EVOLUTIONARY
COLLABORATIVE DESIGN STUDIOS

A THESIS
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DOCTOR OF PHILOSOPHY IN
ART, DESIGN AND ARCHITECTURE

By
Aysu Sagun
September, 2003

I certify that I have read this thesis and that in my opinion it is fully adequate in scope and in quality as a thesis for the degree of Doctor of Philosophy in Art, Design and Architecture.

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ABSTRACT

EVOLUTIONARY COLLABORATIVE DESIGN STUDIOS

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In Collaborative Design Studios (CDS), knowledge and information can be shared in discussions among students and instructors, while developing alternative solutions and the task coordination is achieved through the networked environment. In this study, a model called Evolutionary Design Collaboration (EDC) model is proposed as a framework for the collaboration of design courses, based on situatedness and reflective practice. A CDS including an information and a collaboration web site is conducted at the conceptual design level based on EDC model. The design critiques in redline files and the design diaries are evaluated by segmentation method. The redline files are analyzed with respect to 'design abstraction', 'space and representation' and 'variables' in problem domain and 'micro-strategies' and 'design activities' in design strategies. The analysis of design diaries is based on the behaviors and features of problem requirement and solution spaces. Moreover, two questionnaires are given at the end of CDS to identify usability problems in ease of use and user satisfaction.

It is observed that the content of the critiques in CDS is similar to the content of the critiques of traditional design studios. The concept of situatedness is highly practiced as the new issues are introduced to the current design. Moreover, the active role assigned through collaboration to the students enhanced the design process. The high emphasis on the features of design solutions in design process is a similar approach to face-to-face communication. Finally, the results of the study showed the evolution generated by the reflections of participating courses during the collaboration through Internet.

Keywords: Web-based Design Education, Collaborative Design Studio, Situated Design, Reflective Practice, Evolutionary Design.

ÖZET

EVRİMSEL İŞBİRLİĞİNE DAYALI TASARIM STÜDYOSU

Aysu Sagun
İç Mimarlık ve Çevre Tasarımı Bölümü Doktora Çalışması
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İnternet üzerinden yürütülen İşbirliğine Dayalı Tasarım Stüdyolarında (İTS) iş koordinasyonu sağlanabilir ve tasarım üzerinde yapılan tartışmalarla alternatif çözümler geliştirilirken bilgi ve enformasyon paylaşılınabilir. Bu çalışmada "durumsallık" ve "eylem içinde yansıma" kavramlarına dayanılarak tasarım stüdyosu ve diğer tasarım derslerinin işbirliğine çerçeve oluşturması amacıyla Evrimsel Tasarım İşbirliği (ETİ) adında bir model geliştirilmiştir. Bu model çerçevesinde enformasyon ve işbirliği web sitelerini içeren bir İTS hazırlanmış; bir grup öğrenci ve eğitmen ile kavramsal tasarım aşamasında uygulanmıştır. Kritik dosyalarında bulunan yorumlar ve tasarım günlükleri bölümlere ayrılarak değerlendirilmiştir. Tasarım projelerinde yazılan yorumların analizi için, "tasarım soyutlaması", "problem alanı, çözüm alanı ve çizim ifadesi" ve "tasarım değişkenlerini" içeren problem alanı; ve "mikro strateji" ve "tasarım aktivitelerini" içeren tasarım stratejileri kullanılmıştır. Günlüklerinin analzinde ise problem ve çözüm alanlarının davranış ve özellikleri incelenmiştir. Ayrıca kullanım kolaylığı ve kullanıcı memnuniyetindeki sorunları anlamak amacıyla dönem sonunda verilen anketler değerlendirilmiştir.

Bu çalışmada bir tasarım stüdyosunda işlenen ve tartışılan tüm kavramların İTS' da da tartışıldığı gözlemlenmiştir. Öğrenciler diğer bir tasarım dersinde vurgulanan kavramları da tasarım studyosunda verilen problemin çözümünde kullanarak duruma göre tasarım yapmayı deneyimlemişlerdir. Ayrıca öğrencilere verilen aktif rolün tasarım sürecini ve derslerin ortak çalışmasını geliştirdiği gözlemlenmiştir. Geleneksel tasarım stüdyolarında vurgulanan çözüm alanı özelliklerinin İTS' da da vurgulandığı görülmüştür. Yapılan analizler sonucunda iki derslerin katkıları ve İnternet'in işbirliği için tasarım eğitimine adapte edilmesi, bu çalışmada geliştirilen modelin evrimselliğini vurguladığı görülmüştür.

Anahtar Sözcükler: Web Tabanlı Tasarım Eğitimi, İşbirliğine Dayalı Tasarım Stüdyosu, Durumsal Tasarım, Eylem İçinde Yansıma Modeli, Evrimsel Tasarım.

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1. INTRODUCTION

1.1 General

World Wide Web (WWW) and Internet provide an environment for exchanging ideas and critiques (Gross and Do, 1999). The interaction of students and instructors can be provided in collaborative design environments on the Web that enables the flexibility for time and place constraints in teaching and learning. The students collaborate both in synchronous and asynchronous systems, as well as they have a chance to share different points of view related to their individual designs (Gross, et. al., 1998; Sagun et. al., 2001; Simoff and Maher, 2000). The tools for communication can be decided based on the collaborator's profile, design brief and technological potential (Cheng and Kvan, 2001). In this study, a model is developed as a framework for the online collaboration of courses based on Fischer's Seeding, Evolutionary Growth, Reseeding (SER) Model (Fisher and Oswald, 2002) emphasizing the issues of situatedness and reflective practice. The SER model is a process model that has a cyclic flow enabling evolution of the collaborative study. Finally, an asynchronous Collaborative Design Studio (CDS) that involves an information and a collaboration web site within the framework of Evolutionary Design Collaboration (EDC) model, is constructed and implemented within two semesters as the pilot and case studies, respectively. During the collaborative study, the students used the specific knowledge and experience that they had acquired in two design courses; "Design Studio" and "Design for Disabled".

CDS is an electronically distributed, online workspace, which provides the opportunity for the interaction of geographically distributed students and instructors through computer desktop. The Virtual Design Studios (VDS) are the initiation of CDS as a medium for the collaboration of design students and instructors. Besides CDS enables the students and instructors to collaborate simultaneously in real time (Zimring, et. al., 2001). There are many research studies on the development of CDS. However, most of the researches and implementations involve the development of a collaborative design project among different universities. As Simoff and Maher (2000) stated, design education lacks a clear separation between theoretical knowledge and practical skills and it requires an intensive collaboration of specialists. Thus, an extensive study for collaboration of design studios and theoretical design courses is necessary.

A conceptual framework for the collaborative design studio should involve the determination of roles of participants in a networked environment, structuring the space for navigation and orientation and management of set of actions. Moreover, the structure of the environment should be studied with respect to the purpose of environment, the way it functions, the actions that will take place in the environment, the communication paths and the characteristics of the provided technology. Shared workspaces on the Internet act as a medium for communication, discussion and management. The knowledge and information can be shared in discussions while developing alternative solutions to design problems and the task coordination is achieved through a networked environment in CDS. During a collaborative design study, each participant can work on a

different part of the design project as well as on the same part. Engeli and Hirschberg (1999) stated that since networks provide parallel input and a feedback loop, they are designed to provide right circumstances. Thus, participants of the collaborating team can work in parallel as well as independently while using different tools. In both approaches, the networked environment developed for the collaboration of participants should be flexible enough to adapt itself according to the changing in needs and expectations of the participants and improvements in organizational and technological developments. There is a need to document group activity and make this documentation available. The rules within the networked environment are not limiting factors but preconditions of openness (Engeli and Hirschberg, 1999).

As Maher et. al. (1997) stated, design projects require collaboration of designers, coordination of the information flow and synchronization of the design task. Collaborative design involves communicating and sharing of information. For this reason, the design of a group work necessitates the clear definitions of the terms co-operation, coordination, collaboration and communication, to understand and make a clear distinction among the issues in a group study. The activity that involves the group work of individuals acting as a memory aid and a resource for learning and sharing tasks is called cooperation (Perry, 1997). Coordination is needed to manage behaviors and share goals and tasks. Collaboration is the cooperation of participants working on the same task. In other words, it is a process in which two or more participants facilitate each other's work and creative thinking to find solutions to problems with in the framework of

shared goals. Collaboration is provided by communication, which is the exchange of information in verbal or non-verbal forms. As Engeli and Hirschberg (1999) stated communication is a driving force for collective process. The organization and distribution of a virtual environment is highly dependent on the methodology used for the collaborative activities brought by the virtual environment in design education.

1.2 Computers in Design Education

In a traditional design curriculum, usually the design courses are conducted independent of each other and the students work individually on a design brief and learn the design process as an individual activity. Moreover, the computer as a design and representation medium is not included in the design studio since computer aided design courses are considered independently from the other courses in the design curriculum. The developments in computer, information and communication technology caused the design education increasingly to incorporate with computer technology and its applications in the curriculum with Computer Aided Design (CAD) studies and facilitate collaboration of courses. However, students and instructors need to be aware that CAD or use of computer media is not a separate activity as it is given in the traditional design curriculum, but a tool for design process as well as a tool for representation purposes. Advances in image processing, three dimensional modeling, simulation, multimedia tools and computer networking provide a variety of possibilities for the design instructors and students by quick and simple

access to information, data formulation and communication for exchange of information. Although almost all of the design schools have CAD in their curriculum, their organization often lacks integration of CAD to design studio and the methodology to use computers for collaboration among design courses.

Since architectural design is a collaborative process in professional practice involving the interaction of architects, designers, engineers, technical staff and client, the design education needs to prepare students for the collaboration process throughout the design project. New technologies in CAD and network facilities are supporting and changing the design and construction processes in the design education as well as the design profession. In this context, a new understanding of design collaboration process has been emerged with the wide use of computers in design. The concept of virtual architecture and collaborative design studios developed within this concept are products of this new approach. Clark and Maher (2001) stated that the computer technology and education are the two key elements in virtual learning environments. Virtual architecture sounds to have the purpose of only simulating a physical architecture. However, it also has the purpose of creating a virtual space in which the metaphor of building and rooms in physical spaces can be used for working, playing or even learning. The term “virtual” does not refer to the dictionary definition, which means “non-existing”, since an electronic environment is created to be used for a specific purpose. It can be defined as an online space to gather people for collaboration and communication for specific activities. Active Worlds ® which is a three-dimensional

immersive collaborative modeling world is an example for such an approach (Active Worlds, 2001).

Velasco and Clayton (1998) stated that development of communication channels is not enough for developing the collaboration through computer for design education, so it is necessary to provide collaboration between courses in the design curriculum by group studies and assignments for design studio and computer courses in the department. In relation to this approach, it is possible to use computers in design studio or courses in two ways. It is possible to employ computing resources to do things that the educators have previously done without computer mediation or by conducting teaching and learning methods or experiences impossible without computers (Simoff and Maher, 2000). When we look at various implementations of CAD in different design schools, the integration of computer technology in design education are arranged at various extents such as designating a course to introduce necessary computing techniques or applications for design process and presentation, or integrating computing applications in existing design courses or using computers as a tool for collaborative design projects. Virtual architecture is widely used for integrating CAD in the design curriculum (Table1.1).

Table 1.1: Use of virtual architecture in design curriculum

Computers in design curriculum	**Virtual Architecture**
Introductory computer courses	Simulation of a physical architecture
Integrating computer application in design courses	Simulation of a physical architecture
Collaborative design projects	Functional virtual place Simulation of a physical architecture

The common point in all of the approaches is that an introductory CAD course is a necessary prerequisite for conducting a computer integrated design studio (Velasco and Clayton, 1998), so that students can experience and learn how a designer can use computer as a tool for design or representation purposes and design collaboration to be more effective in the market.

Due to the integration of the newly developed technological tools to design courses, the discussion about the development of design curriculum has been arisen. Integration of the CDS to the overall existing curriculum organization structure necessitates special attention because education methods, requirements and needs vary in each discipline related to its nature. Learning continues as long as one lives in an environment as a natural manner of being. Fischer and Nakokaji (1997) stated that the learners need to access and play a role in the social environment as well as instruction. Sharing knowledge and responsibility through assigning different roles in an educational environment motivate students and instructors in learning and helps in improving their skills. In this way, the students learn how to learn and the instructors can develop their skills and

design knowledge by sharing different points of view. Within this context, social process plays a significant role in design communication.

Although WWW is widely used for broadcasting purposes like television, journal or magazine, that provides one-to-many monologue with a limited interaction, its` potential to be used as a medium for collaborative activities including the construction of shared ideas and artifacts is becoming prevalent (Ambach et. al., 1997). Besides design activity involves the collaborative construction of shared artifacts, it is possible to use WWW to create, share and evolve information spaces and artifacts through design collaboration. In order to use WWW efficiently for collaboration, it is needed to reconceptualize web and redefine the roles and responsibilities of the web users (Ambach et. al., 1997).

1.3 Scope of the Thesis

This thesis investigates the use of CDS for collaboration of interior design courses through the Internet. It is composed of two parts explaining the theoretical basis of the thesis (Chapters 2-4) and implementation of the proposed CDS model (Chapters 5-8). Within the scope of the concepts explained above, the explanation of theoretical issues starts with a clear definition in Chapter 2. Collaboration methods and features, the issues that should be considered during the construction of a CDS and web-based tools used for this purpose are discussed in detail. Also, a comprehensive study on the interactive hosting web-sites is summarized in Chapter 2. In Chapter 3, educational approaches that are taken as the basis for the

development of CDS in this study are explained, involving the conceptual approaches, models and studies developed and conducted for CDS development. Critique mechanism in CDS is emphasized in detail to identify the settings of traditional and collaborative design studios, the nature of critique process and content of the critiques. In the following chapter, the EDC model developed for the collaboration of design courses based on the concepts of situatedness and reflective practice is summarized. The information and collaboration web sites are also explained in detail in Chapter 4.

The second part involves the implementation of the proposed model, starting with a summary of the research setup for CDS in Chapter 5, involving the problem definition, research questions, participants, methodology and the data. The scenario of the collaboration process, which is implemented with 18 students from junior and senior level, is also introduced. In the following chapter (Chapter 6), the methodology used for the evaluation of the case study is explained in detail that involves the evaluation of redline files, design diaries and usability report. The categories of the segmentation method that is based on problem domain and design strategies; and aspects related to behavior and features of problem requirement and solution spaces are summarized with specific examples given from the case study. The descriptive analysis of the critiques found in the redline files and the clues found in the design diaries about the students` design process form the basis for the evaluation of CDS as explained in Chapter 6. The results are analyzed both in quantitative and qualitative terms in Chapter 7. Also, Chapter 7 includes

the analysis and the usability report based on the concepts of perceived usefulness and ease of use and user satisfaction. The results of the data are summarized and explained in a discussion section. Finally, the purpose and results of the discussion related to CDS and the case study are summarized and discussed in Chapter 8 to be a basis for further studies.

2. COLLABORATIVE DESIGN STUDIOS (CDS)

2.1 Approaches to Collaboration

As Shaffer (2001) stated, design is not a process to answer simple questions but a process over time. For this reason, design teaching has to involve the evaluation and implementation of various steps and settings to help students in understanding, exploring and expressing the design brief and the solution for the design problem. The students need motivation for conducting and developing the design ideas for the improvement of design brief. Instructors motivate students through conversations about the project, intellectual quests, drawing sketches, non-verbal clues, introduction of new media or design projects involving similar problems or solutions to the student's design brief.

As Maher et. al. (1997) stated, design projects require collaboration of designers, coordination of the information flow and synchronization of the design task. It is possible to use Collaborative Design Studio (CDS), which is a shared workspace in a networked environment such as Internet where students and instructors can access to research resources, interact and exchange information to discuss and decide on alternative design solutions. CDS provides a flexible environment that a student has control over his/her own educational process since there is also a possibility for collaborative studies. Communication technology is applied for collaborative studies, involving social communication and design/task communication. The student is taken as the center of the environment, in

order to provide facilities to manage their own learning experience (Maher et. al., 2001).

There are three different approaches to conduct a collaborative study: within the university, in which groups of students and design instructors collaborate to develop a solution for a design problem; national, in which design schools in a country collaborate for design projects; and international, in which schools from all around the world collaborate for a design project, sharing information on design methods, cultural differences and different point of views on design. Moreover, all of these approaches may include a multi-disciplinary point of view, including members from related and supporting disciplines in the design teams. In all the approaches, the participants with different levels of responsibility are required.

A systematic organization in a CDS is essential to provide a useful collaborative design environment so that the students can benefit from the advances provided by computer media in their design studies. A systematic organization of virtual learning environment can offer the awareness of collaborative nature of design process, which is a missing approach in traditional design studios, in which students usually work individually. There are different approaches for the organization of the educational virtual environments, in which small group learning, large group learning, self-paced constructivist learning or collaborative learning are supported (Simoff and Maher, 1995). Students, instructors, moderators, site coordinator and design consultants have different roles in

an online collaborative study. The students have a chance to work in a design group, where their responsibility is limited to a part of the project, as well as they have a chance to collaborate and share different points of view related to their individual designs. Fischer and Ostwald (2002) defined two types of communities, communities of practice and community of interest. Participants work together in a certain domain doing the same kind of work in communities of practice. In communities of interest there are various participants with different backgrounds and experiences working on the same problem. The interaction grows as students and participants interact with each other. The social activities are highly based on time concept, since it is possible to use both asynchronous and synchronous systems for social activities.

Engeli (1998) defined three types of views for collaboration, which can be static, dynamic and reactive to user's requests. First one is the overviews at meta-level of the information space that shows the relationships and provides access to information in detail. The second one is the process views that generate information dynamically and show the developments over time. Finally, focused views represent one's experiences on a particular context. Concepts of time and space play an important role in CDS since the organization of these activities is related to the organization of time and space.

2.2 Construction of Collaborative Environments

The construction of a collaborative environment is highly dependent on the technology and budget provided by the participating schools. The construction of a network and the technology provided for the communication require a large amount of money for both schools and the students that participate in the design team. For this reason, the ease of communication and the number of participants in the design teams are closely related to the budget provided for the CDS. It is difficult to support a large class online (Kvan, 1997).

As a collaborative process, constructing and conducting a virtual collaboration environment requires people from various disciplines in addition to the design instructors and students (Shelden et al., 1995). Technical staff for technical assistance in case of a problem, site coordinator and consultants for design and related disciplines have different responsibilities and roles in CDS. The tools for communication and type of communication of the participants are also important issues in the structure of CDS. The communication and collaboration in both of the approaches explained above can be conducted by asynchronous or synchronous methods (See Section 2.3.1). As Shaffer (2001) stated, the ordering of space affects the quality of human life and activity in the space. When an online space is organized well, it is more effective and usable (Cicognani, 2001). The space organization of an effective and successful CDS is highly related with the methodology used for collaboration. The organization of space according to the specific activities taking place is

related to the tools and settings used and required in CDS. The development of course material, the training and adaptation of participating students and instructors, providing support for access should also be considered as well as the tools and methods.

Chiu (1998) claimed that design studios conducted with innovative technology needs “Design Guidance”, involving the structured framework for design studio, the technology being used, level of communication and process model of Computer Supported Collaborative Work (CSCW). There is a need to define the hardware, software and the way the design process is recorded, monitored and analyzed to be used as a starting point for improving techniques and tools in collaboration. He defined process model of collaborative design related to consultation, negotiation, evaluation and confirmation issues in decision making (Chiu, 1998). During the CDS observations of Chiu (1998), it is found that computer supported collaborative work through virtual design studios and collaborative design studios stimulate effective actions of students, enhance performance of collaboration and help the development of solutions generated, by constructing a knowledge base about design collaboration.

2.3 Web-Based Collaboration Tools

2.3.1 Synchronous and Asynchronous Tools

There are two types of communication systems, synchronous and asynchronous systems for online collaboration. The first one, synchronous

communication is a real-time interaction of geographically distributed participants. Chat rooms, audio-video conferencing, white boards can be used for real-time interaction. In this system, there is a time constraint since a particular time should be decided on, in order to meet by the participants. For instance, it is possible to conduct interim and final juries online without place constraints.

The second one, asynchronous communication is a non-real time interaction of the participants in which information is exchanged. In this system, there is no time constraint, since the participants do not have to be online at the same time. Asynchronous tools are necessary for permanent and continuously accessible information and communication whereas synchronous tools are necessary for simultaneous use and communication at the same time (Cicognani, 1996). Web-browsers, electronic bulletin boards, File transfer protocols (FTP), e-mail programs, mailing lists, newsgroups, electronic archives can be used for asynchronous online communication for interaction at different times.

Related to the methods and tools used in the collaborative project, the students have the chance to make research online, work on their own, and consult design experts and design instructors using synchronous or asynchronous tools. It is possible to use one of these communication systems as well as both of them together for a collaborative design education through the Internet. The tools for communication can be decided based on the design brief, technological potentials and representation techniques (Maher and Saad, 1995).

Kvan et. al. (1999) argued that textual communication plays an interesting role in collaborative design problem solving by encouraging divergent thinking and exploration of ideas. It is observed that more ideas are explored by the participants in a chat line communication than audio-video condition in computer mediated environments (Kvan et. al., 1999). However, new tools for communication are being developed as well as the properties and capabilities of these existing tools for online communication such as WAP browsers. For this reason, the developments in the communication technology should be followed and adopted to CDS process.

2.3.2 Use of Internet as a Tool

Interaction and communication in a society, searching and accessing information and knowledge from various resources are irrepressible activities of people as they are the actions needed to improve oneself with new and various information and knowledge. Information and knowledge are the terms that are used interchangeably. However, there are distinctions among the two terms which one should be aware of. Information involves the data and the patterns and relations that occur in time in data. Knowledge involves context to gain deeper understanding of the information and it does not involve only the understanding of creator of knowledge but the understanding of the user. That is knowledge involves beliefs, commitments and assumptions.

There is one-to-many monologue among producers and consumers of information and knowledge in traditional mediums such as television, radio,

newspapers, journals and magazines. However, this kind of information and knowledge limits people in developing a shared understanding by allowing a one way interaction in which the flow of information or knowledge only from one person to the others takes place. This kind of interaction draws boundaries that obstruct exchanging, sharing and discussing different understandings, points of views and ideas. Kalay (1998) claimed that effective collaboration necessitates sharing worldviews, thus the collaboration should involve sharing knowledge, which is more than just sharing information. Ngor (2001) proposed the use of Internet for collaborative studies as an easily accessible and low cost medium for communication. Jeng and Eastman (1998) proposed alternative database architecture to support collaboration and design of team work for innovative design, emphasizing the separate representations used by different specialists.

The products of developing technology in computers and information sciences possess new and dynamic potentials and opportunities for spreading, sharing and exchanging information and knowledge. Fischer (1998a) stated that substrates, which are high-level system development environments supporting complex, open and evolvable systems; organizational learning environments; domain oriented environments; WWW; and interactive environments, in which users can manipulate objects within the environment, are examples of innovative computational environments. In the development of all of the approaches, the emphasis is not to accumulate knowledge but to deliver the useful knowledge needed at the right time to the right person in the right way.

The web and the Internet are the widely used examples for potential products serving people as mediums for accessing, publishing and exchanging ideas, information and knowledge. Nevertheless, as a result of habits gained with traditional broadcasting, the profits gained from the use of web have not been used appropriately. The web that is started to be used for communication has been widely used only for publishing or broadcasting just like a newspaper or television. The proliferation of the web and Internet has increased with the increase in use of web and Internet in communication activities. Augmentation in use of e-mails has emerged a new point of view to develop more functional and useful tools to form frameworks for interaction through computer. These new tools enable the use of web and Internet to create, share, interact and exchange information, in other words, a new way of interaction. Collaborative activities are being conducted through Internet with the recent developments in computer and Information Technology (IT).

The study of collaboration through Internet is a complex process since it involves the investigation of many issues. The approach of Ambach et. al. (1997) involve three models of interaction among web users and web masters as follows: Information Broadcast; Information Broadcast with Feedback; and Evolutionary and Collaborative Design. Information broadcast is simply preparing, arranging and publishing the information for web users. This kind of interaction involves a one way interaction in which the information is carried to web users by web masters. However in the second model, Information with Feedback, although the web user can not make changes on the content of the web document directly, they provide

indirect feedback by e-mail, online forums, etc. for the web masters in more sophisticated web documents. The collaborative activities and the ability to directly modify a document on the web are provided in the third model, Evolutionary and Collaborative Design. Ambach et. al. (1997) defined designing as a collaborative and argumentative process in which many participants with different perspectives and backgrounds develop a shared understanding and accepted web as a medium for collaboration activities to produce a shared understanding and shared artifacts. This definition is valid in every discipline involving design such as engineering, architecture, graphical design, construction and in their inter-disciplinary studies. Below are some of the tools and techniques for interaction in collaborative studies on the Internet (Cicognani and Maher, 1997):

Questionnaires. In order to gather information for the members of teamwork, questionnaires can be developed at the beginning of the VDS semester, to provide information about the students in the design studio and the design instructors. Personal and background information can be included to provide information for the participants in VDS. Moreover, the questionnaires may include questions to understand the attitude to methods, teamwork and previous design briefs. Using the data of this questionnaire, the structure and methods in VDS can be developed.

Web-based bulletin board. An electronic shared space for the teams can be provided for their message and information follow throughout the design process. It may include synchronous tools such as chat prompts as well as asynchronous tools such as e-mail or news sections.

Observed and tape-recorded team meetings on- line. Recording and observation of audio-video conferences of team meetings for discussions on the design problem may help both the students and instructors to refer back to the pervious steps in the design process and provide a means to follow the development of design project.

Informal group discussions. Different attitudes and point of views of different students to design problem can be shared across informal group discussions online. Student-to-student interaction provided online may help the development of the design problem as well as student-to-instructor interactions by sharing of knowledge.

Individual e-mail interaction. For the individual interaction of students with the design instructor is an important issue in design education. This may be provided by asynchronous communication, using e-mails as well as synchronous meetings online, to ignore the constraint of time.

E-mail groups. The discussions about the project can continue further, in addition to the synchronous meeting, using e-mail groups in which both the students in the design team and the design instructors can participate. Moreover, information flow from the related and supporting disciplines such as history of design and engineering can be provided by discussions on the problems related to the design brief.

White-board critiques. The design projects can be reviewed and discussed by the students and instructors synchronously with the use of special tools such as white-boards. The ability provided for drawing on the same drawing at the same time and following the changes synchronously can be

helpful to support online design education since it is possible to develop solutions to the design problem as a team work.

In this study, a research is conducted in market to find out and compare various computer programs and web sites to be used for implementation. It is seen that some companies are offering computer programs or interactive web sites suitable for design project collaboration and management and some are not (See Appendix A.1- A.2).

The computer programs and web sites are studied and categorized related to their functions as follows (See Appendix A.1- A.2):

- Data
- Scheduling and management
- Interaction
- Reports

In addition to download, upload and modification of a file, there are also many other web-based collaboration features, developed and incorporated in collaboration tools (See Appendix A.1- A.2). The features related to the format, storage and access to the data are stated in the first group as *Data*. The time and management features that include team calendar, dynamic-scheduling systems, notifications, etc. form the second group as *Scheduling and Management*. The group of *Interaction* features such as desktop sharing, chat, pooling, etc. and *Report* features for the control and evaluation of collaboration process are the last two features.

The web-based collaboration tools, which are specially developed to involve design and drawing collaboration, include some other specific features such as Internet browser-based viewing of drawings, mark up,

asynchronous and synchronous redlining, dimensioning, viewing and sharing various 2D and 3D CAD formats or documents (See Appendix A.2).

Facilities of computer and information technology are used for constructing and conducting the studies of active design communities. These involve server built-in CAD viewers or CAD plug-ins for viewing and redlining 2D and/or 3D electronic drawings, which is a way of graphical communication by adding textual and graphical data. CAD viewers are the software used by designers, architects and engineers to view, mark up and share CAD documents over the web. The server-built in CAD viewer provides easy access through the web browser without the installation of the CAD viewer on computer. CAD plug-ins for web browsers are also used to expand the functionality of web browsers by allowing the display and redlining of CAD documents by sharing over the web. These tools enable marking drawings with lines, circles and rectangles, highlighting parts of the drawing and adding textual data near by to attach comments or critiques. There are also some other companies hosting interactive collaboration sites for other disciplines, without design collaboration features (See Appendix A.1). It is possible to use them with CAD Viewers that are used to display drawings on the Internet to manage collaborative projects.

Both of the companies with or without design collaboration features have a server and offer a limited secure space for a collaborative project for any disciplinary study. In some of them, project space provided for interaction and sharing documents, is accessible through Internet, using a web

browser only, without any other additional hardware or software requirement, whereas some of them require local hardware and / or download and installation of their own software. Each participant in a project can have permission to enter the project room or web site with an identity name and a password. The project administrators assign the roles, responsibilities and access to specific folders or files for the participants. Limited to these responsibilities and roles, the participants can use and take the advantage of all of the features involved in the project site such as accessing contact list, downloading, uploading or modifying a file.

As a result of the studies of a comprehensive research and evaluation of economic and technological contingencies, one of these companies, ProjectGrid web site is preferred as a tool for web-based collaboration, which enables interactive collaboration with a server built-in CAD Viewer (ProjectGrid, 2002). All features of ProjectGrid are explained in detail in Section 4.3 and can be seen in Appendix A.2. The following chapter explains the models developed for educational approaches in previous studies of CDS.

3. EDUCATIONAL APPROACHES TO CDS

3.1 Conceptual Approaches in CDS

Education and learning are not static activities with one-way interaction. They involve the dynamic exchange of knowledge. Most of the traditional approaches to education can not reflect this dynamism since there is the tendency of seeing students as consumers and instructors as distributors of knowledge. Computational environments can support and enhance new frameworks for education to breakdown this approach. There are many research institutes and universities working on the development of virtual environments to conduct collaborative design studies since 1993. However, they are mostly dealing with the development of tools and psychology and behavior of participants in collaboration process. There is still, the lack of a systematic methodology for the collaboration of design courses in virtual environments. Moreover, an extensive study for collaboration of design studios and other design courses is necessary. As Pereira (2001) stated, the educational theories and architectural design issues should be used during the design process of collaborative learning environments. The use of architectural theories, *participatory design,* which involves users in design process, and *reflective design,* that involves generation of feedback to define problems and uncertainties related to the situations, with these educational theories can enhance the development of collaborative activities. Other architectural design issues can be summarized as the identification of user needs, evaluation and understanding of previous activities within the designed space, technical

issues related to construction, aesthetic and symbolic aspects within the environment and economic constraints (Periera, 2001).

Pereira (2001) categorized educational theories related to *socio-cultural theories, reflective practice* and *critical pedagogy*. The *socio-cultural theories* are defined as the emphasis on the motivation, social cognition, situated learning and appropriation of mediational means. The *reflective practice* is the development of meta-cognitive strategies that improves the understanding of learning process and life long learning related to the concepts of reflection-in action and reflection-on-action. The participants are seen as reflective practitioners with the dialogs they generate to collaborate and improve critical thinking. The theories related to *critical pedagogy* combines reflective practice with socio-cultural theories to emphasize situatedness in learning. It defines education as a process of development and empowerment with transformation and awareness.

Previous approaches that define the design process involve objective points of view in a rationalistic perspective, in which the situations are characterized in terms of identifiable objects and general rules are stated that apply to situations in terms of objective properties (Lueg and Pfeifer, 1997). This approach can be defined as a pre-planned static action without consideration of different situations occurring in a design problem. However a design process can not be pre-planned for the final outcome since it involves a series of situated acts (Reffat and Gero 1999). For this reason, initiation of a design process should involve the understanding of the issues and properties of the design problem related to the current

situation. In other words, consideration of all the current situations is an important fact in design process. Therefore, situatedness is related to the nature of human knowledge, which is constructed dynamically as we perceive the things around us (Clancey, 1995). As Reffat and Gero (1999) stated, what, when and where you do matters to generate a solution for a problem. This approach implies the concept of situatedness.

As Schon (1983) stated, the design situation is shaped by the designer by creating and modifying design, representations and the designers reflects on the actions and consequences and plans the following actions. This process is cyclic since designers generate critiques as articulated knowledge as well as they find a solution to the design problem (Nakokaji and Fischer, 1995). It is not possible to predict the outcomes of a design solution beforehand. The evaluation of the design representations can be used to generate new design solutions related to the design situations.

Situated design, as an alternative for rationalistic design methodology, is developed from the situatedness approach. It starts with the development of a vision for where to go and continues with the analysis of the current situation (Lueg and Pfeifer, 1997). The theory of situatedness implies that ideas and actions are generalizations which are adapted to each environment since the vision and activities arise together (Clancey, 1995). Actions, activities and reflections of humans change and differ related to the perception of each individual and the present social environment. Thus, human knowledge can not be defined as facts, rules or descriptions. It should be evaluated as a capacity for coordinating and sequencing

behavior to adapt to the changes in the environment (Clancey, 1995). The activities among the participants should also be considered as well as the situation, in collaborative design (DePaula et. al., 2001). However, it is not possible for a designer to consider all implications and effects of a potential design action before experiencing it (Smith and Gero, 2001). Moreover, the detection and depiction of each designer varies due to their experiences and perception. Also, new cues can be detected or there may be changes in decisions when a designer observes the same design at another time. Designers need to interact with the space being designed and refer back to their prior experiences, to find a solution for the current design problem. This flexibility would enable continuous changes for evolution of design.

The design and evolution of an artifact is a complex process, which necessitates the discussion and evaluation of different points of view and experiences of participants. A framework is needed to start and conduct this process in a systematic way. The recent approaches to design involves concept of continuous evolution of design and design problem solving rather than applying generic issues and solutions defined in former studies. One example for the evolutionary development of design is Collaborative Problem Solving Environment (CPSE). CPSE, which is developed related to Darwin`s principles of evolution, is defined as a “software work bench” involving tools that can be configured and composed in various ways for constructing and accessing visual information and simulations (Gill, 1999). The principles involve a subjective perspective for the study of focused, innovative, autonomous and individual projects with contextual approach to teach, learn and exchange

knowledge. There is an emphasis on experimentation, integrated design, methodology and goals in relation to continual change in uncertain future.

Evolutionary Artifact Software Design Environment (EVA) is another example for collaboration in software development supporting construction, integration and evolution of representations for mutual understanding. The action-reflection-critique model is a synthesis of design theories with other theories about the way people collaborate for generating solutions to construct a mutual understanding through discussions, creation and modification of design representations (Ostwald, 1995).

3.2 Models of CDS

In modern learning theories students participate in learning activities and are directed to self-directed learning. Fischer (1998a) categorized modern learning theories as learning in relation to the process of knowledge construction, learning as knowledge dependent, learning tuned to situation, distributed cognition and motivational issues. In the process of knowledge construction, the participants are not just the consumers of knowledge but they contribute to the learning process actively. In knowledge dependent approach, the existing knowledge is used to construct new knowledge. The situated approach is domain-oriented in which human-domain interaction is provided as well as human-computer interaction. The information space is constructed relevant to the task. There is the identification of roles and responsibilities among computer and human for distributed cognition. The aim of the motivational issues is to make the participants aware of the

learning and to enable them to contribute to the task (Fischer, 1998a). In this sense there are various approaches and models being developed for online collaborative design education. Some of the models developed for CDS are below:

3.2.1 Seeding, Evolutionary Growth, Reseeding (SER) Model

The *Seeding, Evolutionary Growth, Reseeding* model (SER model) is a process model developed by Fischer (1998b) as a framework for collaboration in design environments. It has the three phases (seeding, evolutionary growth, reseeding) defined for evolutionary process in domain oriented design environments. These domain-oriented design environments involve the construction and use of an archive of previous designs. Moreover, feedback is provided while constructing the system in domain-oriented design environments with simulations (Fischer and Ostwald, 2002).

In SER model, there is a cyclic flow starting with the *seed*. *Seed* is the initial set of domain knowledge, which will evolve in time and use (Fischer and Ostwald, 2002). It should provide a strong information base to evolve in time and enable the participants to react (Fischer, 1998a). It is created by virtual environment creators and domain designers and evolves every time it is used in a new project involving various tacit knowledge. In the first step, *seed* is used to extend, work or explore a problem in *evolutionary growth* phase. The seed provides resources for work and accumulates the product of work in this phase. New requirements, components and

knowledge are articulated during design process by the participants. Information created is related to a specific problem (Fischer and Ostwald, 2002).

Secondly, *reseeding* provides an information space that holds necessary useful information for reuse and evolution. It is necessary to assess the project information created in relation to a specific subject and specify what is needed to be added for the next cycle of seed and evolutionary growth (Fischer and Ostwald, 2002). Users should be involved in this phase as well as the environment developers since they can criticize the structure of the environment and content of information that is being organized for collaboration.

The integration of technology to education is not provided only by the use of new tools in a course. It is a complex process involving the changes in the way one thinks, works and teaches so that education is adapted to the tools of new technology as well as vice versa. Since SER model involves complex systems with contribution of large group of distributed participants, De Paula et. al. (2001) found it similar to the structure of the evolution of collaborative educational projects. De Paula et. al. (2001) proposed an educational model called “courses-as-seeds” as an alternative to traditional education. The SER model is implemented as a framework to develop *Courses-as-seeds* model which is situated in the context of university courses, extending beyond the temporal boundaries of semester-based courses (Fischer and Ostwald, 2002). In this model learners are seen as the constructors of knowledge and active participants. They are expected

to offer knowledge and create a shared understanding. The course is seen as a seed that will evolve continuously in future courses. In this way, a Course Information Environment (CIE) is created to support learning discourse and extension of current state of knowledge or peer ideas and formulate, restructure or use the resources to generate new ideas. It is stated that an evolutionary information space is created by the data generated from each course at each semester (Fischer and Ostwald, 2002). In this way, new knowledge is built up with a collaborative effort. CIE has three web-based components in *courses-as-seeds* model: a course web site for a repository of course materials and course related information; a web discussion forum providing an open communication opportunity among students and instructors; and a community space, containing information about the participants.

The initial state in “courses-as-seeds” model, *seed*, which is intended to evolve, is defined as an open-ended system created by computer environment developers or instructors (De Paula et. al., 2001). In traditional education, students are usually passive participants and only the consumers of knowledge presented by instructors. They interact with the instructor only to satisfy what is required. In “courses-as-seeds” model, this approach is broken to create a community of practice in which students are active participants as well as instructors. In this way, students also construct knowledge related to the course subject, contributing and sharing ideas, experiences and resources. The aim is to accumulate information by keeping and using products and ideas generated in each course for the evolution of future ones. In this way, the nature of “courses-as-seeds”

model provides a basis for collaborative practice in education. Both students and instructors participate actively and form a community of practice for a specific purpose. Moreover, the approach of giving the courses in the same way each semester in traditional education without any evolution is changed.

3.2.2 Collaborative Process Models

Vera et. al. (1998) defined two dimensions for design problem solving in collaborative environments to identify when and what work is done. First one is, Collaborative Process Model, in which the structure of individual expert problem solving in traditional cognitive model of collaboration is considered and participants are defined as agents with problem solving goals and skills. The process starts with the meta planning which involves the execution of task in coordination and then the problem is broken into individually manageable units. The way and the time appropriate for integrating individual efforts in collaboration are discussed respectively and the negotiation and the evaluation of outcome of the design follow. The need for additional meta planning is discussed before the process begins again. The Design Process model involves task-based activities such as gathering and organizing information, defining facts and determining data set.

The Design Process model involves High and Low Level Design activities. High Level Design Activities include site planning, defining major components and identifying privacy routes. Low Level Design Activities

include issues related to drafting actions and interface specific activities related to the medium that is being used.

3.2.3 Collaboration Through Networks as "Virtual Work Place" and "Container of the Work"

One of the approaches is defined by Engeli and Mueller (1999), assigning two roles for the network environments as the "virtual work place" for the participants and "container of the work" that is produced. In the "work place" approach, the activities of the user and user involvement is considered. When CDS is evaluated as the "container of the design project", the organization of working activities and the design process is arranged. A common database is created for the collaborating courses in order to control and store the information about the design process in the CDS. Information about the project is provided by the presentation of content of the design problem, defined layout about the process of design brief and search ability of research on the design concepts. After the information is given to the participants, research activities take place and the data gathered from the research are stored in the database for the students to refer it as they need. Respectively, various design solutions are generated by the students to be discussed. The results of the discussions are loaded to the database to follow the development of the design process. As a result of the discussions, the students end up with a final design solution. The final design projects are stored in the database again to be a guide for the next design projects. The discussions and evaluation

of the final solutions can take place in the virtual space with the use of data in the common database.

As Engeli and Kurmann (1996) claimed that computer generated design agents which are designed to have the ability to learn and act on the behalf of the user, can also be used in CDS if appropriate technology is available, to help to the participants to solve problems related to specific tasks such as navigation, sound or cost. Engeli and Kurmann (1996) stated four kinds of design agents; navigator agent, sound agent, cost agents and agents that has the ability to test the design. Agents are stated as the helper to the users to provide support by solving specific tasks. It is stated that they are designed to have the ability to learn and act on the behalf of the user (Engeli and Kurmann, 1996). In this sense, navigator agent helps the user to reach specific locations and provides tours in the virtual environment. Sound agents enhance the quality of virtual environment with additional sense by playing melodies, speaking the written data and proving sound effects such as footsteps or crashing of a door. Cost agents calculate the cost of the project and display the results with graphical representations so that the designer can indicate the desired quality in design if the design is implemented in real life. The agents created for testing the design simulate the people using the designed product or people populating in the designed building. In this way, the design can be tested for various situations in real life such as fire escape routes.

Most of the researches and implementations about online collaboration involve the development of a collaborative design project among different

universities. There are also interdisciplinary approaches in collaborative studies. P3 Design Collaboration Environment is an example for an interdisciplinary educational approach developed using representation, communication, evolution and negotiation tools for Architecture-Engineering- Construction (AEC) industry, in relation to shared product approach, performance evaluation approach and process-based approach (Kalay, 1998). It is stated that the synthesis of these three approaches in P3 design environment provided advantages for collaborative studies such as semantic clarity, flexibility, scalability, distributedness and non-synchronicity. There are also collaborative studies involving evolution of design solutions among institutions in different time zones. Mini Structured Query Language (MSQL) Database environment is an example of such a study in which participating universities work on the design solution respectively within a common database (Kolarevic et. al, 2000). The following section explains the setting and nature of design development based on the critique system in CDS.

3.3 Focus on the Design Studio through the Critique Mechanism

3.3.1 Setting of Design Studios

In traditional design studios, design teaching takes place in design studios in which personal workspaces and drawing desks are provided for the students. Individual meetings and student-to-instructor interaction take

place face-to-face at physical settings. Although discussions are held among students, design is explored as an individual activity, where students provide alternative design solutions while developing their design project. Students participate in the studio while introducing their own design and observing the other students` design. They develop the design project in the studio, in their free as well as studio hours. However, they need to conduct research in order to gather information for the solution of the design problem out of the studio by visiting the library, interviewing design experts and determining client profiles.

In a CDS, the medium of instruction is changed and all the activities take place in a virtual environment, in other words, in an online environment. Different from the traditional design studios, the nature of CDS involves collaboration. The most important advantage of web-based design education is the flexibility of time and place constraints in teaching and learning. Both the student and the instructor are free from restricted course hours in a restricted place. As Simoff (1999) stated, collaboration on a shared design task can be considered at two levels: single task or multiple task evaluation. In single task evaluation, each participant has his or her own point of view over the whole project where as in multiple task collaboration each participant is responsible for a specific part of the project. CDS can also provide a basis for the representation of previously solved cases for the identification and solution of design problems by reminding students of appropriate solutions and techniques in design process. Related to this concept, a multi-media library of design knowledge and design cases can be constructed as a support for design

education (Mitchell, 1998). The design elements of the space organization should be taken into consideration in such an approach, such as relationship between information and layers of access, organization of activities, social communication, privacy, user engagement in design process, ownership, navigation properties and transformation and feedback (Cicognani, 1996). The online spaces for individual studies, research activities, individual critiques, student discussions and juries are created to satisfy the requirements of design studio activities similar to the traditional design studio. Decrease in the constraints of time and space in CDS provide advantages for design education since the organization of these activities is related to the organization of time and space. The pedagogical issues also need careful attention since the lack of face-to-face interaction needs to be replaced with other conventions such as quick responses to students or ways of expressing notions in communication.

The most important problem in constructing a CDS is related to the financial issues. The construction of a network and the technology provided for the communication is not a cheap process. Moreover, many problems may arise related to the technology of the main tool and hardware, computer, during the CDS process. For this reason, solutions to overcome failures in case of a problem in computer technology used in the system should be generated to minimize the risk of failure of the CDS. Although these problems seem to be restricting the use of collaborative virtual design environments, many positive issues about CDS can be stated. Virtual collaborative design environment imposes a greater responsibility on the students to have a control over their own work than the traditional

design studios (Kvan, 2001). When an online space is organized well, it is more effective and usable (Cicognani, 2001). For this reason, CDS organization has to be well structured to offer a healthy, satisfactory design education. The conventional design studios are organized related to the properties and activities taking place in the studio. In conventional design studio, students mostly work on the design brief individually and learn the design process as an individual activity.

Communication technology is applied for collaboration involving social communication and design/task communication. There are different approaches for the organization of space for collaboration, in which small group learning, large group learning, self-paced constructivist learning or collaborative learning are supported (Simoff and Maher, 1995). These activities may take place within a school providing communication between the students and instructors in the same school or among different universities conducing collaborative projects. The construction of any of these collaborative environments is highly dependent on the technology and budget provided. Related to the methods and tools used in the collaborative project, the students have the chance to make research online, work on their own, access a common database for observing the previous steps taken throughout the projects or previously completed design examples that have the similar design problems, consult design experts, communicate with the design instructors with synchronous or asynchronous critiques and share design ideas with other students using 2D or 3D representations of their design. It is also possible to conduct

interim and final juries synchronously online without time and place constraints.

3.3.2 Design Development through Critique Process

The primary process of design education takes place in design studios (Chaikin, 1998). Conventional approaches to design education allow students to explore solutions for real design problems. First of all, the design brief should be identified by introducing the design problem and specifications of the problem set and the student should explore it through discussions. Intentions of the design instructors related to the design problem should also be explicitly stated in the first meeting of the students with the design instructors. Informal and formal meetings should follow through out the project development process, including desk critiques, student group discussions and interim juries. Desk critiques help the development of design solutions occurring as the individual conversations between the instructor and the student. In this way, students get feedback about the design solutions they have produced and the instructors have the chance to see the development phases of the design project by following what the student's intentions are. By offering suggestions and pointing out the potential problems in student's design, the instructors help the development of the design projects. The discussions held between a group of student also helps the development of projects by introducing different point of views as well as helping the socialization of students. Throughout these discussions, students present their design ideas by using various media and materials, such as 2D or 3D drawing sketches,

sketch models, sculptures, pictures, photographs and written material. Interim juries, in which students, design instructors and experts participate, are motivating students in gathering and summarizing the steps they had taken in project development. At the end of the given time for completion of the design project, a final jury is conducted as a final evaluation and discussion.

As Spridonidis and Voyatzaki (1998) stated, teaching architectural design involves the cultivation of the creativity of students and their critical thinking on design problems. Understanding of design evolves and expands with the critique process, which is a dialog that increase the understanding of design situations, support integration of problem identification and solving; and help access to relevant issues in the information space by highlighting problematic situations and developing arguments about the validity of design solutions (Fischer et. al., 1998). It is a way to share, discuss and reflect design ideas. The students become aware of the breakdowns in their design solutions, see different point of views and opinions and re-interpret their own design for design development as the result of critiques. The nature of this process involves a cycle of conjectures and refutations of design decisions that help the growth of knowledge with a shared understanding. In this way, a stable base is developed for the further growth of knowledge (Fischer et. al., 1998). As Zimring et. al (2001) claimed, the instructors ask questions, reinterpret design features, highlight problems in design, encourage students, reinforce design decisions, recommend new ideas and sometimes direct students to appropriate references at different levels of design abstractions during the critiques.

Use of computer mediated environments for critique process has the same purpose and allow the similar activities. Computers or the web can be used as a medium for online criticism. This would allow participation of students in design critiques through an unstructured collaboration. “Telling and listening” and “Demonstrating and imitating” are the two ways of interaction in a critique process (Schon, 1987) (cited in Demirbas, 2001). These two ways of interaction creates a cyclic process throughout the development of the students` projects. As Demirbas (2001) stated they are interwoven and fill in the gaps in communication within the concept of reflection-in-action. Baker (1994) stated five models of online instruction for interaction. These can be summarized as *The Individualized Instruction Model*, which is a text-based system which can be downloaded from a database; *The Class Model*, in which students have the chance to work together and with an instructor while using an online medium for communication; *The Integrated Class Model*, which is enhanced with research activities and audio and/or visual conferences and supports students to online instructions; *The Group Model*, which involves the collaboration of a small group; and *The Collaborative Group Model*, which includes a consortium of educators with multiple resources in addition to the activities in all previous approaches (Baker, 1994). Therefore, the Collaborative Group Model is the one that best suits the nature of the design education because it can provide the use of all of the possibilities that Internet offers (Figure 3.1) (Sagun et.al. 2001).

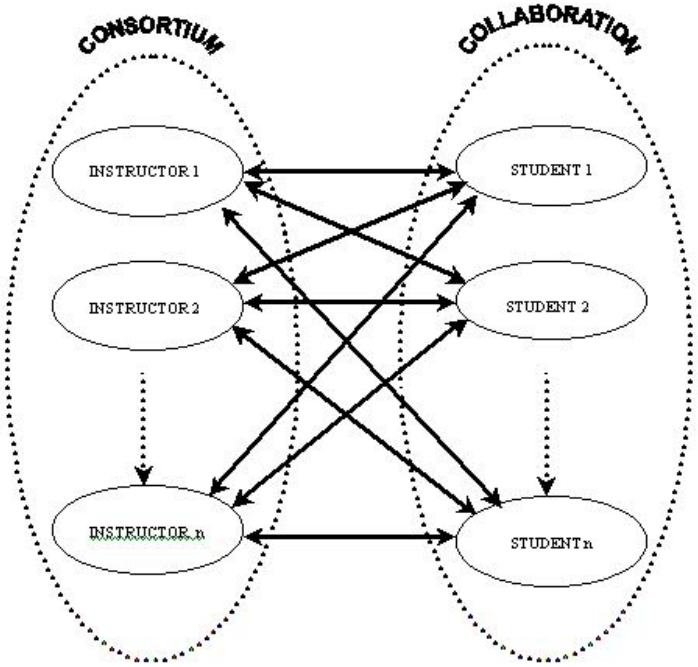

Figure 3.1 Collaborative group model

The unstructured collaboration involves brainstorming or open exchange of ideas and design issues to stimulate thinking within a group, which is usually a missing issue in studio education (Craig and Zimring, 2000). In this way students experience to help each other and have a chance to observe and make use of the comments given to the designs of other students if a database is constructed for keeping designs and critiques that belong to each phase of the design development process. Moreover, the critics have a chance to refer back to the previous steps taken by the student during design development to compare the designs of different students or to follow the design progress at anytime. They are not restricted to specific working hours or place to observe and comment on

design solutions as a result of the flexibility provided by computer mediated virtual environments.

Craig and Zimring (2000) claimed that an online asynchronous environment developed for design education can be used with an existing studio course which provide alternative context that will support open interaction if it is properly structured. The participation and contribution of students in critique process can be provided with such an approach. In this way, the students are encouraged for exchanging of information and working in groups. The limiting factors for the students` productivity in a group work is summarized as evaluation apprehension, free-riding and productivity blocking (Craig and Zimring, 2000). Evaluation apprehension is described as the decrease in participation of students because they find the design knowledge of others in the group more than their own design knowledge. It is claimed that the lack of social issues in an asynchronous environment can decrease this factor since social weight of exchange is decreased. Moreover, it is stated that students would contribute more when they interact with others and feel the sense of belonging to a community (Craig and Zimring, 2000). In this way the weakness lasted as a result of feeling their contribution as useless, which is refereed as free-riding, is also diminished. The less concentrated leadership in asynchronous environments also prevents loss of ideas while others are talking, in other words the production blocking is prevented (Craig and Zimring, 2000).

3.3.3 Content of the Critiques

The content of the critiques can be based on three factors as discussed by Marcus et. al. (1996): a) prior experience, b) intrinsic nature of information and c) organization of information flow among parties (cited in Demirbas, 2001). The information and knowledge communicated in design critiques are based on the class level and experience of the students. As Uluoglu (2000) stated, the teaching of design does not have a specific way but depends on multiple exercises and communication among design students and instructors. The design critiques manipulate students and enhance the design, by pointing out the efficient and useful solutions and types, levels and location of inconsistencies in the design while exchanging design knowledge. The design knowledge communicated in design critiques involves declarative aspects such as specifications and relations within the design and procedural aspects that depends on planning and operations (Uluoglu, 2000). Uluoglu (2000) discussed the design knowledge under four topics as categories, structuring, representation and content where the first three consist of generalizable (objective) results and the last one personalized (subjective) results. Concept is the keystone in categorization of knowledge in both descriptive and normative manner. A course of action of planning and operating is defined as the procedural knowledge in order to describe work, problem solving, search of a solution, development of a solution and description of the end product. Interpretation of the design of a student by spotting negative and positive aspects is an action of structuring knowledge. The

representational forms of knowledge transmission are categorized as reflective knowledge (in which interpretations and descriptions are stated), operative knowledge (in which coaching and demonstrations are made), contemplative knowledge (where questions, reminders and problem statements are raised), directive knowledge (where completions, conflictions, positive and negative statements are found), associative knowledge (where examples, analogies and scenarios are referred) and other informal communication issues (Uluoglu, 2000). Finally, the content is the quality of knowledge depending on quantitative and qualitative aspects of conceptual structure. In other words, the number of concepts derived by the designer is quantitative and the meaning of the concept and relationship with the other concepts is qualitative aspects of knowledge (Uluoglu, 2000).

The content of design knowledge is based on the design process. In this study, the content of knowledge that is exchanged through critiques are categorized and analyzed related to the problem domain and design strategies. In problem domain the levels of design abstractions, references to problem and solution spaces and functional, behavioral and structural aspects of the design are discussed. The levels of design abstractions in a design process are based on the categorization made by Gero and Mc Neill (1998). During the knowledge exchange through critiques, critics refer to different levels of design such as space, subspaces, objects and their interactions. Moreover, these comments of the critics either refer to design problem or solution spaces as explained by Maher and Tang (2003). During the design process, the transferred knowledge can be oriented

towards the functional, behavioral and structural aspects of design. Gero and Mc Neill (1998), also, stated that the critics could analyze a solution, propose a solution or refer to explicit strategies in their comments and critiques. These are named as micro-strategies and categorized under design strategies. The direct reference to high and low level design activities can also be observed during design development as defined by Vera et. al. (1998) as design strategies. The detailed explanation of these concepts can be found in Chapter 6 that explains the methodology for the analysis of the case study. The results of the case study are explained in Chapter 7 indicating the participation levels and emphasis of the participants of a CDS in the critique process. Beforehand, the model developed for the collaboration of two design courses and the research set up for the case study are explained in Chapters 4 and 5.

4. EVOLUTIONARY DESIGN COLLABORATION (EDC) MODEL

4.1 Nature of EDC Model

Course planning and design is a complex process when it is to be implemented on the web (Sagun et. al., 2001). The instructors need to design the learning experience when preparing a web-based architectural design course with the technological advances. The face-to-face collaboration among the students and instructors in traditional design studios can be enhanced with innovative tools developed in computer and information technology. The systematic exploration of issues concerning design and collaboration in an online environment can construct a continually developing useful archive of knowledge to be used in different design problems with different situations. Moreover, the knowledge related to specific design issues can be stored and augmented to be used for further design studies.

In order to guide the students in such a complex design process, critiques of instructors of participating courses are needed. Also critiques of other students developing their own design project on the same design problem would be effective. As Cheng (1995) stated, critiquing each other's work enable students to see the assignment through other eyes. Instructors may also learn and improve themselves with the questions generated by the participation of students since they may encounter questions that they

have never seen or guessed. In this way, students guide the instructor to receive the information and knowledge they want and need.

As Periera (2001) stated, it is necessary to take both educational and architectural design theories into consideration while designing collaboration for design education. Based on this idea, the Evolutionary Design Collaboration (EDC) model for implementation of CDS is developed related to situatedness and reflective design concepts using the three phases of SER model (Figure 4.1). The conceptual design process is evaluated and designated to organize the activities of participants within the design studio throughout the collaborative work. The EDC framework developed for the collaboration of two design courses is constructed in relation to two dimensions defined in their model of design collaboration by Vera et. Al. (1998): collaboration and design processes as explained in Section 3.1.

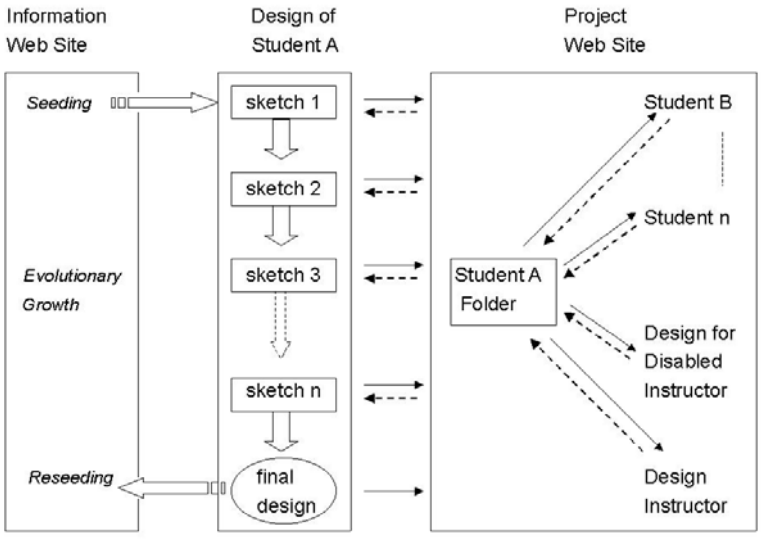

Figure 4.1: EDC Model

The CDS study involves asynchronous interaction of participants for collaboration of two design courses. Thus, the participants of the project are not restricted for critique time as it is in traditional course hours. Specific dates are given for submission and critiques of files to complete a number of critiques for project development in CDS schedule. They are free to submit or critique projects within the given dates at any time. Through out the CDS process, members of the two groups have some roles, responsibilities and requirements. The students are responsible for both improving their own design project with the help of critiques of other group members and making comments and on the project of the other student in his/her group each week. Instructors are responsible for submitting comments and critiques by the redline files created in ProjectGrid each week. In addition to the design archive developed by the critique files, each student is required to keep a simple design diary in which any changes, abstractions, transfers, removed items and/or additions in their design are noted each week.

The participants and levels of design process related to the activities of participants are shown in Figure 4.2 by concentric circles as design problem, conceptual design initiation, conceptual design development, submission and evaluation.

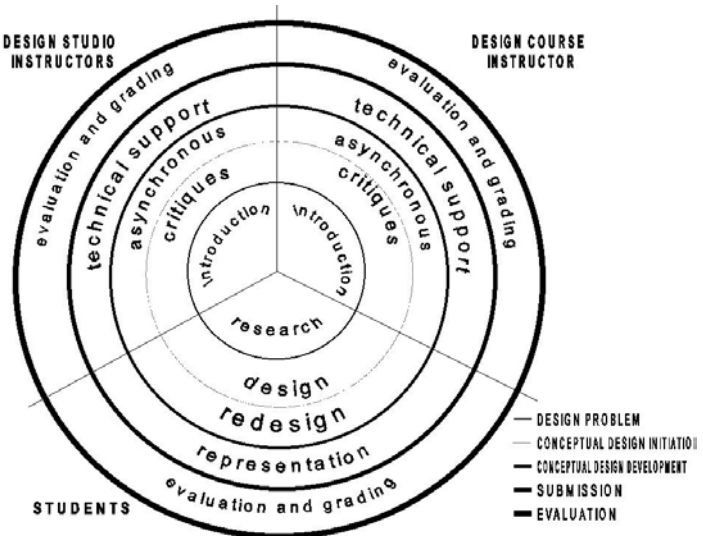

Figure 4.2: Design Process in CDS: participants and activities.

In EDC model, the collaboration process is situated in the sense that a new concept is introduced in design problem each semester with respect to the knowledge gained in another design course and the evaluations of representatives of different design courses on design help students enlarge their perspective and enable them to generate new ideas and solutions. The students are required to redesign their design project according to a new situation, which is taking disabled people into consideration. It helps them converge the design knowledge they have gained in both of the courses. As a result of the collaboration among the participants of the two design courses, the design evolves and solutions are improved for the new problem involving the needs and requirements about disabled people. The results, data and design solutions generated during the collaborative study do not create a solution path but they would be a base for the study of a next group. The collaboration process of two courses would be enriched

and evolved in each semester. Various implementations can be conducted with groups of other design courses in this way.

The design process has also a reflective nature in the sense that the students develop their design by reflecting their new ideas and solutions in each step as the result of the critiques. This approach brings a new perspective and issues to think about. The dimensions, materials and circulation routes should be reconsidered in their current design related to the new concept introduced. The students should satisfy the requirements of the second course in their problem solving process without destroying the requirements satisfied for another course.

In order to reflect the nature of *evolutionary growth*, an open-system should be provided so that the system can be modified in evolutionary growth phase and can be reseeded in time (Fischer and Ostwald, 2002). Open systems are the systems designed and constructed to provide collaboration. It is also necessary for synthesizing and reconceptualizing the currents system. Cycle of evolution and reseed provides a base for future evolution.

CDS has two web sites on the Internet related to SER model used for collaboration of two courses and the interaction of participants (Figure 4.1). One of them is the, “Information Web Site”, in which *seeding, evolutionary growth* and *reseeding* phases are organized. The second one is the “Project Web Site” provided by ProjectGrid for *evolutionary growth* and collaboration process. The basic features in ProjectGrid will help the participants of the CDS to communicate, interact, share and exchange

information and ideas through the Internet for developing their design project at conceptual design level. The web sites of CDS are explained in detail in the following sections.

4.2 Information Web Site

A web site is constructed for the CDS to conduct and implement EDC framework for collaboration of two design courses as a one way bridge from seed to evolutionary growth (Sagun, 2002) (Figure 4.3).

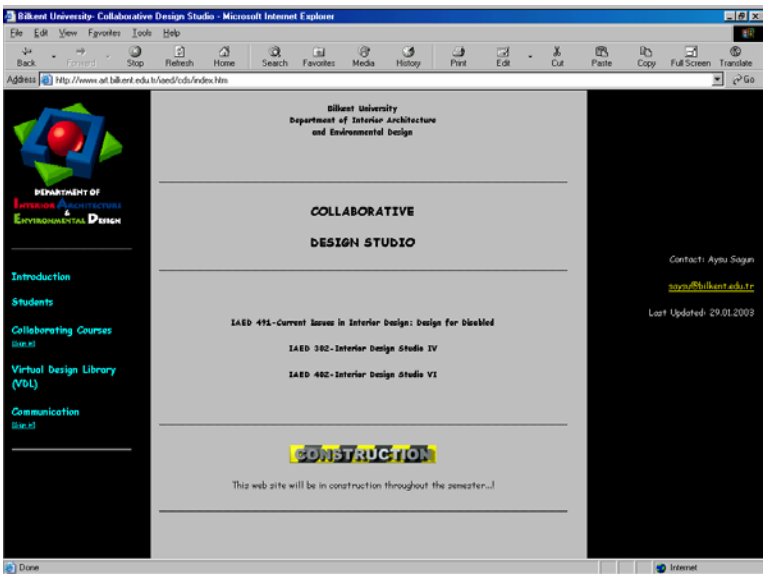

Figure 4.3: A snapshot from CDS Web Site.

Cheng (1998) stated that a parent site linked to component sites, a child site as destination, constructing sites within each other involving one of them selected as dominant, providing reciprocal bridges from one site to other or one way bridge form one site to other can be used to join web sites in a collaborative study. The CDS web site constructed within the

EDC model is a bridge allowing access to *seeding, evolutionary growth* and *reseeding* phases, in other words it is an access for informing participants about the course process and retrieving the knowledge generated at each semester, providing a space and tools for collaborative work. It has five main links related to the project process (Figure 4.4).

SEEDING	Introduction CDS Information Schedule Technical Requirements and Support Students Group Study Class Notes Student Projects Tutorials
EVOLUTIONARY GROWTH	Collaborating Courses IAED 491 IAED 301 IAED 401 CDS Communication Announcements Participants
RESEEDING	Virtual Design library CDS Project Archive “Design for Disabled” Archive

Figure 4.4: Organization of CDS web site

The links for *Introduction* and *Students* formulate the *seed* of the CDS. The *Introduction* page (Figure 4.3) includes information about CDS, in which use of computers and the Internet for design studies, the purpose of CDS, the implementation process and the brief explanation of hosting firm of the project are stated. The link for *Schedule* in introduction involves the timetable for the collaborative design process. Basic hardware, software requirements, prerequisite knowledge needed to participate in CDS project,

available features in the server company and basic trouble shooting information are also stated in introduction part through the link for T*echnical Requirements and Support*.

The basic topics related to design information are grouped under the second link *Students* (Figure 4.3), to provide easy access. The link for *Group Study* involves the objectives, requirements and responsibilities of the participants. Accumulated knowledge, information sources and references related to collaborating courses are stated in *Class Notes* in this part. There are sub links to specific topics discussed in collaborating courses, design checklists, glossary of design terms and online references. The projects of participating students are published through the link *Student Projects*. A *Tutorial* page including links for the information about use of AutoCAD and ProjectGrid is also provided in this part.

The information about the collaborating courses, their objectives, the design project details can be accessed through the link of *Collaborating Courses*. The *evolutionary growth* occurs in this section. A link to the CDS Project Site (ProjectGrid, 2002), which is the interactive collaboration site for discussing and sharing ideas and developing design projects appears as a bridge to collaborative activities. The collaboration through ProjectGrid will be explained in detail in the next section.

Communication of participants in *evolutionary growth* phase is also provided by the information documented in *Communication* page. The links for Communication includes contact information about each participant and also sub-pages for *Announcements* about the project.

The final link, Virtual Design Library is constructed for *reseeding*, in other words, for constructing an archive of information space by storing useful information that can be refereed back throughout the course or *reseeding*/development of the course for next semesters. It includes the design and drawings of previous projects and a library of CDS projects submitted by the participants to the project site.

4.3 Project Web Site

4.3.1 Organization of activities

As Engeli (1998) stated, it is a good chance for the students to experience and discuss collaborative work since networks and networked thinking are important for the future of professional practice. The students had a chance to experience this process in the case study exploring the collaboration of two design courses through the interactive web site, ProjectGrid. ProjectGrid is an interactive project collaboration web site developed to maximize opportunities in digital communication and cooperation for project management in cyberspace. It provides project specific web sites by subscription. It is possible to manage the entire program of projects from a single interface in ProjectGrid after adding members to the project. It introdeces quite an user-friendly interface that do not necessitate a special training.

The project members participate in the project with an e-mail invitation, in which the information about the handle and password required to log in are

stated. Entering this information in log-in screen, the participants can launch to CDS Project Site in ProjectGrid.

The homepage of project site includes twelve basic Tabs (Projects, Files, Pictures, Financial, Schedule, Tasks, Minutes, RFI, Contacts, Search and Settings) that are used for the collaboration activities and a tab for logging out (Figure 4.5).

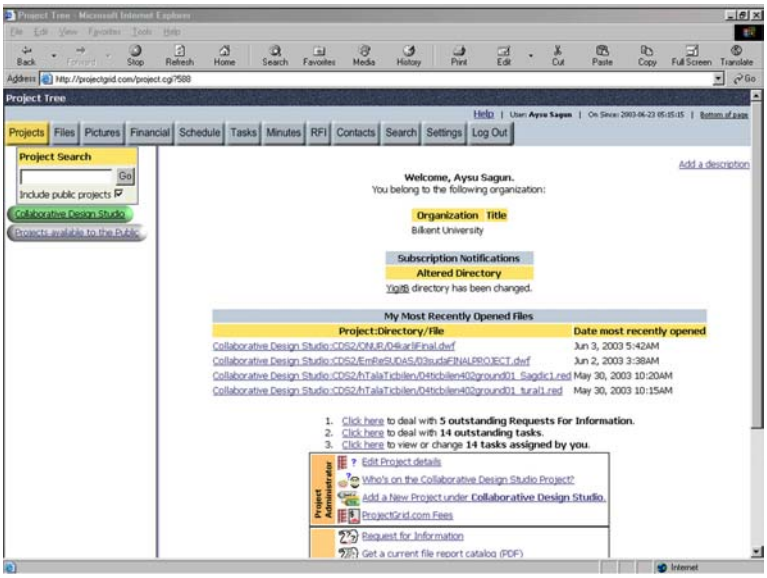

Figure 4.5: Homepage of CDS project site

Project tab provides a link to the public and team projects. Folders and files can be created, uploaded and accessed from the *File* tab (Figure 4.6). It is possible to assign administrative right for each folder. The members subscribed to a folder are notified by e-mail in case of a new upload.

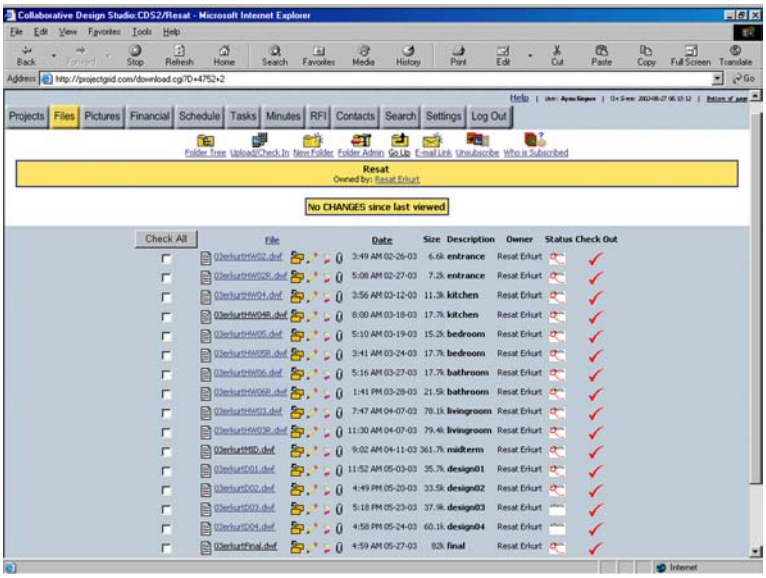

Figure 4.6: Files tab

An image album is present for creating an image archive and quick access to image documents such as documents in JPG formats. The thumbnails of these images can be viewed through *Picture* tab (Figure 4.7).

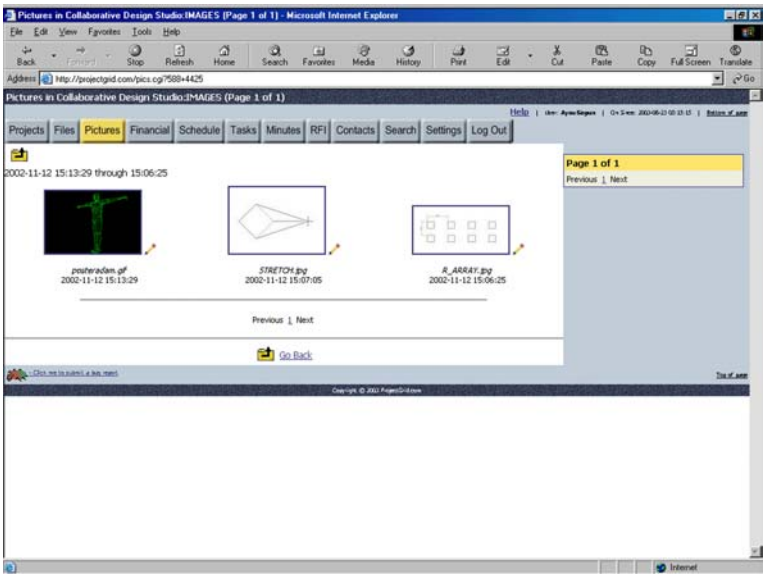

Figure 4.7: Pictures Tab

Financial Tab is used for calculating the budget of the project to work on economic facts. Since CDS is an educational project, financial issues are not studied. However, it is necessary to develop a schedule for design process to manage time and conduct a systematic study. The *Schedule* Tab is used to keep all team members accountable for deadlines and tasks (Figure 4.8). The schedule of the design process is uploaded to the dynamic scheduling system, which notifies the participants for any incoming assignment. When an assignment is given to the participants, it is possible for them to view the drawing files, mark them up for critiques and add comments on them within the system. The schedule can easily be changed online through the Internet Browser.

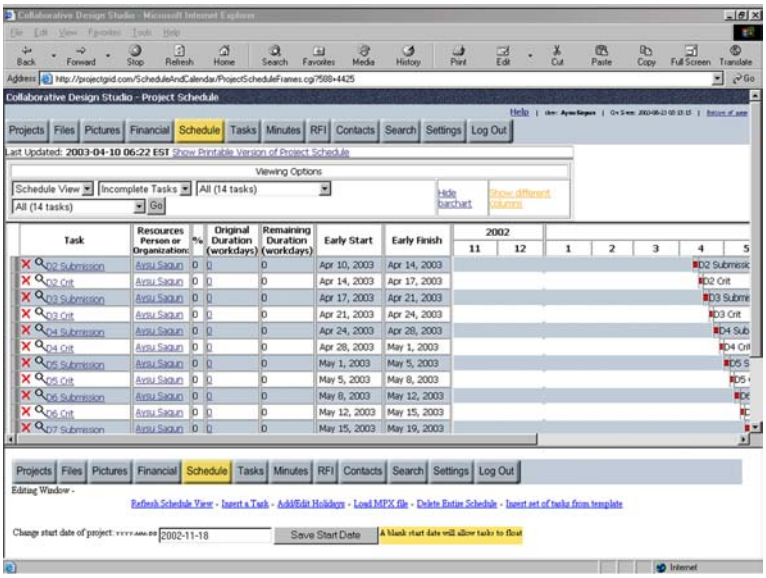

Figure 4.8: Schedule tab

It is possible to assign tasks to each member and notify them by e-mail automatically through the *Task* Tab. Through the meeting *Minutes* tab, you can enter pertinent meeting information and distribute electronically. Tasks

can also be assigned to members on the project schedule and their To-Do list. Moreover, Request for information (RFI) can be send and replied by all participants to discuss any question or problem about the design and project (Figure 4.9). The participants are notified for any new RFI and files uploaded to the project site by e-mail since there is a dynamic scheduling and notification system.

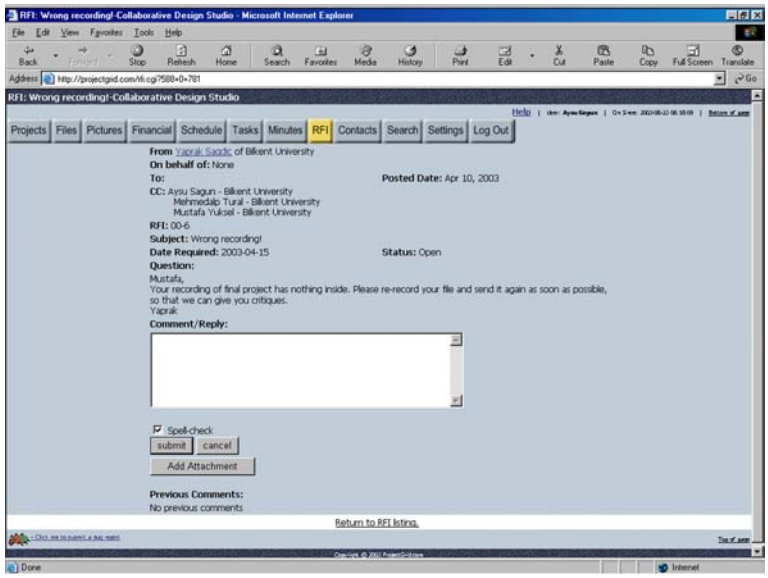

Figure 4.9: RFI tab

Contact information about the members of the project and direct e-mail links for them can be found in *Contacts* tab. It is easy to find any file in folders by using *Search* tab. The settings tab is used for managing the files and information of the members.

4.3.2 Sharing of Drawings

While working together, the participants in a design project needs a common language. Drawing is the language that designers use to

express their design ideas and concepts. The interaction and exchange of information between the student and the instructor in a design studio is also provided by this common language, drawings and sketches by pens and pencils. Orthographic drawings such as plan, section and elevation are the two dimensional abstractions that enables the observer to construct the design model in their mind (Sagun, 2001).

Unlike traditional design studios, computer drawings and representations are used through Internet for communication. Computer drawings can be created in various CAD programs, which may have different formats. In this study the drawings are created in AutoCAD and converted to Drawing Web Format (DWF) format since *dwf* is used to view 2D electronic drawings in ProjectGrid. A *dwf* file can be defined as a vector image and an electronic plot that has special viewing properties when displayed in a web browser. It is possible to scale and move this electronic plot within the browser window but it is not possible to make changes on the drawing. They can be marked up or in other words, redlined by special CAD programs used for this purpose.

The *dwf* files are viewed using a built- in CAD Viewer in the ProjectGrid`s server. There is no need to use any other program to view drawings, once the plug-in of CAD viewer is installed in the first time use. Although the *dwf* files can be created in AutoCAD, they can not be viewed in AutoCAD. Moreover, *dwg*, *dxf* or other drawing formats can not be viewed within the ProjectGrid system. If VoloView Express or another CAD Viewer is installed on the computer, it is possible to see

the *dwg* files but they can not be displayed after the redlines are added. For this reason, the participants draw and redesign their designs in AutoCAD *dwg* format related to the critiques and redlines in shared *dwf* files and save the files in both *dwg* and *dwf* formats. Respectively *dwf* files are uploaded to CDS Project Site for the next critique.

It is possible to add redlines and comments on *dwf* files by accessing the *Status* of a file. Once the file is chosen, redline and text can be added to the drawing using the tools in the CAD Viewer (Figure 4.10). The marked up file is saved as a redline file with the extension of *red* in the system or in a local drive.

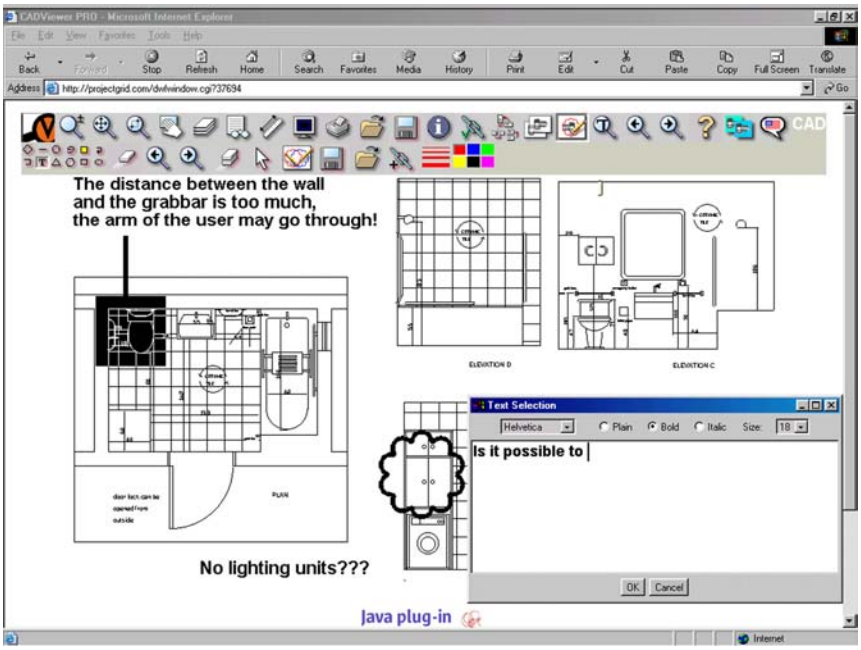

Figure 4.10: An example for a redlined drawing

If there is a red mark on the *Status* of a file, it means that the file has a redline or comment (Figure 4.6). In order to access these redlines, *Status*

of the file should be launched. There is no limit for adding redline files. Each redline file is given a different name and saved in the project site.

It is also possible to share files with a different format such as *doc, ppt, jpeg*, etc. In this case, similar to the drawing documents, the files are displayed and modified within the Internet browser. Finally they can be saved in project site or in a local file in the computer.

In the following chapter, the research setup for the case study conducted using ProjectGrid is explained.

5. THE CASE STUDY: CDS AT BILKENT UNIVERSITY

5.1 Research Setup

5.1.1 Research Problem

Most of the studies on CDS are related to the improvement of tools and there is still, the lack of a systematic methodology for collaboration of design courses through CDS. The aim of the case study is to formulate a framework for the collaboration of design courses through the Internet.

CDS development necessitates the understanding of possibilities and constraints in both design collaboration and the media being used. The participants need to adapt to CDS by learning to communicate, interact, design and represent. The emphasis of the instructors on the skills rather than to teach the ability to use the commands in the CAD package may motivate the students (Roberts and Forster, 1998). Such an approach may help students to integrate various skills gained from various design courses in their design projects. As Kvan et. al. (1999) stated successful collaboration in a computer-mediated environment is achieved by replicating the conditions found in face-to-face experiences.

5.1.2 Research Question

Based on the concepts stated above, the study examines four issues:

1. How to formulate a framework for the collaboration of design courses?

2. How information is transferred through critiques in a CDS?

3. What is the content and level of participation of students and instructors in a CDS conducted through the Internet?

4. What are the design issues (i.e. problem domain and design strategies) that the collaborators emphasize during the critique sessions?

5. What is the usability of the proposed CDS model in terms of system performance and user satisfaction?

Related to the first research question, the existing CDS examples all around the world are studied and their concepts, theories, methodologies and tools are examined. A model, EDC, is formulated as a framework for the collaboration of two design courses (See Chapter 4). Based on the negative and positive issues found in the pilot study conducted with a small group of students (4), the CDS is improved and the case study started in the following term. The data collected during the study is analyzed in quantitative and qualitative terms (See Chapter 7 for questions 2-5).

5.1.3 Participants

Two levels of students are involved in CDS, junior and senior. Totally six groups are formed consisting of two students from the same year, one of their design studio instructor and the instructor of the course "Design for disabled". The subject profile can be seen in more detail in the usability report of CDS in Section 7.3.2.

5.2 Methodology

In this study, the framework for CDS is constructed based on the concepts of situatedness and reflective practice, which are the two concepts in theories of design education. The collaboration process is conducted through the use of the asynchronous communication system due to the restrictions and constraints in budget and available tools for the participating students and instructors.

The study started with a clear definition of CDS including its properties, needs, requirements in architectural design education. CDS involve the design activity by computer mediation and support (Simoff and Maher, 1995). The similarities and differences of CDS from the traditional design studios is studied and examined through a comprehensive research in literature and existing implementations of CDS. Following the outcomes of the research in literature, the EDC model is developed. In the next step, the tools and methods that are used in previous implementations are studied and a research is conducted in detail to find out newly developed

tools and their properties. As a result of the studies of a comprehensive research and evaluation of available tools, economic and technological contingencies, one of the interactive hosting companies, ProjectGrid project site is chosen to be used as a tool for CDS implementation. It is an interactive collaboration web site host that provides opportunity for design collaboration with a server built-in CAD Viewer. All features of ProjectGrid can be seen in Section 4.3 and Appendix A.2. The collaboration features, technological issues and economic constraints are taken into consideration while deciding on the suitable collaboration tool. The local content such as used platform, users base and computer configurations are also considered when choosing the host of collaboration web site. The ease of use is another advantage that is found in ProjectGrid. It is important for the participators to adapt to the system easily so that they will work with pleasure and effectively.

In the next step, the information web site is prepared as the homepage of CDS. The courses are chosen and a pilot study is conducted in Fall 2003 with four students from junior and senior design studios who are taking the collaborating course IAED 491 Design for Disabled. There are two reasons for preferring IAED 491 Design for Disabled course for this implementation. First one is based on the concepts introduced in the course. It makes the students aware of the design issues that should be taken into consideration for universal design, in other words thinking on the needs and requirements of the minority of the society as well as the majority, which is also an emphasis in design studios. The second reason is the level of the course. It is a course at senior level and all the students who are taking this

course are experienced with computers and two-dimensional drawing using computers.

Cheng (2001) defined six steps for teaching design concepts in digital environments. The first step is the introduction of design concept and the construction of computer environment. Secondly, examples are shown related to the collaborative work. The introduction of the assignment follows this step. Respectively the techniques to create, collaborate and represent design are explained. Students apply these techniques in their work in the next step and finally the assignments are reviewed. Related to these concepts in design teaching in digital environments, CDS started with the introduction of CDS structure and process to participating students and instructors. At the beginning of the semester, all participating students and instructors were informed that all the design critiques would be carried out through the Internet environment. It was explained that the aim was not to test their ability in computer usage but the use of Internet for the collaboration of design courses. In the first meeting, the students were asked to respond to the questions in the distributed questionnaire to obtain information about their previous experience with computers (See Appendix B.1). Then a lecture was given to all participants consisting of the basic instructions for CDS participation and use of the system, ProjectGrid. The information about tools and schedule for collaboration are also published in the Information Web Site. A written document was prepared and distributed to the participants that explained the rules and principles to use and participate in CDS and ProjectGrid web site.

The collaboration process started with the registration to the site and uploading of the first design project of each student. The design projects progressed in five weeks with the feedback obtained through asynchronous critiques of the group members in CDS. The due date for submitting the redesigned project in each week was Mondays. Each participant had the opportunity to criticize the redesigned projects by writing the comments in the redline files until the following Thursday**.** In this way, each student had a chance to see comments and redesign the project for the next critique within three days.

In addition to redline files, each student was required to keep a simple design diary each week, in which any changes, transfers, removed items and/or additions in their design are noted in a few sentences. At the end of the semester each participant, including the students, evaluated and graded for the final designs. After the last step, the participants were asked to complete two questionnaires developed to test the performance of the system and the satisfaction level of the users (See Appendix B.2-B.3).

The responses of the students and the observation of the collaboration process in pilot CDS helped in determining the problems and improvement of the CDS. The CDS with 18 students from junior and senior design studios had been conducted in the following spring semester, in a period of five weeks. Meanwhile, a methodology is developed to evaluate the data collected in CDS based on problem domain and design strategies researched during the literature survey (See Chapter 6).

Every step of the design process for each student is archived in the database of ProjectGrid. This archive is a resource for *reseeding* process to develop the course for following semesters. It can also be used as a source by the following CDS students since various solutions to different design problems can be observed. The copy of this archive will be pasted to Virtual Design Library in CDS web site to provide easy access to participants and to prevent loss of information and data at the end of subscription to hosting site ProjectGrid.

In this study, there is a limited time for CDS project site in ProjectGrid because of economic constraints so it is a temporary tool for collaborative process for this study. Future studies with more opportunities of financial support can involve construction of a constant database and collaboration tool.

5.3 Data

The data used to evaluate the case study are the redline files, design diaries and the questionnaires which are given at the beginning and at the end of the case study. In the redline files, critiques of the students and instructors are analyzed and their emphasis on the issues related to the problem domain and design strategies are discovered. All the redline files saved in the personal folders of the students are recorded on a weekly basis for quantitative and qualitative analysis. The design diaries which are also recorded on a weekly basis, helped in the description of the students` emphasis on behavior and features aspects of the problem and solution

spaces during a collaborative study conducted through the Internet. The purpose of the questionnaire given at the beginning of CDS was to determine the profile of the participating students and instructors. Two questionnaires are given at the end of CDS are for identification of the usability problems based on usefulness and ease of use of the CDS conducted within the framework of EDC model and satisfaction of the participants. The results of these two questionnaires can be a basis for the development of the methodology and tools of CDS and further studies on collaboration. The next chapter explains the methodology developed for the evaluation of the data in CDS. The results of the data analysis can be found in Chapter 7.

6. EVALUATION OF CDS

6.1 The Redline Files

Comments and proposals of different design decisions are found in redline files of participants of a design team (Jung and Do, 2000). The intentions and the focus of the design process through the collaborative study are analyzed by using the data in the redline files related to the design 'problem domain' and 'design strategies' (Figure 6.1). The 'problem domain' has three categories for segmentation as 'design abstraction', 'space and representation' and 'variables'. The 'design strategies' are analyzed as 'micro-strategies' and 'design activities'.

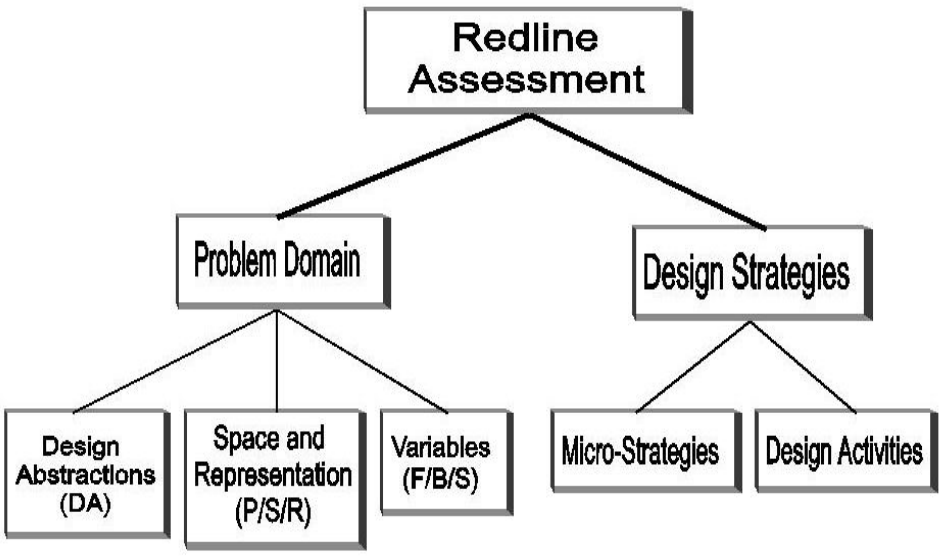

Figure 6.1: Evaluation of redline data

6.1.1 Segmentation of the Redline Files

During CDS, the students working in teams are required to take critiques from each team member every week. Segmentation method is used to observe and analyze the given critiques during the collaborative study. The method of segmentation is focused on the critics` comments and critiques about the redesigned project. In a redline file that is displayed by the CADViewer on the computer screen, the critic marks the border with a circle or a bubble. Each redline file including the comments and critiques of the team members is parsed into small units in order to encode the analysis process. These small units are called “segments”. The segments were driven from a single comment of a critic on a single subject guiding the student’s design decisions. In other words, a segment is a comment of a critic on a specific part of the project (Table 6.1).

Table 6.1: Examples for redline segmentation

Segment Number	Explanation
1	The lavatory should be located in a way that it can be accessed not only from the WC, so it will be better to turn it 90 degrees counter clock-wise.
2	You can assign some functions to the reception hall, like a little cloakroom in it. It will help you to shape, the reception.

Another comment addressing to the same or a new part of the design issue is considered as a new segment. Usually a single comment is stated in a single sentence or phrase but in some cases more sentences or phrases are added to clarify the statement. In that case, all the sentences and phrases related to the same design issue are considered as a single segment. The second segment in Table 6.1 is an example for such a case.

6.1.2 Coding Scheme of the Redline Files

6.1.2.1 Problem Domain

The problem domain coding has three dimensions in clarifying the approaches and navigation of the critics in the problem domain: namely level of design abstraction in design process (DA), emphasis of the domain space as problem, solution or representation (P/S/R) and variables as function, behavior and structure in design (F/B/S). All issues are categorized and coded as in Table 6.2 for the assessment of redlines files. The sub-categories introduced in each group are defined according to the intentions of the critics in terms of their goal and sub-goal in the specific design problem.

Table 6.2: Coding of the problem domain

Design Abstractions (DA)	**Space & Representation (P/S/R)**	**Variables (F/B/S)**
0 - Space as a whole	P - Problem	F - Function
1 - Sub-spaces	S - Solution	B - Behavior
2 - Interactions among sub-spaces	R - Representation	S - Structure
3 - Interactions of objects		
4 - Details of the space and sub-spaces		
5 - The objects within the space		
Rd - Initial requirements of "Design for Disabled"		
Rs - Initial requirements of "Design Studio"		
U - Undefined (such as drawing & representation)		

Design Abstraction (DA)

Gero and Mc Neill (1998) categorized the design process with respect to different levels of abstraction. In this study, the critics` comments are

analyzed similar to design abstractions categorized by Gero and McNeill (1998), in order to achieve a design solution. The numbers corresponding to each level refer to specified needs, questions and comments related to the whole building, subspaces of the building, details of the space or objects within the space and the interaction among subspaces and objects as specified in Table 6.3. The objects include issues like the furniture, accessories, lighting units, doors and windows in a space. The details of a space, subspace and object include the dimension, direction, location, material and construction details. Requirements (R) in DA refer to the statements written to remind the students to satisfy the requirements of the project such as missing issues of the artifact. Requirements for the two courses are differential by the script as ‘d’ stands for ‘Design for Disabled’ course and ‘s’ for ‘Design Studio’. The questions or statements about the representations that can not be understood by the critic are coded as undefined (U). An example for each level of DA is seen in Table 6.3.

Table 6.3: Examples for DA segments.

Segment	DA	Explanation
What kind of spatial references do you have?	0	Whole space
You can assign some functions to the reception hall like a little cloakroom in it. It will help you to shape the reception.	1	Subspace-reception
The circulation to/from the toilets` the circulation to/from the kitchenette and the service circulation to/from the service entrance are congested at this area.	2	Interactions among subspaces- toilet, kitchen and service route
The relation of the bar counter to the sitting units next to it might be uncomfortable for the bosses sitting at that area.	3	Interactions among objects-sitting units and the bar counter
The curved partition panel placed at the entrance does not solve the problem!	4	Detail of the space-partition panel in the space.
Doors must be opened towards outside.	5	Details of the objects-opening direction of the door.
There are no grab bars around the WC and the bathtub.	Rd	Requirement of “Design for Disabled”-grab bars
The Internet area and the TV area are missing! (If they exist somewhere in this plan, they are not as defined space-wise, as required by the project)	Rs	Requirement of “Design studio”
What is this line?	U	Undefined

Domain Space and Representation (P/S/R)

Problem and solution spaces determined by Maher and Tang (2003) are found in design protocols of the designers. In an asynchronous design critique process, there are comments, references or questions related to the representation of a design. Thus, the space and representation (P/S/R) group in this study indicates whether the content of the critique is related to the design problem (P), design solution (S) or design representation (R). The comments on the design representation or comments and questions of the critic for inconsistencies and undefined parts of the drawings, such as

meaningless lines that can not be understood by the critic, are coded as representation (Table 6.4).

Table 6.4: Examples for space and representation segments.

Segment	P/S/R	Explanation
The Internet area and the TV area are missing! (If they exist somewhere in this plan, they are not as defined space-wise, as required by the project)	P	Design Problem
The layout of the area is sparse compared to the rest of the lounge.	S	Solution of the student
What is this line?	R	Representation

Domain Variables (F/B/S)

Maher and Tang (2003) evaluated co-evolutionary design process related to function, behavior and structure issues in design process. In this study, the variables (F/B/S) group indicates whether the critique is related to the aspects of function (F), behavior (B) or structure (S) of the space and objects within the space. Functional aspects include layout and functional use of space or object. The behavioral aspects are related to the use, circulation routes and obstacles. Construction systems, details, dimensions and materials used for the space or object are involved in structural aspects (Table 6.5).

Table 6.5: Examples for variable segments.

Segment	F/B/S	Explanation
Also symmetrical arrangement of the drink counters are unnecessary and causing difficulty in maintaining the service.	F	Function-drink counter
The obstacles on the way to the showertub may create some accessibility problems.	B	Behavior - bathroom
Did you think of any sound insulation precautions?	S	Structure-sound insulation

An example for coding redlines of a student design with respect to problem domain can be seen in Appendix C.1.

6.1.2.2 Design Strategies

The coding system focusing on the design strategies has two dimensions related to the emphasis of critics on micro-strategies and design activities (Figure 6.1). The sub-categories introduced in each group of encoding are defined related to the approaches in design critiques through the redline files.

Micro-Strategies

The three categories of micro-strategies are based on the system defined by Gero and Mc Neill (1998) (Table 6.6). As Gero and Mc Neill (1998) stated, the critics could analyze a solution, propose a solution or refer to explicit strategies in their comments and critiques. The group for “analyzing a solution” includes the responses of the critics to the design solution submitted by the student. The second group includes the proposals of the critics for project development. Finally the critiques including explicit

strategies are the statements or proposals that refers to a requirement, knowledge or strategy (Table 6.6).

Table 6.6: Coding focused on micro-strategies

Micro-strategies		
Analyze a Solution	**Propose a Solution**	**Explicit Strategies**
Js- Justify a design decision	Ps- Propose a solution	Rak- Refer to an application knowledge
Rs- Reject a design decision	Cs- Choices for solution	Rdk- Refer to the DD knowledge and requirements
Cu- Clarify a problem in future use	Lp- Looking back to a previous solution.	Rsk- Refer to the DS knowledge and requirements
Wm- Warning for missing issues		Rds- Refer to the design strategy
Co- Comparison		
Rp- Refer back to a previous solution		
Qs- Question space properties		
Qo- Question object properties		
Qr- Question representation		
Qc- Question design concept		

The first two codes under ‘analyze a solution’ refer to justification (Js) and rejection (Rs) of the design decision of the student, since the analysis of a design in the collaboration of two design courses justifies or rejects a design solution. If the critique warns about a missing issue (Wm) or clarifies a problem (Cu) about the actual future use of the designed space or object, they are coded as separate issues. Other items in coding of this group are related to the comparisons (Co) or references (Rp) to the previous solutions of the critics while stating their comments or expressing ideas during design analysis process. Moreover, the students can communicate through drawings about some missing, undefined issues in

the designs related to the design concept (Qc), space (Qs) and objects (Qo) within the space or missing and undefined design representations (Qr) in the drawings. These problems are also questioned by the critic through redline files and e-mails to understand the design idea properly as coded in the last four groups under analysis of solution in Table 6.6.

The critiques related to ‘propose a solution’ are coded as three separate groups in micro-strategies. In addition to the analysis of design, it is also possible for a critic to propose a new solution (Ps) or choices of new solutions (Cs) to the previous wrong solutions, missing issues or unsolved problems in the design using the redlines. The proposal may include one (Ps) or more new solutions (Cs) or refer back to the previous solutions (Lp), leaving the choice to the owner of the design.

Moreover, ‘explicit strategies’ are related to the knowledge of the application (Rak), the knowledge and requirements of the design domain (Rdk) and design strategies (Rds) discussed in collaborating courses (Design for Disabled and Design Studio) and various design strategies (Rsk) are found in the redline files of the critics to help the improvement of the design project of the students (Table 6.7). These explicit strategies form the third group of the micro-strategies.

Table 6.7: Examples of micro-strategy segments.

Segment	Analyze a solution
It is very important to give alternatives for both the left-handed and right-handed people. Thank you.	Js
The coffee table in the middle is huge to be reached.	Rs
If you leave so much space in a cubicle like this for the healthy people than they may feel themselves as lost	Cu
There are no grab bars around the WC.,	Wm
The last drawing was, better for nursing area.	Co
You still did not change the design of grab bars.	Rp
Did you think of any sound insulation precautions?	Qs
Does this grab bar become an obstacle to access seat and sitting down?	Qo
Is there a wall there?	Qr
	Qc
Segment	**Propose a Solution**
You can assign some functions to the reception hall like a little cloakroom in it. It will help you to shape the reception.	Ps
To locate either the door or the WC/lavatory area on the other side will create an easy access and maneuvering area.	Cs
The last drawing was, better for nursing area.	Lp
Segment	**Explicit Strategies**
Sofa for three people cannot be used efficiently in a lounge like this. No one will like to seat shoulder by shoulder.	Rak
You must leave 30 cm free space on the latch side of the doors for the feet of wheelchair user. Otherwise the doors can not be opened.	Rdk
The Internet area and the TV area are missing! (If they exist somewhere on this plan, they are not as defined space-wise, as required by the project)	Rsk
How do you provide food service to the counter from the kitchenette without interrupting the public circulation?	Rds

Design Activities

The requirements of a design problem can be related to high level (HL) or low level (LL) design activities. The high level activities include broad decisions which have a significant effect on the following design decisions

such as decisions on layout and circulation whereas low level activities include resolving issues of design problem such as identification of materials and design elements used in the design (Vera et al, 1998). The design activities in the design problem are categorized related to these two levels for coding. HL design requirements include the comments or critiques of the critics on layout (LY), circulation (CR), dimension (DM) chosen, shape and geometry (SH) used, construction systems (CS) and obstacles (OA) within the design space. LL design requirements include comments or critiques of the critics about secondary issues of the design such as lighting (LT), material (MT), furniture (FR), signs (SG) and accessories (AC) (Table 6.8).

Table 6.8: Coding of the design requirements

High level		**Low Level**	
LY	Layout	LT	Light
CR	Circulation Route	MT	Material
DM	Dimensions (space)	FR	Furniture
SH	Shape/Geometry	SG	Signs
CS	Construction System	AC	Accessories
OA	Obstacles/ Accessibility	U	Undefined decisions
U	Undefined decisions		

The term ‘undefined’ (U) is used for any comment or question of the critic about an unclear representation of the students. These issues are categorized based on the critiques of the pilot study. Coding examples of the design activities can be seen in Table 6.9.

Table 6.9: Examples for design activity segments.

Segment	**HL**
The CIP lounge should introduce different layout groups for different numbers of patrons.,	LY
The circulation to/from the toilets` the circulation to/from the kitchenette and the service circulation to/from the service entrance are congested at this area.	CR
If you leave so much space in a cubicle like this for the healthy people, they may feel themselves as lost.	DM
Symmetrical arrangement of the drink counters is unnecessary and difficult to maintain the service.	SH
This type of a kitchen wall may create some utility system problems and also it cannot be perceived easily by the users and the customers. Do you really have to design that wall in that curvilinear shape?	CS
Does this grab bar become an obstacle to access the seat and sit down?	OA
What is this line? Hmm??	U
Segment	**LL**
No night lamps??	LT
What is the material in between these two people who are expected to make private telephone conversations?	MT
Sitting shoulder by shoulder is not a good solution. A sofa for two and two armchairs will be better.	FR
For my opinion` people do not have time to read a book but they may read a magazine or newspaper so may be labeling there as "shelves for magazines & newspaper" is better.	SG
This type of a grab bar can be very dangerous. You should have left only 4 cm space between the wall and the grab bar. Otherwise the user may break his/her arm.	AC

An example for the coding of the redline files of a student's design with respect to the design strategies is in Appendix C.2.

6.2 The Design Diaries

During the design process, the students were required to submit a design diary for each redesigned phase of the project that include a brief explanation of the changes they had made consisting of the additions, removals or modifications on the designed space properties or objects within the space. Each week the decisions taken and the reasons for the modifications on the project were noted by each student in a design diary in a few sentences. Segmentation method is used for observing and analyzing the design diaries similar to the approach in the analysis of redline files.

6.2.1 Segmentation of the Design Diaries

The segmentation of design diaries is focused on the intention of the student during the design development process. Therefore, each segment of the design diaries is driven from a single intention of the student (Table 6.10).

Table 6.10: Examples for design diary segmentation

Segment Number	Explanation
1	The kitchen and its storage area were unnecessarily large, so I made the kitchen area smaller.
2	The design of the grab bars was not right because someone handling the grab bar can be injured, if his hand slips. I have changed the design of the grab bars.

A segment in the design diaries also may include more than one sentence or phrase in explaining the single design intention of the student pertaining

to the design project. In that case, all the sentences and phrases related to the same intention or modification explained in the design diary is considered as a single segment. The second segment in Table 6.10 is an example for such a case.

6.2.2 Coding Scheme of the Design Diaries

Each week, the students wrote down their design decisions, intentions and the reasons of any modification, addition and subtraction that they had done in their design project in the design diaries. Encoding of design diaries is based on problem and solution spaces of the design process. Maher and Tang (2003) developed a co-evolutionary design model, in which, the problem requirements and solution spaces evolve in parallel. A coding scheme is developed for co-evolutionary design, based on the features and behavior in the problem requirement and solution spaces in design process. In this study, the coding system is developed with respect to behavior and features in problem requirement and solution spaces similar to co-evolutionary design coding approach (Maher and Tang, 2003). Requirements in coding refer to the requirements of design problem involving statements about both features (R-fe) and behaviors (R-be) in design problem (Table 6.11). R-fe involves students` statements including decisions and modifications based on the design problem and requirements of the two collaborating courses during design process. For instance, the modification made by the student as a result of a requirement of one of the collaborating courses is considered as R-fe. R-be includes the statements including decisions and modifications related to the behavior of

the problem requirements throughout the design process. Thus, any statement made related to the requirements of a previous critique can be an example for R-be. Solution space also involves statements based on features (S-fe) and behaviors (S-be) in design solutions of the student (Table 6.11). The decision of a student that explains the features of a design solution is considered as S-fe such as definitions, explanations and statements about a new item added to the design. A decision involving a development or change in design as a result of a success or failure in behavior of a design solution is considered as S-be, such as changes in the dimensions of a space or an object in order to provide accessibility to the designed space.

Table 6.11: Requirements and solution

	Requirements	**Solution**
Feature	R-fe	S-fe
Behavior	R-be	S-be

Each statement of the student about a modification or decision noted in the design diary is taken as a segment and coded related to the problem and solution spaces. Examples for each type of segment can be seen in Table 6.12.

Table 6.12: Examples for design diary segments.

Segment	Requirements and solution
I place the food counter in front of the kitchen door to prevent the traffic between kitchen and food counter,	R-fe
According to the critics, I understood that the traffic in between WC and kitchen would create chaos.	R-be
I used sliding doors for the entrance of the shower rooms.	S-fe
Also I put the Internet and telephone services in the same area so the reception area is enlarged.	S-be

An example of the coding design diary of a student can be seen in Appendix C.3.

6.3 Conflicting Critiques during Design Development

The design solutions of the students in design development phase are based on various design decisions and critiques. When a student obtains more than one critique on the same design issue, s/he has to analyze, synthesize and make new decisions by reinterpreting the design while rethinking on the rejected solutions, proposals and critiques (Figure 6.2). The student has to decide and accept one of the conflicting critiques and reject the other through the evaluation of critiques of team members. The decision of the student can be shaped through singular or comparative evaluation approaches. Singular evaluation involves observing and evaluating several alternatives in turn on its own merits to find an acceptable solution whereas comparative evaluation involves a systematic

parallel evaluation of alternatives against identical criteria to choose the best one (Ball et. al., 2001). Also, s/he has to rethink on the design problem to develop the design and find a better solution that would satisfy the design requirements of both of the critiques (Figure 6.2).

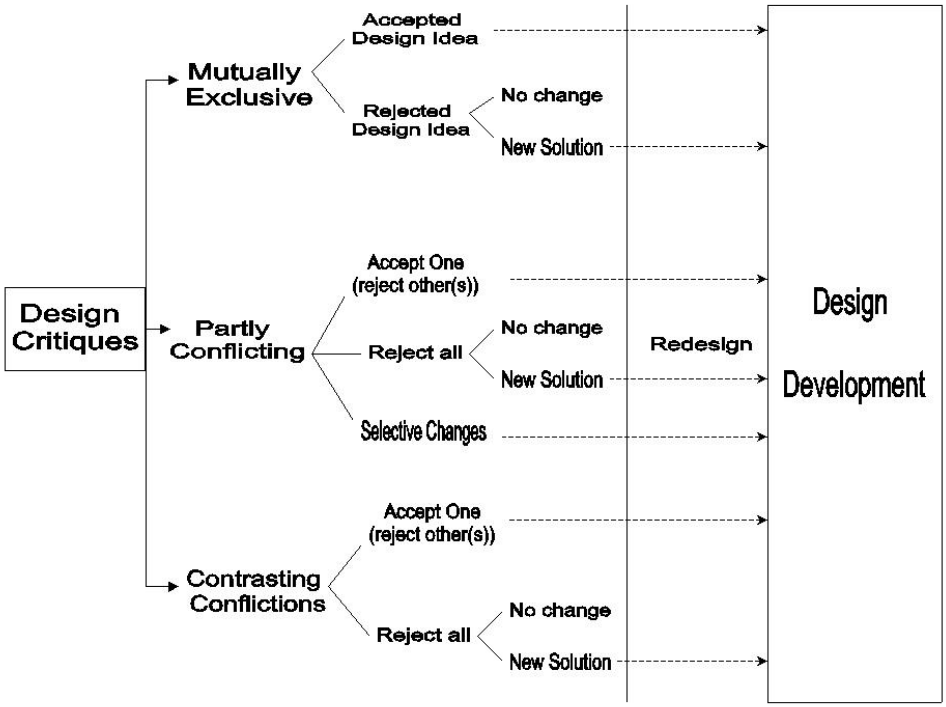

Figure 6.2: Students` response to design critiques for design development.

Ball et. al. (2001) introduced Naturalistic Decision Making (NDM) for exploring solution behavior. A comprehensive summary is given for exploration of solution options in NDM tradition by Ball et. al (2001). It is stated that several courses of action are generated and evaluated in order to find the best solution. A single solution can be evaluated to test its appropriateness for the current situation and it is either used as it is or a second option is generated as a solution. Retrieval of one or more

alternatives is another choice for finding the best solution for a problem. If the alternatives are not satisfying the problem or sub-problems, it is also possible to use the best satisfying solution among alternatives rather than optimal. Another approach may be selecting and modifying the whole or part of one of the alternative solutions to fit in the required solution. In this case, as Chakrabarti and Bligh (2001) stated, it is important to be aware of the potential and satisfaction level of the provisional solution after deducing or modifying the wrong parts. Similar to these approaches, a student can either make use of a design idea generated by one of the critics in the group by accepting to apply it in the next phase of the design for the design development or rejects it. There may also be some conflicting comments due to the different requirements of the two courses or to different approaches to the solution by the group members. All of these steps are helpful to the students in developing their projects step by step while rethinking and redesigning.

6.4 Usability of CDS

A usable interactive system or a product should enable a specific group of users to achieve a specific task in a particular environment. In developing a usable product or system, it is necessary to provide both physical accessibility that involves the right physical interface and cognitive accessibility that involves matching functionality, terminology, information and interface to the users` needs (Bevan, 1999). Simply, any technique

used to evaluate a product or system is called `usability testing` (Rubin, 1994). More specifically, usability testing refers to a process in which the degree of the usability criteria satisfaction is evaluated during the interaction of the specified user by the product or system within a specific environment. Usability testing is an approach that is similar to the classical experimental methodology, by focusing on the determination of the usability deficiencies such as issues related to functionality, ease of use and satisfaction of the specified target user for computer based environments or products. A system or product can be defined as usable related to its particular task carried out in a particular environment by a particular user group. Any change in the characteristics of the product or systems, user, task or environment may produce a change in the usability of the product or system. Thus, the basis for the development and evaluation of a product or a system involve the understanding and specification of context in detail by considering the user, task and both physical and social environments. Bevan et. al. (1991) called all these characteristics as the “context of use” in which the system or product is being used.

Measuring of usability starts with the definition of the product or system as well as the components that will be tested. The context of use and evaluation targets and contexts are specified and problem and test objectives are stated with usability requirements such as effectiveness, productivity and satisfaction. In the next step, a representative sample of end-users is selected and task and actual work environment are represented. Then an evaluation for testing performance and satisfaction is

prepared related to these contexts to conduct user tests. Respectively, the qualitative and quantitative data collected in user tests are analyzed and metrics are identified for interpretations. Finally, a report is prepared explaining the usability test conducted with the users of the system (Bevan, 1999b). Recommendations for the improvement of the tested design of the product or system are also stated for further studies.

The evaluation of usability of a system or product is the interpretation of results of the usability measurements and it involves the specification of problem and test objectives with respect to usability requirements such as effectiveness, productivity and satisfaction. The usability measurements are beneficial for predicting, ensuring and improving product quality; controlling and improving the production process; deciding on the acceptance of a software product; and also choosing a product among the alternatives (Bevan and Curson, 1997). There are two purposes of usability evaluation. The first one, formative evaluation, aims to identify the specific usability problems to remove usability defects for improvement of the product or the system. The second one, summative evaluation, aims to summarize the usability by demonstrating the capability to a third party and testing against usability requirements (Jokela, 2001; Earthy, 1999).

The usability problems are analyzed in detail in formative approach of usability measurement. Expert opinions including immediate recommendations for improvements, detailed analysis of user interaction records with respect to goals and sub-goals, analysis of checklists filed by users, and analysis of the checklists involving the evaluation of usability

specialists are the techniques for the detection of problems in usability (Bevan et. al., 1991).

There are various other usability evaluation techniques such as inspection methods including heuristic evaluation or checklists focusing on potential problems; observational skills or video recording to find out the usability problems in early system development phase; program instrumentation records to determine the frequencies and times of user actions while using the system; and questionnaires to get subjective feedback from the users about the system being evaluated (Perlman, 1998). The evaluations are based on usefulness, ease of use, user satisfaction and acceptability. In this study, two questionnaires are chosen to be distributed to the CDS participants at the end of the semester to find out whether the EDC model is useful and easy to use for the collaboration of design courses and to see if the participants are satisfied with the information and collaboration web sites. In the following chapter, the results of the usability questionnaires are explained in detail as well as the quantitative and qualitative analysis of the data gathered during the study.

7. INTERPRETATION OF RESULTS

Evaluation of data in Internet studies needs a special attention since there is a subjective experience to understand and interpret the users in relation to being and collaborating in the Internet medium. As Riva and Galimberti (2002) stated, Internet research necessitates a heterogeneous approach for using two basic approaches of data analysis; qualitative and quantitative analysis. An integrated research approach is introduced for the evaluation of Internet studies, in which both qualitative and quantitative methodologies are used together. Complementary Explorative Data Analysis (CEDA) is a framework for such an approach that uses both qualitative and quantitative data to balance the strengths and weakness of each method (Sudweeks and Simoff, 1998).

In qualitative analysis, the characteristics of the phenomenon is studied through identification and categorization of major dimensions and regularities occurring in unstructured textual data by exploring communication patterns of texts such as archived discussions of collaborative studies, discussions and e-mails. In quantitative analysis, the numerical data of concepts are quantified, in other words the measurable data of communication patterns such as the form, type, time and range of content data are used to observe behavior. In an integrated research approach, the qualitative data is quantified by coding the concepts gathered from interviews or discussions and the quantitative data is qualified using quotes from data to support statistical patterns.

Based on this approach, the data gathered in CDS are evaluated through both qualitative and quantitative methodologies. The participation levels, engagement of students in collaborative process and frequency of interactions are discovered through the observation of communication patterns in a quantitative data. Respectively, the qualitative data gathered from redline files and design diaries are coded and quantified for statistical analysis to explore and explain issues emphasized through the textual data produced in redline files during the collaborative study.

7.1 Analysis of Quantitative Data

7.1.1 Redline Files

During CDS study, totally 175 critiques were given by the participants throughout the design process that lasted five weeks. In the analysis of data, 650 segments are defined within 175 critiques. It is observed in the personal folders of students that the highest number of critiques were in the first week. The total number of critiques was approximately the same in the following three weeks and the lowest at the last week of the collaborative study (Figure 7.1).

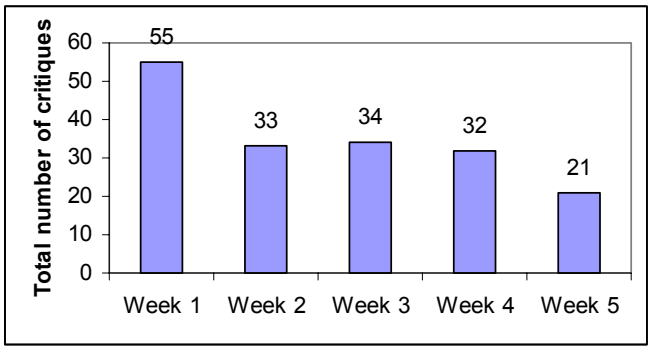

Figure 7.1: Total number of critiques per week

The number segments were derived and it is observed that the number of segments produced per week was also decreasing both in junior and senior teams (Figure 7.2).

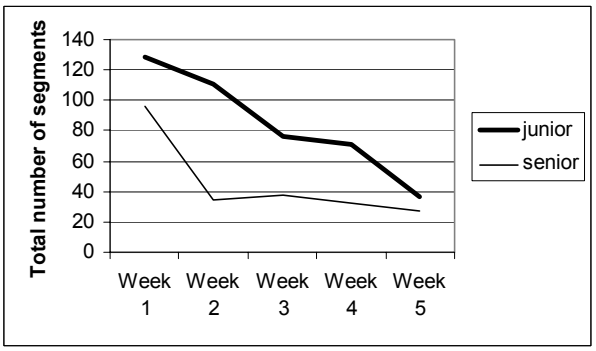

Figure 7.2: Total number of segments produced each week

The dynamics of the participation in CDS can be seen in Figures 7.3 and 7.4. In order to determine the level of participation of the team members in CDS, the critiques of each participant and the number of segments in the critiques are determined. Figure 7.3 illustrates the percentage distribution of critiques given by junior and senior students and instructors of the two courses. It shows that CDS is characterized by high participation of

students (31% and 18%) and instructor of the course “Design for Disabled” (29%).

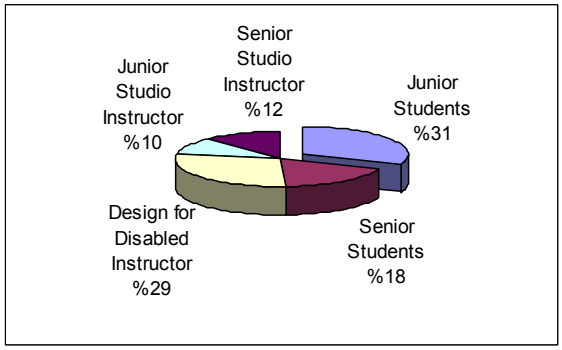

Figure 7.3: Percentage distribution of participation in CDS related to the number of critiques produced by team members.

The total number of segments produced by each participant is also determined to illustrate the amount of participation of the groups. It is observed that the highest number of segments is produced by the instructor of “Design for Disabled” course (Figure 7.4). The students are introduced to new concepts within the scope of “Design for Disabled” course and this may be the reason of having high number of segments.

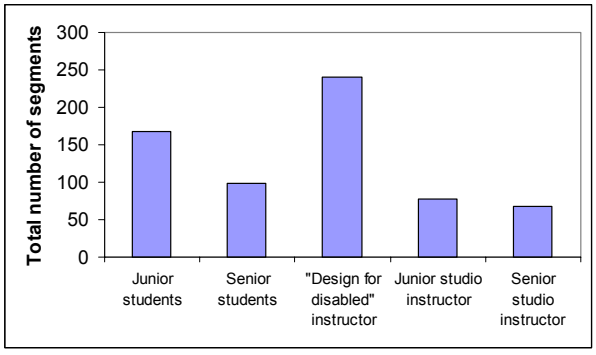

Figure 7.4: Total number of segments produced by the participants.

Figure 7.5 shows the total number of segments produced by the participants through the collaboration process. The number of segments produced by the senior students and the “Design for disabled” course instructor decreases each week as the design project progresses. There is not a decreasing or increasing pattern for the number of segments produced per week by the other participants.

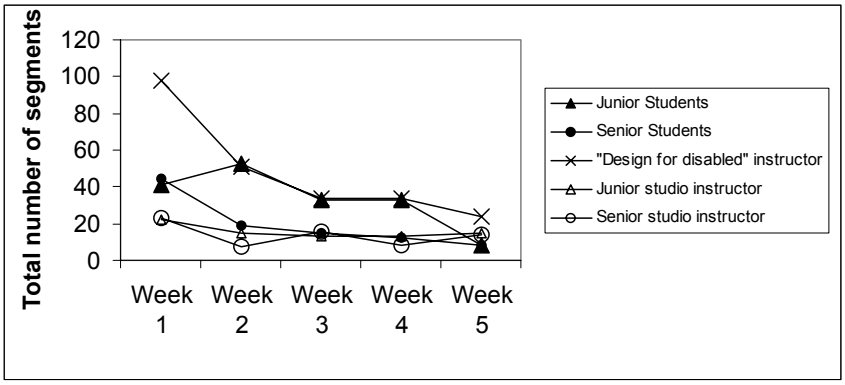

Figure 7.5: Total number of segments produced by the participants.

7.1.2 Design Diaries

The number of design diary segments is also determined to observe the design process of the students. Totally 61 design diaries were submitted by the students. The total number of diaries submitted each week can be seen in Figure 7.6.

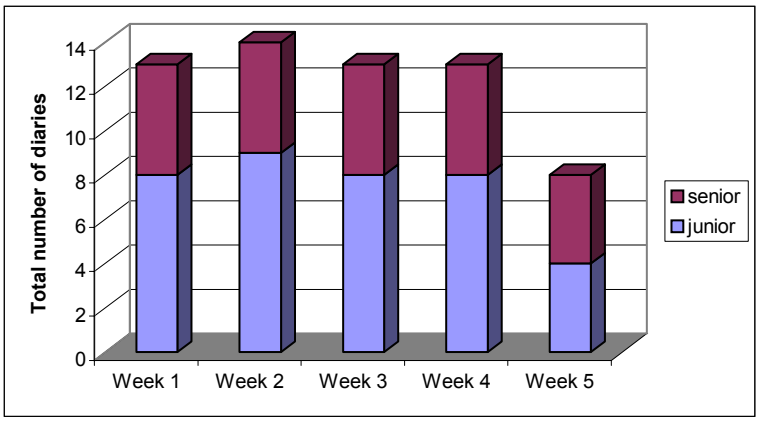

Figure 7.6: Total number of diaries submitted by the students each week.

The total number of segments found in the design diaries is 221, where the number of segments produced by the third year students is 144 and the number of segments produced by the fourth year students is 77. There is a decrease in the number of segments in design diaries of the third year students as weeks progress whereas we can not find a decreasing pattern in the number of segments per week for fourth year students as it is illustrated in Figure 7.7.

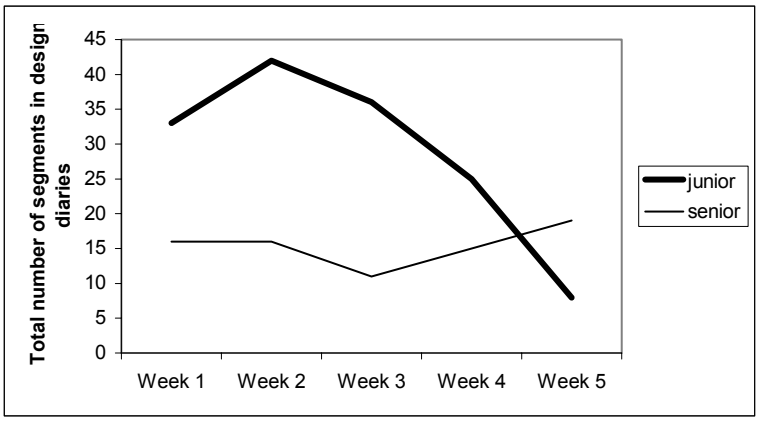

Figure 7.7: Total number of segments in the design diaries.

7.2 Analysis of Qualitative Data

In addition to the analysis of quantitative data in CDS study, the qualitative data in redline files and design diaries are also quantified to see the major focus of critiques and the tendencies of the participants in the design process. In this way, it is observed whether the collaboration of design courses on the Internet within the framework of EDC model satisfies the requirements of the collaborating courses.

7.2.1 Redline Files

Each category of redline files is quantified and the distribution of issues is determined as follows:

Problem Domain

The analysis of data with respect to the first category, design abstractions in problem domain indicate that the greatest percentage of the segments

(27%) is referring to the details of the space and sub-spaces (4). The other important issue discussed in critiques is referring to the details of the objects within the space and subspaces (5) with 22%. The percentage distribution of all issues related to design abstractions in CDS can be seen in Figure 7.8.

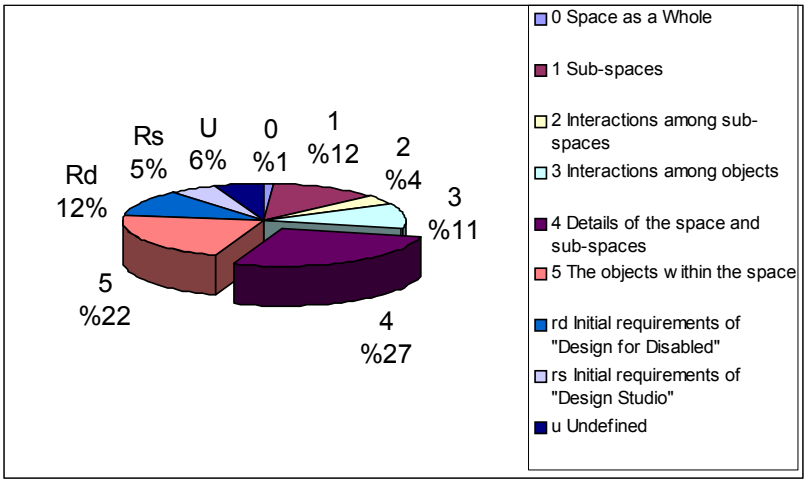

Figure 7.8: Percentage distribution of design abstraction issues

When we observe the emphasis on the requirements of the two courses, Design for Disabled and Design Studio, the percentages are 12% and 5% respectively. Moreover, the emphasis of junior and senior teams is similar in design abstraction levels during the collaborative study (Figure 7.9).

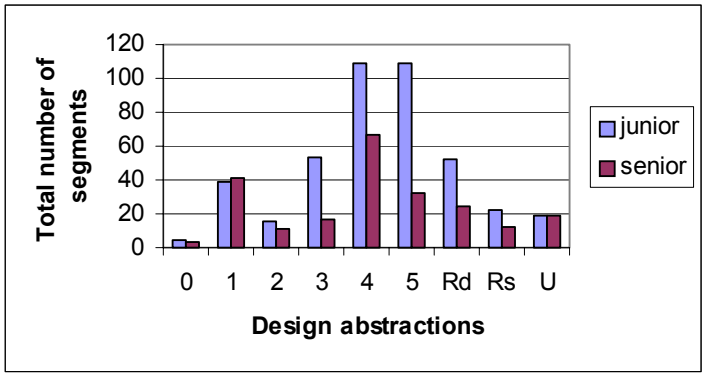

Figure 7.9: Total number of design abstraction segments of junior and senior teams.

The analysis of data with respect to the second category (problem, solution and representation) of problem domain illustrated that CDS is characterized by a high proportion of references to solution space of the problem (65%). It was then followed by problem (23%) and representation (12%) (Figure 7.10). Moreover, again junior and senior teams have a similar approach (Figure 7.11).

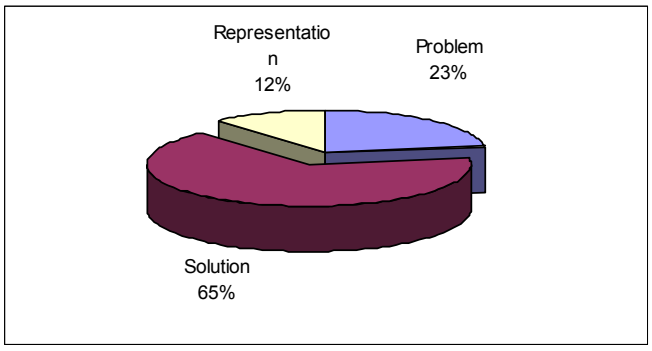

Figure 7.10: Percentage distribution of P/S/R in design space and representation.

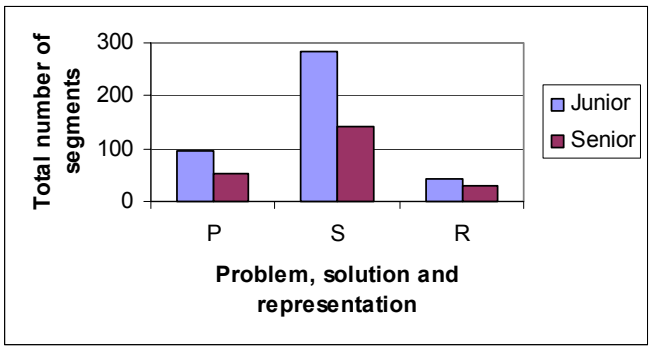

Figure 7.11: Total number of problem, solution and representation segments of junior and senior teams

The analysis of the third category, function, behavior and structure in problem domain, indicated that the majority of the critiques refer to discussions on behavioral aspects of the design domain (67%) (Figure 7.12). The percentages of function and structure are found to be 24% and 9%, respectively. The emphasis of junior and senior teams on the issues of the third category is again similar (Figure 7.13).

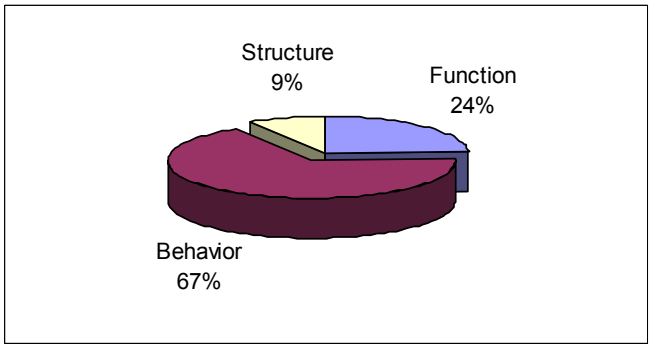

Figure 7.12: Percentage distribution of design variables.

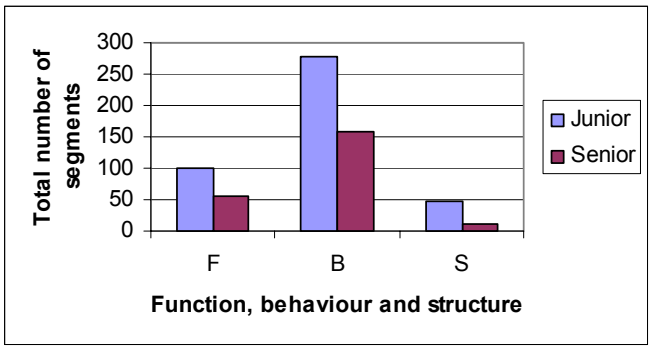

Figure 7.13: Total number of design variable segments of junior and senior teams.

Design Strategies

When the total number of segments are analyzed according to the design strategies, it is observed that the majority of the critiques are about design analysis (68%); where proposing a solution (24%) or explicit strategies (8%) are less in numbers (Figure 7.14).

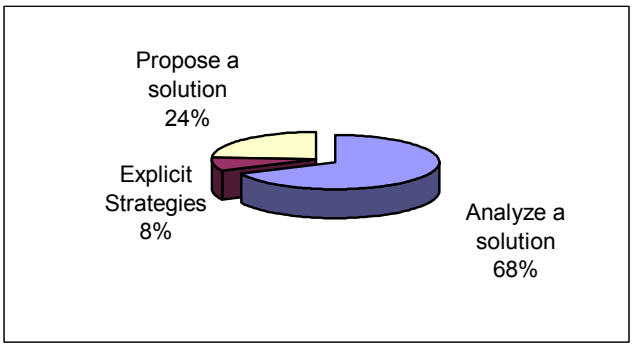

Figure 7.14: Percentage distribution of micro-strategies

For further information on design strategies at micro-strategies level, the results are analyzed and categorized within the three groups independently. In the first group “Analyze a Solution”, the highest number

of design critiques belong to the code rejecting a solution (Rs) as 31% of the total. The following most frequently stated issues are referring to the questioning of space properties (Qs) with 21% and questioning representation (Qr) with 16%. Figure 7.15 shows the emphasis of design abstraction in junior and senior collaborative studies.

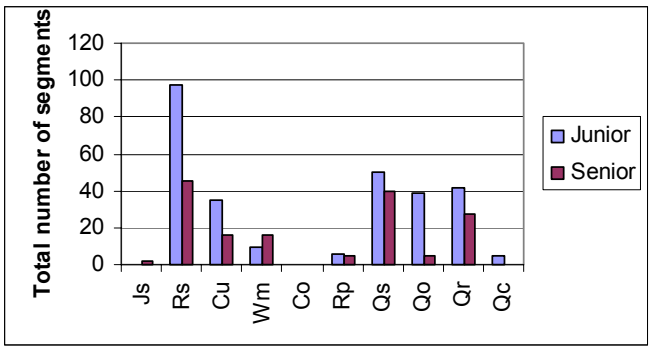

Figure 7.15: Total number of 'analyzing a solution' segments of junior and senior teams.

In the second category, "Proposing a solution", it is found that the critics preferred to propose a single solution (Ps) for the design problem (98%) rather than proposing choices (Cs) for the solution (2%) in both teams (Figure 7.16). Moreover, it is observed that senior teams did not provide any choice for design solution. None of the teams referred back to previous solutions (Lp) of design steps during the critique.

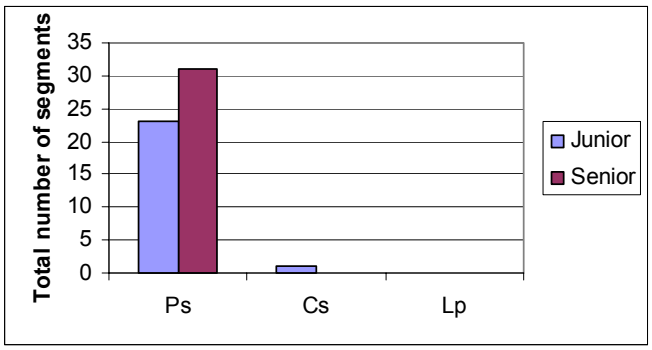

Figure 7.16: Total number of “proposing a solution” segments

In the third category, it is found that 55% of the total number of segments related to explicit strategies refer to the knowledge and requirements of “Design for Disabled course” (Rdk) which is more than “Design Studio” (Rsk) (15%). However, the emphasis of junior teams is more than senior teams on the initial requirements of “Design for Disabled course” (Rdk) in explicit strategies (Figure 7.17).

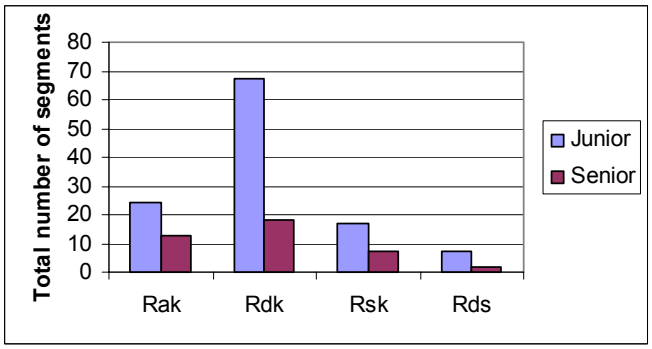

Figure 7.17: Total number of “explicit strategies” segments.

The analysis of “design activities” indicates that the critiques are more on the high-level design activities (53%) than the low level ones (47%) (Figure 7.18).

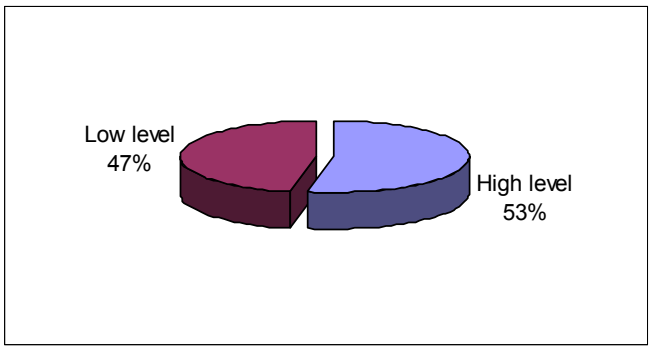

Figure 7.18: Percentage distribution of design activities.

Layout (LY) and dimension (DM) are the two issues that are mostly observed among the other high-level design activities, as 48% and 23%, respectively. In low-level activities, most of the references are found to accessories (AC) (37%) and furniture (FR) (33%) in the critiques of the participants of CDS. The approaches of junior and senior teams look similar in high design activities as it is seen in Figure 7.19. However, the emphasis of senior students on furniture is more than accessories in low level design activities (Figure 7.20).

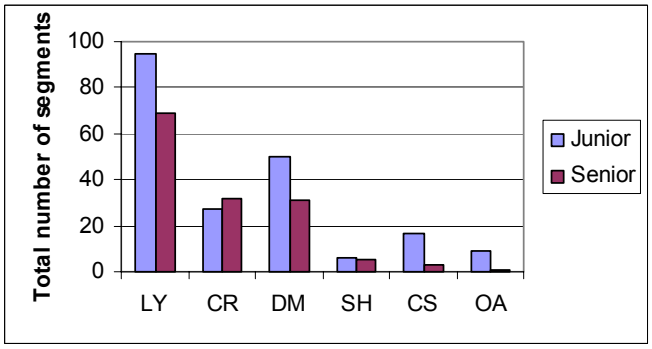

Figure 7.19: Total number of “high level” segments.

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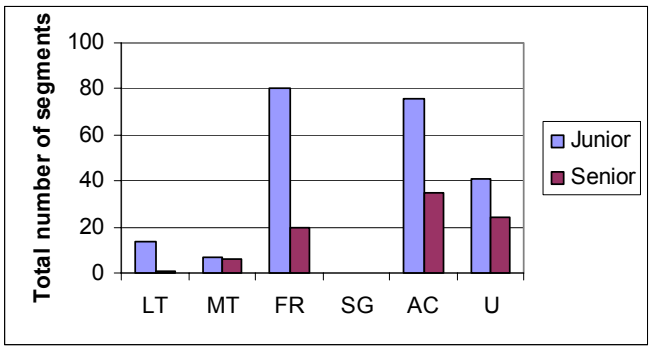

Figure 7.20: Total number of “low level” segments.

7.2.2 Design Diaries

In the analysis of design diaries, it is found that the students mostly deal with the features of solution space (37%) and problem requirement (31%) during design development process (Figure 7.21). The percentage distribution of behavioral aspects of problem requirements (R-be) is less with 11% than the behavioral aspects of solution space (S-be) with 21%.

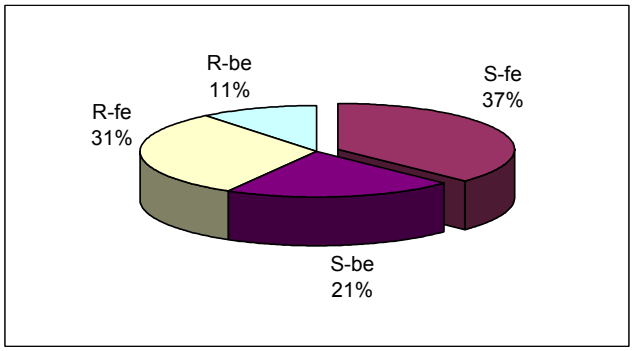

Figure 7.21: Percentage distribution of emphasis on features and behaviors of problem requirements and solution spaces.

The emphasis on features and behavior of problem requirements and solution spaces varies during design development for each week as it is seen in Figure 7.22.

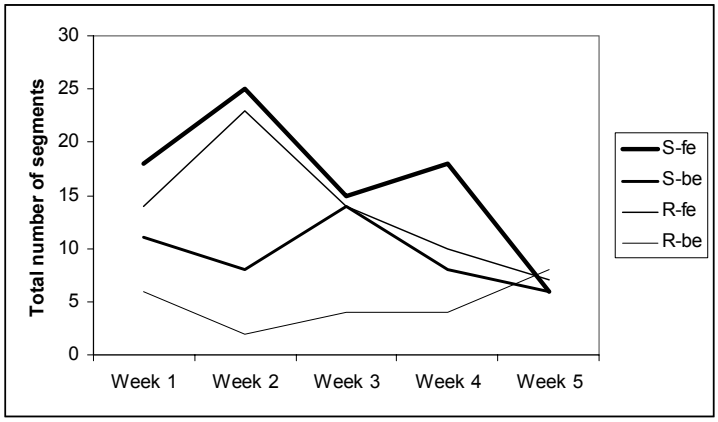

Figure 7.22: Total number of segments related to problem requirement and solution spaces per week.

In the design diaries, it is observed that there is a difference in the approaches of junior and senior students to design development. Figure 7.23 reveals the comparison of the approaches of junior and senior students during design development. The junior students are mostly dealing with the features of the problem requirements and solutions of the project. However, there is almost a homogenous emphasis on features and behavior of problem requirement and solution spaces in the design development of the senior students whereas the junior students have less emphasis on the behavioral aspects of problem requirements (Figure 7.23).

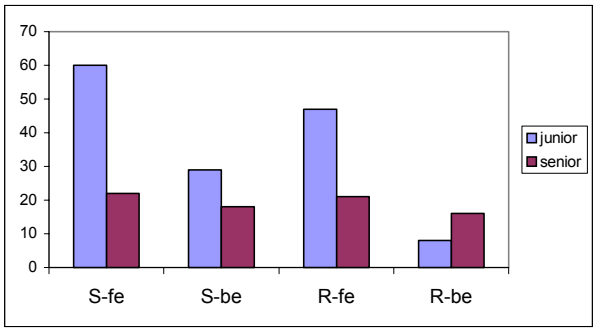

Figure 7.23: Comparison of the total number of segments in design diaries of junior and senior students

7.3 Usability Evaluation through Questionnaires: The Case Study (CDS)

As Kwahk and Han (2002) stated, the usability process requires the determination of the relevant usability dimensions, the effective usability measures, and the appropriate evaluation techniques. Related to this process, the usability of the CDS system constructed for the collaboration of design courses is evaluated with summative approach through two questionnaires developed for the evaluation of computer software and interface and systems. In this way, the deficiencies in CDS can be determined for improvement and as a basis for further studies. There are many questionnaires developed to evaluate user interfaces in literature (Perlman, 1998). In usability studies, questionnaires are used to measure user satisfaction and quality of use. As Kirakowski (2003) stated, it is a method used for elicitation, recording and collecting information. The information gathered using a questionnaire can be used for subjective

measures and performance measures since they provide feedback from the user's point of view. A questionnaire requests subjective comments and answers. Basically, there are three types of questions in questionnaires (Kirakowski, 2003). First, 'factual' type of questions that focus on observable and public information such as the number of years that a respondent has been studying a subject. The second one is the 'opinion' type of questions that do not have a right or wrong answer but requests information on what the respondents think about a particular subject. Asking whether the respondents liked something or not, is an example for the opinion type of questions. The third type of questions focus on the 'attitude' of the respondent asking their response to events and situations like their response to working with a particular product.

Closed-ended and open-ended questions can be used in questionnaires. Closed-ended questions are scaled in a numeric code and do not allow any individual comment of respondent; while open-ended questions request comments and answers which can not be summarized in a numeric code (Kirakowski, 2003). In both cases, the measurements are independent from the system, user and task. It is a cost-effective method and it provides quick feedback. However, in order to use a questionnaire for the evaluation of a system, it is required to check the reliability of the questionnaire. Reliability is the ability of the questionnaire to give consistent results when completed by like-minded people under similar conditions. Besides the validity of the questionnaire is important. The validity of the questionnaire is the extent in which the gathered information is matching with the research question, target objectives and hypothesis (Kirakowski, 2003). Checking

the reliability and validity of a questionnaire is a very detailed and long-term process, so it is possible to use questionnaires that are tested and standardized by institutions as a result of comprehensive studies.

7.3.1 Questionnaires

In this study, the “Perceived Usefulness and Ease of Use” (PUEU) and the “Questionnaire for User Interface Satisfaction” (QUIS) questionnaires are chosen to be used for system evaluation (Perlman, 1998). Both of the questionnaires have a scale from best to worst scores to evaluate the user approach in their context. The first one, PUEU has 12 opinion type of questions with a five point scale from –2 to 2 (See Appendix B.2). The questions are categorized under two headings as: ‘perceived usefulness’ and ‘ease of use’. Davis (1989) claimed that the validity of most of the subjective measures in practice is not tested. Therefore a scaled questionnaire is prepared during the development of PUEU and validated for the variables, perceived usefulness and perceived ease of use, that determine the user acceptance. The questions do not have any right or wrong answers, but focused on respondents’ thoughts. Measurements of perceived usefulness explores the tendency of people to use a particular system or a product, in other words, the extent to which they believe it will help and enhance their job performance. The particular system or product can be useful by the users but may require too much effort to use. Thus, in addition to perceived usefulness, the perceived ease of use is also measured in PUEU to find out whether the product or the system is free of effort or not. Davis (1989) found out that perceived usefulness and

perceived ease of use were significantly correlated with both self-reported current usage and self-predicted future usage.

The second one, QUIS is developed in University of Maryland (See Appendix B.3) to measure the user's subjective ratings of human-computer interface. It is composed of twenty-seven attitude type of questions with a ten point scale from 0 to 9 that are used to get feedback from the respondent about how they feel when they are interacting with the system. QUIS is used to measure the attitudes of users while working with a particular system or product. As Chin et. al. (1988) stated user acceptance of a system is a critical measure of success in system development in addition to performance measures such as speed and accuracy. QUIS is a questionnaire focusing on the system characteristics and system output and it is developed to measure the users` subjective rating of human computer interface, which is a missing concept in users` subjective satisfaction tests. The questionnaire consisted of five sections, namely: the overall reaction of users to the software being used; screen; terminology and system information; learning; and system capabilities (Chin, et. al., 1988). QUIS was tested for its reliability among a large number of users such as students, computer professionals, computer hobbyists and novice users under different experimental conditions (Chin et. al., 1988).

These two questionnaires are chosen because they are standardized as a result of validity and reliability tests and developed to evaluate user satisfaction and ease of use of the system from the user' s point of view. Moreover, both of them are quite short and simple to understand which is

also an important factor in the evaluations conducted by using questionnaires.

7.3.2 Usability Report of CDS

Product Description

EDC model is developed for the collaboration of two design courses through the Internet. An information web site and a project web site is constructed for collaboration within the framework of EDC.

Test Objectives

The aim of the test is to measure and see the quality in use, in other words usability of CDS developed within the framework of EDC model related to the context of use. For this reason the problems of the CDS system are identified to remove defects for the development of collaboration of courses through the Internet. The objectives of the questionnaires used for this purpose are:

- To evaluate the usability of EDC system in the collaboration of two design courses related to perceived usefulness and ease of use.
- To evaluate the user satisfaction of EDC system in the collaboration of two design courses.

7.3.2.1 Method

Context in Use

The study is conducted through the Internet with two levels of studio students who are taking the IAED 491 “Design for Disabled” course. Each student group is consist of two or three students of the same year studio (IAED 302 or IAED 402), a design studio instructor and the instructor of the "Design for disabled" course (IAED 491).

User Profile

Prerequisite knowledge capabilities expected of EDC participants are:

- Familiarity with a PC and a basic working knowledge of Microsoft Windows
- Familiarity with AutoCAD 2D drawing
- Familiarity with using an Internet Browser
- Familiarity with sending and receiving e-mail
- Minimum (2 semesters) of design experience

Table 7.1: Students` profile

Characteristics	Range	Frequency Distribution
Computer Use	None to 5+ years	66% 1-5 years 28% 6-10 years 6% 10+ years
Internet Use	None to 5+ years	72% 1-5 years 28% 6-10 years
Education Level	Junior Senior	61% 39%
Gender	Male Female	100% 0%
Education Major	Interior Architecture and Environmental Design	100%
Operating System Experience	Windows	100%
Software Experience	Word Excel PowerPoint AutoCAD PhotoShop	94% 39% 50% 100% 61%
Internet Experience	E-mail Internet browser Chat programs Messengers	94% 100% 78% 56%

Table 7.2: Instructors` profile

Characteristics	Range	Frequency Distribution
Computer Use	None to 5+ years	67% 6-10 years 33% 10+ years
Internet Use	None to 5+ years	100% 6-10 years
Gender	Male Female	33% 67%
Department	Interior Architecture and Environmental Design	100%
Operating System Experience	Windows	100%
Software Experience	Word Excel PowerPoint AutoCAD PhotoShop	100% 100% 100% 100% 100%
Internet Experience	E-mail Internet browser Chat programs Messengers	100% 100% 0% 100%

Environment

CDS is conducted through the Internet within the framework of EDC model. The CDS has an information web site (http://www.art.bilkent.edu.tr/iaed/cds/index.htm) and a project web site (http://projectgrid.com) for collaboration. Basic hardware and software requirements for participation in CDS are:

- PC (preferably minimum Pentium II for an appropriate speed of access)
- Internet access
- Internet Browser (to access Project Web Site for collaboration)
- AutoCAD program (to create drawing files as *dwg* and *dwf*)
- An e-mail account (through an Internet browser or e-mail program)

Optionally, they also may use:

- PhotoShop and scanner- for presentations (including jpg, gif, etc.)
- PowerPoint- for slide presentations
- Word Processor- for textual presentations
- Any other 2D or 3D CAD software for creating and presenting their design.

Task List

The tasks required to participate in the collaborative process defined by EDC model are listed in Table 7.3:

Table 7.3: Tasks for collaboration process in EDC.

Task	Task Description	Task Requirements
1	Accessing CDS information web site	Internet access
2	Logging in ProjectGrid	ID, password and e-mail account
3	Creating a personal folder	Log in ProjectGrid
4	Design and drawing	AutoCAD use
5	Converting drawing format	Use of “dwfout” command in AutoCAD
6	Uploading a drawing file	Conversion to *dwf* format
7	Notifying group members	New file upload and e-mail account for group members
8	Viewing a drawing	Server built-in CAD Viewer in ProjectGrid
9	Redlining a drawing	Use of commands in CADViewer in ProjectGrid
10	Viewing a redline file	Server built-in CAD Viewer in ProjectGrid
11	Redesigning and redrawing project	AutoCAD use
12	Requesting Information by e-mail	E-mail account
13	Giving Information by e-mail	E-mail account
14	Submitting files by e-mail	E-mail account

Experimental Design

At the beginning of the semester, all participating students and instructors were informed that all the design critiques will be carried out through the Internet environment. It was explained that the aim was not to test their ability in computer usage but the usability of Internet for the collaboration of design courses. In this introductory meeting, the students were asked to respond to the questions in the distributed questionnaire to obtain information about their previous experience with computers (See Appendix B.1). A written document was prepared and distributed to the participants that explained the rules and principles to use and participate in ProjectGrid web site. At the end of the semester, the participants were asked to

complete two questionnaires developed to test the performance of the system and the satisfaction level of the users (See Appendix B.2- B.3).

Usability Metrics

The usability of CDS developed within the framework of EDC model is evaluated from the user's point of view through ease of use and user satisfaction. Two standardized questionnaires developed for the evaluation of computer software, interface and systems are used that are given after the collaborative tasks are completed at the end of the semester. The first questionnaire, the Perceived Usefulness and Ease of Use (PUEU), has items related to perceived usefulness and ease of use. The second questionnaire, the Questionnaire for User Interface satisfaction (QUIS) has items related to software being used; screen, terminology and system information; learning; and system capabilities. The details of the two questionnaires were explained in Section 7.3.1 previously.

7.3.2.2 Results

Perceived Usefulness and Ease of Use (PUEU)

The results of the PUEU questionnaire reveal that generally instructors responded in a more positive manner than the students. The number of responses of the instructors at scale 2 is the most frequent response in the 5-point scale from –2 to 2 whereas students mostly 'agree' at scale 1. Figure 7.24 and 7.25 show the distribution of the responses for the questions of PUEU. The questions of PUEU can be seen in Appendix B.2.

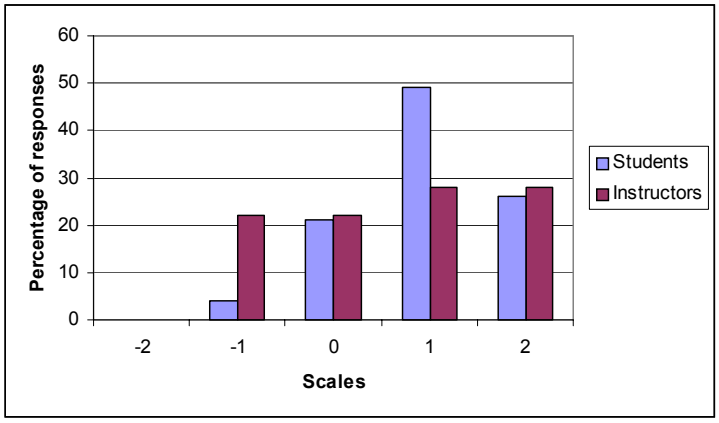

Figure 7.24: The distribution of the responses of the students and instructors to questions related to perceived usefulness (questions 1-6) in PUEU.

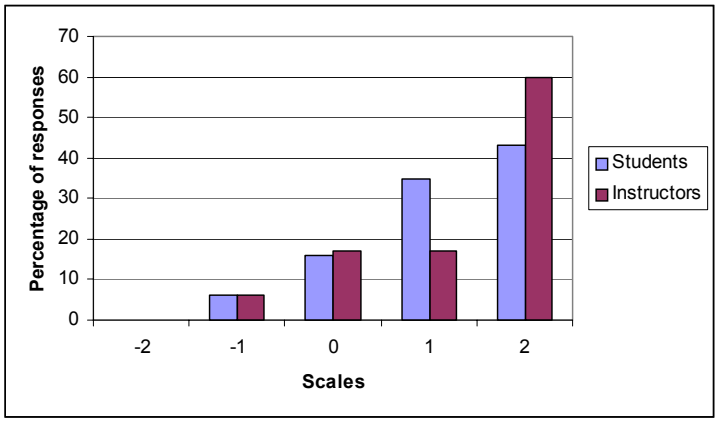

Figure 7.25: The distribution of the responses of the students and instructors to questions related to perceived ease of use (questions 7-12) in PUEU.

The overall average of all the responses of the instructors is 1.58 whereas the overall average of the students is 1.05 in the 5-point scale from '-2, disagree' to '2, agree' (Table 7.4 and 7.5). These findings are on the 'agree' direction of the overall interpretation of the PUEU. The average scores of the responses of students and instructors to the perceived

usefulness of the system is 0.96 and 1,33 respectively. The mean of the responses to the questions related to the ease of use is 1.13 by students and 1,83 by instructors. The problem in perceived usefulness is found to be in the use of the system for improvement of the job performance (See question 2 in Appendix B.2*)*. When the question related to the use of system enhancing the job performance (See question 4 in Appendix B.2*)*, the design for disabled and junior studio instructors had positive response whereas the senior studio instructor has a negative response which may be due to the lack of three dimensional representation of drawings in the system. The senior studio instructor stated this problem in the negative aspects of the questionnaire. The ease of the system to do what is desired is not found enough by the students whereas the instructors found CDS easy to do their job except the junior studio instructor (See Question 8 in Appendix B.2). However, the instructors did not find it flexible enough for interaction (See Question 10 in Appendix B.2).

Table 7.4: Analysis of the students` responses in PUEU.

		mean	median	standard deviation
Perceived Usefulness	**1**	0,88889	1	0,83235
	2	0,72222	1	0,7519
	3	0,83333	1	0,85749
	4	1	1	0,76696
	5	1	1	0,90749
	6	1,33333	1	0,59409
		0,96296		
Perceived Ease of Use	**7**	1,16667	1,5	1,04319
	8	1	1	1,13759
	9	1,11111	1	0,7584
	10	1,11111	1	0,83235
	11	1,27778	1	0,66911
	12	1,16667	1,5	1,04319
	Average	1,13889		
	Overall Average	1,05093		

Table 7.5: Analysis of the instructors` responses in PUEU.

		Design for Disabled Instructor	Junior Studio Instructor	Senior Studio Instructor	Mean	Median	Standard deviation
Perceived Usefulness	**1**	2	2	-1	1	2	1,73
	2	0	1	0	0,33	0	0,57
	3	2	2	-1	1	2	1,73
	4	1	0	-1	0	0	1
	5	1	1	-1	0,33	1	1,15
	6	2	1	0	1	1	1
Average		1,33	1,17	-0,66	0,61		
Perceived Ease of Use	**7**	2	1	2	1,67	2	0,57
	8	2	-1	2	1	2	1,73
	9	2	0	2	1,33	2	1,15
	10	1	0	2	1	1	1
	11	2	1	2	1,67	2	0,57
	12	2	0	2	1,33	2	1,15
Average		1,83	0,17	2	1,33		
Overall Average		1,58	0,67	0,67	0,97		

Questionnaire for User Interface Satisfaction (QUIS)

The analysis of the responses of the students and instructors to QUIS reveals that scale 1 is the most frequent respond in the 5-point scale from –2 to 2. Figures 7.26 -7.30 show the percentage distribution of the responses for the questions of QUIS. The questions of QUIS can be found in Appendix B.3.

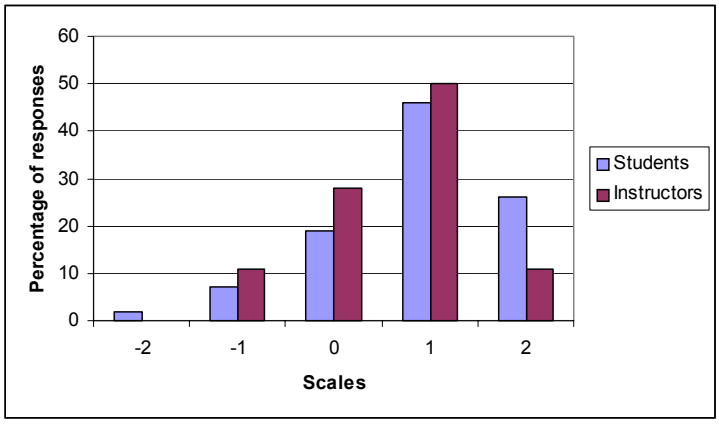

Figure 7.26: The distribution of the responses of the students and instructors to questions related to overall reactions (questions 1-6) in QUIS.

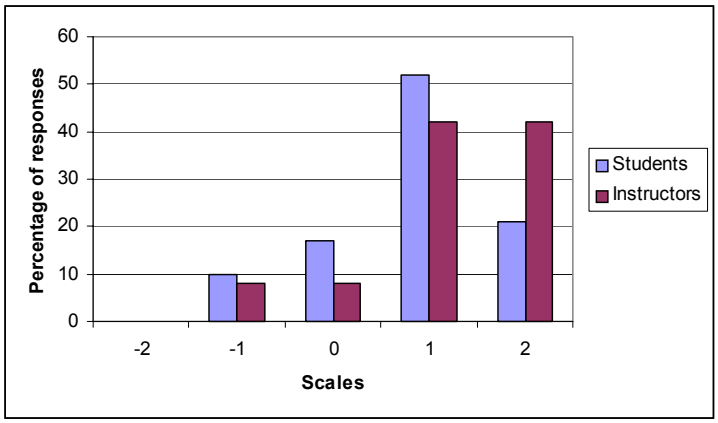

Figure 7.27: The distribution of the responses of the students and instructors to questions related to screen (questions 7-10) in QUIS.

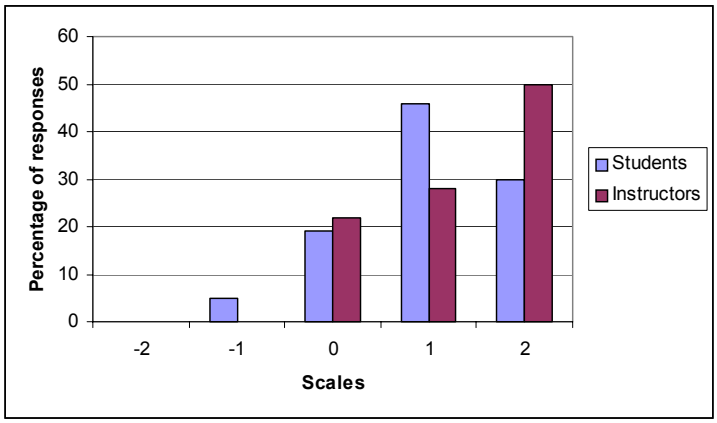

Figure 7.28: The distribution of the responses of the students and instructors to questions related to terminology and information (questions 11-16) in QUIS.

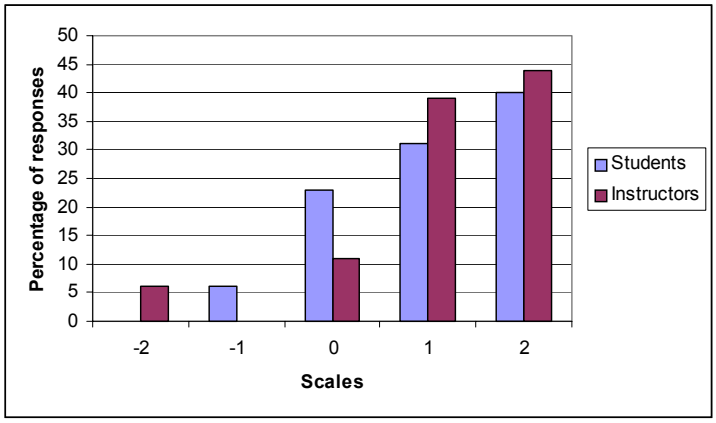

Figure 7.29: The distribution of the responses of the students and instructors to questions related to learning (questions 17-22) in QUIS.

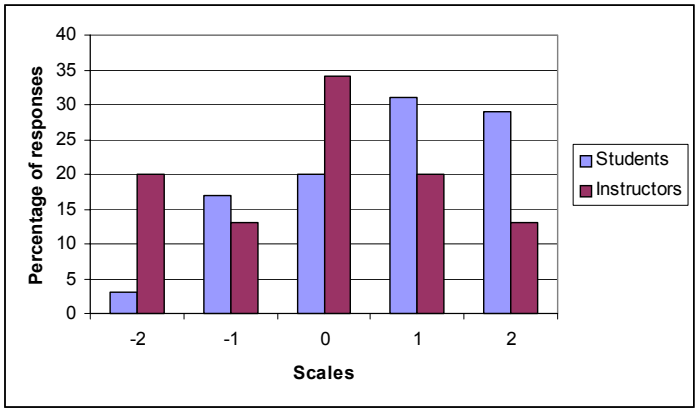

Figure 7.30: The distribution of the responses of the students and instructors to questions related to capabilities of the site (questions 23-27) in QUIS.

The analysis of the QUIS showed that the overall averages of all the responses of the students and instructors are 0.89 and 0.84 respectively in the 5-point scale through positive to negative statements from –2 to 2 (Tables 7.6 and 7.7). This result is on the positive direction for the overall interpretation of QUIS by the students and instructors. The common

problem was stated in the capabilities of the project site with means of 0.65 and –0.067 respectively. The most important deficiency defined by both students and instructors was the speed of connection (See question 23 in Appendix B.3). The responses of the students also revealed that it was not easy to correct mistakes done during the use of the system (See Question 26 in Appendix B.3).

Table 7.6: Analysis of the students` responses in QUIS.

		Mean	Median	Standard deviation
Overall Reaction	**1**	1	1	1,028992
	2	1,22222	1	0,878204
	3	0,88888	1	0,758395
	4	0,61111	0,5	0,978528
	5	1	1	0,840168
	6	0,44444	1	1,096638
	Average	0,86111		
Screen	**7**	0,88888	1	0,832352
	8	1,11111	1	0,758395
	9	0,72222	1	0,894792
	10	0,66666	1	0,970143
	Average	0,84722		
Terminology & System Information	**11**	0,94444	1	0,872604
	12	0,88888	1	0,900254
	13	1,16666	1	0,8557
	14	1	1	0,766965
	15	0,94444	1	0,872604
	16	1,11111	1	0,758395
	Average	1,00925		
Learning	**17**	0,88888	1	1,02262
	18	1,16666	1,5	0,985184
	19	1,16666	1	0,857493
	20	0,94444	1	1,055642
	21	1,11111	1	0,900254
	22	0,88888	1	0,900254
	Average	1,02777		
Site Capabilities	**23**	0,05555	0	1,392088
	24	0,83333	1	1,098127
	25	0,72222	1	1,178511
	26	0,66666	1	1,084652
	27	1	1	0,907485
	Average	0,65555		
	Overall Average	0,89095		

Table 7.7: Analysis of the instructors` responses in QUIS.

		Design for Disabled Instructor	Junior Studio Instructor	Senior Studio Instructor	Mean	Median	Standard deviation
Overall Reaction	**1**	0	0	0	0	0	0
	2	1	1	2	1,33	1	0,59
	3	-1	0	1	0	0	1
	4	1	1	1	1	1	0
	5	1	1	2	1,33	1	0,58
	6	0	-1	1	0	0	1
Average		0,33	0,33	1,167	0,61		
Screen	**7**	-1	0	2	0,33	0	1,53
	8	1	1	2	1,33	1	0,58
	9	1	2	1	1,33	1	0,58
	10	1	2	2	1,67	2	0,58
Average		0,5	1,25	1,75	1,17		
Terminology & System Information	**11**	0	2	2	1,33	2	1,15
	12	1	0	2	1	1	1
	13	1	2	2	1,67	2	0,58
	14	1	2	2	1,67	2	0,58
	15	1	1	2	1,33	1	0,58
	16	0	0	2	0,67	0	1,15
Average		0,67	1,167	2	1,278		
Learning	**17**	1	2	2	1,67	2	0,58
	18	1	2	2	1,67	2	0,58
	19	1	2	2	1,67	2	0,58
	20	1	1	1	1	1	0
	21	-2	0	2	0	0	2
	22	1	0	2	1	1	1
Average		0,5	1,167	1,83	1,167		
Site Capabilities	**23**	-2	-2	1	-1	-2	1,73
	24	-1	0	1	0	0	1
	25	1	0	2	1	1	1
	26	0	-2	0	-0,67	0	1,15
	27	-1	0	2	0,33	0	1,53
Average		-0,6	-0,8	1,2	-0,067		
Overall Average		0,296	0,63	1,593	0,84		

The students also stated their negative and positive comments about the system in the questionnaires, which helped us to identify the reasons of the problems. The statements of the students are as follows:

“We could communicate in CDS with our teachers more than in class”.

“It is easier and more comfortable to work on our projects at home”

“Using Internet for education is useful because it makes our studies easier and faster”

“Getting critiques through the Internet is easy”

“Displaying, reaching and sharing drawings on the Internet is good and make our work easier.”

“Sharing projects and the possibility of seeing each others projects is really good and helpful”

“It was enjoyable for me to give critiques to my friends”

Moreover, the system was useful to the students in experiencing the critique process. It was stated in the questionnaire as a positive aspect as *“We got an idea about giving critiques to the other students”*

However the deadlines for the submission of the projects for the critiques was found to be limited. One of the students stated that *“Deadlines can be more flexible”.* The students also found the CDS system satisfactory for the collaboration of the two courses. The positive responses of the students stated in QUIS are as follows:

“We got critiques very quickly”

“It was enjoyable working on the Internet with such a program”

“It is an easy system to learn and work with”

However, the students sometimes had problems due to the breakdown of the Internet connections, which was a common problem all over the

country at the time of the CDS implementation. The students stated their problems during the CDS study as:

“We sometimes had problems in uploading”.

“It was hard to learn to use the toolbar in the CadViewer”

“Sometimes the critiques were not uploaded within the deadline”

“It was sometimes hard for me to understand my friends` drawings because they did not add enough information about the project such as labels or dimensions.”

“It was sometimes hard to give and receive critiques because of the speed of Internet connection”

“I had problems in displaying the drawings because of the speed of the Internet connection.”

The instructors stated that CDS has a clear and organized structure allowing freedom to work at any time. They found the system easy to learn and use. However they complained that the accessing, loading, redlining and evaluation time for the projects were elongated because of the problem in the Internet connection. They emphasized that the system was useful to gain time to evaluate the designs if the Internet connection was not so slow during the CDS study. Moreover, they stated that advanced features allowing representation of materials and lighting design can enhance the system.

Finally, since all of the participants were familiar with the computers, computer drawings and use of the Internet, they did not have any difficulty in participation and presentation. Nevertheless the problem in speed and connection through Internet during the period of CDS study caused delays in uploading and accessing design files, although the students had prepared their projects within the deadlines. The analysis of the responses of the participants would help to take precautions against the failure of a next CDS implementation. The following chapters explain the methodology for the analysis and results of the data in CDS implementation, which would help to improve the content of the design brief and collaboration in a further study.

7.4 Discussion

The collaborating courses are all studio courses offered in the Department of Interior Architecture and Environmental Design at Bilkent University and their aim is the development of the project within a defined conceptual framework. Issues such as ergonomics, space planning, hierarchical organization, functionality, furniture layout, lighting, appropriate use of material, color, design of all components of the interiors (architectural elements, accessories and their design details) are considered based on the defined framework during the project development. The segmentation categories are defined based on the pilot study and the requirements of the collaborating courses for the analysis of CDS developed within the

framework of EDC explained in Chapter 4. The results of the analysis of redline and design diary data in CDS indicate that all of these issues are discussed during a collaborative study on the Internet. However the amount of emphasis on the different design issues varies. The details of the space and sub-spaces is the mostly discussed issue during the collaborative study. The critiques of the participants refer to the solution space more than problem space or representation. Low number in critiques to representation supports that the participants do not have much difficulty in communicating design through the Internet. The behavioral aspects of the design and design elements are mostly discussed during the design communication to test and criticize the design solutions of the students. As Gero (1999) indicated, the particular behavior and structure variables are produced in response to various situations encountered by the designer. This finding reports the situatedness character of the CDS. As design strategies, the unsatisfactory solutions are rejected and when there is a need for proposing a solution, a single solution is proposed in stead of providing choices. Mostly the layout, accessories and furniture are discussed in design critiques in order to develop the design process. Most of the references and critiques are related to the “Design for disabled” course which formulated the design concept for CDS project and introduced new issues to be considered in the design brief.

At the end of the semester, all the team members graded the projects. The correlation between the various design issues and grades are tested. The highest correlation is found between the number of segments and the students` grades (Coefficient Correlation=0.618), which shows that the

grades increase as the number of segments in redline files increase. The students had taken face to face critiques from other design instructors in design studio during the project development so the grades of the design studio are also analyzed. The correlation among the grades of design studio and CDS project is low (Coefficient Correlation=0,26), which may be due to the evaluation and critiques of other design instructors in design studio. The grades of CDS project are higher as a result of their active participation in each other `s designs.

Moreover, the redlines of the highest (students 1 and 5) and lowest (students 2 and 18) grades in CDS are analyzed. It is observed in the critiques of the highest emphasis is on ‘the details of the spaces’ (4) in problem domain (See students Appendix D.1). There is also an emphasis on the ‘details of the objects within the space’ (5) in one of the lowest grades. In the other two categories of problem domain, `solution space’ and the ‘behavior of design’ are the most emphasized issues in both highest and lowest grades (See Appendix D.1).

In design strategies, the highest number of critiques of the highest grades are the requirements of the design for disabled course (Rdk- explicit strategies) and rejecting a solution (Rs- analyze a solution) in micro-strategies (See students 1,5 in Appendix D.2). This shows that the more the students are encouraged to think on design solutions, the more the solution of design problem is developed. The critiques of the lowest grades also include a high number of questioning space properties (Qs- analyze a solution) and questioning representation (Qr- analyze a solution) in addition

to rejecting a solution (Rs-analyze a solution) (See students 2 and 18 in Appendix D.2), which may be due to the lack of experience of the students in using computers for design. In design activities of design strategies, it is also observed that the critiques of the students with the highest and lowest grades mostly involve the emphasis on the issues of high level activities, namely layout (See students 1, 5 and 2, 18 in Appendix D.2).

The analysis of the design diaries showed that the students mostly developed their projects in considering the features of their solution space based on the critiques. This is a similar approach to face-to-face communication that occurs in traditional design studio. The highest number of segments are belonging to the segments of the features of the 'solution space' of the students with the highest grades (See students 1,5 in Appendix D.3). There is no evidence about the students with the lowest grades since they did not submit any design diaries.

8. CONCLUSION

In this study, a model is developed as a framework for a Collaborative Design Studio (CDS) based on the concepts of situatedness and reflective practice. The model is called Evolutionary Design Collaboration model (EDC). The objective of the study is to provide the collaboration of design studio and other courses by examining the previous applications of virtual and collaborative design studios. Based on this concept, a CDS is constructed within the framework of EDC, involving an information web site and a project web site. It is a shared asynchronous online environment, in which a collection of efforts are taken by teams of students and instructors for navigation through research resources, interaction and exchange of information to discuss and decide on alternative design solutions at conceptual level for a design problem. The students are required to redesign the design project given in design studio including the requirements of another design course “Design for Disabled” (See Appendix E.1 and E.2). Examples for junior and senior design projects can be seen in Appendix E.3 and E.4.

As Clancey (1995) stated, knowledge is an analytic abstraction rather than a set of description, rules or facts. Thus, the collaboration of two courses is a necessary issue in design curriculum since it would increase students` attention and understanding in using the knowledge and requirements in both of the design courses for their design projects. The traditional courses assign strict roles to students and instructors as the consumers and distributors of knowledge. In this case, students do not have a

responsibility for active participation but a responsibility to get and memorize the knowledge presented by the instructors. The dynamic interaction and collaboration through the web can provide many possibilities to change and develop the passive participation of students. The different roles in various modes of interaction through the web can enhance the design, conductance and evolution of courses.

CDS construction is a complex process that has to incorporate collaboration and design activities related to the advances in communication and computer technology. A systematic organization in a CDS is essential to provide a useful collaborative design environment so that the students can benefit from the advances provided by computer media in their design studies. A systematic organization of virtual learning environment can offer the awareness of collaborative nature of design process, which is usually not emphasized or a missing approach in traditional design studios, in which students work individually. Related to this concept, DePaula et. al (2001) reconceptualized courses as *seeds* related to *Seeding, Evolutionary Growth, Reeseding* (SER) model rather than finished products, highlighting the different paradigms of education and learning skills such as self-directed learning and collaboration. This approach is an alternative for traditional courses, which give active roles for both instructors and students by shifting among roles of learner, designer and contributor. The three phases of SER model are used to construct the CDS web site, which is a bridge among two web sites, for designing collaboration of two design courses.

Collaborative design involves communicating and sharing of information. Maher and Simoff (1999) stated that the evaluation of individual participation could identify both the amount of contribution to the project and the content of the contribution. For this reason, interactions among the participants and critiques of the participants at each phase of the design development are recorded to evaluate the collaboration on the shared tasks. The data gathered during the collaborative study is evaluated to see whether the collaboration of two design courses through the Internet can satisfy the process, needs and requirements of a design studio. The data used to evaluate the CDS conducted within the framework of EDC model are the critiques of the participants, in other words the redline files, and students` design diaries. The segmentation method is used and the categories of segments are defined based on the pilot study and the requirements of the collaborating courses for the analysis of CDS and explained in Chapter 6.

The results of the analysis of redline and design diary data in CDS indicate that all of the issues discussed in a design studio are also discussed during a collaborative study on the Internet. However the amount of emphasis on the different design issues varies. Moreover, the results of the standardized questionnaires distributed at the end of the study for usability testing revealed that the students found the EDC framework usable and satisfactory although sometimes they had problems in Internet connection. The problem in Internet connection was mainly because of a common problem in Internet connections all over the country during the period of CDS implementation. The results of the usability testing questionnaires as

well as the participation levels, the emphasis on problem domain and design strategies of the students and instructors of the two courses are explained with quantitative and qualitative data analysis in Chapter 7.

This study emphasizes the dynamic evolution generated by the reflections of participating courses and adaptation to education. However, the study was restricted by financial and technical base. Future studies would involve an advanced technology for synchronous communication and three-dimensional representation. The computer programs or web sites developed for these purposes can be used to provide more flexible and advanced communication of design with improved features for capabilities of interface and speed. In that case, it would be also possible to conduct and analyze the process in CDS among different universities with advanced features and tools for database and collaboration.

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APPENDIX A

A.1 Companies offering computer programs or web sites without design features for collaboration and management.

		BSCW	CHAProject	ProjectRooms	Same-Page	TeamWare	YZManager
	Web-browser based access	x	x	x	x	x	x
	Local Hardware/Software Requirement	.	.	.	.	.	x
D	File-base Driven Storage	x	.	x	x	.	.
A	Data-base Driven Storage	.	x	.	.	x	.
T	Sub-Project	x	.	x	x	x	.
A	Search Engine	.	.	.	x	.	.
	Back-up	x	.	x	.	.	.
	Audit Trail	.	.	x	.	.	.
	RFI	.	.	.	.	.	.
	Multiple File format	.	x	x	x	x	.
	Multiple Document Interface	.	.	.	.	.	.
S	Team Calendar	.	.	x	x	x	x
C	Dynamic Scheduling System	.	.	.	.	x	.
H	Dynamic Control Assignment	.	.	x	x	x	.
E	On-demand Notification	x	x	x	x	x	.
D	Scheduled Notification	x	x	x	x	x	.
U	Pull-based Technology	.	.	.	.	.	.
L	Automatic Track File Version	.	.	.	.	.	.
E	Public Information	.	.	.	.	.	.
	Financial Management	.	.	.	.	.	x
	File Download	x	x	x	x	x	x
I	File Upload	x	x	x	x	x	x
N	Contact List (Participant Information)	x	.	x	x	x	x
T	Standalone Mode (Offline)	.	.	.	.	.	.
E	Desktop Sharing	.	.	x	.	x	.
R	Chat (Private & Public)	.	.	x	x	x	x
A	Pooling / Voting	.	.	.	x	.	.
C	Whiteboard	.	.	x	x	x	x
T	Image Album (Thumbnails)	.	.	.	.	.	.
I	Web CAM	.	.	.	.	.	.
O	Fax	.	.	.	.	.	.
N	SMS	.	.	.	.	x	.
	Measurement of Project Progress	.	.	x	.	.	X
R	Activity logs	.	.	.	x	.	X

A.2 Companies offering computer programs or web sites for design project collaboration and management.

		Actify Spinfire	Alibre Design	BIW	Citadon CW	DrawingRoom	DrawingViewer	Ereview	EZ Meeting	OneSpace	Online PM	Project Desk	ProjectGrid	ProjectMates	ProjectPoint
	Web-browser based access	.	.	.	x	x	x	x	.	x	x	x	**x**	x	x
	Local Hardware/Software Requirement	x	x	x	x	.	.	.	x	x	.	.	**.**	.	.
D	File-base Driven Storage	x	x	.	x	x	.	.	.	.	.	x	**.**	.	x
A	Data-base Driven Storage	.	.	x	x	.	.	.	.	x	x	.	**x**	x	x
T	Sub-Project	x	x	.	x	x	.	.	.	x	.	x	**x**	x	x
A	Search Engine	.	.	.	x	.	.	.	.	x	.	x	**x**	x	x
	Back-up	.	x	x	x	x	.	.	.	.	x	x	**x**	x	x
	Audit Trail	.	x	x	x	.	x	x	.	.	x	.	**x**	x	.
	RFI	.	.	x	x	.	.	.	.	.	.	.	**x**	x	.
	Multiple File format	.	.	x	x	.		x	x	x	.	x	**x**	x	x
	Multiple Document Interface	x	.	.	.	.	.	.	x	.	.	.	**x**	x	x
S	Team Calendar	.	.	.	x	.	.	.	.	.	x	x	**x**	x	x
C	Dynamic Scheduling System	.	.	.		.	.	.	.	x	.	x	**x**	x	x
H	Dynamic Control Assignment	x	.	.	x	.	x	.x	x	x	.	x	**x**	x	x
E	On-demand Notification	x	.	x	x	.	x	x	.	x	x	x	**x**	x	x
D	Scheduled Notification	.	.	x	.	.	x	.	.	x	x	.	**x**	x	x
U	Pull-based Technology	.	.	x	.	.	.	.	.	x	.	.	**x**	.	x
L	Automatic Track File Version	.	.	.	.	.	.	.	.	x	.	.	**.**	.	x
E	Public Information	.	.	.	.	.	.	.	.	.	x	.	**x**	.	.
	Financial Management	.	.	.	.	.	.	.	.	.	.	.	**x**	x	.
	File Download	x	x	x	x	x	x	x	.	x	x	x	**x**	x	x
I	File Upload	x	x	x	x	x	x	x	.	x	x	x	**x**	x	x
N	Contact List	x	x	.	x	x	.	.	x	x	x	x	**x**	x	x
T	Standalone Mode (Offline)	x	x	.	.	.	.	x	x	x	.	.	**.**	.	.
E	Desktop Sharing	.	x	.	.	.	.	.	x	x	.	.	**.**	x	.
R	Chat (Private & Public)	x	x	.	.	.	.	x	x	x	.	.	**.**	x	.
A	Pooling / Voting	.	x	.	.	.	.	.	.	.	.	.	**.**	.	.
C	Whiteboard	.	.	.	.	.	.	.	x	.	.	.	**.**	x	.
T	Image Album (Thumbnails)	.	.	.	.	.	.	.	.	.	x	.	**x**	x	.
I	Web CAM	.	.	x	.	.	.	.	.	.	.	.	**.**	x	.
O	Fax	.	.	.	.	.	x	.	.	.	x	.	**.**	x	.
N	SMS	.	.	.	.	.	x	.	.	.	.	.	**.**	.	.
	Measuring Project Progress	.	.	.	x	.	.	.	.	x	.	x	**.**	x	.
R	Activity logs	.	.	.	.	.	.	.	.	.	.	.	**.**	.	x
	Internet -Based Viewing	.	.	.	.	x	x	x	.	.	x	.	**x**	x	.
	Asynchronous Redlining	x	x	x	x	x	x	x	x	x	.	.	**x**	x	x
C	Synchronous Redlining	x	.	.	.	.	.	.	x	x	.	.	**.**	.	.
A	Multiple Mark-up	.	.	.	.	x	.	x	.	.	.	.	**.**	.	.
D	Dimensioning	x	x	.	.	.	.	.	.	x	.	.	**.**	x	x
	Multiple CAD Format	x	.	.	.	.	x	.	.	.	.	.	**.**	x	x
	2D CAD	x	x	x	x	x	.	x	x	x	x	.	**x**	x	x
	3D CAD	x	x	.	.		.	x	x	x	x	.	**.**	x	x

APPENDIX B

B.1 Background Questionnaire

University
Faculty of Art, Design and Architecture
Department of Interior Architecture and Environmental Design

COLLABORATIVE DESIGN STUDIO

QUESTIONNAIRE I

Background Information

This questionnaire is prepared to gather information about the students and instructors who will participate in the Collaborative Design Studio. Please read and answer the following questions carefully.

Name:

Design Studio Year:

E-mail Address: ***You will use this e-mail address for subscribing to the group work so please give a VALID e-mail address, preferably your Bilkent e-mail address**.

1. How long have you been using computers?

   [ ] For …….. year(s). (Please specify) [ ] Never used

2. For what purposes do you use computer? (Please sort your answers by assigning numbers. Assign 1 for the one you use the most)

   [ ] Writing documents, HW, etc.
   [ ] Drawing
   [ ] Internet
   [ ] Games
   [ ] Others……..(Please specify)

3. How long have you been using Internet?

   [ ] For …….. year(s). (Please specify) [ ] Never used

4. For what purpose(s) do you use Internet? (Please sort your answers by assigning numbers. Assign 1 for the one you use the most)

   [ ] Internet Research
   [ ] E-mail
   [ ] Chat
   [ ] Mailing List
   [ ] Games
   [ ] Others……..(Please specify)

5. Please specify the computer software and program(s) you are familiar with. (You may choose more than one.)

   [ ] Word
   [ ] Excel
   [ ] PowerPoint
   [ ] AutoCAD
   [ ] PhotoShop
   [ ] Others:…….(Please specify)

6. Please specify the Internet program(s) you are familiar with. (You may choose more than one. Please specify if you use other programs)

   [ ] Netscape
   [ ] Explorer
   [ ] Other Web browser(s)…….. (Please specify)
   [ ] FrontPage
   [ ] Other program(s) for web page design……...(Please specify)

   [ ] FTP Programs
   [ ] Other program(s) for file transfer……..…(Please specify)

   [ ] ICQ
   [ ] IRC
   [ ] Other program(s) for chat……(Please specify)

   [ ] MSN Messenger
   [ ] AOL Messenger
   [ ] Other program(s) for instant messaging……(Please specify)

Thank you! ☺

B.2 CDS System Evaluation Questionnaire 1

Perceived Usefulness and Ease of Use (PUEU) (Davis, 1989)

PERCIEVED USEFULLNESS		**-2**	**-1**	**0**	**1**	**2**		**NA**
1. Using CDS in my job would enable me to accomplish tasks more quickly	Disagree						Agree	
2. Using CDS would improve my job performance	Disagree						Agree	
3. Using CDS in my job would increase my productivity	Disagree						Agree	
4. Using CDS would enhance my effectiveness on the job	Disagree						Agree	
5. Using CDS would make it easier to do my job	Disagree						Agree	
6. I would find CDS useful in my job	Disagree						Agree	
PERCIEVED EASE OF USE		**-2**	**-1**	**0**	**1**	**2**		
7. Learning to operate CDS would be easy for me	Disagree						Agree	
8. I would find it easy to get CDS to do what I want it to do	Disagree						Agree	
9. My interaction with CDS would be clear and understandable	Disagree						Agree	
10. I would find CDS to be flexible to interact with	Disagree						Agree	
11. It would be easy for me to become skillful at using CDS	Disagree						Agree	
12. I would find CDS easy to use	Disagree						Agree	

Negative Aspects: 1. 2. 3.
Positive Aspects 1. 2. 3.

B.3 CDS System Evaluation Questionnaire 2

Questionnaire for User Interface Satisfaction (QUIS) (Chin et. al., 1988)

OVERALL REACTION TO THE SOFTWARE		**-2**	**-1**	**0**	**1**	**2**		**NA**
	1. terrible						Wonderful	
	2. difficult						easy	
	3. frustrating						satisfying	
	4. Inadequate power						Adequate power	
	5. dull						stimulating	
	6. rigid						flexible	
SCREEN		**-2**	**-1**	**0**	**1**	**2**		**NA**
7. Reading characters on the screen	hard						easy	
8. Highlighting simplifies task	not at all						very much	
9. Organization of information	confusing						very clear	
10. Sequence of screens	confusing						very clear	
INFORMATION		**-2**	**-1**	**0**	**1**	**2**		**NA**
11. Use of terms throughout information and collaboration sites	inconsistent						consistent	
12. Terminology related to task	never						always	
13. Position of messages on screen	inconsistent						consistent	
14. Prompts for input	confusing						clear	
15. Computer informs about its progress	never						Always	
16. Error messages	unhelpful						helpful	
LEARNING		**-2**	**-1**	**0**	**1**	**2**		**NA**
17. Learning to operate the information and collaboration sites	difficult						easy	
18. Exploring new features by trial and error	difficult						easy	
19. Remembering names and use of commands	difficult						easy	
20. Performing tasks is straightforward	never						always	
21. Help messages on the screen	unhelpful						helpful	
22. Supplemental reference materials	confusing						clear	

CAPABILITIES		-2	-1	0	1	2		NA
23. Information and collaboration sites speed	too slow						fast enough	
24. Information and collaboration sites reliability	unreliable						reliable	
25. Information and collaboration sites tends to be	noisy						quiet	
26. Correcting your mistakes	difficult						easy	
27. Designed for all levels of users	never						always	

Negative Aspects:
1.
2.
3.
Positive Aspects
1.
2.
3.

APPENDIX C

C.1 An example for the coding of the redline files according to the problem domain.

	Student A REDLINES-Week I	DA	P/S/R	F/B/S
Student B	1 You can load some functions to the reception hall like a little cloakroom in it. It will help you to shape, the reception.	1	S	F
	2 Does this grab bar become an obstacle to access the seat and sitting down?	3	S	B
	3 For my opinion` people do not have time to read a book but they may read a magazine or newspaper so may be labeling there as "shelves for magazines & newspaper" is better.	Rs	S	F
	4 What is this line?	U	R	B
Course 1 Instructor	1 The lavatory should be located in a way that it can be accessed not only from the WC, so it will be better to turn it 90 degrees counter clock-wise.	5	S	B
	2 If you leave so much space in a cubicle like this for the healthy people, they may feel themselves as lost.	1	S	B
	3 The door of the shower room seems to be opened towards outside.	4	S	F
	4 The obstacles on the way to the shower tub may create some accessibility problems.	3	S	B
	5 In a lounge like this it will be very unpleasant to sit with two other people shoulder by shoulder.	3	S	F
	6 The coffee table in the middle is huge to be reached.	3	S	F
	7 What is the material of the panel between these two people who are expected to make private telephone conversations?	5	P	S
	8 Did you think of any sound insulation precautions?	5	P	S
Course 2 Instructor	1 The circulation to/from the toilets` the circulation to/from the kitchenette and the service circulation to/from the service entrance are congested at this area.	2	S	B
	2 The layout of the area is sparse compared to the rest of the lounge	1	S	F
	3 The Internet area and the TV area are missing! (If they exist somewhere in this plan, they are not as defined space-wise, as required by the project)	1	P	F
	4 The relation of the bar counter to the sitting units next to it might be uncomfortable for the bosses sitting at that area.	3	S	B
	5 Also symmetrical arrangement of the bar counters are unnecessary and difficult to maintain the service.	3	S	F

C.2 An example for the coding of redline files according to design strategies.

	Student A REDLINES-Week I	Micro-strategies	Design Activity
Student B	1 You can load some functions to the reception hall like a little cloakroom in it. It will help you to shape, the reception.	PS	LL-FR
	2 Does this grab bar become an obstacle to access the seat and sit down?	Qr	HL- OA
	3 For my opinion` people do not have time to read a book but they may read a magazine or newspaper so may be labeling there as "shelves for magazines & newspaper" is better.	PS	LL- SG
	4 What is this line?	Qr	U
Course 1 Instructor	1 The lavatory should be located in a way that it can be accessed not only from the WC, so it will be better to turn it 90 degrees counter clock-wise.	PS	LL- FR
	2 If you leave so much space in a cubicle like this for the healthy people, they may feel themselves as lost	Cu	HL- DM
	3 The door of the shower room seems to be opened towards outside.	Rs	HL- OA
	4 The obstacles on the way to the shower tub may create some accessibility problems.	Rs	HL- OA
	5 In a lounge like this it will be very unpleasant to sit with two other people shoulder by shoulder.	Cu	HL- LY
	6 The coffee table in the middle is huge to be reached.	Ds	LL- FR
	7 What is the material of the panel between these two people who are expected to make private telephone conversations?	Qo	HL- MT
	8 Did you think of any sound insulation precautions?	Qs	HL- MT
Course 2 Instructor	1 The circulation to/from the toilets` the circulation to/from the kitchenette and the service circulation to/from the service entrance are congested at this area.	Rs	HL- CR
	2 The layout of the area is sparse compared to the rest of the lounge	Rs	HL- LY
	3 The Internet area and the TV area are missing! (If they exist somewhere in this plan, they are not as defined space-wise, as required by the project)	Wm	HL- LY
	4 The relation of the bar counter to the sitting units next to it might be uncomfortable for the bosses sitting at that area.	Cu	HL- LY
	5 Also symmetrical arrangement of the bar counters are unnecessary and difficult to maintain the service.	Rs	HL- SH

C.3 An example for the coding of a design diary according to features and behaviors of problem requirements and solution spaces.

Week	Statement	Problem/ Solution
1	In the first drawing I tried to create linearity in the lounge to emphasize the circulation.	S-be
	Also, I choose the furniture which has more curvilinear lines (forms) to provide easy accessibility for disabled with suitable sizes for all the gate and door.	S-be
2	According to the critics, I understood that the traffic in between WC and kitchen would create chaos. So I changed the place of the kitchen and I think it is good to hide the kitchen door.	P-be
3	According to the critics for the second drawing I realized that the circulation area is not enough for the disabled people in TV unit so I changed the sitting order in that area.	P-be
	Also I put the Internet and telephone services in the same area so the reception area became bigger.	S-fe
4	At the 3. drawing linearity lost its identity, which I have been trying to provide from beginning of the project.	S-be
	According to the critics for the 3. drawing tried to create linearity again, and I changed the order of the sitting units in TV area, I used the same order with 2. drawing but I changed the dimensions.	S-fe
5	I put the food counter in front of the kitchen door to prevent the traffic between kitchen and food counter.	S-be
	I brought the Internet and telephone services area to the center of the lounge to provide easy perception from everywhere.	S-be
	I changed the order of seating in TV area again, I brought the same order with whole lounge.	S-fe
6	I designed entrance door and services door and I put automatic sliding doors.	S-fe
	I changed the disables toilets.	S-fe
	I used sliding doors for the entrance of the shower rooms.	S-fe

APPENDIX D

D.1 Number of problem domain segments in redline files

		Junior students											Senior students							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Studio Grades		1,7	1	1,7	2	4	2	1,7	2	1,7	2,3	2	2,7	3,7	2,7	2,7	3	3,3	2,7	
CDS Grades		3,7	2,3	2,7	3,3	3,7	3	3,3	2,7	3,3	3	2,7	3,3	3	3,3	3	3,3	2,7	2,3	
A																				
B	0	1	0	3	0	0	1	0	0	0	0	0	0	0	2	0	1	0	0	
D S	1	4	7	3	6	2	6	3	0	2	1	5	7	4	7	3	12	1	7	
E T	2	4	2	1	3	0	0	1	0	4	0	1	4	2	2	1	1	0	1	
S R	3	7	2	2	13	3	2	6	7	4	3	3	3	4	4	0	5	0	1	
I A	4	15	5	7	12	17	17	10	12	1	6	7	11	5	17	4	10	5	15	
G C	5	10	7	8	10	16	16	19	5	2	6	9	7	4	7	4	8	1	1	
N T	rd	8	0	1	16	4	4	10	5	3	0	2	3	5	3	5	3	2	4	
I	rs	6	1	2	3	0	0	3	2	4	1	0	1	1	4	0	3	2	1	
O	u	0	1	0	2	6	3	6	0	0	1	0	9	1	2	2	5	0	0	
N																				
P	P	19	3	4	14	7	12	16	11	3	3	3	12	3	12	8	6	4	8	
S	S	30	18	21	43	31	31	42	18	17	14	19	24	20	34	9	37	5	14	
R	R	6	4	2	8	10	6	0	2	0	1	5	9	3	2	2	5	2	8	
F	F	17	4	5	15	10	14	15	8	6	3	3	8	6	15	7	8	4	8	
B	B	37	19	21	42	36	27	35	16	13	11	20	32	20	32	12	37	7	19	
S	S	1	2	1	8	2	8	8	7	1	4	4	5	0	1	0	3	0	3	
																				Correlation
Total number of segments		55	25	27	65	48	49	58	31	20	18	27	45	26	48	19	48	11	30	0,618

D.2 Number of design strategy segments in redline files

		Junior students											Senior students							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
	Studio Grades	1,7	1	1,7	2	4	2	1,7	2	1,7	2,3	2	2,7	3,7	2,7	2,7	3	3,3	2,7	
	CDS Grades	3,7	2,3	2,7	3,3	3,7	3	3,3	2,7	3,3	3	2,7	3,3	3	3,3	3	3,3	2,7	2,3	
	Js	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	
M	Rs	7	7	10	18	9	11	15	9	6	2	4	9	6	8	5	15	0	2	
I	Cu	4	3	1	1	5	4	3	1	3	5	5	6	1	5	0	3	1	0	
C	Wm	0	0	0	2	0	0	2	1	1	1	2	1	3	3	3	2	2	2	
R	Co	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
O	Rp	2	0	0	3	0	1	0	0	0	0	0	0	0	0	0	4	0	1	
	Qs	8	4	3	6	6	7	6	3	2	2	3	6	5	8	5	6	3	7	
S	Qo	1	0	2	12	6	6	4	5	0	1	2	1	1	1	0	2	0	0	
T	Qr	5	4	1	5	9	6	5	1	1	1	4	8	2	2	2	5	1	7	
R	Qc	0	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	
A		27	18	17	47	36	36	36	20	14	13	20	31	18	29	15	37	7	19	
T	Ps	2	1	0	1	6	6	1	3	1	2	0	8	1	9	0	6	1	6	
E	Cs	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
G	Lp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
I		3	1	0	1	6	6	1	3	1	2	0	8	1	9	0	6	1	6	
E	Rak	4	3	2	2	2	0	7	0	0	1	3	2	1	4	2	1	2	1	
S	Rdk	11	3	3	12	4	7	13	7	1	2	4	2	5	4	2	1	1	3	
	Rsk	8	0	5	2	0	0	1	0	1	0	0	2	0	2	0	2	0	1	
	Rds	2	0	0	1	0	0	0	1	3	0	0	0	1	0	0	1	0	0	
		25	6	10	17	6	7	21	8	5	3	7	6	7	10	4	5	3	5	
D																				
E	LY	13	11	10	20	10	8	10	4	2	4	4	13	9	10	6	17	1	14	
S	CR	6	1	1	2	0	5	3	3	4	1	1	3	4	8	6	2	4	5	
I	DM	10	1	4	7	10	5	5	0	1	2	5	8	5	8	1	5	2	0	
G	SH	0	0	0	0	0	0	1	0	4	0	1	0	1	3	0	0	0	1	
N	CS	2	0	1	6	1	0	2	3	1	1	0	1	0	0	0	1	0	1	
	OA	1	0	0	4	0	1	0	2	0	1	0	0	0	1	0	0	0	0	
A		32	13	16	39	21	19	21	12	12	9	11	25	19	30	13	25	7	21	
C																				
T	LT	5	0	2	1	1	2	0	3	0	0	0	0	0	1	0	0	0	0	
I	MT	2	0	1	0	1	1	0	1	0	1	0	0	2	0	0	0	1	3	
V	FR	9	3	3	9	5	15	15	7	4	3	7	4	1	6	2	7	0	0	
I	SG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
T	AC	5	5	4	12	12	6	13	7	2	4	6	8	3	8	2	7	3	4	
Y	U	2	4	1	4	8	6	9	1	2	1	3	8	1	3	2	9	0	1	
		23	12	11	26	27	30	37	19	8	9	16	20	7	18	6	23	4	8	
																				Correlation
	Total number of segments	55	25	27	65	48	49	58	31	20	18	27	45	26	48	19	48	11	30	0,618

D.3 Number of behavior and features of problem requirement and solution spaces in design diary segments

	Junior students											Senior students						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Studio grades	1,7	1	1,7	2	4	2	1,7	2	1,7	2,3	2	2,7	3,7	2,7	2,7	3	3,3	2,7
CDS grades	3,7	2,3	2,7	3,3	3,7	3	3,3	2,7	3,3	3	2,7	3,3	3	3,3	3	3,3	2,7	2,3
S-fe	7	0	11	2	11	4	3	11	0	9	2	0	3	7	2	10	0	0
S-be	5	0	10	1	4	5	2	1	0	1	0	0	2	7	2	7	0	0
R-fe	7	0	5	2	5	7	3	7	0	6	5	3	2	7	0	9	0	0
R-be	0	0	2	0	0	1	1	0	0	2	2	4	1	1	2	8	0	0
Total	19	0	28	5	20	17	9	19	0	18	9	0	7	8	22	6	34	0	0

APPENDIX E

E.1 IAED 302 Interior Design Studio IV design brief

BİLKENT UNIVERSITY
Faculty of Art, Design and Architecture
Department of Interior Architecture and Environmental Design
2002-2003 Spring Term

IAED 302 Interior Design Studio IV

TERM PROJECT: A RESIDENCE FOR A FAMILY

This semester we will focus on the design of a residential complex. The complex will include the main residence, the guesthouse and the garden. The project will be composed of two parts, each with its own final review.

Part 1: In the first phase of the project, you are given the guesthouse of the residence. As the name suggests, the visitors of the main residents use the guesthouse temporarily. It is situated in the grounds of the residence. Your contribution will be to propose an interior design scheme for the given layout. This will include lighting design, surface treatments/finishes, window treatments, color and material selection and the design or selection of furniture, upholstery, doors, accessories, etc. Your interior design decisions in guest house will be a guidance and determining factor for your design scheme in main residence and garden since you will be required to establish a conceptual connection between the two.

Part 2: In the second phase of the project, you will be responsible to design the main house and the grounds (outdoor areas). Special attention should be given to connecting the guesthouse with the main residence while designing the outdoor areas. Please remember that one of the major objectives of this course is setting powerful inside-outside relationships (in terms of physical and visual connection).

The house will be customized for a family with five members, composed of adults and children. You will assume that one of the members will have a talent to entertain (playing instrument, dance, cooking, etc.). Accordingly, the program and the space will be articulated to accommodate such an entertainment activity. Within these limitations, you will be free to compose the family for which you will design.

Required spaces for Part 2 are:

- Entrance hall
- Living area
- Dining area
- Area for entertainment
- Sleeping quarters
- Food preparation (kitchen)
- Bathrooms
- Exercise area

- Laundry / maintenance
- Outdoor areas: patio, garden, recreation, walkways, parking, driveway

The site for the project is located in Gazi Osmanpasa, Ankara. It includes grounds and two existing buildings to be converted into residences. The small building is approximately 60 square meters in area with 260 cm. ceiling height (clear) and will be converted into the guest house in the first phase of the project. The larger one is composed of three sections with varying areas and ceiling heights and will be adapted as the main residence in the second phase. The grounds add up to approximately 1500 square meters in area and are covered with trees.

For part 2, you are required to include a second floor within the given volume. Total area of the second floor will be calculated as the 50% of the ground floor. You are responsible for determining the structural system that will carry the mezzanine floor.

Interior extensions beyond the perimeter of the building in any direction are not permitted. The given elevation however may be manipulated according to the below guidelines:

- Window openings may be combined to have larger openings without disturbing the structural system.
- Window and door openings may be converted into smaller windows
- Doors or entrances may only be assigned at the existing door openings
- The shape of the openings may not be altered.
- Exterior wall may not be punctured or torn down to create new openings.

In this part you will allocate both the interior spaces and the landscape elements in respect to the orientation of the building: natural light, views, shades, etc. should be taken into consideration.

E.2 IAED 402 Interior Design Studio VI design brief

BİLKENT UNIVERSITY
Faculty of Art, Design and Architecture
Department of Interior Architecture and Environmental Design
2002-2003 Spring Term

IAED 402 Interior Design Studio VI

TERM PROJECT: TELEVISION BROADCASTING CENTER

The instructional objectives of IAED 402 are guiding students in creative thinking, decision-making and in design process at advanced level. Students are expected to achieve experience in design research and investigation on specific functional and technical factors as well as solving the problems of complex activity patterns. They will be asked to exercise appropriate use of materials, finishes, fixtures and furniture for specific interior environments regarding functional, financial, and aesthetic concerns.

Considering the context of the course objectives, the subject of the graduation project has been decided as a visual communication facility: Television Broadcasting Center.

Communication is a vital issue in the world today. The media especially in terms of visual broadcasting has made considerable development technologically and socially. The efficiency and effectiveness of visual broadcasting in developing social opinion, social consciousness and providing information has become a social phenomenon.

As well as its informative role, media has cultural, political, educational and recreational functions, and contributes to the progress of society.

Term project will be limited to a television-broadcasting center within the wide range of media world and the type of broadcasting will also be specialized in a subject chosen from the list below by each student.

News
Political and Social Topics
Science
Art and Culture
Music
Geography
History
Sports
Education
Fashion
Movies (cinema) etc.

These general topics can be specialized further according to the preferences and / or decisions of each student.

Students are expected to investigate and comprehend the subject and propose a term project program for their own in full detail according to the topic chosen.

In general, the spaces required for a television center may be consisting of; entrance lobby, offices, studios (both with or without audience), spaces for technical and non-technical facilities of broadcasting, multipurpose halls, spaces for visitors to special programs (entrance, resting, etc.) areas for personnel, technical and social service areas, wet areas, storage etc.

Administrative organization and space requirements for the facilities held in media center has been searched by graduate students of 1997-1998 master program of our faculty and submitted as a report.

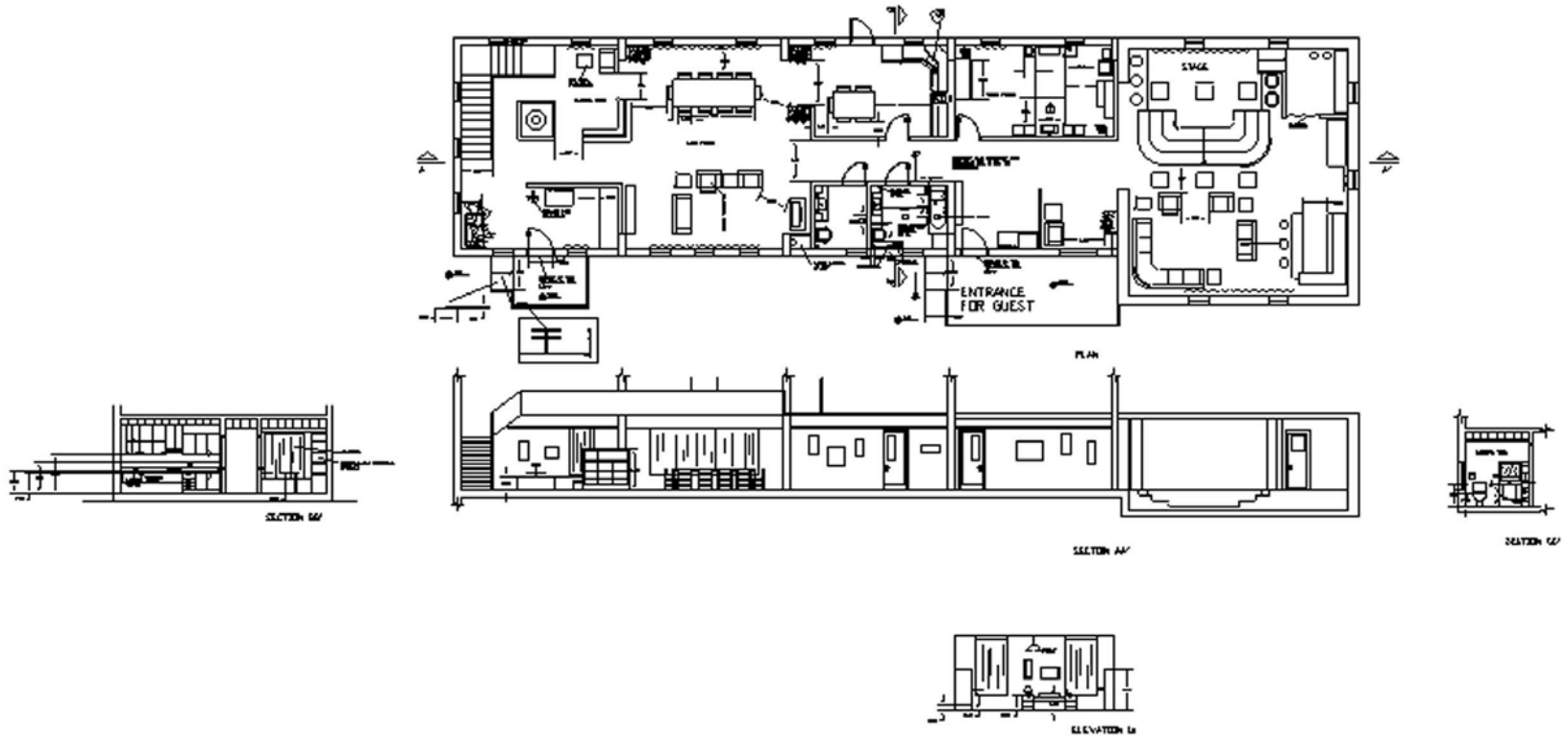
The building to house this specific function is going to be the building of Gallery of Contemporary Arts, belonging to the Municipality of Çankaya. It is located at the cross of Kennedy and Tunus street across skyscraper, previously used by İş Bankası.

The information about the building will be acquired by structural and architectural analysis of the project of the building and by the investigation in the building by each student.

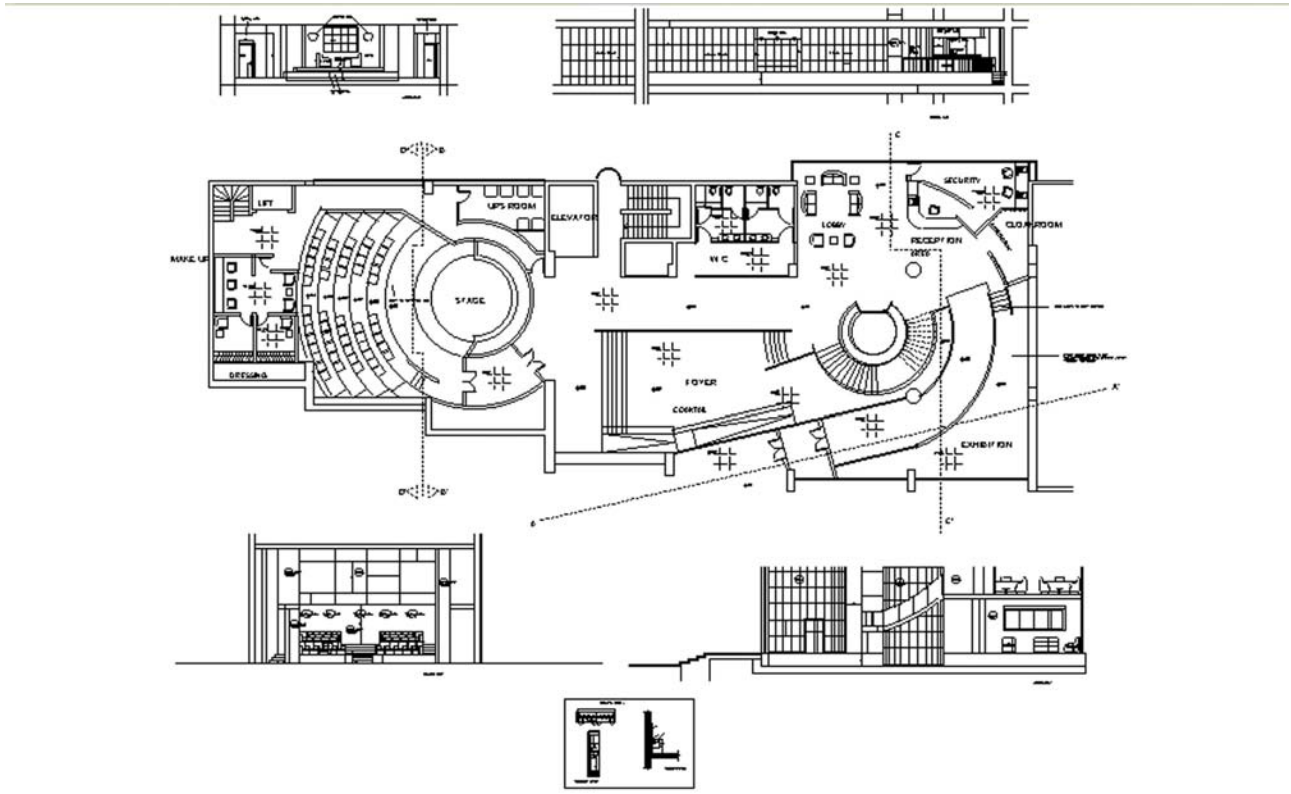
E.3 An Example for a junior project (Student number 7)

N. KORCA BAYHAN

98043000



E.4 An Example for a senior project (Student number 14)



LIST OF TERMS

2D CAD	Support for viewing and redlining 2D CAD documents.
3D CAD	Support for viewing and redlining 3D CAD documents.
Activity logs	The reports on site, files or the members` participation on the project.
Asynchronous Redlining	Embedded interface or drawing tool to create mark-up files for discussions and critiques.
Audit Trail	Complete content capture with record and playback of documents, meetings and discussions to retrieve and refer back to the previous steps of the project.
Automatic Track File Versions	Detection and alert for a newer version of a file when it is uploaded to the system.
Back-up	The system takes and keeps the copy of project data and documents at specified intervals to prevent loss of data.
Built-in CAD Viewer	The possibility of viewing drawing files such as .dwg, .dwf or .dxf via Internet Browser without running any other CAD or graphic software.
Chat (Private & Public)	Synchronous textual communication is provided through an embedded chat window.
Contact List (Participant Information)	It is possible to keep a list of participants in the project including their contact information such as phone, address, e-mail, etc.
Data-base Driven Storage	Always accessible indexed database, which allows the users to search for the information using a wide range of criteria.
Design / Drawing Collaboration	Storing and retrieving drawings online for collaboration.
Desktop Sharing	Possibility for the participants to view the screen and manipulate each other's computer
Dimensioning	Ability to measure and give dimension on the shared drawings.
Dynamic Control Assignment	Tiered security created at various levels for each participant, such as restricting or giving permission to read, write, add or delete files.
Dynamic Scheduling System	Project schedules can be created within the online system and alerts can be sent automatically by the system to keep all members accountable for deadlines and tasks.
Fax	The service provided for the participants to receive recent or important developments on the project by fax.
File Download	Taking a copy of project data or document to work on or personal local archiving of project data.
File Upload	Adding new data such as information, pictures, drawings, mark-up files for the project.
File-base Driven Storage	Multi-layered storage with subfolders.

Financial Management	Possibility of creating, modifying and monitoring the project budget information, including purchase orders and pay applications. It is customizable to sub-projects and specialized fields.
Image Album (Thumbnails)	Storing and retrieving project images and photos to keep the participants up-to-date on project process. Thumbnails are created for quick view.
Internet Browser-Based Viewing	The possibility of viewing pictures, photo and drawing files via Internet Browser regardless of any other hardware or CAD and graphic software.
Local Hardware or Software Requirement	Need for a special hardware or software to participate in collaborative system.
Measurement of Project Progress	Reports on the project process.
Multiple CAD Format	Support for multiple CAD formats.
Multiple Document Interface	Possibility of opening and more than one documents in separate windows to work on each individually.
Multiple File format	Various file formats are supported to be published; such as .doc, .ppt, htm, .pdf, .xls, wrl, gif, .jpeg, .dwf, .dwg, etc.
Multiple Mark-up	Each participant's redlining and annotation is stored on a separate layer.
On-demand Notification	The members can be notified with e-mail or message alerts about meetings, outstanding tasks or assignments by the manager of the project.
Pooling / Voting	Possibility to create questions about the project for the participants to vote for.
Public Information	Allowing public to have access specific information and photos.
Pull-based Technology	The technology in which the database recognizes the publisher, document type and date of the new data uploaded to the system and the person who should be informed about this.
RFI	Participants can be kept informed of the progress of the project and instruction request relevant to their work.
Scheduled Notification	The members can be notified automatically with e-mail or message alerts about meetings, outstanding tasks or assignments by the system.
Search Engine	Any required data or file can be searched according to the name or description.
SMS	The service provided for the participants to receive recent or important developments on the project by SMS on cellular phones.
Standalone Mode (Offline)	Possibility for the participants to work on the projects alone and offline when they are not connected to Internet.
Sub-Project	Possibility to create sub-projects for a better organization.
Synchronous Redlining	Embedded interface or drawing tool to mark up drawings for discussions and critiques in real time.
Team Calendar	Project schedules can be created and published for project

	team.
Voice File	Storing and retrieving voice files online.
Web CAM	Enabling remote access through camera.
Web-browser based access	Possibility of accessing workspace and project data through Internet without any other local software.
Whiteboard	Synchronous visual communication is provided for simple sketches without dimension.

LIST OF ABBREVIATIONS

AEC	Architecture-Engineering Construction Industry
CAD	Computer Aided Design
CDS	Collaborative Design Studio
CEDA	Complementary Explorative Data Analysis
CIE	Course Information Environment
CPSE	Collaborative Problem Solving Environment
CSCW	Computer Supported Collaborative Work
DOC	Word Document Format
DWF	Drawing Web Format
DWG	Drawing Format
DXF	Drawing Interchange Format
EDC	Evolutionary Design Collaboration
EVA	Evolutionary Artifact Software Design Environment
FTP	File Transfer Protocol
GIF	Graphics Interchange Format
HTML	HyperText Mark-up Language
IEC	International Technoelectrical Commission
ISO	International Organization for Standardization
IT	Information Technology
JPEG	Joint Photographic Experts Group
MSQL	Mini Structured Query Language
NDM	Naturalistic Decision Making
PPT	PowerPoint Format
PUEU	Perceived Usefulness and Ease of Use
QUIS	Questionnaire for User Interface Satisfaction
RED	Redline Format
RIF	Request for Information
SER	Seeding, Evolutionary growth, Reseeding
VDS	Virtual Design Studio
VE	Virtual Environments
WAP	Wireless Application Protocol
WWW	World Wide Web