 (9.1%)	6 (54.6%)	4 (36.4%)	
	Adobe Acrobat	2 (18.2%)	3 (27.3%)	4 (36.4%)	2 (18.2%)	
	MS Access	9 (81.9%)	2 (18.2%)			
Messaging applications	Oulook Express	9 (81.9%)	1 (9.1%)	1 (9.1%)		
	Netscape Messenger	6 (54.6%)	1 (9.1%)	1 (9.1%)	3 (27.3%)	
	Eudora	11 (100%)				
	MS Messenger	4 (36.4%)	1 (9.1%)	3 (27.3%)	1 (9.1%)	2 (18.2%)
	Yahoo Messenger	5 (45.5%)	1 (9.1%)	2 (18.2%)	1 (9.1%)	2 (18.2%)
	ICQ	2 (18.2%)	2 (18.2%)	2 (18.2%)	5 (45.5%)	
Graphic editing applications	Adobe Photoshop	1 (9.1%)	2 (18.2%)	4 (36.4%)	4 (36.4%)	
	Adobe Illustrator	10 (91%)			1 (9.1%)	
	Corel Draw	10 (91%)			1 (9.1%)	
	Corel Photo paint	10 (91%)			1 (9.1%)	
	MS PhotoEditor	7 (63.7%)		1 (9.1%)	1 (9.1%)	2 (18.2%)
	ACDSee	5 (45.5%)	3 (27.3%)	1 (9.1%)	2 (18.2%)	
3D Modeling and Animation Applications	3D Studio MAX		3 (27.3%)	6 (54.6%)	2 (18.2%)	
	AutoCAD	7 (63.7%)	2 (18.2%)	2 (18.2%)		
	CADkey	10 (91%)	1 (9.1%)			
	Studio Tools	8 (72.8%)	2 (18.2%)	1 (9.1%)		
	MAYA	9 (81.9%)	1 (9.1%)			1 (9.1%)
	Pro Engineer	11 (100%)				
	I-DEAS	11 (100%)				
	CATHIA	11 (100%)				
	ArchiCAD	11 (100%)				
	Rhinoceros			6 (54.6%)	5 (45.5%)	
Web-publishing Applications	MS Frontpage	8 (72.8%)	1 (9.1%)		1 (9.1%)	1 (9.1%)
	MS Publisher	10 (91%)				1 (9.1%)
	Netscape Composer	10 (91%)				1 (9.1%)
	Macromedia Dreamweaver	9 (81.9%)			1 (9.1%)	1 (9.1%)
	Macromedia Flash	7 (63.7%)	2 (18.2%)		1 (9.1%)	1 (9.1%)
	Macromedia Director	9 (81.9%)	1 (9.1%)			1 (9.1%)

Virtually all of the students had at least beginner level knowledge on basic office applications (MS Word 100%, MS Excel 90.9%, MS PowerPoint %100 and Adobe Acrobat 81.9%). About half of the students were familiar with an instant messaging application (MS

Messenger 45.5%, Yahoo Messenger 36.4%, ICQ 81.9%). Almost all of the students used Adobe Photoshop (81.9 %) at least in beginner level for graphic editing. All of them used 3D Studio MAX (100 %) and Rhinoceros (100%) at least in beginner level for 3D modeling and animation. A great majority of the students (81.9%) had never used MAYA at the time the questionnaire was distributed. MAYA was used for the simulation of the projects in the 8th and 9th weeks of VDS. To overcome the difficulties about the utilization of MAYA, tutorial sessions were held locally in 3rd, 4th and 5th weeks of VDS. At least %63.7 of students had never used a web-publishing application. Although the illiteracy of students on web-publishing applications was figured out, no tutorial sessions were held; since uploading and downloading contributions to/from Infobase did not require any web publishing applications.

4.4 Observations During the Process

During the course, observations were focused on the communication between the participants, technological constraints and design process. Personal observations during the weekly meetings were systematically logged and the final jury was recorded with a digital camera for further reference. Issues observed can be classified under 3 main titles; communication related issues, technological constraints and requirements of the design process.

4.4.1 Communication Related Issues

During the first 4 weeks as students worked locally and uploaded their contributions to Infobase, the communication among distant students was at the minimum level. Although they worked individually, students used MSN Messenger for weekly meetings, with audio and video transmission. It was observed that they had informal conversations as well as design discussions.

After the 4th week, it was observed that groups connecting to Internet from home collaborated without any problems; however, groups with no internet connection other than university facilities experienced difficulties in planning synchronous communications and division of tasks. The students in these groups also rarely checked their e-mail accounts;

as a result problems occurred in asynchronous communication. On the other hand, groups with permanent Internet connection communicated 3 or 4 times a week and discussed their design in detail. It was observed that they exchanged information very efficiently and organized the process in a more controlled manner. The group without internet connection never exchanged a file synchronously while the groups with permanent connection exchanged files up to 7 Mb.

4.4.2 Requirements of the Design Process

It was observed that during the concept generation stage students created freehand sketches and concept drawings by using traditional media and then scanned the sketches for digital media. Although they were asked to submit their contributions one day before weekly meetings, they scanned and uploaded their contributions during the meeting hours. The main reason behind the late uploading was the inaccessibility of scanners for the students (See Chapter 4.3.2).

During the first 4 weeks, students selected a concept from the ones created a week before and improved it for the next week. It was observed that contributions which were modeled in 3D and rendered on computer were not selected for further improvement. That might be because of the finished look of the contributions.

After 4th week students started to refine their concepts and exchanged draft renderings or design ideas. It was observed that students used MSN Messenger instead of Infobase for the exchange of these draft renderings. This might be because of both privacy and usability reasons. Students perceive Infobase as a presentation environment instead of a file sharing environment because of the rating and commenting functions.

Students were required to present their works at the 9th week of the course. The design jury was held in the video conference room. Three main issues were observed during the jury. First of all, the image quality of presentations transmitted to the Netherlands was very poor. Second, due to the crowded environment it was very hard to understand the distant speech. And finally, because of the dimmed environment it was hard to see anything other than the

projected image of the computer screen, moreover participants confused where to look, the screen or the camera of the video conferencing equipment.

4.4.3 Technical Limitations

The video conferencing room of METU, Faculty of Architecture was capable of conducting video conferencing sessions and individual communications via video conferencing equipment and multimedia PCs. Although everything seemed to be in order, when a device started to interact with another one, problems occurred due to incompatibility of two systems. It was observed that computer tools required careful planning and testing procedures before initiating the course. The compatibility of the systems must be guaranteed and before making any changes system has to be backed-up.

To give an idea, some of the technical problems are listed as follows;

- Even though the software packages and computer platforms were the same because of the version conflicts students could not open some files, which they had created at home.

- The scanner in the video conferencing room did not work under Windows XP, because of a driver problem.

- Students experienced problems in establishing audio/video conversations via MSN Messenger, due to the settings of computers.

- As Infobase does not accept large files, students had to use FTP servers for asynchronous and MSN messenger for synchronous file transfers. As a result some of the steps in the development of the product became vague for other participants and instructors.

- The 3D models created in Rhinoceros couldn't be transferred to Alias MAYA during the first weeks. As a result students had to learn modeling with MAYA. This

took time from design studio; students practiced software instead of designing their product.

- The screen resolution of computers in video conferencing room was set to 1024x768 pixels initially. Because of this setting, students couldn't see the "contribute" button on Infobase interface. Some of the students e-mailed their contributions to instructors to upload.

These technical issues showed that technical support is an essential part of VDS especially for students with little computer knowledge.

4.5 Interviews

Interviews (See Appendix C for interview questions) were conducted with each Turkish group to get information on their frequency and channel of communication, and on the way they coordinated design work within their group.

The results of the interviews are listed in Table 4.4.

Table 4.4 Results of the interview with Turkish students

	G1	G2	G3	G4	G5
How do you communicate with your distant partner?	E-mail MSN	E-mail MSN	E-mail MSN	MSN	e-mail
Do you communicate with your distant partner without weekly meetings?	yes	yes	Yes (very structured)	yes	no
How many times a week?	2 (15-30min)	5 (1.5 hours)	3 (3-4hours)	2 (2-3hours)	-
How do you transfer files?	E-mail attachment	MSN, E-mail	MSN	MSN	Never transferred
How do you coordinate your tasks?	We work individually, and then select the best one.	In concept generation, worked individually, in presentation, shared tasks	We work individually, and then select the best one.	Task Sharing	Task sharing

The results of the interview showed that 4 out of 5 groups collaborated on their design tasks by utilizing asynchronous and synchronous communication tools. They reported that they used e-mail to decide on a synchronous meeting time and to send smaller files. However, one group reported that they never met synchronously, other than the weekly meeting hours. They had problems due to the late responses from each other. Both the Turkish students and the Dutch students complained about the lack of interest at the other side. The students in this group did not have access to a network connection at home and replied to each other with a delay and that might be the main reason behind the problems. Groups with permanent connection reported that they had synchronous meeting for 3 to 4 hours when they saw each other online and discussed their design tasks. As a result it can be concluded that the availability of network connection is an essential factor to sustain collaboration and communication.

Students reported (3 of 5 groups) that they did the same task individually and during the meeting they decided on the best one and continued on that work. That approach might overcome the early fixation of design concepts and poor exploration of problem space (see Chapter 3.8.1)

4.6 Post-Course Satisfaction Questionnaire

After the course, a questionnaire (Appendix B) composed of 45 close ended questions was used to collect data on students' opinions about the course. The questionnaire was divided into 7 thematic parts, in the first part demographic information of the student was collected. In the second part students' overall rating for the course was asked. In the third part students' opinions about the elective course was collected. In the next part, questions related to online design education were grouped. In the fifth part opinions about the application of information technologies in the course were collected. In the sixth part questions regarding the comparison of traditional design studio and virtual design studio were grouped and finally in the seventh part questions about the design process and stages of design were grouped.

The questionnaire was distributed to 11 Turkish and 5 Dutch students; of these 10 Turkish 4 Dutch students returned the questionnaire.

As demographic information about the students is listed above (See Chapter 4.2.2) it will not be repeated again.

4.6.1 Overall Rating

Students were asked to mark their overall rating for the course from a five degree scale from unsuccessful (1) to successful (5). The means and standard deviations are as follows:

Table 4.5 Overall rating for the course

	N	Min	Max	Mean	Std Dev
Overall Rating	14	3	5	4,07	0,61

Analysis of overall rating shows that students found the course successful.

From 3rd part to 7th part students marked a five degree scale from strongly disagree (1) to strongly agree (5). The results of the remaining of the questionnaire will be discussed in the following sections.

4.6.2 Elective Course

There were 9 items measuring the satisfaction from VDS as an elective course. The results are shown in table 4.6.

Table 4.6 Satisfaction of students from VDS as an elective course

	N	Min	Max	Mean	Std Dev
I will recommend this elective to my friends.	14	3	5	**4,00**	0,78
This elective course was very useful to me	14	3	5	**3,64**	0,63
This course was an interesting experience	14	4	5	**4,43**	0,51
Such courses should be placed in must courses	14	1	5	**2,79**	1,05
I feel I can achieve design related tasks faster in this course.	14	2	3	**2,36**	0,49
This course is interesting to participate.	14	3	5	**4,14**	0,77
International contacts are very important for elective courses.	14	1	5	**3,43**	1,08
There should be similar courses in the electives of the department.	14	2	5	**4,00**	1,10
Working with international partners was an interesting experience	14	3	5	**4,57**	0,64

Analysis of the responses showed that students thought VDS was an interesting experience (mean score=4.43, std. dev=0.51) and interesting to participate (mean score=4.14, std. dev=0.77). Students indicated that they wanted to see similar courses among the electives of their departments (mean score=4.00, std. dev=1.10), but they disagree on placing similar courses as must courses of their departments (mean score=2.79, std. dev=1.05). Although they agreed that working with an international partner was an interesting experience (mean score=4.57, std. dev=0.64), they were neutral on the importance of international contacts for elective courses (mean score=3.43, std. dev=1.08). Students were neutral on the usefulness of this course to them (mean score=3.64, std. dev=0.63) and they disagreed (mean score=2.36, std. dev=0.49) on the item "I feel that I can achieve design related tasks faster in this course".

4.6.3 Online Design Education

There were 9 items to measure the opinions of students about online design education. The responses to related items in the questionnaire showed that students found the course subject very useful for their design education and professional life and they agreed that publishing works on internet was a motivating factor (See Table 4.7).

Table 4.7 Satisfaction of students from online design education

	N	Min	Max	Mean	Std Dev
The course subject is very useful for my design education and professional life.	14	2	5	**4,00**	1,10
I feel more competent in design by taking this course	14	2	5	**3,29**	1,20
Working with an international partner increased my international communication skills	14	3	5	**4,21**	0,69
Working as a team for a design project is very useful	14	1	5	**3,71**	1,13
Using a website as a design studio has many advantages	14	2	5	**3,29**	0,91
Publishing my works to the internet was a motivating factor	14	2	5	**4,07**	0,99
Seeing each others work and sharing knowledge on the website is very useful in learning from friends.	14	3	5	**4,21**	0,80
Virtual design studios might replace traditional design studios.	14	1	4	**2,57**	1,15
Web-based communication should be embedded in traditional design studios.	14	3	5	**3,71**	0,82

Students agreed that sharing knowledge on the website and seeing each others work was very useful in learning from friends (mean score=4.21, std. dev=0.80), but they were neutral on the item "using a website as a design studio has many advantages" (mean score=3.29, std. dev=0.91) and they slightly disagreed on the item "Virtual design studios might replace traditional design studios" (mean score=2.57, std. dev=1.15).

The responses to related items showed that students agreed on the usefulness of online environment and the utilization of web-based communication tools in traditional design studio, but they thought that VDSs could not replace traditional studio environments.

4.6.4 Information Technologies

There were 9 items to measure the utilization of information technologies and the perceived satisfaction from computer hardware and software. The responses to the items in this section is listed in Table 4.8

Table 4.8 The perceived satisfaction from computer hardware and software

	N	Min	Max	Mean	Std Dev
This course helped me to improve my computer aided design skills.	14	3	5	**3,64**	0,74
This course helped me to improve my computer-based communication skills	14	3	5	**3,79**	0,57
I feel more competent with the new CAD and communication tools that I learned in this course.	14	2	5	**3,57**	1,08
Learning computer tools and solving computer related problems takes too much time	14	1	5	**3,14**	1,23
Internet connection speed creates problems.	14	1	5	**3,71**	1,13
The hardware and software in the university are sufficient.	14	1	5	**3,71**	1,32
The hardware and software in my home is sufficient.	14	2	5	**4,00**	0,87
I am sure that the tools I've met in this course will be useful for me in the future.	14	1	5	**3,86**	0,86
My CAD knowledge was insufficient to succeed in this course.	14	1	3	**1,64**	0,84

The mean scores for the items, "I feel more competent with the new CAD and communication tools that I learned in this course." and "Learning computer tools and solving computer related problems takes too much time." are 3.57 (std. dev=1.08) and 3.14 (std. dev=1.23) showing that students neither agreed, nor disagreed on these items. Although there were some technical problems during the course (See Chapter 4.4.3) students managed to overcome these problems as they have knowledge on computer hardware and software (See Chapter 4.3.3).

Students agreed that the course helped them to improve their CAD (mean score=3.64, std. dev=0.74) and computer based communication (mean score=3.79, std. dev=0.57) skills. At the beginning of the course Turkish students had little knowledge about the modeling,

rendering and physical simulation application, Alias MAYA, and instant messaging applications (See Chapter 4.3.3), but they learned to use these applications during the course.

Students agreed that the hardware and software in the university are sufficient (mean score=3.71, std. dev=1.32) and the hardware and software at their home is sufficient (mean score=4.00, std. dev=0.87). It was figured out that students were satisfied by the hardware and software infrastructure; however, they agreed (mean score=3.71, std. dev=1.13) that internet connection speed created problems.

Students disagreed that the CAD knowledge they possessed was insufficient for the course (mean score=1.64, std. dev=0.84), which means that they had the necessary computer literacy to successfully complete the required tasks during the design process. That was also observed from the quality of end-products and presentations of groups.

4.6.5 Comparison of Traditional Design Studio and VDS

In this part of the questionnaire, 9 questions were asked to students to compare VDS with traditional design studio. The results of this part are listed in Table 4.9.

The responses of students to the related items showed that students neither agreed nor disagreed (mean score=3.43, std. dev=0.85) on the existence of differences between the course and a traditional design studio. Moreover, they had a neutral opinion (mean score=3.50, std. dev=0.94) on the item "I followed a different design process in this course".

Students disagreed (mean score=2.86, std. dev=1.09) on the item "I feel the absence of face-to-face desk reviews with instructors", which shows that they were satisfied with the online feedback.

Students agreed (mean score=3.92, std. dev=0.95) that seeing each other's work on weekly basis was useful in learning from peers and; moreover they agreed (mean score=3.69, std. dev=0.63) that they learned from peers as well as instructors.

Table 4.9 Comparison of Traditional design studio and VDS

	N	Min	Max	Mean	Std Dev
This course is significantly different from a traditional design studio in terms of design process.	14	2	5	**3,43**	0,85
I followed a different design process in this course.	14	2	5	**3,50**	0,94
I feel the absence of face-to-face desk reviews with instructors.	14	1	5	**2,86**	1,09
Seeing each other's work weekly was useful in learning from peers.	13	2	5	**3,92**	0,95
I learned from my peers as well as my instructors.	13	3	5	**3,69**	0,63
In this course, I sketched and searched for alternatives less than usual	14	1	5	**2,79**	1,12
Having to work in digital media forced me to design with computer tools.	14	3	5	**4,00**	0,78
I feel that I should improve my CAD skills.	14	1	5	**3,21**	1,31
Sketching with pen and pencil and scanning them is easier than sketching with CAD tools.	14	1	5	**2,57**	1,65

Responses given to the item "In this course, I sketched and searched for alternatives less than usual (mean score=2.79, std. dev=1.12)" showed that in ID 319-VDS, students' exploration of problem space and their search for alternatives were not different from a traditional design studio.

Although students thought that digital media forced them to design with computer tools (mean score=4.00, std. dev=0.78), the item "Sketching with pen and pencil and scanning them is easier than sketching with CAD tools (mean score=2.57, std. dev=1.65)" showed that students did not feel uncomfortable when they used computer media for sketching and converting conventional media to digital media.

4.6.6 Stages of Design Process in Virtual Design Studio

There were 9 questions to assess students' perceptions on the stages of design in virtual design studio. The responses given to the items listed in table 4.10 pointed to remarkable conclusions about the stages of design process in VDS.

Table 4.10 Stages of design process and VDS

	N	Min	Max	Mean	Std Dev
VDS is very useful in concept generation	13	2	5	3,38	0,96
Having to use digital media in concept generation was a limiting factor for me.	14	1	4	2,36	0,84
I sketched less than I do in a similar project in traditional design studio.	14	2	5	3,14	1,23
All the projects are affected from each other in terms of form and function.	14	2	5	3,57	0,85
Communicating with 3D CAD models is better than 2D orthographic drawings.	14	3	5	4,14	0,77
Evaluation of the project with an online jury was interesting.	14	4	5	4,36	0,49
3D Cad models are very useful in detail design of the project.	14	3	5	4,29	0,61
Presenting my work to an international partner is a motivating factor.	14	2	5	3,93	0,99
Testing my design with computer generated physical simulation (dynamics) helped me create a better design	14	1	5	3,64	1,39

Students neither agreed nor disagreed (mean score=3.38, std. dev=0.96) on the item "VDS is very useful in concept generation"; however, they thought that having to use digital media for concept generation was not a limiting factor. Also, students' responses to the item "I sketched less than I do in a similar project in traditional design studio (mean score=3.14, std. dev=1.23)" showed that in VDS students did not sketch less than they did in a traditional design studio.

Students agreed that communicating with 3D CAD models was better than 2D orthographic drawings (mean score=4.14, std. dev=0.77)", 3D Cad models were very useful in detail design of the project (mean score=4.29, std. dev=0.61) and testing their design with computer generated physical simulation (dynamics) helped them create a better design (mean score=3.64, std. dev=1.39). The responses to related items showed that students found computer tools useful in design communication, detail design and design simulation.

The items "Presenting my work to an international partner is a motivating factor" and "Evaluation of the project with an online jury was interesting" were related with design

presentation and online juries. Students agreed (mean score=3.93, std. dev=0.99) that presenting their works to an international partner was a motivating factor for them. Also they agreed (mean score=4.36, std. dev=0.49) that evaluation of projects with an online jury was an interesting experience.

4.7 Limitations of the Case Study

The course was planned for equal number of students from each school. As some of the students dropped the course, the inequality forced Turkish students to form local groups of two. The tutor critics and instructor involvement were kept at a minimum level, to compensate the inequality of distribution in the groups. Instructors encouraged the collaboration and information exchange among groups, instead of the instructor – student interaction. As a result, private instructor-student design reviews couldn't be observed during the case study.

Remote experts did not involve in the design process as much as the instructors. Therefore interaction between students and remote experts couldn't be observed.

Students used the MSN messenger instant messaging application for synchronous communication. Due to the default settings of MSN Messenger, the texts of communications between group members and students' communications at home couldn't be recorded.

As it is mentioned at 5.4.3 technical limitations section Infobase, the virtual environment used in the course did not permit the uploading of large files; as a result, students used MSN messenger, e-mail attachments and local FTP sites for file transfers. Utilizing different media caused gaps in the tracking of design process. Students preferred to upload finished concepts once a week to Infobase, ignoring the iterations they used.

There is a gap of one hour between Turkish time and Dutch time; this relatively small time difference did not give the opportunity to test design environment and process in the presence of time shift. A further study can be conducted in cooperation with a country which has a further time difference with Turkey.

Although the above mentioned limitations affected the recorded amount of raw data, the amount of data collected by personal observations, interviews and questionnaires created a reliable basis for the evaluation of the course.

4.8 Further Studies

Future work regarding the online design education should focus on the development of a better environment for design exchanges. Collaborative virtual environments like Infobase, should be improved and developed to support the nature of design and the requirements of design education.

4.9 Discussion

Regarding the literature survey carried out during the study the following evaluations can be made;

It was observed that the availability of computer hardware, software and network connection is directly proportional with the efficiency of group-work and collaboration. Groups who had an accessible permanent network connection at home collaborated efficiently, on the other hand groups, who lacked the accessibility of an internet connection at home experienced problems and never had a synchronous interaction; moreover their asynchronous interactions were at minimum level (See Section 3.6.2.1).

Students were able to fix some software and hardware problems occurring during the studio. However, due to occasional serious technical problems students couldn't upload their contributions to Infobase and video conference sessions couldn't be conducted. These problems showed that technical support is an essential and necessary input for a VDS (See section 3.8.3).

In general terms the pre-course questionnaire showed that students had at least beginner level computer literacy on office applications, communication applications, graphics editing applications, 3d modeling and animation applications. Also the post-course questionnaire showed that students thought that their computer skills were sufficient to complete the

course and learning new computer tools did not take so much time for them. With this data it can be said that students equipped with necessary computer literacy and a proper background would not be frustrated with the utilization of sophisticated computer tools in virtual design studio (See Section 3.7.2).

The design process in the case study was pre-structured and the durations of the phases of design process were defined by instructors in the schedule. The first 4 weeks were reserved for concept generation, as the early refinement of design alternatives and poor exploration of design space were discussed in literature extensively (See Chapter 3.8.1). According to the observations and responses given to the questionnaires' related parts the amount of sketching, design concepts and solution alternatives did not changed significantly in the virtual design studio, which is contrary to the literature (See Chapter 3.8.1.2). However, it was also observed that concepts submitted as photorealistic renderings and finished-look were not chosen by students for further development, which is in-line with the literature.

During the concept refinement and detail-design phases computer tools were used extensively. Students agreed that computer tools were useful in design communication, detail-design and physical simulation of design ideas. They also agreed that using digital media was not a limiting factor for designing. That is also contrary to the literature (See Chapter 3.8.1.2).

The shared environment was a motivating factor for students to upload contributions. They argued that publishing works on the net and presenting to an international partner were motivating factors for themselves. However, it was observed that due to social and practical reasons some of the works of the students were not uploaded to Infobase.

Students pointed out that they did not feel the absence of face to face desk reviews with instructors and they agreed that they learned from their peers as well as their instructors during VDS. The responses of students to the related questions showed that seeing each others' work was very useful for learning from friends, which was in accordance with the literature (See Chapter 3.8.4).

The virtual design jury, which was a simulation of a traditional design jury, was frustrating in terms of many aspects (See Chapter 4.4.2), as put forward by the literature (See Chapter 3.8.5.3)

After having completed the course, students agreed that virtual design studio improved their CAD and computer mediated communication skills. They also said that the skills they improved in VDS would be useful in their future academic and professional life, which was mentioned in the literature as one of the main motivations of VDSs.

It can be seen that the results of the case study are in accordance with the literature in the usefulness of VDSs; however, on the computers' role in concept generation and the necessity of desk reviews, the findings of the case study shows discrepancies with the literature.

CHAPTER 5

CONCLUSION

In this chapter the subjects discussed will be put in a framework, through the interpretation of findings of the case study and reviews of the literature survey.

The study will be reviewed in three main parts which are; the main motives that affect the emergence of problem, definition of problem and the analysis of the problem.

5.1 The main motives that affect the emergence of the problem

The driving force, identified in the first part of the research, which promoted the collaborative online design environments, is the need for collaboration both in design education and in design practice. Today, product design process involves collaboration of various professionals from different disciplines. The design process has become so sophisticated and the pressure to shorten the time required to design and market a product is so heavy that one single designer cannot achieve all these tasks. To develop expertise during the design process, design firms promote collaboration and they think that collaborating using computer media is the most efficient way to reach expertise and the market. As a result of the utilization of online collaboration technologies and online design environments, design schools started to teach their students these issues in order to prepare them for the demanding requirements of the design practice.

The other motivation is to diminish geographical distances, to be able to organize design projects with different cultures. Exposing students to schools from different cultures enables them to view the design process from different perspectives and help to identify the degree of their design skills in an international platform. Online design education is efficient and effective in terms of budget and time to achieve this goal.

As a result of the above mentioned motives collaborative online design environments or in general term virtual design studios have emerged.

5.2 Definition of the Problem

One of the main arguments on design education stems from the point that the conventions of design education are well-established and modifying these conventions and changing the medium in which design is taught creates problems. The mechanisms of design education; exploration of design problem space via sketches and ambiguous drawings, private or group desk reviews, peer learning in informal studio environment and the traditional open design juries were indicated as the main problematic areas while creating an online industrial design environment.

The results of empirical studies available in literature show that the exact simulation of traditional design studio through audio / video transmission does not lead to efficient work. The necessity and success of the conventional elements of traditional design studio, which are concept generation with idea sketching, desk reviews, peer learning and design juries, have been proved for years now. However, the way of their utilization in virtual design studios is still not very well structured. The way of application of traditional design methods or traditional design teaching methods in virtual design environments is identified as the main problem in literature. In the next section this problem will be evaluated with regard to the case study discussed in chapter 5.

5.3 Evaluation of Problem

The application of traditional design studio elements; concept generation with sketching, peer learning and a design jury were observed and evaluated during the case study, nevertheless, due to the limitations of the case study desk reviews couldn't be observed.

The findings regarding the utilization of computer tools in the early phases of design process are very promising. The early fixation of design concepts, early refinement of

alternatives and poor exploration of problem space were identified in the literature (See section 3.8.1). The findings of the case study showed that the number of concepts created was not less than a similar project in traditional design studio. Identifying the period for concept generation and imposing a minimum number of concepts helped the students to overcome the problems identified in the literature.

The literature on peer learning in a virtual design studio pointed out that publishing works to public and seeing others' work motivated and encouraged students to participate in studio activities; moreover, literature showed that seeing others' work helped in learning from peers. In accordance with the literature, the shared database utilized in the web-environment in the case study enabled students to see each other's work. The responses from the students showed that this feature of the virtual design studio was a motivating factor and seeing others' work was very useful for learning from their peers.

The problematic aspects of simulation of traditional design juries identified in the literature remained unsolved. The technical limitations of screen resolution and absence of cross referencing between different images were the main problems of conducting an online jury. Although the limitations of technology were very well assessed during the case study, the final works of groups were presented in an online jury. The jury was conducted in a video conference session and the session was video taped. The analysis of the jury session showed that the problems identified in the literature couldn't be overcome.

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APPENDIX A

VDS Questionnaire

Bu anket ID 319 – Virtual Design Studio dersinin değerlendirilmesi ve geliştirilmesinde kullanılacaktır.

Bu ankette alınan bilgiler 3. şahıslara verilmeyecek veya 3. şahıslar tarafından kullanılmayacaktır.

A. Kişisel Bilgiler

1. Öğrenci No :
2. Cinsiyet : ☐ Bay ☐Bayan
3. Yaş :
4. Öğrenim Durumu : ☐Lisans ☐ Yüksek Lisans Sınıf : ___

B. Donanım ve Internet Bağlantısı

5. Evde internet Bağlantınız var mı? Varsa, tipini işaretleyiniz.
   ☐ Bağlantım Yok ☐ Modem ☐ Kablo

6. Bağlantı hızınız nedir? Bağlantı hızınız rahat çalışamanıza olanak veriyor mu?
   ☐56 Kbps ☐128 Kbps ☐ Broadband (T1 / LAN)

   ☐ Evet ☐ Hayır

7. Evde Bilgisayarınız var mı? Varsa kaç yıllık?
   ☐ Yok ☐Var - ____yıllık

8. Aşağıdaki donanimlardan hangilerine sahipsiniz veya kolaylıkla ve hızlı erişim imkanı bulabiliyorsunuz?

   ☐ Yazıcı ☐ Tarayıcı ☐ Dijital Kamera ☐Dijital Video Kamera

   ☐ Tablet ☐ Ploter ☐ 3D Tarayıcı ☐ Diğer .....

9. Bilgisayar donanımı hakkında bilginiz ne düzeydedir? Bugüne kadar hiç bilgisayar içinden bir parça söküp yerine taktınız mı?
   ☐ Az ☐ Orta ☐İyi ☐ Çok iyi

   ☐ Hayır sökmedim ☐ Evet söktüm ☐ Sistemi kendim topladım

C. Yazılım ve Haberleşme Ortamı

10. Aşağıdaki yazılımları ne sıklıkla kullanıyorsunuz?

	Günde 1 Kere	Haftada 1 Kere	Ayda 1 Kere	Yılda 1 Kere
3D Modelleme (Maya, Rhino, 3D Max, Studio Tools, Solid Works etc.)				
2D Teknik Çizim (AutoCAD etc..)				
Graphic Design (Adobe Photoshop, Adobe Illustrator, CorelDraw, FreeHand, etc...)				
Multi Media Sunum (Flash, Director, Dreamweaver, etc..)				
Ofis Uygulamaları (Word, Excel, Iexplorer, Netscape etc...)				

11. Daha önce ortak çalışma araçları (Collaborative working tools) kullandınız mı? (örnek; Msword'teki ortak çalışma araçları, BlackBoard, YahooGroups etc...)

☐ Evet Belirtiniz; ..... ☐Hayır

12. Aşağıdakilerden hangilerini, hangi düzeyde kullanıyorsunuz?

		Hiç kullanmadım	Başlangıç düzeyde	Orta	İyi
Ofis Uygulamaları	Word				
	Excel				
	Powerpoint				
	Acrobat Reader				
	Access				
E-posta uygulamaları	Outlook Express				
	Netscape Messenger				
	Eudora				
		Hiç Kullanmadım	Başlangıç düzeyde	Orta	İyi
	MS messenger				
	Yahoo messenger				
	ICQ				
Resim işleme uygulamaları	Photoshop				
	Illustrator				
	CorelDraw				
	Corel Photopaint				
	Ms Photo Editor				
	ACDSee				
3D modelleme ve animasyon uygulamaları	3D Studio MAX				
	AutoCAD				
	CADKey				
	Studio tools				
	MAYA				
	ProEngineer				
	I-DEAS				
	CATHIA				
	ArchiCAD				
	Rhinoceros				
Web yayıncılığı uygulamaları	MS Frontpage				
	MS Publisher				
	Netscape Composer				
	Macromedia Dreamweaver				

	Maromedia Flash				
	Macromedia Director				

14. Bu dersi tercih etme sebebinizi ve dersten beklentilerinizi lütfen belirtiniz.

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Teşekkürler

APPENDIX B

Participant Satisfaction Questionnaire for ID 319 Virtual Design Studio

Personal Information

1. What is your age? _____
2. What is your nationality? _____
3. What is the number of your team? _____
4. What is your department? _____

1. Overall Rating

	Unsuccessful				
My overall rating for the course is;	[1]	[2]	[3]	[4]	[5]

2. Elective course

	Strongly Disagree 1	2	3	4	**Strongly Agree** 5
1. I will recommend this elective to my friends	[ ]	[ ]	[ ]	[ ]	[ ]
2. This elective course was very useful to me.	[ ]	[ ]	[ ]	[ ]	[ ]
3. This course was an interesting experience	[ ]	[ ]	[ ]	[ ]	[ ]
4. Such courses should be placed in must courses	[ ]	[ ]	[ ]	[ ]	[ ]
5. I feel I can achieve design related tasks faster in this course.	[ ]	[ ]	[ ]	[ ]	[ ]
6. This course is interesting to participate.	[ ]	[ ]	[ ]	[ ]	[ ]
7. International contacts are very important for elective courses.	[ ]	[ ]	[ ]	[ ]	[ ]
8. There should be similar courses in the electives of the department.	[ ]	[ ]	[ ]	[ ]	[ ]
9. Working with international partners was an interesting experience.	[ ]	[ ]	[ ]	[ ]	[ ]

3. Design Education

	Strongly Disagree 1	2	3	4	Strongly Agree 5
10. The course subject is very useful for my design education and professional life.	[ ]	[ ]	[ ]	[ ]	[ ]
11. I feel more competent in design by taking this course.	[ ]	[ ]	[ ]	[ ]	[ ]
12. Working with an international partner increased my international communication skills.	[ ]	[ ]	[ ]	[ ]	[ ]
13. Working as a team for a design project is very useful.	[ ]	[ ]	[ ]	[ ]	[ ]
14. Using a website as a design studio has many advantages.	[ ]	[ ]	[ ]	[ ]	[ ]
15. Publishing my works to the internet was a motivating factor.	[ ]	[ ]	[ ]	[ ]	[ ]
16. Seeing each others work and sharing knowledge on the website is very useful in learning from friends.	[ ]	[ ]	[ ]	[ ]	[ ]
17. Virtual design studios might replace traditional design studios.	[ ]	[ ]	[ ]	[ ]	[ ]
18. Web-based communication should be embedded in traditional design studios.	[ ]	[ ]	[ ]	[ ]	[ ]

4. Information Technologies

	Strongly Disagree 1	2	3	4	Strongly Agree 5
19. This course helped me to improve my computer aided design skills.	[ ]	[ ]	[ ]	[ ]	[ ]
20. This course helped me to improve my computer-based communication skills	[ ]	[ ]	[ ]	[ ]	[ ]
21. I feel more competent with the new CAD and communication tools that I learned in this course.	[ ]	[ ]	[ ]	[ ]	[ ]
22. Learning computer tools and solving computer related problems takes too much time	[ ]	[ ]	[ ]	[ ]	[ ]
23. Internet connection speed creates problems.	[ ]	[ ]	[ ]	[ ]	[ ]
24. The hardware and software in the university are sufficient.	[ ]	[ ]	[ ]	[ ]	[ ]
25. The hardware and software in my home is sufficient.	[ ]	[ ]	[ ]	[ ]	[ ]
26. I am sure that the tools I've met in this course will be useful for me in the future.	[ ]	[ ]	[ ]	[ ]	[ ]
27. My CAD knowledge was insufficient to succeed in this course.	[ ]	[ ]	[ ]	[ ]	[ ]

5. Traditional Design Studio

	Strongly Disagree 1	2	3	4	Strongly Agree 5
28. This course is significantly different from a traditional design studio in terms of design process.	[ ]	[ ]	[ ]	[ ]	[ ]
29. I followed a different design process in this course.	[ ]	[ ]	[ ]	[ ]	[ ]
30. I feel the absence of face-to-face desk reviews with instructors.	[ ]	[ ]	[ ]	[ ]	[ ]
31. Seeing each other's work weekly was useful in learning from peers.	[ ]	[ ]	[ ]	[ ]	[ ]
32. I learned from my peers as well as my instructors.	[ ]	[ ]	[ ]	[ ]	[ ]
33. In this course, I sketched and searched for alternatives less than usual	[ ]	[ ]	[ ]	[ ]	[ ]
34. Having to work in digital media forced me to design with computer tools.	[ ]	[ ]	[ ]	[ ]	[ ]
35. I feel that I should improve my CAD skills.	[ ]	[ ]	[ ]	[ ]	[ ]
36. Sketching with pen and pencil and scanning them is easier than sketching with CAD tools.	[ ]	[ ]	[ ]	[ ]	[ ]

6. Stages of Design

	Strongly Disagree 1	2	3	4	Strongly Agree 5
37. VDS is very useful in concept generation	[ ]	[ ]	[ ]	[ ]	[ ]
38. Having to use digital media in concept generation was a limiting factor for me.	[ ]	[ ]	[ ]	[ ]	[ ]
39. I sketched less than I do in a similar project in traditional design studio.	[ ]	[ ]	[ ]	[ ]	[ ]
40. All the projects are affected from each other in terms of form and function.	[ ]	[ ]	[ ]	[ ]	[ ]
41. Communicating with 3D CAD models is better than 2D orthographic drawings.	[ ]	[ ]	[ ]	[ ]	[ ]
42. Evaluation of the project with an online jury was interesting.	[ ]	[ ]	[ ]	[ ]	[ ]
43. 3D Cad models are very useful in detail design of the project.	[ ]	[ ]	[ ]	[ ]	[ ]
44. Presenting my work to an international partner is a motivating factor.	[ ]	[ ]	[ ]	[ ]	[ ]
45. Testing my design with computer generated physical simulation (dynamics) helped me create a better design	[ ]	[ ]	[ ]	[ ]	[ ]

Thank you
:)

APPENDIX C

Interview Questions;

Hafta içinde grup arkadaşınızla nasıl haberleşiyorsunuz? a) Kaç defa? b) Nasıl organize oluyorsunuz? c) Dosya alışverişinde bulunuyormusunuz? Nasıl? d) Hangi büyüklükte dosyaları alıp veriyorsunuz?	
Ders haricinde grup arkadaşınızla haftada kaç saat ve kaç defa görüşüyorsunuz?	
İşleri nasıl koordine ediyorsunuz?	

ID 319 Virtual Design Studio

Project Brief

Design an original
3-dimensional game with either 2 or 3 balls, for children aged between 3 and 12 years old. This means that you can also design the game for children aged 3 only, or for example aged between 10 and 12.

Other requirements are:

- gravity must be an essential element for the game
- either 2 or 3 balls must be used in the game at the same time
- you must make up a real set of game rules
- in the game the user has to solve a problem or learn a skill
- after several times of playing, the game should still be interesting
- the game should inspire the children to play
- the design (shape, color etc.) and the game rules have to be suitable for the targeted age group

APPENDIX E

GLOSSARY

Asynchronous: A type of communication that occurs with a time delay between the steps in a dialog, allowing participants to respond at their own convenience.

Authoring tools: High-end computer programs designed for creating computer-based training, interactive presentations and multimedia.

Collaboration: Working together or with someone else for a project.

Communication: To share or exchange opinions, feelings, information etc…

Computer-based training (CBT): An interactive instructional approach in which the computer, taking the place of an instructor, provides a series of stimuli to the student ranging from questions to be answered to choices or decisions to be made.

Course: A set of lessons or classes on a specific subject.

Design Education: The process of developing a person's design skills by means of a set of instructions and design projects.

Design: A creative activity, the aim of which is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life cycles.

Distance Learning: A system and a process that enables learners and instructors in different locations to collaborate.

Distributed learning: A system and process that uses a variety of technologies, learning methodologies, on-line collaboration, and instructor facilitation to achieve applied learning results not possible to be achieved through traditional education, in a completely flexible, anytime/anywhere fashion.

Education: The process by which a person's mind and character are developed through teaching.

e-learning: A term referring broadly to technology-based learning.

Evaluation: Judging the value or degree of the design project.

Instructor-led training (ILT): The kind of training in which learners are taught by an actual person: an instructor, teacher or faculty member.

Interaction: Having an effect on each other (instructor on learner, learner on learner) or something else (software, hardware) by being or working together.

Internet (Web) Based: Data stored on a computer, which can be accessed and/or edited through World Wide Web (www).

Multimedia: A general term that usually refers to computer programs that use a combination of sound, video, animation, pictures, and/or text.

Online (on the line): something or someone directly connected to a web of computers and available via a computer connected to that web.

Online Course: A set of lessons, classes or instructions published via electronic media and available through a computer network.

Online Design Studio Participant: A person who attends to a design studio, which is available via a computer network in the form of an instructor, a student or a reviewer.

Participant: A person who takes part or has a share in a design project as an instructor, a student or a reviewer.

Real-time: The processing of information that returns a result so rapidly that the interaction appears to be instantaneous.

Studio: The space in which industrial design students work together on their projects under the supervision of one or more instructors.

Synchronous: A type of two-way communication that occurs with virtually no time-delay, allowing participants to respond in real time.

Virtual design studio: Carrying out a design project in computer environment from conceptual design phase to the product realization.

Web-based training (WBT): A form of computer-based training in which the training material resides on pages accessible through the World Wide Web. Typical media elements used are text and graphics. Other media such as animation, audio, and video can be used, but require more bandwidth and in some cases additional software.

Whiteboarding or Shared Whiteboard A term used to describe the placement of shared documents or material on an on-screen "shared notebook" or "whiteboard."