To My Family

COLLABORATIVE ENVIRONMENTS TO ENHANCE CREATIVITY OF DESIGN STUDENTS: USE OF COLLABORATIVE CREATIVITY SUPPORT TOOLS

**A DISSERTATION
SUBMITTED TO THE DEPARTMENT OF
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IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN ART, DESIGN AND ARCHITECTURE**

**By
Ahmet Fatih KARAKAYA**
September, 2011

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

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Ph.D in Art, Design and Architecture
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Collaboration and creativity are integral parts of design education process. Tools to support collaborative design process, as well as tools to support creativity in the process now being used together in design education. Therefore in this study, the Collaborative Creativity Support Tool (CCST) is proposed and applied to the design process that is conducted both synchronously and asynchronously. CCST is composed of design students, knowledge domain and design field. MOODLE learning environment is utilized for collaboration and enhancing creativity processes in knowledge domain, and Google SketchUp 3D modeling tool is used in the design field. Data collection is composed of observations during and after the study, surveys, correspondence logs, 3D models, interviews and statistics that were obtained by MOODLE forum logs. To evaluate effectiveness of CCST, segment analysis over demographic data, communication frequencies, communication codes, indicators of creativity, analysis of creativity in design education is used. Findings of the empirical research indicate that CCST supported design students in both collaborative and creative processes.

Keywords: Collaboration, Creativity, Support tools, Design education, Computer-aided design

ÖZET

TASARIM ÖĞRENCİLERİNİN YARATICILIĞINI GELİŞTİREN İŞBİRLİKÇİ ORTAMLAR: İŞBİRLİKÇİ YARATICILIK DESTEKLEME ARAÇLARININ KULLANIMI

Ahmet Fatih Karakaya
Güzel Sanatlar, Tasarım, ve Mimarlık Fakültesi
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Eylül, 2011

İşbirliği ve yaratıcılık süreçleri tasarım eğitiminin ayrılmaz birer parçasıdır. İşbirlikçi tasarım sürecinin desteklenmesine yönelik araçların yanı sıra yaratıcılık sürecini destekleyen araçlar da artık eğitimde kullanılmaktadır. Bu çalışmada, İşbirlikçi Yaratıcılık Destekleme Aracı (İYDA) üzerinden tasarım öğrencilerinin eşzamanlı ve eşzamanlı olmayan tasarım süreçleri incelenmiştir. İYDA, tasarım öğrencisi, bilgi alanı ve tasarım alanlarından oluşmaktadır. MOODLE eğitim ortamı işbirliği için bir bilgi alanı ve Google SketchUp 3B modelleme aracı yaratıcılık için tasarım alanı olarak kullanılmıştır. Çalışma sırasında ve sonrasında toplanan veriler anket, yazışma logları, 3B modeller, mülakatlar ve MOODLE istatistikleri ile elde edilmiştir. Sonuçta öğrencilerin demografik verileri, iletişim sıklıkları, iletişim kodları, yaratıcılık belirteçleri, yaratıcılık segmentleri analizleri ile tasarım eğitiminde İYDA kullanımı incelenmiştir. Yapılan çalışmalar sonucunda destekleme aracının hem yaratıcılığı hem de işbirliğini destekeledigi görülmüştür.

Anahtar Sözcükler: İşbirliği, Yaratıcılık, Destekleme araçları, Tasarım eğitimi, Bilgisayar destekli tasarım

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1. INTRODUCTION

In today's design world, collaboration between geographically distributed, multidisciplinary teams is becoming a standard practice. However, design education has not been able to adjust to this rapid shift. Today's design education rarely supports multidisciplinary distributed teams, where design students mostly work individually on their projects that do not help those building teamwork or communication skills between the disciplines (Soibelman et al., 2003).

Considering design as an interactive process, where a designer frequently interacts especially with her/himself in pursuing a satisfactory design solution, it may be emphasized that in collaborative design, this interaction is increased and diversified in which each group consults with the instructor(s) and the other groups throughout the collaborative process. Besides the efforts of the instructor(s), collaborating with fellow students and developing a project together contribute positively to the design process. This process is an open-ended one while it maintains a focus on the overall goal. Usually collaborators develop a very strong ownership for the process and respond very positively to the fact that they are given almost a complete responsibility in dealing with the problem posed to them (Panitz, 2005).

The impacts of Information and Communication Technologies (ICT) on design fields have been enormous in the recent decades. Rapidly developing technological infrastructure, broad-band Internet connections, and easy access to technology have all facilitated the acts of capturing, storing, distributing, searching, and generating design information without the limitations of physical boundaries. Design professionals are increasingly using the new ICT applications as a competitive advantage in the market (Cerovsek & Turk, 2004). Besides, use of such tools in design education provides opportunities for broadening the horizons of the educational methods and preparing the students for their prospective practices (Agostinho et al., 2002; Karakaya & Şenyapılı, 2008). Computer Aided Design (CAD) courses and use of the Internet are noticeable examples of the integration of ICT into design education curriculum.

Considering design education, use of image processing, three dimensional modeling, simulation, multimedia tools and computer networking provide many advantages to the design instructors and students. Rapid and simple accesses to information, easy data formulation and effective communication in information exchange are examples of these possibilities. Internet facilities and usable CAD software have the potential to change design studio process. In traditional design studios, design students get face-to-face critiques either individually or as a group. Today, design students can get their studio critiques on a website using CAD software via the Internet; they can develop their projects collaboratively.

Among the several ICT applications in design education, the web-based design studios are attracting the major attention of researchers (Craig & Zimring 2000; Sagun, 2003; Rummel et al. 2005). The studio is the main medium for the acquisition of design knowledge in architectural education and it is widely assumed that it is the core while the other courses are complementary to it (Teymur, 1992). Broadfoot &

Bennett (2001) define web-based design studio as a studio that is distributed across space and time where the participants can be in different locations while handling the design communications via computers.

There has been extensive and growing body of literature on web-based collaborative design studios in the last decade (Simoff & Maher, 1997; Simoff & Maher, 2000; Chiu, 2002, Elger & Russell, 2001). The web-based collaborative design studios provide the following advantages compared to traditional design studios:

- Design students do not need to attend a physical studio, but can join a project from anywhere using their web browsers.
- Design students can participate in simultaneous collaborative processes.
- Shy students can express their ideas more easily in online studios in comparison to face-to- face (traditional) design studios.
- Web-based applications provide various computer applications and medium types as plug-ins or in helper formats, in which the students can create more visual and complex presentations.
- On-line archiving of design information and keeping track of past experiences provide accessibility opportunities for the other web-based design studios.

1.1. Problem Statement

Web-based/virtual design studios provide the opportunities for integrating the benefits of new technologies and the Internet into the design education curriculum. However, having reviewed the literature on web-based design studios (Karakaya, 2005), two important deficiencies are identified in the existing studies:

1. Despite the importance of collaboration in design education, collaboration has not been supported enough in the current web-based design studios. Some problems can be prevented with the use of collaboration support tools
2. Design is a complex problem solving process. Since the nature of design problems can be described as ill-defined and unstructured, design solutions require creative skills. Therefore, design students should be creative and design education should enhance the creative skills of design students. However, the current web-based design studios do not support the creative skills of design students.

1.2. Aim and Scope

The design process involves complex and ill-defined problems. Thus, designers have to interact with each other in a creative process to generate alternative design solutions. Interacting with each other to solve design problems requires collaborative activities. In design education, both creative and collaborative nature of design process should be supported at the same time. In this respect, this study aims to develop a system model for collaborative creative support tools for the computer aided design software. The tools comprise the advantages of using both the web and the virtual design studio opportunities. With the support of this tool, creative and collaborative skills of design students can be enhanced. Besides, these tools provide environments for social creativity where design students share their ideas and acts as a trigger for expressing their ideas.

1.3. Structure of the Thesis

The chapters of the thesis are organized as follows. In the second chapter, theoretical framework of the study is shaped; collaboration concept is deeply analyzed. Collaboration models, their potential and requirements of Computer Aided Design process to support design students are examined.

In the third chapter, current creativity support studies are compared with traditional studies, also, technological infrastructure of the studies is examined. The related studies are investigated to find their potentials and requirements so that a design strategy for the experiment research would be decided. Moreover, evaluation methods of creativity support tools are dwelled upon in this chapter.

The fourth chapter which is methodology, the study is explained in detail. In the light of aim and scope, the research questions and hypotheses are explained. The system model and its components are figured out deeply in this chapter.

The empirical research chapter, fifth chapter addresses the research questions by investigating CCST. In this chapter; the procedure, the design brief, subjects and instruments are explained. The fifth chapter not only demonstrates the findings of the study but also discusses these findings in terms of support of creativity and support of collaboration. This chapter also compares findings with relevant studies.

The final chapter, chapter six draws an overall conclusion. The dissertation's contribution to the literature is stayed in the last chapter. In this respect, the possible research questions are discussed for further studies. This chapter is followed by list of references and the design brief, the questionnaires, semi-structured interview questions and sample projects are provided in appendix.

2. COLLABORATIVE DESIGN MODELS

Traditionally, architectural, industrial, landscape, and interior design educations are mainly based on project-based design studio courses. In a traditional studio environment, design students express themselves in drawings, generate and evaluate alternative design solutions, and ultimately make decisions all through the design process (Gross and Do, 1997). Panitz (2005) defines collaboration as a philosophy of interaction, in which individuals are responsible for their actions, including learning and respect the abilities and contributions of their team members. A team member shares authority and accepts responsibility for the team actions. The main concept of collaborative learning is consensus through cooperation by team members, in contrast to competition.

Achten (2002) defines collaborative design as "working together in a manner to enhance each participant's contribution to the design" (p.1). Collaboration can facilitate design process for both individuals and teams. Stempfle and Badke-Schaub (2002) state importance of design teams as "design teams are of major importance in any organizational context because, with increasing complexity, groups of individuals work together in order to accomplish problems they cannot solve on their own" (p.477). Collaboration in design process does not necessarily follow a linear path; creative process may require a return to earlier phases with many iterations.

Soibelman et al. (2003) demonstrate alternative design strategies for a collaborative design process (Figure 2.1).

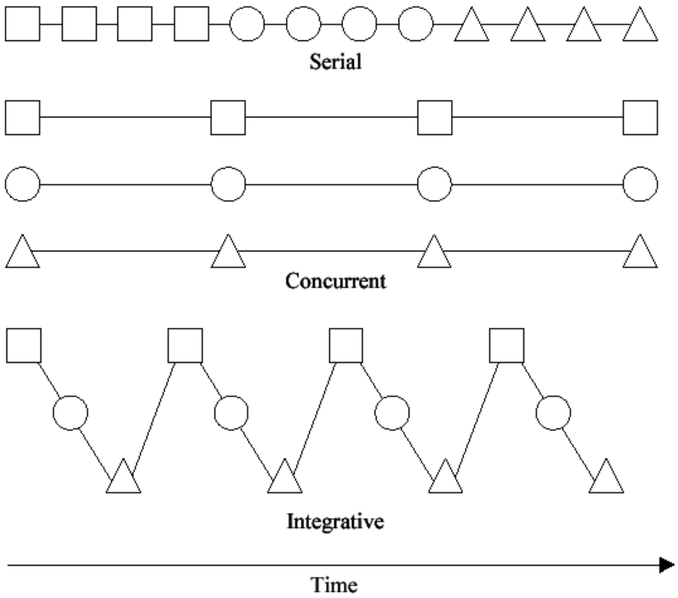

Figure 2.1 Alternative approaches to collaborative work. (Soibelman et al., 2003, p. 84)

The first design strategy mentioned in Soibelman et al. (2003) is the serial collaboration approach. In the serial collaboration approach, the design teams complete their workload and another design team develops it further. Every part of the project is completed by another design team and collaborative design process constitutes a chain. In a design studio, each design student may responsible for his/her boundaries; at the end of the project all the completed parts of the project form the design artifact together. Clearly defined requirements of the design project leads to serial collaboration between different disciplines. In this approach, the design teams follow a linear path.

In some cases, design process may require concurrent collaboration. Every design team may handle the whole project. In a design studio, design students from different backgrounds may contribute to common requirement of the design project. At the end of the project, each design team end up attending all the phases of the design project. In this approach, the design teams follow a parallel path.

The integrative collaboration approach is based on iterative participation of the design teams. The design teams are integrated in a design project. Each phase of the design project is completed with the participation of the design teams. Considering this approach in the design studio, although each design student is responsible for its boundaries, in each part of the project the design teams work together. These alternative approaches to collaborative work involve different levels of interactions between the team members.

In distributed collaborative design projects such as product development and building design, many designers may participate in different locations throughout the lifecycle of the project. The distributed nature of this type of collaboration may cause many challenges from both technological and management perspectives. Based on the literature review, collaborative design models can be grouped as being static or dynamic in nature. Awareness collaborative design models are static models since they are based on the structure. On the other hand, computational models are dynamic as they are based on the process of the collaborative work.

2.1. Awareness Models

Dourish and Bellotti (1992) cited in Cao et al. (2005) define awareness as 'an understanding of the activities of others, which provides a context for your own activity' (p.302). Awareness has been acknowledged as a critical requirement for successful collaboration (Farooq, 2007). Cao et al. (2005) propose two types of awareness models: artifact structure model and process structure model.

2.1.1. Artifact structure model

Cao et al. (2005) state “a design process, designed to produce an artifact, typically consists of several components and each component may have many sub-parts” (p.302) and can be represented as an ‘artifact tree’. In a collaborative design process, designers with different backgrounds are interested in different parts of the *artifact tree.* Every sub-part is connected with the others and they all together form the artifact.

The artifacts produced during a collaborative design process are often interdependent. For example, in a collaborative building design process, each team member (i.e. architect, civil engineer, interior architect, and electrical engineer) is interested in a different sub-part of the artifact and changing a component of an artifact (as wall size, position, etc.) affects the other components of the artifact (such as static, layout plan, lighting etc). The degree of dependency among the artifacts can vary from strongly dependent to weakly dependent scale. As an example, changing the color of a wall is weakly dependent on the structure of the building or the circulation pattern in the building.

Figure 2.2 demonstrates the Artifact Structure Model. The relationship among the components is depicted at different hierarchical levels with emphasizing their different degrees of dependency. The dashed lines demonstrate the direct dependency relationship and the continuous lines represent the sub relationship.

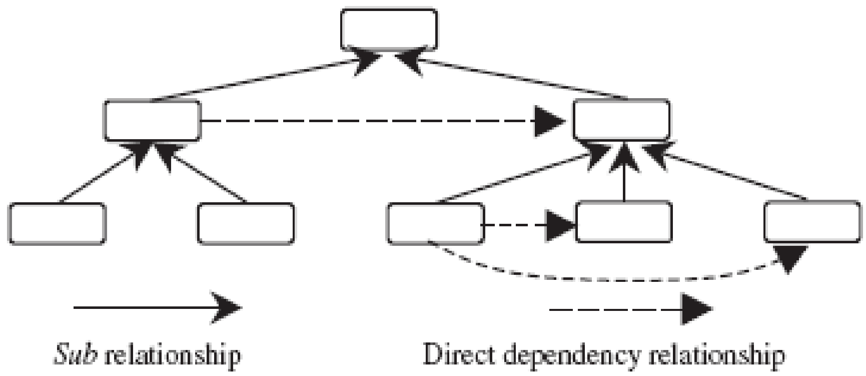

Figure 2.2 Artifact structure model (Cao et al., 2005, p. 302)

2.1.2. Process structure model

Cao et al. (2005) separates collaborative design process model into two layers. In the upper layer, there is a project plan model and in the bottom layer there is a library of workflow models with a set of tasks (Figure 2.3). Activities and their relationships are in the project model and "it provides high level ordering constraints for the entire design process" (p. 303). In the bottom layer, "tasks are fulfilled by invoking applications and services by a person or by a structured workflow" (p. 303). Team members should be aware of each other's work to coordinate tasks. For example, in building design process, all changes in plans, furnishing, etc. should be stored in the workflow library for future changes by other disciplines. Changing the width of a window may require a new lighting plan.

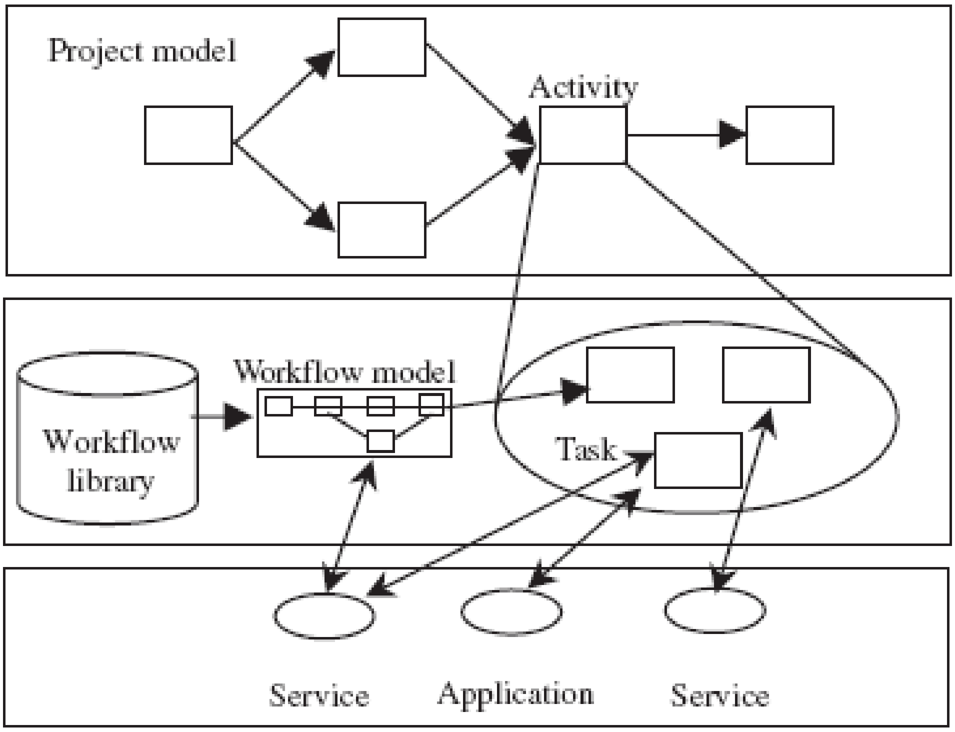

Figure 2.3 Process structure model (Cao et al., 2005, p. 303)

2.2. Computational Models

Computer aided design systems are important for design professionals with advantages such as low product development costs, easiness in modifying drawings and saving time on drawings. CAD enables designers in layout, develop work on screen, print it out and save it for future editing. An efficient CAD system should also assist designers at the initial phase of a design process.

Sprumont and Xirouchakis (2002) categorize the existing CAD systems into five focus areas with special emphasis given to CAD activity as visualization and representation; calculation and simulation; communication; knowledge processing; and, human computer interaction. In the existing CAD systems, visualization and representation are based on 2 and 3 dimensional geometric drawings, and user commands are generated as drawings on the screen. The CAD systems can analyze design projects and generate solutions by using qualitative and quantitative methods. As an example, a designer can calculate or simulate the lighting conditions of a building by using a capable CAD system. Most of the CAD systems allow designers to communicate with other designers while working on a project. Communication capabilities of the CAD systems support collaboration between designers that are working on the same project at different locations. The purpose of human computer interaction is to facilitate the utilization of the computer by the user. The user interface of a CAD system is important for data acquisition and manipulation.

2.2.1. Computer aided design activity model

Sprumont and Xirouchakis (2002) propose a CAD activity model in which tasks, sub-tasks, their relationships and manipulated elements of the CAD activity are demonstrated in Figure 2.4. In the model, the CAD activity is defined by a focused domain. The focused domain represents the part of a design problem and determined by the artifact. Knowledge processing and data processing are the components of the focused domain (Figure 2.4 a). The focused domains in the model are functions, assembly, manufacturing and safety. The dashed lines represent partial solutions between function and manufacturing, manufacturing and safety, and assembly and safety. The continuous lines between focused domains represent the coordination information (Figure 2.4 b).

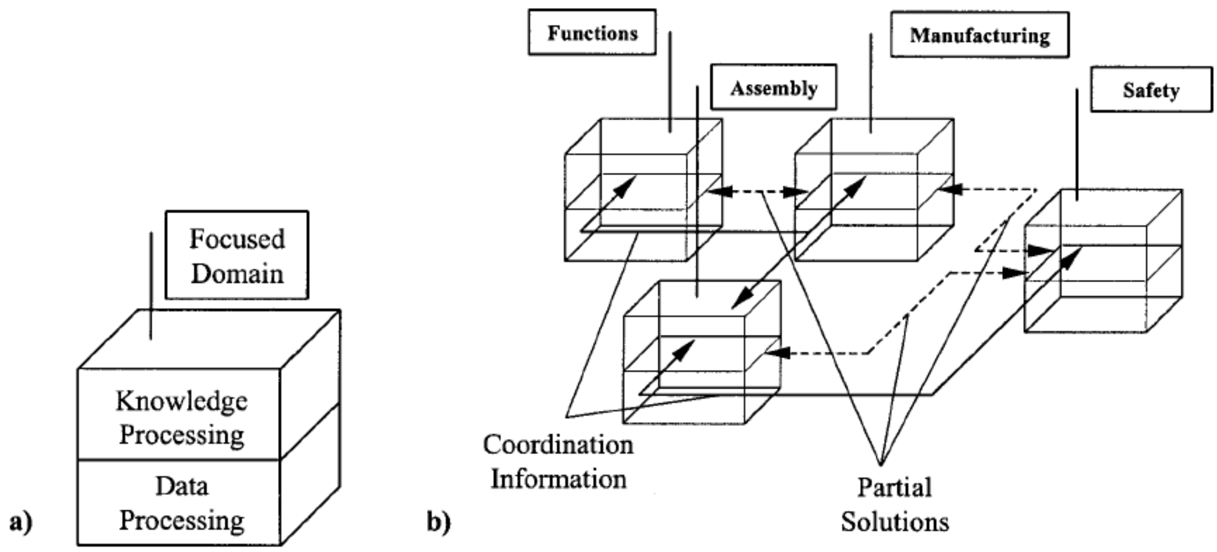

Figure 2.4 a) Elementary CAD activity, b) CAD process combining elementary CAD activities (Sprumont and Xirouchakis (2002), p.132).

The CAD activity model demonstrates the focused domain and the relationships between the activities from a specific viewpoint. However, in a design studio, there are multiple viewpoints that are based on the background differences. The next model explains a framework for a collaborative design process considering different viewpoints.

2.2.2. Multiple viewpoint current working knowledge model

According to Meehan et al. (2007) “the formalism defines design knowledge elements, and their relations, within and across different viewpoints and their evolution through the design activity” (p.144). In a collaborative process this approach allows designer to formalize knowledge within the viewpoints of other designers as concepts with attributes and constraints. This formalism provides a causal link relation across different viewpoints. Concept constraints indicate application conditions, while attribute constraints represent dependencies between individual attributes. Figure 2.5 represents the views of basic structures and networks in collaborative design and interrelations of concepts and knowledge. In this model, “the viewpoints are modeled as a series of structures (function, working principle, and solution) and networks (desired mode of action, actual mode of action, and construction network)” (p.144).

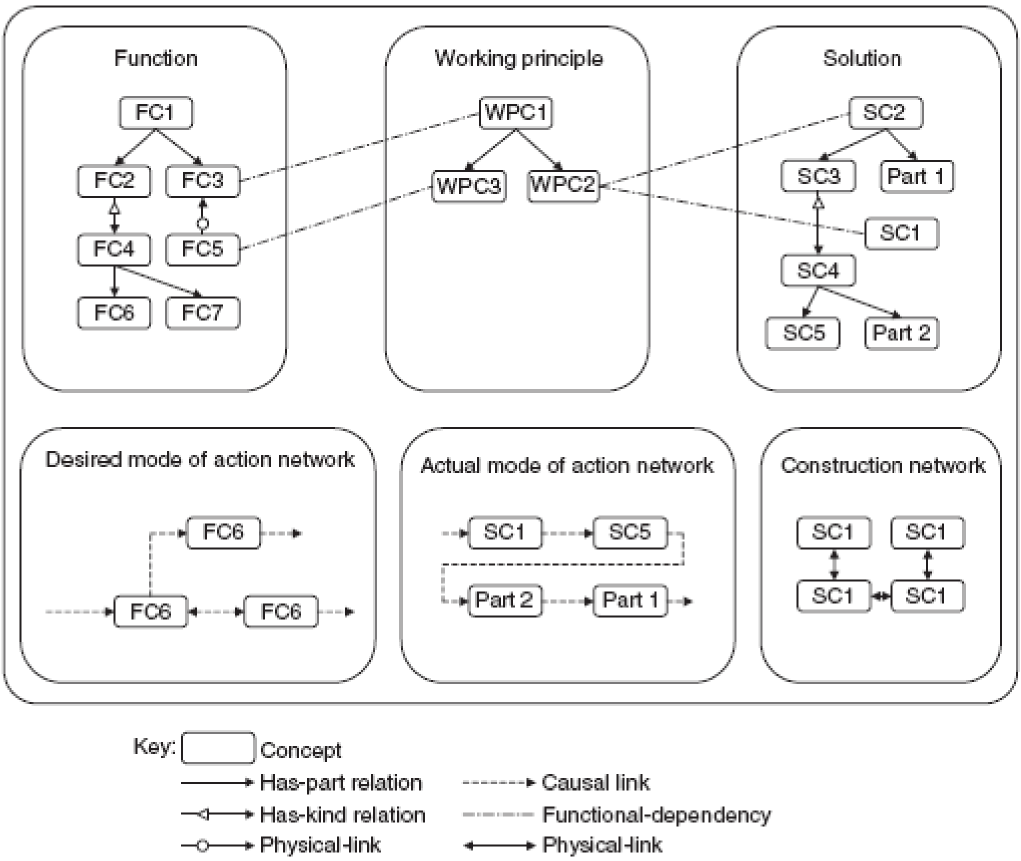

Figure 2.5 Multiple viewpoint current working knowledge model (Zhang, Y., 1998 cited in Meehan et al., 2007, p. 144)

There are models that integrate creativity and collaboration and can be used in design process as a collaborative creative support tool. The next chapter defines and exemplifies the creativity support tools.

3. CREATIVITY SUPPORT TOOLS

In cognitive psychology, design activities are described as problem-solving situations in which designers produce an artifact that should fit a specific function and satisfy different requirements (Malhotra et al., 1980). Cross (2006) identifies five aspects of designerly ways of knowing:

- Designers struggle with ill-defined problems.
- Designers attempt to solve ill-defined problems by proposing and trying solutions rather than by seeking all possible information.
- Designers have constructivist point of view, developing proposals and building on them in practice.
- Also they use professional codes to translate abstract solutions into working objects.
- Using codes enables designers to read and write the object languages of design.

Cross (2006) examines the nature of design ability as a general skill and he focuses on design as a human capacity and a human way of knowing. Since design problems are ill-defined, at the beginning of the problem, designers have incomplete materials and mental representations. By choosing design options, designers can start a problem solving process and go from problem space to solution space.

To create alternative design options/solutions, design process requires creativity and collaboration together. In design process, "knowledge and information need to be exchanged, different skills have to be coordinated, and the information communicated by others needs interpretation so that new ideas can be created and new solutions can be found" (Hilliges et al., 2007, p.137).

3.1. Creativity

Creativity is a widely used concept and there are many definitions of creativity in the literature (Hasırcı, 2005). Creativity definitions can be grouped into three categories as focusing; on the *creative product*, on the individual characteristics of a *creative person* who is able to produce new ideas or products, and on the *creative process* (Albert & Runco, 1999; Perry-Smith, 2006). In this study, creativity will be analyzed in terms of creative process.

In the literature, there are various approaches to creativity theories in terms of occurrence of creativity. Some scientists claim that creativity is an individual phenomenon, on the contrary, others argue that physical, social and interaction contexts are important for creative process. Although today's design education is mostly depended on face-to-face communication, human-computer interaction and computer mediated human to human interaction also play an important role in guiding cognitive processes.

3.1.1. Individual Creativity

Simon and his colleagues (1962) describe creativity as a person's individual act of problem solving and state some conditions:

(1) The product of thinking has novelty and value for the thinker or his culture;

(2) The thinking is unconventional;

(3) It requires high motivation and persistence; and

(4) The problem as initially posed was ill-defined, so that part of the task was to formulate the problem itself.

According to Warr and O'Neill (2005), this conditions "assist the creative process, allowing the individual to explore and transform conceptual spaces in their mind more easily than a less creative person" (p. 119).

3.1.2. Social Creativity

Fischer et al. (2007) defines social creativity as working together to solve a problem with the help of computer media and technologies. Collaboration process is a core concept for social creativity in design projects that requires expertise in a wide range of domains. Solving design problems requires "different perspectives, exploit conceptual collisions between concepts and ideas coming from different disciplines, manage large amounts of information potentially relevant to a design task, and understand the design decisions" (Fischer et al, 2007, p.16). These are the components of social creativity and collaborative creativity in other terms.

Csikszentmihalyi's (1996) definition of creativity is based on the interaction between individual, field and domain as a social process. Field and domain influence individuals' creative actions. On the other hand, individual changes the field and the domain.

In National Science Foundation Workshop Report, Shneiderman et al. (2005) state the goal of creativity support tools is to develop improved software and user interfaces that give power to users to be more productive and innovative. Creative support tools can be used by engineers, scientists, designers and people from many other disciplines. Human-computer interaction (HCI) and user interfaces are very important in developing creative support tools.

Schneiderman et al. (2005) state that the improved interfaces search more effectively the intellectual resources, develop collaboration among even geographically distributed teams and provide rapid design processes. Improved user interfaces are also important in the exploration of alternatives and preventation wrong choices. Also, comparing the creativity support tools with the traditional ones, Nakakoji (2005) concludes that “because creativity is such a humane matter, designing, developing, and evaluating tools for supporting creativity will uncover issues and challenges that have not been so obvious in the traditional HCI research framework” (p.70). The developments in human centered computer technologies can improve the usability of creativity support tools. Hence, the developments in creativity support tools are closely related with the human computer interaction researches especially with the user interfaces.

According to Greene (2002), computer tools can assist creativity on two different levels: on the first level, they can be used in knowledge gathering, knowledge sharing, knowledge integration, and idea generation; and on the second level, creativity support tools can enable the generation of creative artifacts in a particular domain by providing critical functionality in clear, direct, and useful ways. Creativity support computer tools should provide support on both of these levels and also, integrate them.

3.1.3. Creativity Models

Creativity and creative process have many dimensions and involve various social factors that influence creativity, as cultural milieu, collaboration, and rivalry (Simonton, 2001; Hasırcı, 2005). Csikszentmihalyi (1996) explains the social characteristic of creativity as it “does not happen inside people’s heads, but in the interaction between a person’s thoughts and a socio-cultural context. It is systemic rather than an individual phenomenon” (p. 23). Csikszentmihalyi (1996) developed a theoretical model, in which he explains the creative process as an interaction between individuals, knowledge domains, and fields or social groups (Figure 3.1).

According to Csikszentmihalyi (1996), an individual’s work become creative when one interacts with other individuals. In the model, ‘domain’ refers to culture; a set of symbols, rules and procedures, ‘field’ refers to social organization of the domain; new ideas, performance, or products, and ‘individual’ refers to a person who has new ideas or sees new patterns. Domain transmits structured information to individual, individual produces new ideas for field, and field selects new ideas of the individual for domain. The dashed line between field and individual represents the information flow and continuous lines represent idea selection (Figure 3.1).

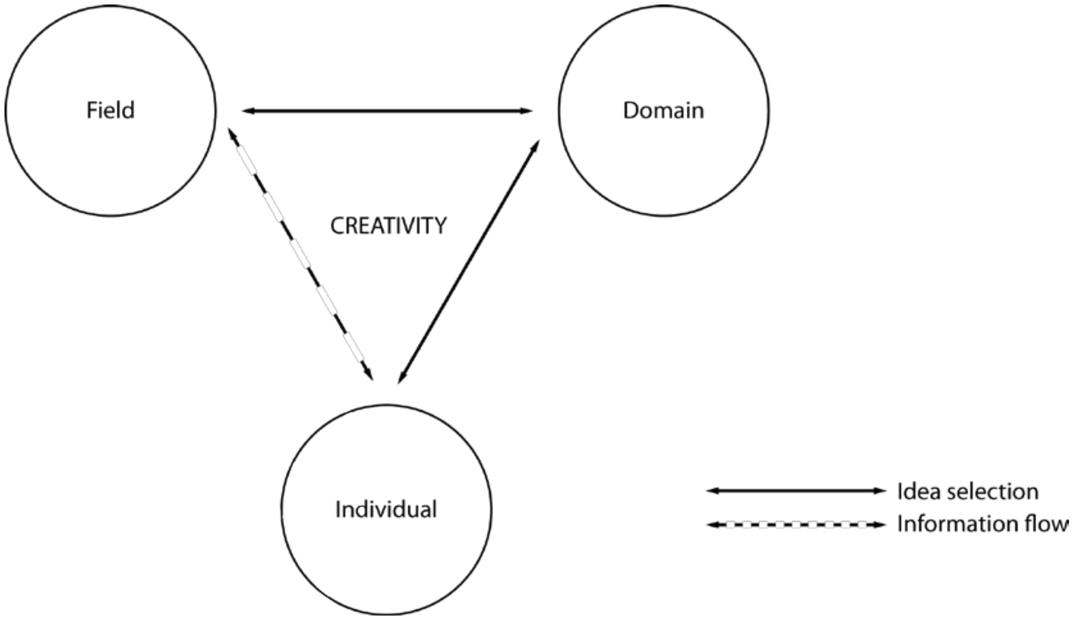

Figure 3.1 Representation of Csikszentmihalyi's creativity model

Shneiderman (2002) proposes a creativity model that is composed of collect, relate, create and donate phases (Figure 3.2). This model distinguishes from Csikszentmihalyi's creativity model with its progressive characteristic. In this model, in the 'collect' phase, creative people learn from previous works stored in libraries, the Web, and other sources. In the 'relate' phase, creative people consult with peers and mentors at different stages of process. Exploring, composing and evaluating possible solutions take place in the 'create' phase. In the last phase, which is 'donate', creative people distribute the results and contribute to libraries, the Web, and other sources.

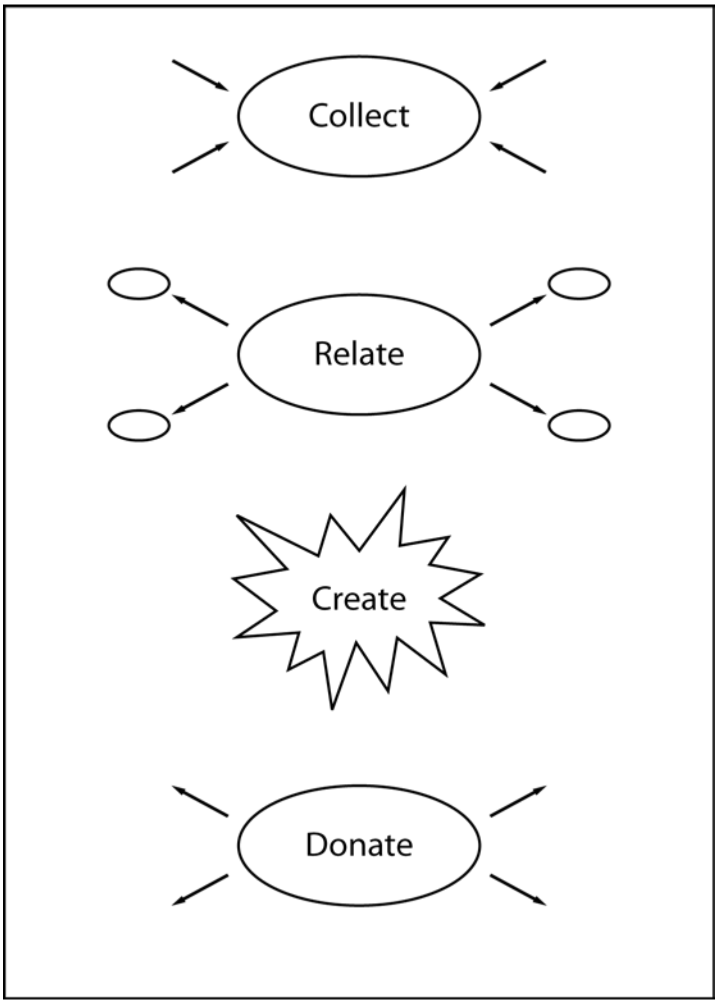

Figure 3.2 Shneiderman's creativity framework (Shneiderman, 2002, p.117)

These phases require strong collaboration in design process. Guilford (1950) noted that there was "considerable agreement that the complete creative act involves four important steps" (p. 451), traditionally identified as (a) preparation, (b) incubation, (c) illumination, and (d) verification. Research on creativity highlights the importance of social interactions, mentoring, and collaboration in creative work (Amabile, 1983; Csikszentmihalyi, 1996; Candy and Edmonds, 2002; Klemmer et al., 2002).

3.2. Current Creativity Support Tools

In the literature, some applications and environments of creativity support tools are present, such as; the Envisionment and Discovery Collaboratory (EDC), Caretta and I-LAND (Warr & O'Neill, 2007). Each of these tools support design process in a different way. Warr & O'Neill (2007) describe these tools as "EDC supports the design process as a group activity; Caretta supports personal and shared spaces throughout the design process; and I-LAND supports individual, sub-group and group activities in design" (p.128).

The EDC which is developed by University of Colorado at Boulder, creates shared understanding to support social creativity (Figure 3.3). The EDC website describes the working principle of the EDC as "participants using the EDC convene around a computationally enhanced table, which serves as the Action Space. Currently implemented using as a touch sensitive surface, the Action Space allows users to manipulate the computational simulation projected on the surface by interacting with the physical objects placed on the table" (EDC website). The table in the EDC is supported by a second computer with a touch sensitive surface behind the participants. This surface serves as the Reflection Space.

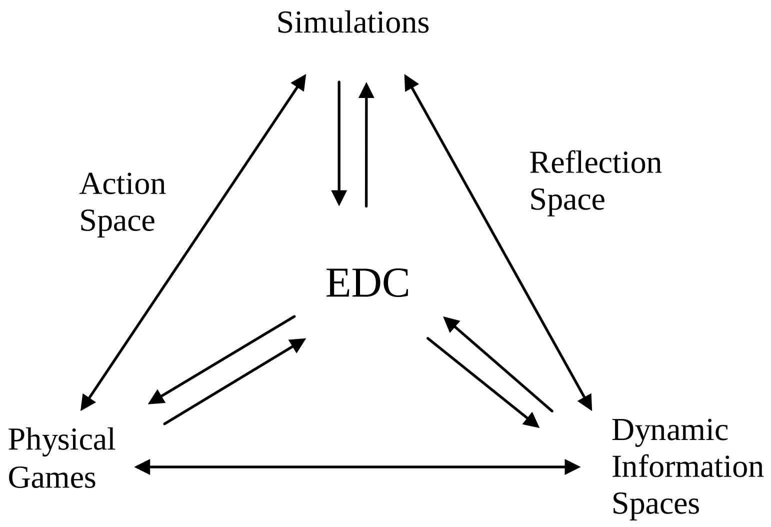

Figure 3.3 The EDC framework (adapted from Warr and O'Neill, 2007)

The Caretta is developed by Sugimoto et al. (2004) that integrates personal and shared spaces to support face-to-face collaboration by using a Personal Digital Assistant (PDA) and a multiple input sensing board (Figure 3.4). "Users of *Caretta* can discuss and negotiate with each other in the shared space by manipulating physical objects, while they individually examine their ideas in their own personal spaces." (Sugimoto et al., 2004, p.41). The main characteristic of Caretta that differs from other support tolls is that Caretta enables use of physical objects as well as virtual objects.

The Caretta supports individuals instead of teams; this is the difference of the Caretta from the EDC. On the other hand, Caretta does not support sub-groups and data cannot be transferred from user PDA to multiple inputs sensing board.

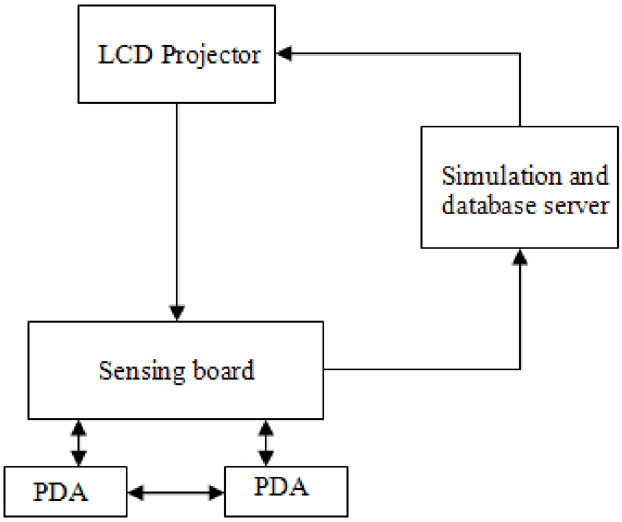

Figure 3.4 Caretta system overview (Adapted from Sugimoto et al., 2004)

The i-LAND environment is developed by Streitz et al. (1999); it is a vision for future work spaces supporting the cooperative work of dynamic teams with changing needs. Streitz et al. (1999) explain the i-LAND as "its design is based on an integration of information and architectural spaces, implications of new work practices and an empirical requirements study informing our design. i-Land consists of several 'room ware' components, i.e. computer-augmented objects integrating room elements with information technology" (p. 120). Warr & O'Neill explain using several room ware components in the i-Land as "provides different interaction spaces supporting the dynamics of the design team – individual, sub-group and group activities" (p.129).

3.3. Evaluation of collaborative creative design process

Collaborative creative design process should be evaluated through both qualitative and quantitative methodologies due to its multi-dimensional characteristics, Sagun (2003) concludes that quantitative data in collaboration can be documented by the observation of the communication patterns in “participation levels, engagement of students in collaborative process and frequency of interactions” (p.94). The data obtained through in depth interviews, design diaries and recorded communications between students and instructors are the sources of qualitative data in collaborative design process. Noble and Letsky (2002) propose four cognitive-based metrics to evaluate collaboration effectiveness. These metrics can be applied either to individual team members or teams.

The first one is the product metrics that measure product quality and efficiency. The second one is the task performance metrics that evaluate workload, flexibility, level of engagement, schedule adherence and overall performance. The third one is the information interaction metrics that measures individual contributions, group understanding, consensus and effectiveness of group process. The last metrics is the cognitive metrics that measures understanding of team members’ workload, deadlines, responsibility and team goals.

According to Hewett et al (2005), multi dimensional characteristics of creativity cannot be evaluated with traditional metrics and a rich set of metrics should be developed for describing the problem solving process and evaluation of the creativity support tools. Hewett et al (2005) also compare the controlled study, field study, survey and deep ethnography techniques that are used in the evaluation of creative support tools; and conclude that controlled studies are good for evaluation of specific questions and areas that are ready to develop. Controlled studies are advantageous in measuring the relationship between cause and effect. The disadvantages of controlled studies can be stated as being time consuming and having low external validity in evaluating creativity.

On the other hand, field studies are good in understanding the problems and the corresponding scope at early stages in evaluating creativity. Survey is good for a quick overview or description of a phenomenon as a technique used in creative support tools, since it is easy to manage and analyze. However, limited value and self-report are the disadvantages of the survey technique in comparison to the other studies.

4. METHODOLOGY

This study examines the effects of online Course Management Systems on design students, in terms of creativity and collaboration. The design project is conducted in a web-based environment with Google Sketch Up 3D modeling software.

Based on the previous literature review, the research objectives and hypotheses, the proposed system model, the selected software, and the online course management system are explained in the following sections. Additionally, a study for the proposed system model is conducted.

4.1. The research questions and hypotheses

In this research, the questions are pertained to the use of a support tool in a creative and collaborative environment. In this respect, the research questions are as follows:

Use of a support tool in creative and collaborative environment:

Q1. Does the creativity of design students be supported by computer systems?

Q2. Do design students affect each other's ideas during a collaborative design session?

The related hypotheses of the study are as follows:

H1- Use of computers in design process affects collaborative creativity processes.

(Q1; Q 2.)

H2- Use of a support tool with drawing/modeling software enhances the creativity of design students. (Q 2)

4.2. Proposed System Tool

Considering the previous studies related to collaborative design and creativity, this study proposes a collaborative creativity system tool for design students. The proposed system tool consists three main environments in line with Csikszentmihalyi’s (1996) creativity model; namely, *The Design Field* is a shared space where design students can collaborate with the fellow students, *Knowledge Dom*ain that contains a database for drawings and critiques and *Design Student* as the individual (Figure 4.1).

The users that log-in to the Course Management System (MOODLE) can upload/download the design drawings and design critiques in order to share and generate new design ideas with the team members. Google SketchUp modeling software is utilized as the drawing tool of the proposed system model.

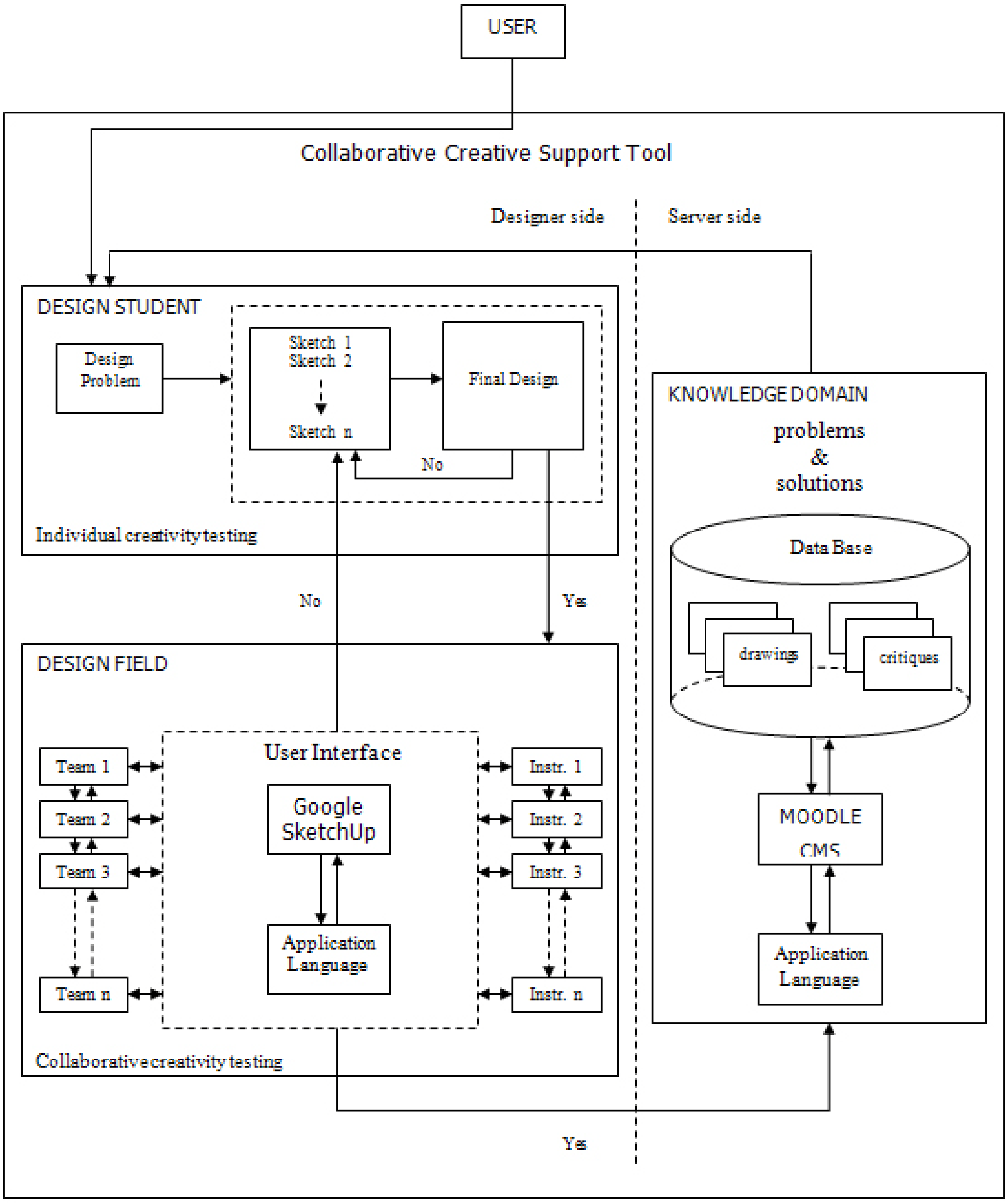

Figure 4.1 Proposed System of CCST

The proposed system tool is based on Liu's (2000) *Dual Generate-and-Test Model of Creativity*, which is a unified model of creativity in design computing. Liu (2000) presented a synthesis of the individual and social views of creativity in the tool. In Liu's model, individual creativity supports the social level. In the tool, creativity includes two generate-and-test loops: one at the level of the individual and the other at the level of society. The generate-and-test loop at the individual level (*design student* in the proposed system model), provides creative thinking, incorporating problem finding, solution generation and creativity evaluation. The collaborative generate-and-test loop model (*design field* in the proposed system model) represents the interactions among the design students and design instructors. The knowledge domain of the tool stores design problems and solutions; CAD drawings and text based critiques.

4.2.1. The Design Student

In the proposed system tool, the design student involves with the design problem as an individual. The design student analyzes the objectives; draws sketches to generate alternative solutions and among the alternatives the most suitable solution is selected (Liu, 2000).

Sketching is an important process in creativity and in early design phases design students use sketches frequently. A design student draws lots of sketches to form an idea or a concept. One of the sketches that are selected after individual creativity test is stored in the design field as an alternative.

4.2.2. The Design Field

In *the design field*, during design process, the design students create 3D drawings of the design project. The team members can also modify previous drawings that are retrieved from the knowledge domain and database. The design field composed of drawing environment and database.

4.2.2.1. Drawing Environment

As the drawing environment, Google Sketch Up is chosen as the computer aided design (CAD) tool and software of the creativity support tool (Figure 4.2). Sketch Up is an easy to learn 3D modeling software. It allows designers to draw freely by the help of its simple user interface.

Google Sketch Up is available for both Windows and Mac operating systems, and it works the same way on both. Some features of Sketch Up are very appropriate to use as a common drawing environment because it can import and export drawings from/to other software in 2 dimensional [.dwg (drawing), .dxf (drawing exchange format), .pdf (portable document format), .epix (piranesi image format)] and 3 dimensional model formats [.3ds (3D studio), .vrml (virtual reality modeling language), .obj (3D object file format), .fbx (3D file interchange format), .xei (extended enterprise integragration)] formats (Sketch Up User's Guide, 2006).

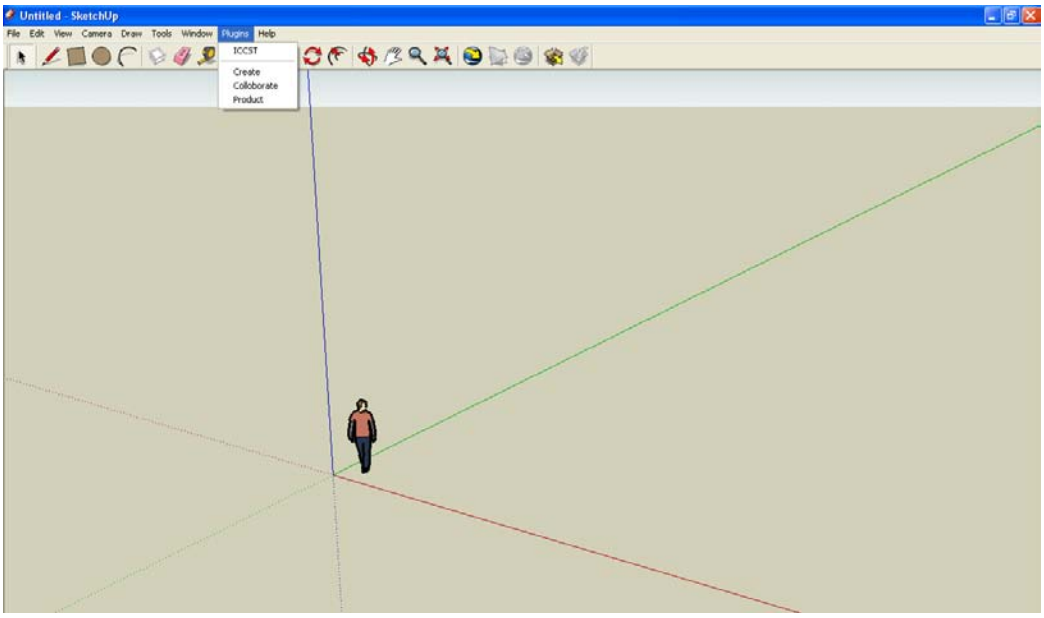

Figure 4.2 Google Sketch Up drawing window

Google Sketch Up drawing area is a screen which is defined by the user coordinate system (UCS) where users can create their models. The three dimensional (3D) space of the drawing area is identified visually by the X, Y and Z axes (SketchUp User's Guide, 2006). Figure 4.3 demonstrates the menus, dialog boxes and toolbars in the drawing area that allow designers to define design actions through the mouse selections and keyboard shortcuts (Sketch Up, 2006). Status bar gives information about user activities.

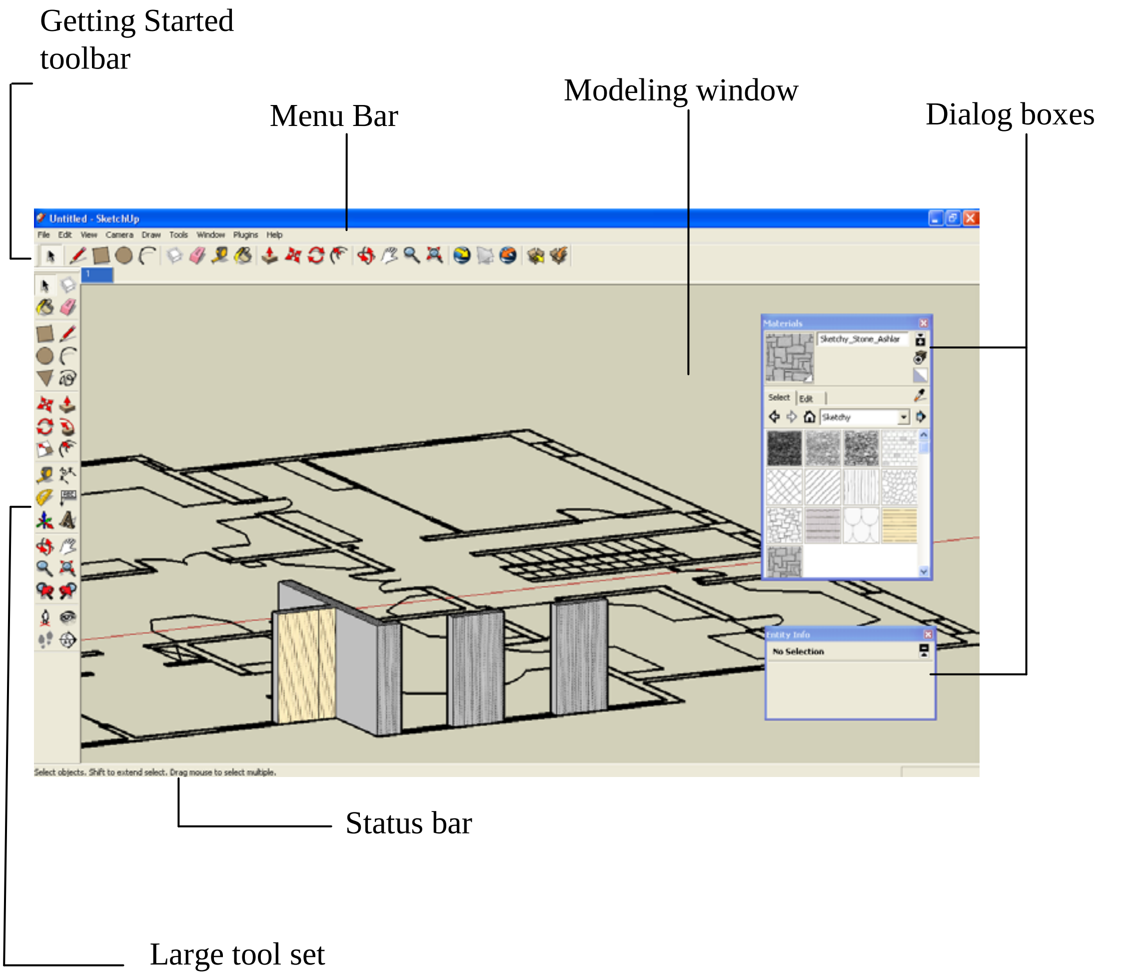

Figure 4.3 Google Sketch Up user interface

4.2.2.2. Google SketchUp Database

Google SketchUp drawing database can store data either as a single entity or library components (SketchUp User's Guide, 2006). Basic drawing commands such as surfaces, faces, arcs, curves, lines, 3D poly-lines and polygons are single entities that the database can store for further use. As well, Google SketchUp provides to combine these entities to form a new component. Users can create their drawings either from single entities or stored components in the component library.

In addition to database, Google SketchUp has a connection to Google 3D Warehouse which is a collaborative library (SketchUp, 2006; SketchUp User's Guide, 2006). Google 3D Warehouse allows users to download a model/ a drawing into the drawing area. Google 3D Warehouse can be used as a web-based database to support collaboration between designers, while they search, share, and store their drawings.

4.2.3. The Knowledge Domain

Knowledge domain can be defined as the knowledge which is valid and directly used for a pre-selected domain of human endeavor or an autonomous computer activity. Yoshitaka et al. (1994) defined domain knowledge as " a way for a class to present knowledge representing a certain concept held by objects in the class" (p.14). In this study, the class refers to database and objects refer to drawings and critiques.

The drawings and critiques of design students are stored in the database of the knowledge domain. When the design students retrieve previous comments or critiques, the knowledge domain acts like 'catalyst' in generating new ideas as well as in developing them.

The database of MOODLE provides the background information. While working together, the design students 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 students and instructors in a design studio are also provided by drawings and sketches. Compatibility of the MOODLE with the Google Sketch Up format '.skt' provides opportunities to the design students share their ideas easily (Figure 4.4).

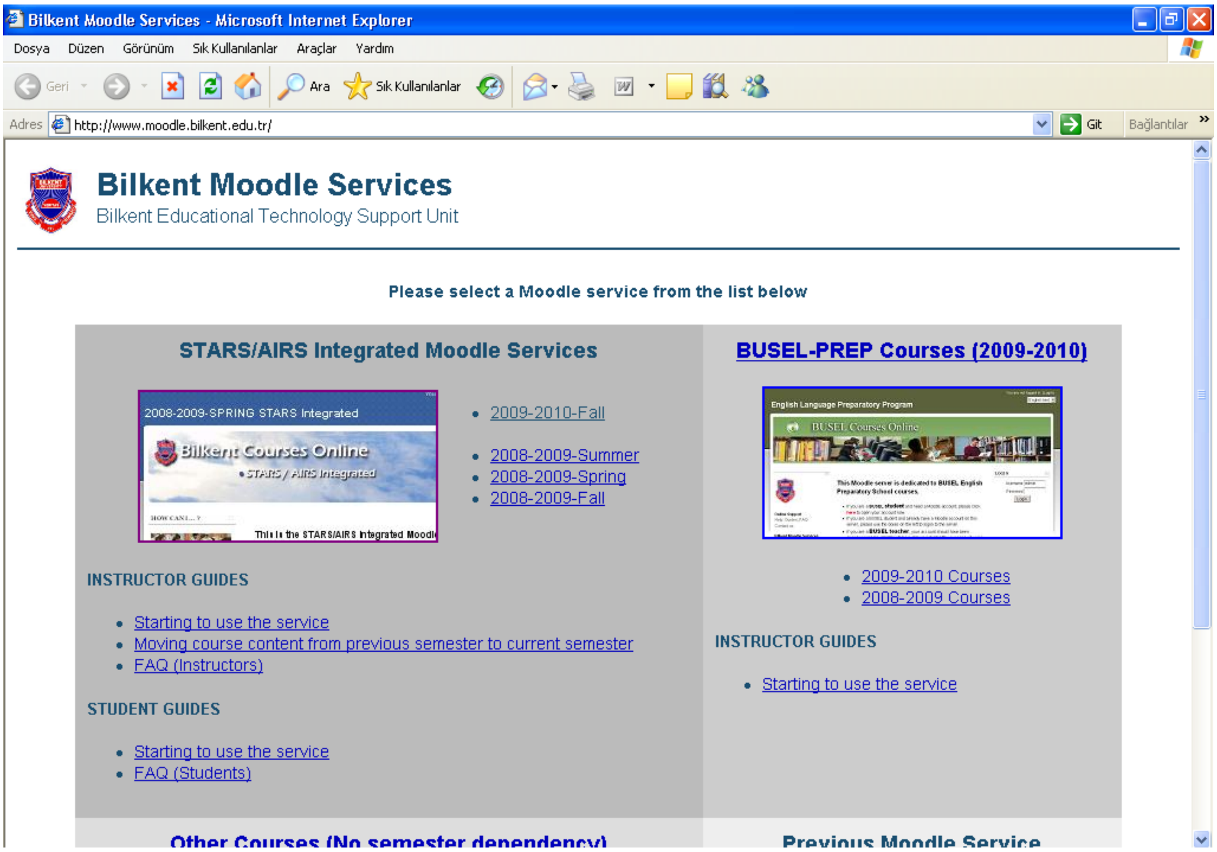

Figure 4.4 Bilkent MOODLE page

Collaborative creativity results from individuals working together on a task in a complex social system and taking a more heuristic than algorithmic approach with an outcome consisting of a useful and novel product, service, procedure, or process (Amabile, 1996; Paulus, 2000; Woodman et al., 1993). In collaboration process, complementary interests exist even where the outcomes by each individual party may differ, although design students are able to achieve common benefit but at the same time, retain ownership of their individual achievements (Mamykina et al. 2002).

During design collaboration, designers cannot reach immediately to a final decision due to the large number of simultaneous comments. Reading each incoming comment, solving the related problem and answering each comment are crucial issues in collaborative creativity test. Collected data is analyzed and related with the other ideas to generate new ideas. Since various viewpoints of design students are essential for this phase, different ideas may enrich the design projects. Communication among design students is also important for the collaboration process. The MOODLE forums can facilitate the communication and data acquiring of the team members in design process.

After idea generation, the design teams can select a group of alternative solutions based on the given critiques and forum posts, they modify their drawings accordingly on Google Sketch Up. When the design students upload their revised drawings, the MOODLE represents the revised drawings and the loop continues (see Figure 4.1). Drawing and ideas are stored in the database of *knowledge domain* for further use and research.

4.2.3.1. MOODLE

A Course Management System (CMS) is a kind of software used to create, develop, store, deliver and grade course materials in an electronic format, as well as enhancing communication (http://www.MOODLE.org). MOODLE is a CMS that is a free, Open Source Software (OSS) package. It is the most well-known OSS system that has an impact on the higher education (Porter, 2006). MOODLE is freely available for downloading from the Internet (http://www.MOODLE.org).

MOODLE is the acronym for Modular Object Oriented Developmental Learning Environment (Cole & Foster, 2005). This CMS is designed to help educators create effective online learning communities (Figure 4.5). MOODLE is currently being used in 53,986 sites, through 4,505,223 courses, by 42,779,419 users in 212 countries (05.06.2011, http://MOODLE.org). Bilkent University uses the MOODLE in 601 courses (05.06.2011, http://2010-2011-spring.moodle.bilkent.edu.tr).

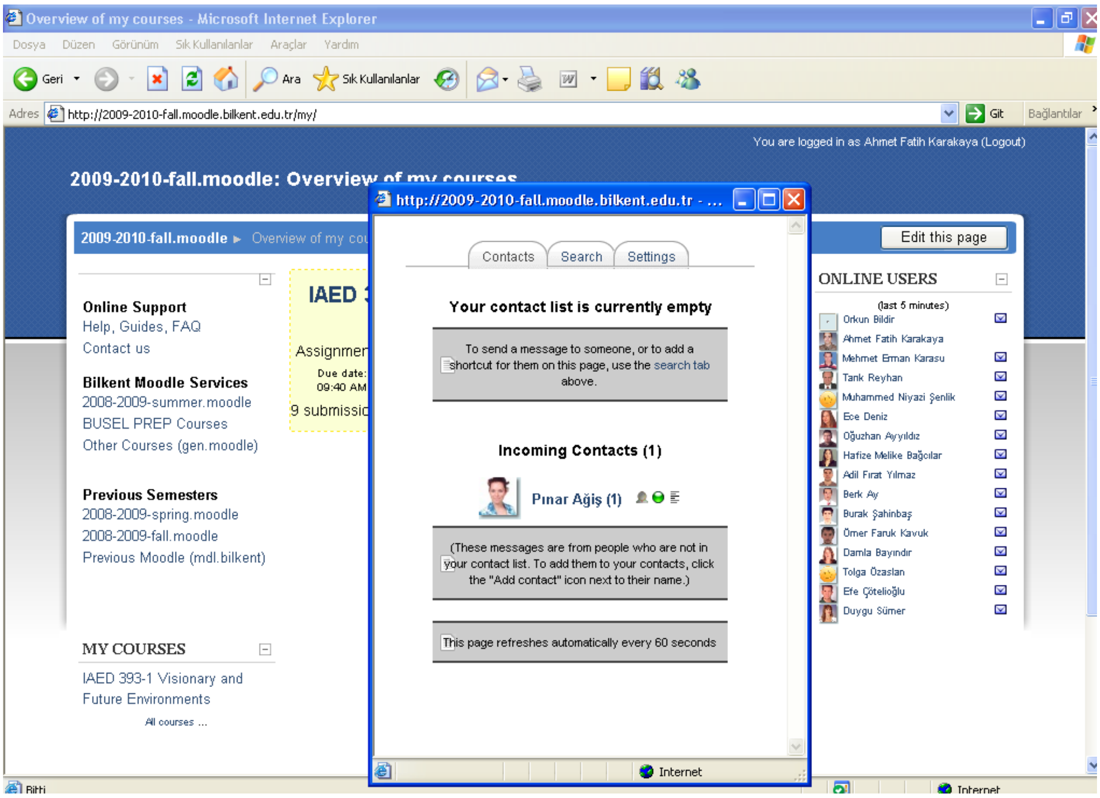

Figure 4.5 MOODLE message window

4.2.3.2. MOODLE Interface Elements

Design students can access MOODLE interface by using almost any web browser, including Internet Explorer, Mozilla Firefox, Google Chrome and Macintosh Safari. It is important that students have a familiarity in using their browser. The MOODLE interface consists of mainly 3 parts: the navigation bar, side blocks and course content area (Figure 4.6). The difference between the student interface and the instructor interface is achieved by 'turn editing on' button. Only, the instructors can change course content or add new activities by using turn editing on button.

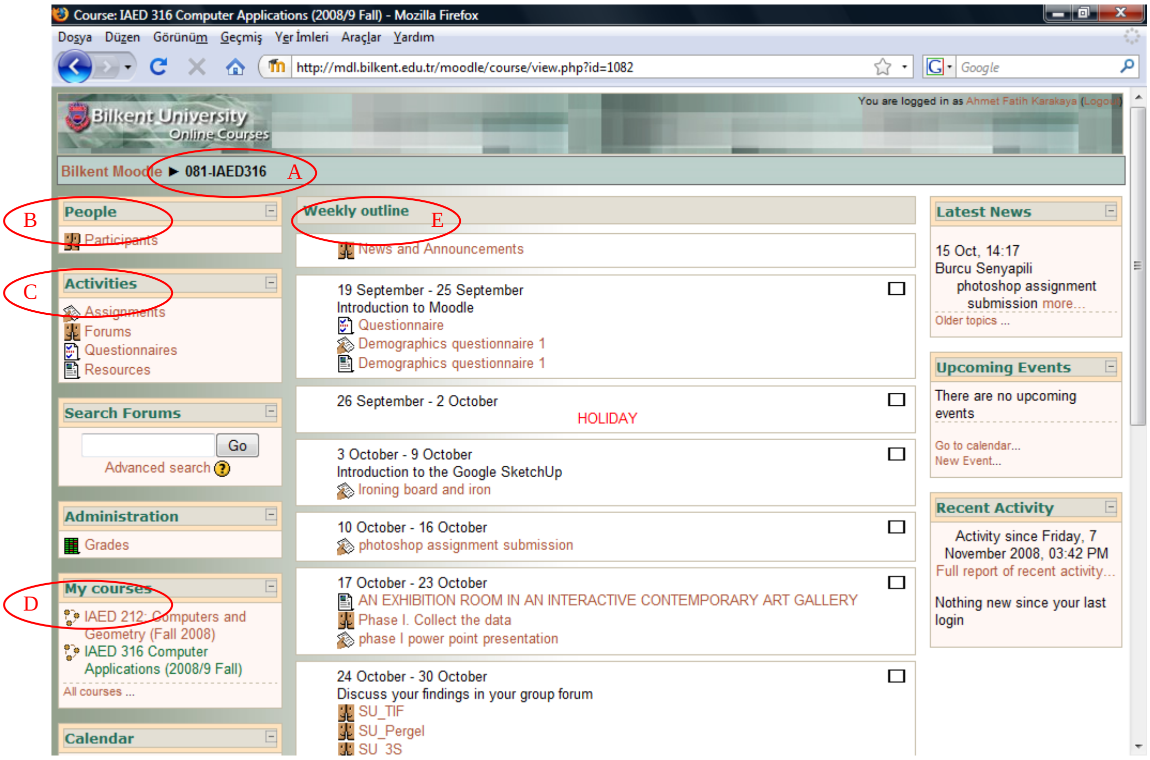

Figure 4.6 MOODLE student interface

'Navigation bar' (A) shows the current location in MOODLE. Users can easily change the location by simply clicking on the navigation bar.

The MOODLE homepage and also each course homepage contains additional blocks on the left or/and right. There are many varieties of these 'side blocks' each designed to provide additional information or functionality to the student or instructor. 'People window' (B) in the MOODLE interface consists of three sections: Participants (shows list view of everyone enrolled in course), Groups (specific student groups) and Edit profile. This window helps instructors to create groups and design students to reach other users and group mates. 'Activities window' (C) demonstrates assignments, forums, questionnaires and resources of the course (Figure 4.6). The content creation of the course and announcements of the news and grades takes place in activities window. ‘My Courses window’ (D) lists the courses taken. By selecting the course in this window, the course content area (E) changes.

‘The course content area’ (E) is the main part of the interface. All the activities and information about the course are shown here. There are many ways to create the course content: one of them is ‘weekly outline format’, the course is organized week by week, with a clear start date and a finish date. Instructors can add content, forums, quizzes, and so on in the section for each week. Another one is social format, this format is composed of one main forum, can be used as a course notice board. The last way to create a course content in MOODLE is topic format. Only the topics of the course are demonstrated and related activities can be added under each topic.

Using the ‘my courses’ window of MOODLE, instructors can give assignments, announce events, give grades, manage course content and make quizzes and open forums (Figure 4.7). Student users of MOODLE can participate to forums, upload and download files, take quizzes, follow their grades and attendances.

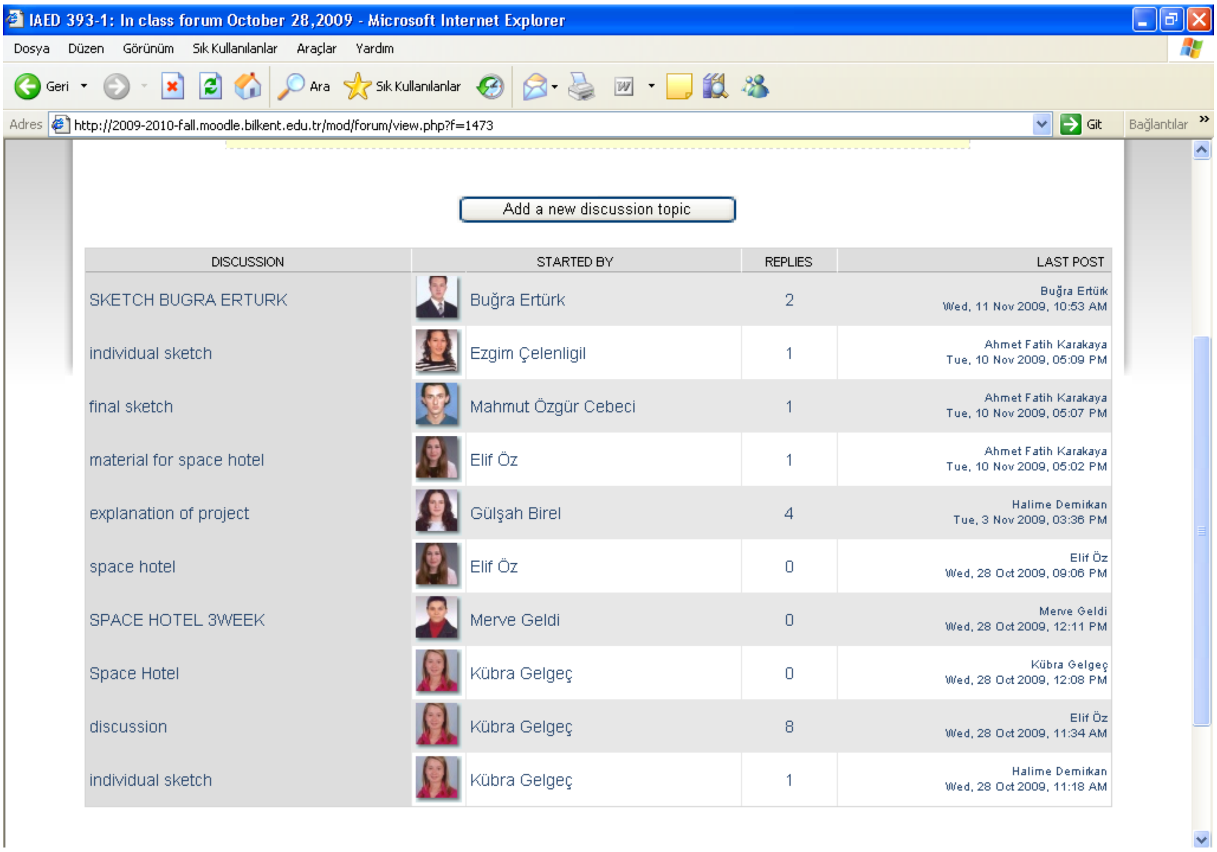

Figure 4.7 A forum session in MOODLE course page

4.2.3.3.MOODLE in the Design Studio

Although most of the regular courses in other disciplines are text based, the design studio communication is mainly based on drawings. The design students express their ideas by drawings, sketches and photographs. Martens and Achten (2008) described the usage of MOODLE in teaching of design studio in 6 areas: " (1) background information, (2) the goal of the design studio, (3) themes of the projects, (4) files required for the projects, (5) organizational matters, and (6) news updates about the studio" (p. 159).

4.3. The Instruments

Three questionnaires that are named as questionnaire 1, questionnaire 2 and questionnaire 3, were conducted respectively. The first questionnaire reveals demographic characteristics of participants. The second questionnaire is for determining the satisfaction levels of participants in use of the support tool. The last questionnaire is for assessing the participation levels of students and the familiarity levels among the team members in collaboration process.

Questionnaire 1 (see Appendix B) was applied before the study to investigate the demographic data of design students and familiarity to computer usage including information on age, gender, computer, Internet and e-learning backgrounds. Questionnaire 2 was applied after the study to determine the satisfaction and experience levels of design student with MOODLE and Google SketchUp (see Appendix C). In the questionnaire, the participants were asked to consider and state their level of agreement with each statement by using a 5-point Likert scale that ranges from 1 (strongly disagree) to 5 (strongly agree), and 3 represents a neutral response. Questionnaire 2, related to student satisfaction level was composed of mainly three groups of questions; collaboration process, creativity process and support tool.

The third questionnaire is a team participation rating form that was applied after the study (see Appendix D). The questionnaire was adopted from Oakley et al. (2004). In the team participation rating form, the students rate their team members' contribution in terms of frequency, quality and creativity. The scale of the questionnaire is in percentages; excellent (100%-90%), very good (89%- 80%), satisfactory (79%-75%), ordinary (74%-70%), marginal (69%- 60%), deficient (59%- 50%), unsatisfactory (49%- 40%) and superficial (39%-0%) were the possible ratings. In addition to their team members, students rate their own contribution.

In addition to the questionnaires, a semi-structured interview (Appendix E) was conducted with each participant. Twelve questions were grouped under four headings: creativity, collaboration, support tool and process. The questions 1, 2 and 6 were related to collaboration, the questions 7, 8 and 9 were related to creativity, the questions 3, 4, 5 and 10 were related to support tool and two open-ended questions (Q11 and Q12) are related to process.

4.4. Analysis of the Problem Solving Activities

This study involves both synchronous and asynchronous interactions in design process. As synchronous interactions, the design team members discussed their ideas and sketches in an online setting within the course hours. The MOODLE forums provided a technical infrastructure for online messaging and uploading/downloading a variety of files such as text documents, SketchUp 3D models, image files, etc. In the synchronous setting, the team members and design instructors interacted with each other while giving critiques, generating alternative solutions and deciding on a suitable solution for the design problem. On the other hand, asynchronous interactions among the design team and design instructors occurred after the class hours.

The creative process is being analyzed by the researcher by using the MOODLE database and communication records of the design students. As Reushle et al. (1999) suggested the electronic discussion group activities can also be used as evaluation instruments. The students participated in group discussions through the MOODLE forums. In this study, these discussions involve activities such as giving constructive comments to a design, criticizing other students' designs or participating in collaborative process. In literature, the use of online discussion groups has demonstrated that contributions to online discussion are assessable and learners contribute meaningfully to group discussions (Alvesson and Karreman 2000, Dennen 2007, Reushle et al. 1999).

In this study, the design students’ problem solving activities are analyzed under the headings of decision process, communication activities and indicators of creativity. Analyzing the decision process could give some valuable findings about creativity part of the system model (see Figure 4.1). In line with this, analysis of the communication phase could figure out collaborative part of the study.

For evaluating the creative process and analyzing the support given by MOODLE to the design students, segmentation method is used. This method is focusing on MOODLE posts, the segments were driven from a single comment or critique based on a single issue of the design project. This single issue may be stated in a single sentence or phrase, but in some cases more than one sentence may be used in order to clarify a certain design issue. These segments are the parts of critiques or comments that affect the design student’s creative process. The analyses are grouped under creativity codes, communication patterns and indicators of creativity.

4.4.1. Decision Process Analysis

The creativity codes are acknowledged from Farooq's (2008) dissertation as: "the coding scheme consists of […] macro level codes, each comprising several micro level codes" (p.41). *Social influences, information sharing, shared understanding, divergent and convergent thinking* are named as the macro codes (Table 4.1).

Table 4.1 The creativity segment codes (adapted from Farooq, 2008)

Segment Codes	Team	Subject	Example
Social influences			
Groupthink	T1	S1	*We should use spherical forms*
	T1	S2	*Agree*
	T1	S3	*OK, I will try to install in SketchUp.*
Normalization	T2	S4	*We can try another way to rotate cells.*
Majority influence	T8	S21	*Photographers could use larger screens.*
	T8	S23	*The larger screens may cause the more problems in space.*
	T8	S21	*I think screens are available for use.*
	T8	S23	*The size of screens is optimal right now.*
	T8	S22	*Let's leave it as is the case then.*
Information sharing			
Common information pooling	T5	S14	*It should not be a prism; we have to create G force at this module.*
	T5	S13	*We must use a torus to create G force in the space.*
Unique information pooling	T5	S15	*We should also design special pipe for water flow in the space.*
Shared understanding			
Reflexivity: reflection	T5	S15	*Rotating the performance area would be better.*
	T5	S13	*I uploaded a file against your idea, look at the new form.*
Reflexivity: planning	T3	S7	*Eating and resting modules can be located around the central module.*
	T3	S9	*Then, how to enter the cylinder, we must think of another solution.*
Reflexivity: action/adaptation	T7	S20	*Louvers or curtains may cause a dark atmosphere in the restaurant module.*
	T7	S19	*I can work on transparent material substitute of curtains.*
Divergent thinking			
Generation of multiple persp.	T3	S8	*Guest rooms can be connected with each other.*
	T3	S9	*We can align all the rooms and then connect to central cylinder.*
Reflection of multiple persp.	T3	S8	*Transparent openings may cause a weak the structure.*
	T3	S7	*We need to think transparent parts in terms of harmful rays…*
Convergent thinking			
Critical evaluation of persp.	T4	S10	*What about a sphere for gathering module?*
	T4	S11	*I think we should give up the idea of the sphere. It will be difficult to design.*
Perspective implementation	T2	S4	*Eating module should be connected with central socializing module.*
	T2	S6	*Instead of performance module, eating module can be connected with center.*

Social influences macro code includes groupthink, normalization and majority influence. When a design team desire consensus and there is a strong leadership, this situation was coded as groupthink. As seen in Table 4.1, all members of Team 1 have consensus on having spherical form of space hotel. If in a creative group there is no well defined solution to the problem, then normalization occurs. As seen in Table 4.1, a member of Team 2 (S4) asks to try another way to rotate cells. When in a creative group the majority of the group supports one decision, then the majority influence occurs. In Team 8, Subject 21 proposed to expand the size of screens; however all the other team members stated that the size of screens should not change and as the majority influence the screen size was kept as the same. In this study, the polarization and minority dissent micro codes that were stated in Farooq's study (2008) were not realized in the MOODLE forums.

Information sharing occurs in two situations: common and unique information pooling. When the information is known by all the team members it is coded as common information pooling; if only one member knows, it is coded as unique information pooling. As seen in Table 4.1, Subject 13 reminds the team members for a well known geometrical shape to create a G force; on the other hand, only Subject 15 is aware of water flow problem.

Shared understanding macro code is also known as group reflexivity includes three micro level codes consisting of reflection, planning and action/adaptation. Reflection comprises of critical thinking, attention, awareness and evaluation components. As an example, in Table 4.1, Subject 13 uploaded a revised form of space hotel as a reflection of the previous segment that proposed a rotated form. When the group design plans are built up, it is coded as planning, as seen in Table 4.1, team members try to design central module integrated to the other modules. In the reflection stage as team members refer to the goal-directed behaviors to achieve desired changes, it is coded as action/adaptation. Subject 19 adapts a new idea in to project for more visibility.

Divergent thinking code refers to taking different views to generate new ideas. When the team members generate a set of new ideas from different angles, it is the generation of multiple perspectives. For example, Subject 8 and Subject 9 generate different ideas for room allocation (Table 4.1). If the team members reflect different views and solutions to a new idea, it is coded as the reflection of multiple perspectives. Members of Team 3 state their opinions about transparent surfaces on the shell (Table 4.1).

Convergent thinking is coded as selecting alternative solutions and generating new design. Focusing on solutions derived from a set of ideas is coded as critical evaluation of perspectives. As seen in Table 4.1, members of Team 4 have a discussion on the shape of the space module. If the selected solution is implemented, it is perspective implementation.

4.4.2. Phases of the Communication Activities

Besides Farooq's (2008) coding scheme for creativity, this study also uses Jonassen & Kwon's (2001) communication patterns for analyzing design critiques. Since the frequency of communication between team members influences the effectiveness of creative problem solving process, MOODLE posts are divided into phases.

The communication acts between student-student and student-instructor are analyzed in eight phases of communication as in Jonassen & Kwon's (2001) study. Each phase identifies different action categories or periods in communication. The division of phases follows Poole & Roth's (1989) procedure. According to the procedure, a "phasic period occurs when three or more consecutive phases have the same phase classification" (Jonassen & Kwon, 2001, p.40). The eight problem solving phases are named as *problem analysis* (PA), *problem critique* (PC), *orientation* (OO), *criteria development* (CD), *solution development* (SD), *solution approval* (SA), *solution* critique (SC) and *nontask* (NT). For each action category, an example from the MOODLE posts can be seen in Table 4.2.

Table 4.2 The action categories (adapted from Jonassen and Kwan, 2001)

Action Categories	Team	Subject	Example
PA	T2	S5	We should use special structures in theatre stage for flying and disappearing
PC	T1	S3	Shell thickness is important, how much it should be?
OO	T7	S19	We should use pyramids to enlarge shell
CD	T5	S14	Social space module should have waste evacuation
SD	T8	S23	We could install cameras into a thick shell
SA	T4	S11	Great idea
SC	T7	S20	To use pyramids is good idea but has to consider friction
NT	T1	S3	I was alone in my room yesterday, it was difficult

On problem analysis (PA) phase the action is to state or define the problem. If the action is to evaluate the problem analysis statements the problem critique (PC) phase occurs. If the action is to orient or guide team process, it is defined as the orientation (OO) phase. Uploading the design files and their relevant ideas about design alternatives are grouped under the solution development (SD) phase. Nontask (NT) phase is coded when communication includes off-topic statements. This study uses individual acts as a base for the interaction patterns among design team members.

After transforming communication acts into phases, each design team's communication phases were analyzed to find out the significant periods of phases. Every sequential three phases are identified as a period and a period continues until the other period occurs.

4.4.3. Indicators of Creativity Analysis

The design process of teams was analyzed in order to find out some indicators of creativity. The criteria for evaluating creativity indicators are derived from Vandeleur et al. (2001). The indicators are grouped under direct and indirect categories each having sub-categories. Direct indicators of creativity are "…observable behavior that is a prerequisite for creativity to take place…" (Vandeleur et. al, 2001, p. 269) while indirect indicators of creativity are not necessary for creativity to take place, but they enhance creative activities.

The direct creativity indicator category consists of *generating ideas*, *experimenting* and *persistence* sub-categories (Table 4.3). Generation of new ideas is an important aspect of creativity, since students may not be able to find a suitable solution in the first sketch. Generating number of ideas help students to come up with a good idea after many ideas. Experimenting is another aspect of creativity that occurs when students try different solutions for a design problem. Another direct creativity indicator is persistence. If students carry on their idea to develop it for a better solution, persistence occurs. Persistence involves a cyclic procedure between idea generation and experimentation.

Table 4.3 Indicators of creativity

	Creativity indicators	Team	Subject	Example
Direct Indicators	Generating ideas	T7	S19	Space tourists may see the earth from the resting modules
		T7	S20	We can cover all the modules with a transparent material
		T7	S19	Also we can rotate modules around central module to see different angles
	Experimenting	T5	S14	The eating area should not be usual
		T5	S15	How the space tourists eat something without gravity?
	Persistence	T3	S8	We should use cylindrical shape for connection module
		T3	S7	If we use a cylinder, we cannot create a G force, we should still use a torus
Indirect Indicators	Group interaction	T2	S4	Could you add some light into the activity module?
		T2	S6	Ok, I'll modify it
	Pre-knowledge	T8	S22	We should design plumbing.
		T8	S21	Without a gravity force, water behaves differently.
	Motivation	T1	S2	I've added the new design.
		T1	S3	It's very functional, looks great :)

In this study, indirect creativity indicators were subcategorized as *group interaction*, *pre-knowledge* and *motivation* (Table 4.3). Group interaction occurs when students criticize the sketch of the team members to trigger more ideas. When design students use their previous knowledge, experience and skills to create something, it is called pre-knowledge indirect indicator of creativity. Motivation is a driving force to achieve goals in design process. To evaluate design team's creativity in terms of direct and indirect categories, MOODLE posts were analyzed and frequency of posts in each sub-category was identified.

4.4.4. Indicators of Collaboration Analysis

The design process of teams was analyzed in order to find out some indicators of collaboration. Indicators of collaboration could give valuable data to analyze collaboration part of this study. The criteria for evaluating collaboration indicators are derived from Calvani et al. (2010). Indicators of collaboration are constituted of 5 factors; *extent of participation*, *equal participation*, *extent of roles*, *reactivity to proposals* and *rhythm* (Table 4.4).

Table 4.4 Collaboration Indicators (adapted from Calvani et al. 2010, p.220)

Indicators of collaboration	
Equal participation	Homogeneous level of participation in interactions
Extent of roles	Amount of dialogic roles assumed
Reactivity to proposals	Proposal of new ideas discussed by team members
Rhythm	Routine participation in collaborative activity

The first indicator is *extent of participation (EXP).* This indicator describes design team member's participation in quantitative dimension of MOODLE forum posts. To be an indicator of extent of participation, forum posts should initiate a discussion or at least should develop design project for a better design solution alternative. Effective forum post can be defined as a forum post which is segmented in any action categories (see Table 4.2). Frequency of forum posts for each team member could be use to analyze EXP.

Related to group participation, in an online design group, each team member should participate in a similar degree to increase effectiveness of the design team. *Equal participation (EQP)* indicator is based on the frequency of the MOODLE forum posts. If one of the team members is monopolizing the design procedure and other team members are not active enough, the design team is not well-balanced.

Another indicator of collaboration is *extent of roles (EXR)*. In a design team, each student should not play the same role; each team member should be flexible in terms of giving critiques, drawing the design project and developing the presentation. Analyzing diversity of action categories (PA, OO, SD etc.) in MOODLE forum posts provide the data for this collaboration indicator.

In an online setting, new ideas or design critics sometimes not to be taken into consideration. Proposal of new ideas or design critiques should be discussed in design teams to develop better alternatives for design problem. *Reactivity to proposals (REP)* indicator is analyzed by using number of orientation (OO), solution development (SD) and solution critique (SC) action categories in MOODLE forum posts.

To analyze collaboration indicators, all related MOODLE forum posts are distributed to each indicator. According to number of indicators in each group, quartiles are decided. The points are attributed according to quartiles as first quartile equals to 1 point, second quartile equals to 2 points, third quartile equals to 3 points and fourth quartile equals to 4 points. After distributing points to each quartile, the results are shown in a radiant graph that demonstrates design team's collaborative behavior.

The collaborative creative support tool is tested through an empirical study. The study is a hybrid study in terms of communication and the computer setting, participants, design project and procedure will be explained in detail in the next chapter.

5. THE EMPIRICAL RESEARCH

In this chapter, the empirical research is presented. The research questions that are addressed and hypothesized (see chapter 4.1) are tested in this study. The study is conducted in the “IAED 393 Visionary and Future Environments” studio in the Department of Interior Architecture and Environmental Design at Bilkent University. The aim is to investigate the effectiveness in use of Google SketchUp and MOODLE during design process as a collaborative creative support tool. An interior design project is assigned to design students (Appendix A).

The study is a hybrid study that combines both synchronous-asynchronous communications as well as face-to-face and distributed interactions between students and instructors. The term *asynchronous* refers to different times while the term *distributed* refers to different places. Members of the design teams communicated with each other both during the class hours in the studio (synchronous and physical environment) and out of the class hours from different places (asynchronous and virtual environment).

5.1. The Computer Setup

Google SketchUp is the main software that is used in this study. MOODLE is utilized as a web-based learning environment. Usage of auxiliary design software such as AutoCAD, Photoshop was limited to control the effectiveness in use of the creative collaborative support tool. Each design student had a personal computer with the Microsoft Windows operating system and broadband Internet connection.

5.2. The Subjects

This study was conducted with a sample of 26 third and fourth year students in the Department of Interior Architecture and Environmental Design at Bilkent University, Ankara. The age range was 21-28. Among the participants there were 7 males and 19 females. The students formed 9 design teams and worked together throughout the study. The students were experienced in designing spaces with Google SketchUp and AutoCAD. All participating design students had their own computers at home and all had connection to the Internet.

5.3. The Design Project

The design students were asked to design a space hotel for the accommodation of 6 single space tourists. The space hotel is an orbital station that consists of several modules (see Appendix A). It should contain a public area and several private areas to meet the following basic needs of space tourists:

- Sleeping
- Cleaning
- Eating
- Exercising
- Socializing

5.4. The Procedure

The duration of the study is 8 weeks. During the study, the design students worked in 9 teams in which 8 teams were composed of 3 and one team was composed of 2 interior architecture students.

In the first week of the study, the design students were informed by the instructor that they would be participating to an online group activity. Also, they were informed that they would receive the design critiques and would meet in the same virtual learning space. MOODLE and the design project were introduced to the design students and a questionnaire was completed. In the following four weeks, the design students were asked to design the space hotel and allocate the required spaces by using the 3D modeling tool.

On the fifth week, the design projects were criticized by a preliminary jury. Two other design instructors were invited as preliminary jury members. For the preliminary jury, the design students uploaded their projects to MOODLE.

During the design project, the design team members worked on the shared task in a collaborative environment (MOODLE forums) using synchronous and asynchronous communication platforms. At the end of the study, a final jury was conducted as a final evaluation and discussion. Final jury members evaluated the student projects.

In this study, each design team was treated as a design project group. Reading, summarizing, re-reading, and comparing each design project with the other projects, provide deeper interpretation for this study. The data from the MOODLE activity reports (Figure 5.1), the MOODLE forums (Figure 5.2), chat logs and MSN logs were extracted; number of forum posts and critiques to each design idea was counted. A narrative content coding protocol was used to identify indicators of creative thought in the textual data (Amabile et al., 2005); both the occurrence and frequency of ideas were coded.

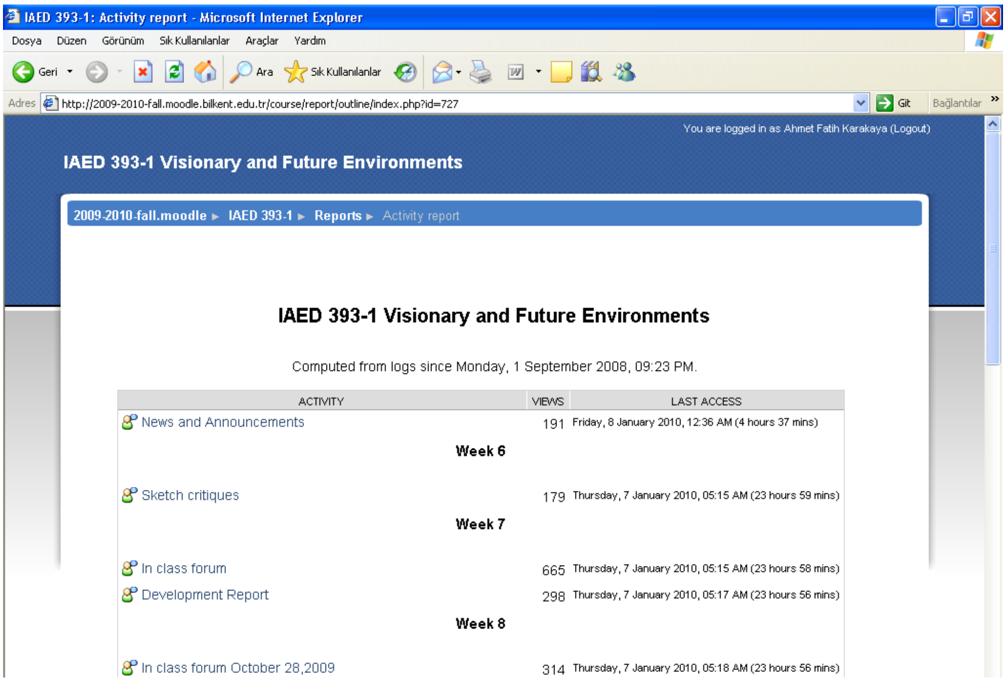

Figure 5.1 MOODLE Activity Report

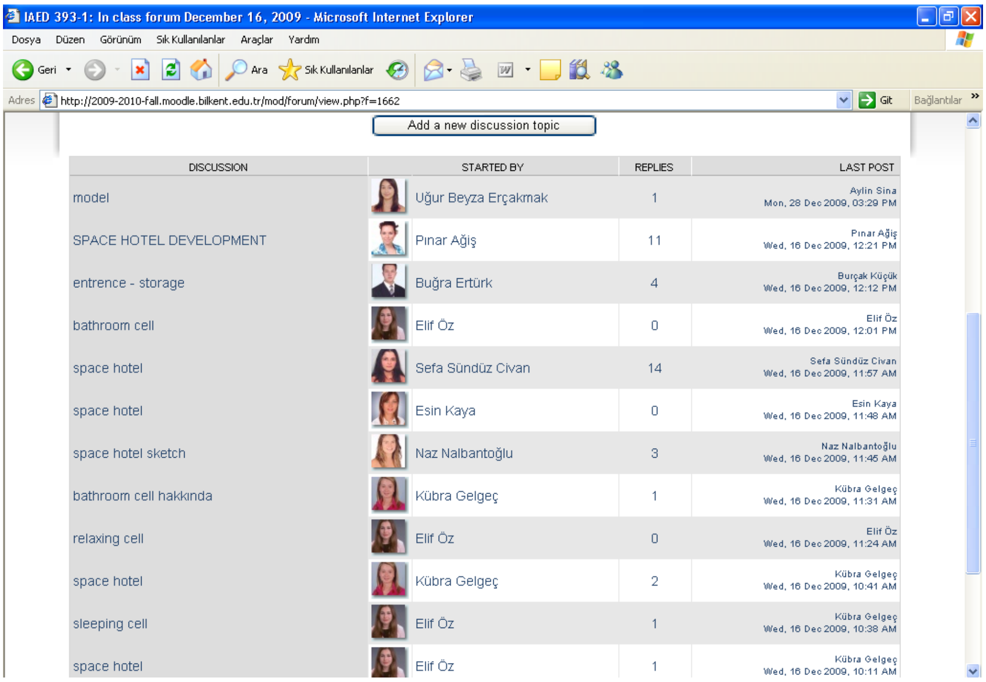

Figure 5.2 An example from forum discussion page

Jonassen & Kwon (2001) stated that the effectiveness of social creativity is dependent on the communication acts among the design team members. In class hours, structured synchronous interactions were organized in the design studio. Also, design teams sometimes interacted synchronously after the class hours. The design team members and instructors were not time dependent to submit their projects and give critiques. The MOODLE activity reports provided quantitative data of design team member activities throughout the study (Figure 5.3).

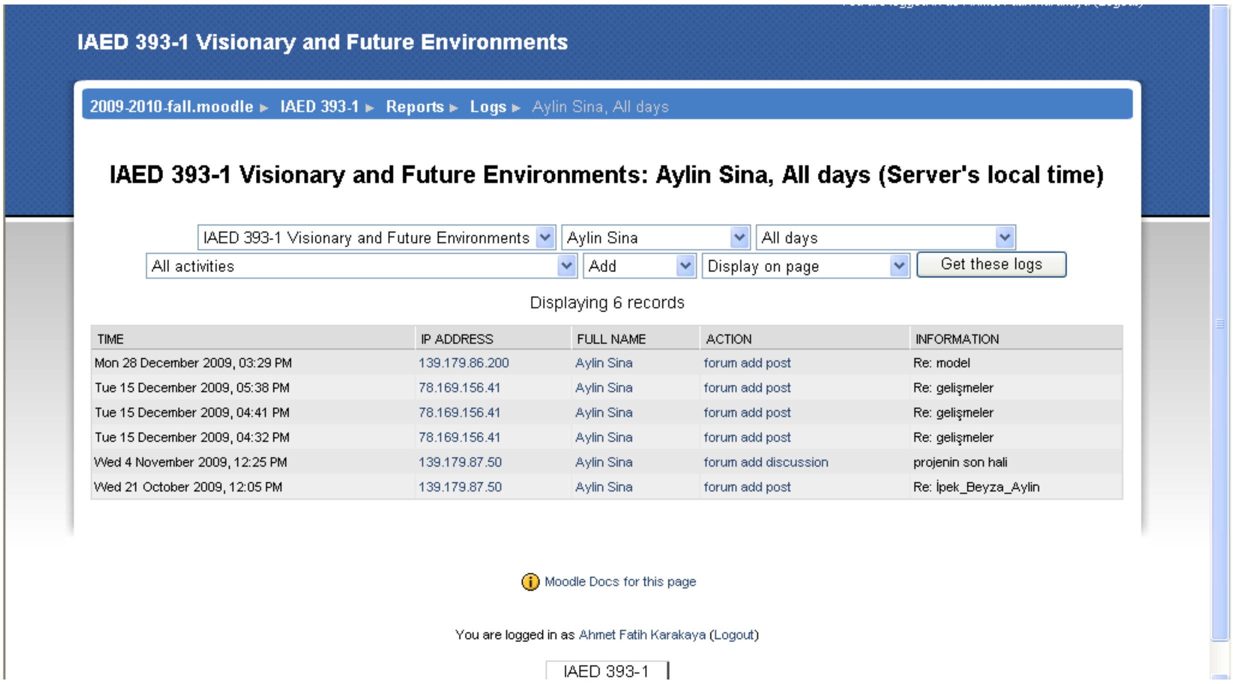

Figure 5.3 An example of design team member activity report

The design teams collaborated while developing their projects in this study. The collaboration models were explained previously in Chapter 2. On the first week, each team member was asked to upload individual sketches. The design team members generated a number of ideas about the design project. After individual testing process (see CCST model), each member uploaded the sketches explaining his/her best view. After individual sketches, each team member criticized the other team members' ideas, made modification comments on the sketches and discussed the alternative solutions. After the team testing process (see CCST model), a final solution was generated and one team member uploaded it to the MOODLE forum. These uploaded files could be downloaded and observed by the other design teams and instructors. Some teams collaborated serially, while others preferred concurrent collaborative design model (see Figure 2.7).

On the second week, only the design team 2 developed their project collaboratively. Other teams did not write down their ideas and critiques, they only uploaded a final sketch. In the following weeks, the design teams collaborated synchronously and asynchronously. Following each structured synchronous session, the participating teams uploaded a final solution. To develop a final solution, ideas were selected after individual and team tests, while design teams were referring to the knowledge domain for previously solved cases and given critiques.

5.5. Findings

The data gathered in the study are evaluated through both qualitative and quantitative approaches to balance the strengths and weakness of each method. In this integrated method; the MOODLE forums and MSN logs are used to gather data for communication phases and decision process analysis in terms of creativity codes in addition to in-depth interviews as the qualitative part of the analysis. The numerical and measurable data such as frequency, time, participation levels, number of generated ideas and alternative solutions per one problem are revealed through the quantitative part.

This sub-section consists of findings and discussions of questionnaires, semi-structured interviews and online discussion analysis. In the first and second parts qualitative and quantitative data are analyzed, in the third part, evaluations of the support tool take place.

5.5.1. The Questionnaires

In the study, the demographic (questionnaire 1), user satisfaction (questionnaire 2) and group participation (questionnaire 3) questionnaires were applied. This part finds out statistical analysis and discussions of the demographic data, working with support tool, collaborative design process and creative design process.

Analysis of questionnaire 1 did not only help to figure out the demographic background of design students, but also indicated the experience level in computer/software and computer usage of the design students. Questionnaire 2 demonstrated the satisfaction level of the students in the usage of the support tool during creative and collaborative design activities throughout the study. Group participation questionnaire gave clues about the familiarity of design students and contribution levels of team members to the design project.

5.5.1.1. Related to Demographic Characteristics and Computer/Internet Background of the Student Group

Using Questionnaire 1 (see Appendix B), the demographic characteristics of design students and their experience level in computer usage were obtained. Twenty-six students were involved in filling the questionnaire. The student group was composed of third and fourth year students. The demographic information indicated that the age mean is 21.5 for the group that consisted of 7 male and 19 female students.

In the study, every design student has a computer and a broadband connection to the Internet both at home and at the design studio. All the necessary softwares were installed on each computer. Participating design students had previous computer experience, the minimum one being 3 years and the maximum one being 20 years. The average computer experience of the students is 11.88 years. The design students were categorized according to level of experience with computers, category 1 indicates that it started before primary school years, category 2 points out during primary school and category 3 shows after primary school years. According to the results, most of the students began to use computer during their primary school years, so they are very experienced in using computers (Figure 5.4).

All students are experienced in computer aided design (CAD); the minimum one being 1 year and the maximum one being 7 years. The average for CAD experience is 3.11 years. When the results examined, CAD experience categories are revealed as category 1 is before the second year in the university, category 2 is during the second year and category 3 is after the second year in the university. Results demonstrate that majority of design students have been using CAD tools since their second year in university (Figure 5.4).

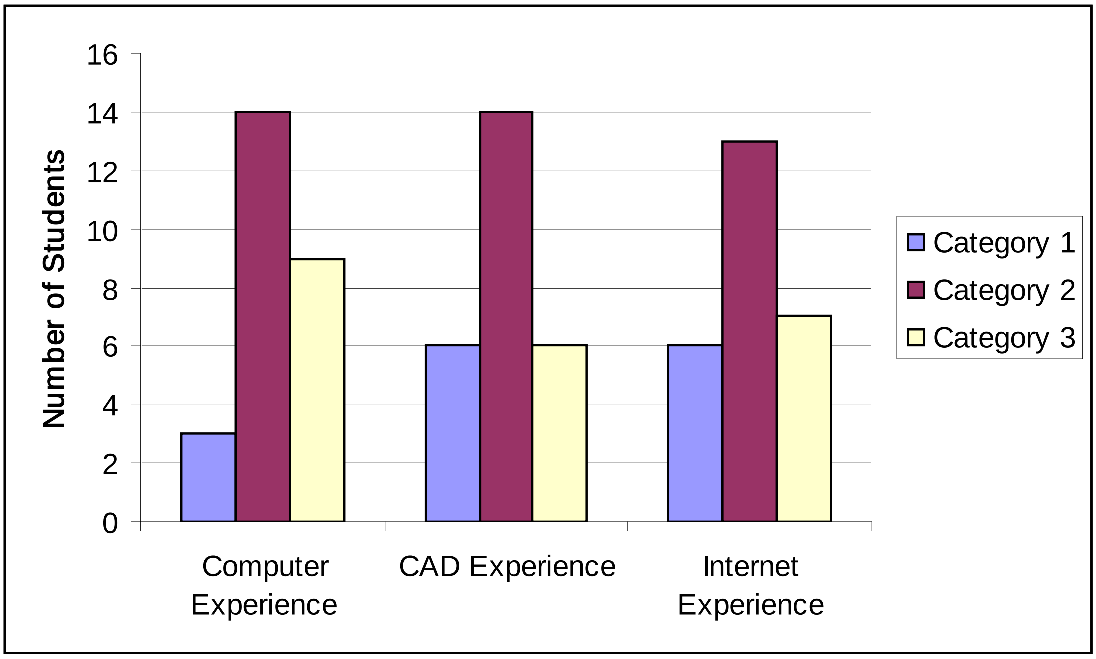

Figure 5.4 Experiences of the design students

All design students had previous internet experience, the minimum one being 1 year and the maximum one being 14 years. The average internet experience of the students is 8.35 years. When analyzing the Internet usage, majority of students have more than 10 years of Internet experience (category 3). According to Internet usage, category 2 point outs between 8 and 10 years experience and category 1 point outs less than 8 years experience (Figure 5.4). The findings indicate design students' Internet experience is not higher compared to computer usage; however students use the Internet at least since their high-school years.

The design students previously used the computer for activities such as writing, drawing, and/or connecting to the Internet. One student also uses computer to watch TV and other one uses to watch DVD films. Majority of the students use computers for CAD and Internet activities (Figure 5.5). CAD usage includes both 2D (AutoCAD) and 3D (3DSMax, Rhino, Cinema4D) softwares.

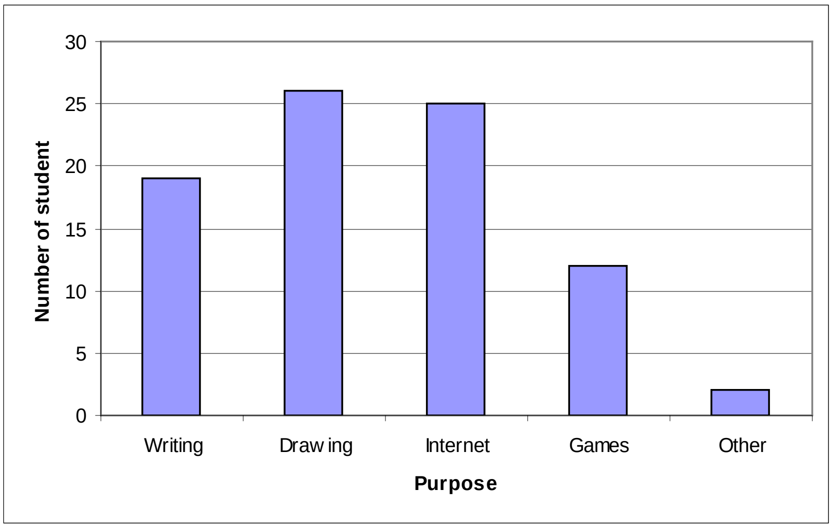

Figure 5.5 Purpose of computer usage

Most of the design students are familiar with MOODLE and some students had collaborative design experience. The design team members are also friends, they spend time together after class hours and they were studying together (Figure 5.6).

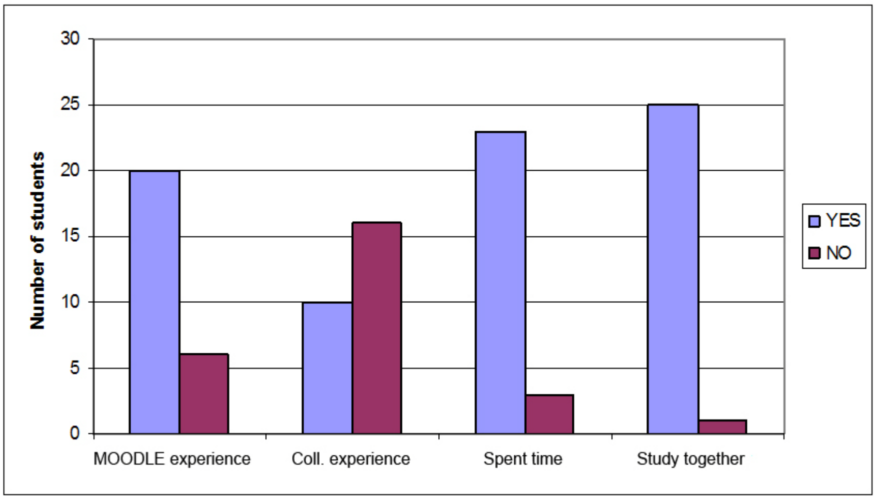

Figure 5.6 Experiences with tools and team members

5.5.1.2. Related to the Collaborative Creative Support Tool

Questionnaire 2 was applied after the study (see Appendix C). Participating design students were asked to answer questions on a 5- point Likert scale about collaborative creative support tool (CCST). In this study, MOODLE and Google SketchUp are utilized as a support tool.

Twelve students strongly agreed and 8 students agreed that CCST *contributed positively to their learning experience* (Question 1, m=4.53, std.dev=0.5). When they were asked about the positive contribution of CCST on *collaboration* (Question 2) and *creativity* (Question 3) at a time, they stated that creativity (m=4.65, std.dev=0.49) is more supported than collaboration (m=4.35, std.dev=0.49). The findings indicated that CCST usage improved both collaborative and creative activities of design students.

According to the students, CCST contributed positively to product development (Question 4, m=4.5, std.dev=0.61), they indicated that with the help of the MOODLE, they better followed the process. Also, they stated that they better understand and evaluate different viewpoints (Question 5, m=4.45, std.dev=0.6), understand the value of ideas of others (Question 7, m=4.45, std.dev=0.69) and understand the importance of their own ideas (Question 6, m=4.45, std.dev=0.69).

5.5.1.3. Related to Design Team Participation Rating Form

To evaluate team participation is crucial in this study as Sonnenburg (2004) stated "collaborative creativity can only emerge, if all participants actively take part in the process of communication". The results of the questionnaire 3 indicated that design students were aware of their contributions and their team members' participation (Table 5.1).

Table 5.1 Findings of design team participation questionnaire

Subject	himself/herself	Team member 2	Team member 3	spent time w/ team members	previously study together
S1	89	80	75	Yes	No
S2	80	100	95	Yes	Yes
S3	90	95	90	Yes	Yes
S4	98	95	95	Yes	Yes
S5	95	100	95	Yes	No
S6	95	100	95	Yes	No
S7	70	70	70	Yes	No
S8	90	85	70	No	No
S9	50	50	50	Yes	No
S10	90	90	90	Yes	Yes
S11	90	90	90	Yes	Yes
S12	90	90	100	Yes	Yes
S13	95	95	95	Yes	Yes
S14	95	95	95	Yes	Yes
S15	95	95	95	Yes	Yes
S16	80	80	n/a	No	No
S17	70	30	n/a	Yes	Yes
S18	80	80	90	Yes	Yes
S19	80	90	75	Yes	No
S20	90	90	90	Yes	Yes
S21	100	100	100	Yes	Yes
S22	100	100	100	Yes	Yes
S23	100	100	100	Yes	Yes
S24	100	100	100	Yes	Yes
S25	90	90	90	Yes	Yes
S26	100	100	100	Yes	Yes

Twenty-four students have spent time with team members before the study. Also, eighteen students have studied with team members before study. Team eight members rated all members as excellent participators, hence, their individual total number of MOODLE forum posts were not equal.

5.5.2. Findings of Semi-structured Interviews

After the study, semi-structured interviews (see Appendix E) were conducted to understand the creativity supporting issues with design students. The questions were grouped under three headings: creativity process, collaboration process, and support tool for design process. Twelve questions were directed to design students and students evaluated the study in terms of both positive and negative aspects of the study (Appendix E).

5.5.2.1. Related to Collaboration Process

The students complained about planning of the collaboration sessions. Nine out of 26 students stated that sometimes, they were not able to get together through several days. According to seven students, if there was a specific appointment time for the group actions, their inter-team communication would be better.

As an example, Subject 9 said that “my posts were not seen by my team members until they are online, if they were not checking the forum activities frequently, I had to wait”. Another student (T3, S7) said that “our communication was not continuous, sometimes they have noticed my weekend post at the next class hour” and another student (T7, S20) claimed “if an appointment time was set between the class hours, our communication would be more effective in that way”.

On the contrary, 13 out of 26 students supported the idea of having not previously set time for collaboration sessions instead of exact appointed times. They claimed that having not set an appointment time made them more creative. For example, Subject 23 claimed “without time limit, to deal with the design project was very productive, at the concentrated hours for example 01:30 am, I gave better critics to the project”. Another student, (T2, S5) supported the idea of being free of time as “other team members sleep in the early morning or late at night, weekend, I saw what they developed and continue with the project”.

15 out of 26 students were unsatisfied with the number of given critiques. Ten of the students claimed that other design students had a chance to see and analyze their project, although they did not give any critiques or comments for the development of their projects. According to some students, being able to see the critiques of the instructors given to the other projects helped the groups to develop their project without having the same critiques from the instructors.

5.5.2.2.Related to Creativity Process

Twenty-two out of 26 students agreed that MOODLE supported their creative skills. Seeing and tracing the ideas of other design students enhanced the creativity of design students. Eight out of 26 students said that they generated new ideas after the critique of their team members; eleven students stated that using 3D model for the design project helped them to generate new ideas. Three students claimed that generating new ideas were based on their personal abilities such as intelligence, knowledge or cognitive abilities.

According to 24 students Google SketchUp supported their creative skills. 17 students indicated that advanced view options of the Google SketchUp as a reason for creativity support. According to 13 students lighting, material and rendering features of the software were the main creativity support characteristics. Nine students said that high usability level of the software and its time-saving characteristics were the two reasons of creativity support.

5.5.2.3. Related to Support Tool for Design Process

According to 24 design students, they were happy in using 3D modeling software since it helped them in understanding and seeing the potentials of the project. They stated that while having free hand drawings they were limited in visualizing the third dimension.

19 students agreed that MOODLE supported their collaborative work in terms of seeing and sharing the critiques easily. 21 of the students stated that they would like to have critiques through MOODLE forums as well as traditional face-to-face critiques also in the other design studio courses.

5.5.3. Findings of Problem Solving Activities

In this part, the forum posts were analyzed to find out the collaborative and creative progress of each student. Each session of design communication was analyzed by using the forum post time; continuous posts with 5 or 10 minutes delay of different design students were coded as a synchronous session. The design teams worked together in 51 sessions synchronously.

Table 5.2 shows activities of the design teams. These activities include the total number of posts, sessions and synchronous sessions in design process and also the total number of generated ideas and sketches produced by each team. Design team members were allowed to criticize the other teams as well.

Table 5.2 Design team activities throughout the study

Design Teams	No. of posts	No. of sessions	No. of synch. sessions	No. of ideas	No. of sketches
T1	124	17	7	15	12
T2	94	9	3	9	7
T3	16	4	3	3	4
T4	24	19	10	26	31
T5	38	8	4	13	9
T6	15	11	2	21	27
T7	76	10	7	13	24
T8	56	22	13	21	17
T9	19	4	2	6	4
Total	462	104	51	127	135

In Figure 5.7, the total numbers of MOODLE forum posts for each week are shown. Every week, design students started a discussion in the design studio and continued it through the week. The MOODLE forum posts were mostly composed of design critiques, comments, questions and uploaded 2D or 3D drawings. Attendance to forum critiques was not stable, at the first week and at the last week of the study design students generated more forum posts compared to other weeks.

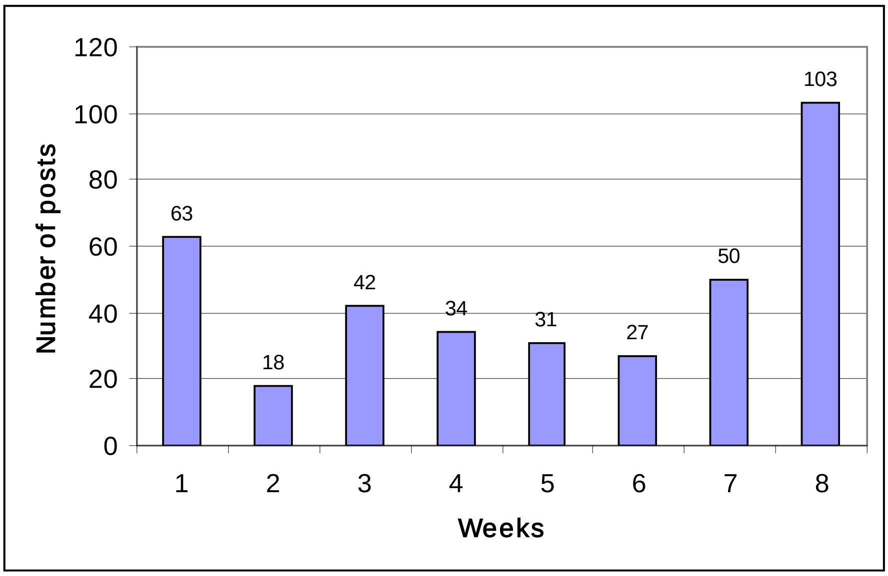

Figure 5.7 Total number of forum posts through weeks

5.5.4. Findings of Communication Acts

The MOODLE forum posts were analyzed to find out the communication acts in design teams as stated in Jonassen & Kwon's (2001) study as eight phases of communication (see Chapter 4.4.2). The communication acts were coded under eight phases named as: problem analysis (PA), problem critique (PC), orientation (OO), solution development (SD), solution approval (SA), solution critique (SC) and nontask (NT) and three or more consecutive phases identifies a phasic period. Figure 5.8 demonstrates communication acts of the design teams through the study. Each Phase is identified with at least three sequential communication acts. Each phase is identified with at least three sequential communication acts. There were no criteria development, solution critique and nontask phasic periods in this study.

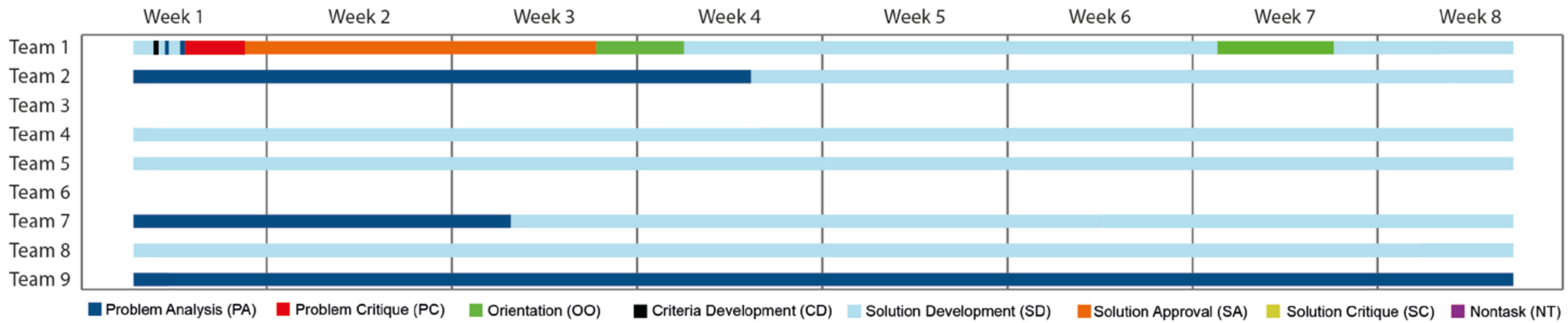

Figure 5.8 Gantt chart of the communication acts

Throughout the study, the design team 1 created 8 phases, design teams 2, 7 and 8 created 3 phases, design teams 4, 5 and 9 created 1 phase and teams 3 and 6 did not create any communication act phase. The most occurred phase in design communication is solution development phase. Problem critique and orientation phases occurred only in the design team 1. The longest phase was solution development phase in the design team 8. The shortest phase was a problem analysis phase that occurred in the design team 9. Although the design team 1 created four different phases in their communication acts, other design teams created only problem analysis and solution development phases.

5.5.5. Findings on Decision Process Analysis

To analyze each design team's decision process; every forum post of design students were analyzed and segmented as social influence, information sharing, reflectivity and thinking (Table 5.3). Social influences are composed of *Group think*, *Majority influence* and *Normalization* segments. *Common information sharing* and *unique information sharing* segments are grouped under information sharing. Design student's reflective forum posts are segmented as *reflection*, *planning* and *action/adaptation*. Thinking decision process are segmented as *divergent* and *convergent* thinking segments.

Table 5.3 Number of segments in the decision process of design teams

	Decision Process				
Teams	Social Influence	Info Sharing	Reflectivity	Thinking	Total
T1	15	6	25	23	69
T2	8	9	24	14	55
T3	1	1	4	4	10
T4	2	2	8	9	21
T5	4	3	8	5	20
T6	2	2	5	3	12
T7	10	3	22	13	48
T8	4	1	26	9	40
T9	1	4	0	2	7
Total	47	31	122	82	282

Table 5.3 demonstrates that the design teams 1 and 7 had high number of both social influence and reflectivity segments. The design team 9 had no reflectivity segment through the study. Although the number of social influence segments is low in teams excluding teams 1 and 7, the team 8 had the highest number of reflectivity segments. The design team 1 had the highest number of total segments; the design team 9 had the lowest number of total decision process segments. Reflectivity segments were more frequent according to the highest number of total segments in decision process and information sharing segments were less frequent. Thinking segments are composed of both divergent and convergent thinking segments; the design team 1 had the highest number of thinking segments and the design team 9 had the lowest number of thinking segments.

5.5.6. Indicators of Creativity Analysis

The design teams were evaluated in order to find out some creativity indicators point of view. The criteria for evaluating creativity are derived from Vandeleur et al. (2001). The indicators are grouped under direct and indirect categories each having sub-categories. The direct creativity indicator had three sub-categories that were *generating ideas*, *experimenting* and *persistence* (Table 5.4). The indirect creativity indicators were named as *group interaction*, *pre-knowledge* and *motivation*. To evaluate a design team's creativity in terms of direct and indirect categories, MOODLE posts were analyzed and frequency of posts in each sub-category was identified (Table 5.4).

The design team activities are identified as *strong* if there were 10 and more segments in the group communication. If a design team's communication includes 5 to 9 creativity indicators, the sub-category is rated as *average*. The creativity indicators are rated as *weak* when 4 or less segments were spotted in the design team communication.

Table 5.4 Creativity indicators of design students

	Direct Creativity Indicators			Indirect Creativity Indicators		
Team	Generating Ideas	Experimenting	Persistence	Group interaction	Pre-knowledge	Motivation
T1	Strong	Average	Weak	Strong	Average	Strong
T2	Average	Average	Weak	Average	Weak	Weak
T3	Weak	Weak	Strong	Weak	Average	Weak
T4	Average	Weak	Weak	Average	Weak	Weak
T5	Average	Strong	Average	Average	Weak	Average
T6	Strong	Average	Average	Strong	Average	Weak
T7	Strong	Strong	Average	Strong	Average	Average
T8	Average	Weak	Weak	Average	Weak	Weak
T9	Weak	Weak	Weak	Weak	Weak	Weak

According to Table 5.4, design team 1 generated many design ideas; however, the persistence of the team was weak. Although they communicated each other strongly, they were not persistent on an idea as the final solution; they continuously changed their design solutions. On the other hand, design team 3 generated fewer ideas than the design team 1, the persistence of the design team was strong and they developed their design alternatives and finalized it as the design solution. However, their group interaction was weak and as well as their motivation.

The design team 7 had the highest number of direct creativity indicator segments and the design team 1 had the indirect creativity segments during the study. According to the findings of creativity indicators analysis, the design team 9 was the weakest team in the study.

5.5.7. Indicators of Collaboration Analysis

In order to analyze indicators of collaboration, MOODLE forum posts were distributed to each indicator. According to number of posts in each indicator quartiles were decided. Quartiles were graded from 1 to 4, 1 having the lowest number of segments. Design team grades for each indicator are shown in Table 5.5.

Table 5.5 Indicators of collaboration analysis results

Design Teams	Extent of participation	Equal participation	Extent of roles	Reactivity to proposals	Rhythm	Total
T1	4	3	4	3	3	17
T2	4	2	2	2	2	12
T3	1	2	2	1	1	7
T4	2	4	2	4	3	15
T5	2	3	3	2	2	12
T6	1	3	3	4	2	13
T7	3	3	2	4	2	14
T8	3	3	3	3	4	16
T9	1	1	1	1	1	5
Average	2.3	2.7	2.4	2.7	2.2	

According to the results of indicator analysis, radar graphics were plotted. Radar graphics is a multivariate analysis method that involves observation and analysis of more than one statistical variable at a time. The variables of radar graphics are indicators of collaboration. Radar graphics demonstrates relationship between design team's indicator of collaboration grades and average grades.

The design team 1 values are above average for all indicators (Figure 5.9). The graph demonstrates that the design team 1 has an effective collaborative design process in terms of indicators. Extent of participation and extent of roles indicators were graded 4, indicated that number of MOODLE forum posts are high and each design student has flexibility in taking active roles. Reactivity of proposals, rhythm and equal participation is near average scores.

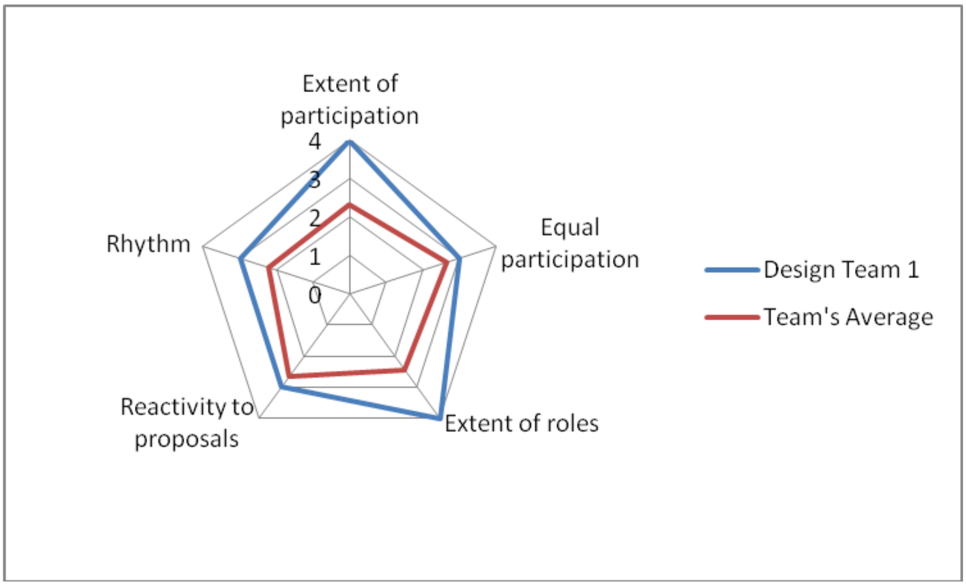

Figure 5.9 Design team 1 indicators of collaboration analysis

The design team 2 is above average for extent of participation; however, other indicator grades are below the average (Figure 5.10). The numbers of MOODLE forum posts are high. On the contrary, the distribution of these posts is not well balanced among the team members, equal participation score is below the average. This situation affects other indicators as well; reactivity and rhythm scores are also below the average scores.

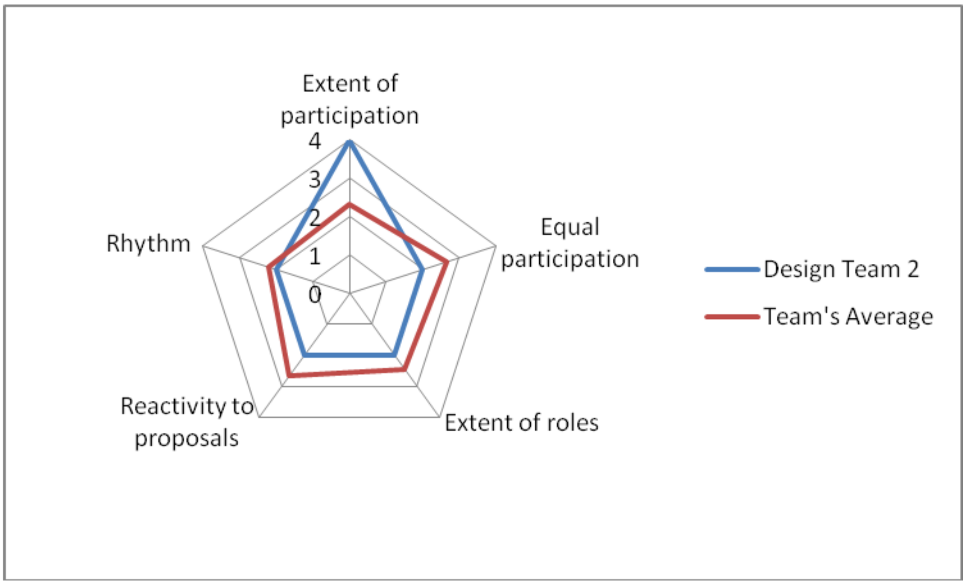

Figure 5.10 Design team 2 indicators of collaboration analysis

The third design team values are below average for all variables (Figure 5.11). The weakest indicators are *extent of participation*, *rhythm* and *reactivity to proposals*. On the other hand, equal participation and extent of roles scores are better but not enough to catch average scores. Responsibility sharing and flexibility of roles are slightly below the average.

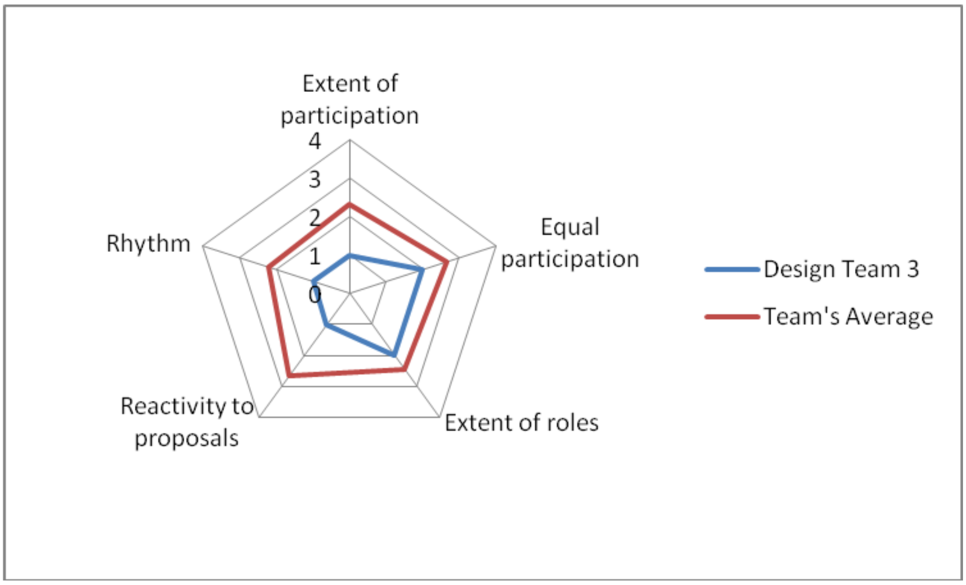

Figure 5.11 Design team 3 indicators of collaboration analysis

The design team 4 is above the average for rhythm, reactivity to proposals and equal participation and below the average for the indicators of extent of participation and extent of roles (Figure 5.12). Although their number of MOODLE forum post number is not high, they equally participate to the process and react to their ideas to develop the design project.

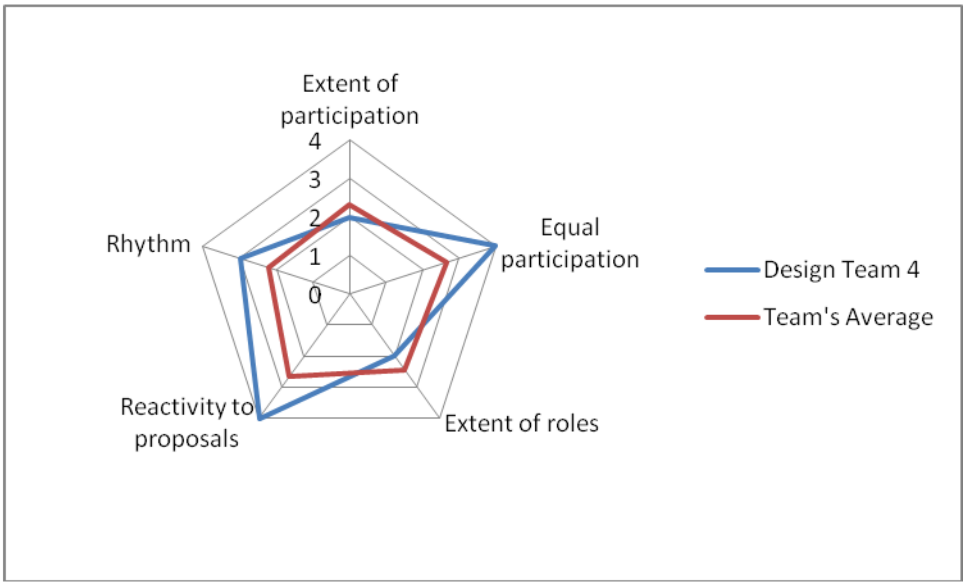

Figure 5.12 Design team 4 indicators of collaboration analysis

The design team 5 is close to the average scores for all indicators (Figure 5.13). Equal participation and extent of roles indicators are above the average, demonstrate that team members take equal responsibility to develop project and they undertaken various tasks. Since their extent of participation score is below the average, rhythm and reactivity to proposals scores are also below the average.

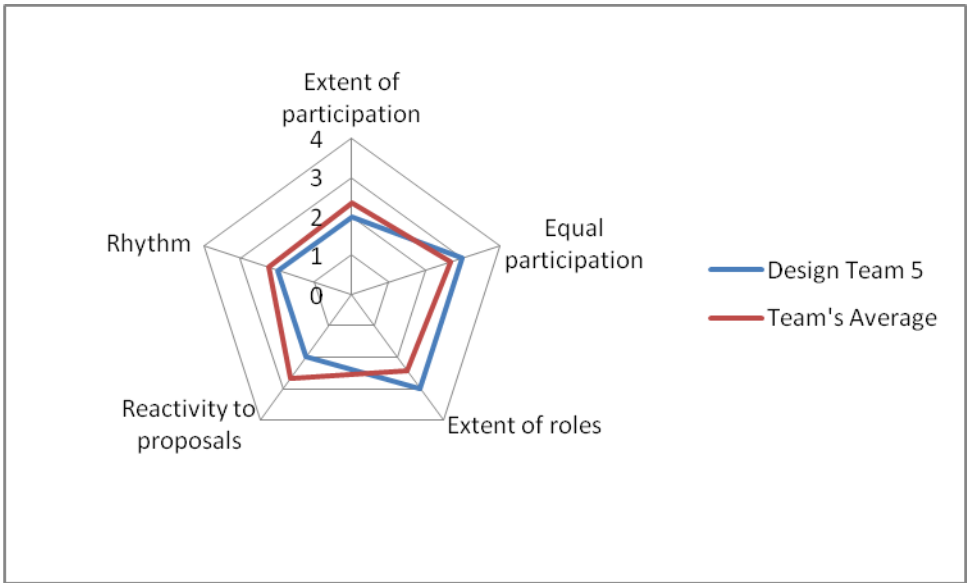

Figure 5.13 Design team 5 indicators of collaboration analysis

The design team 6 is above the average on the indicators of equal participation, extent of the roles and reactivity of proposals (Figure 5.14). On the contrary, extent of participation and rhythm scores are below the average. Although the number of MOODLE forum posts is below the average score, the team members generated alternative design solutions.

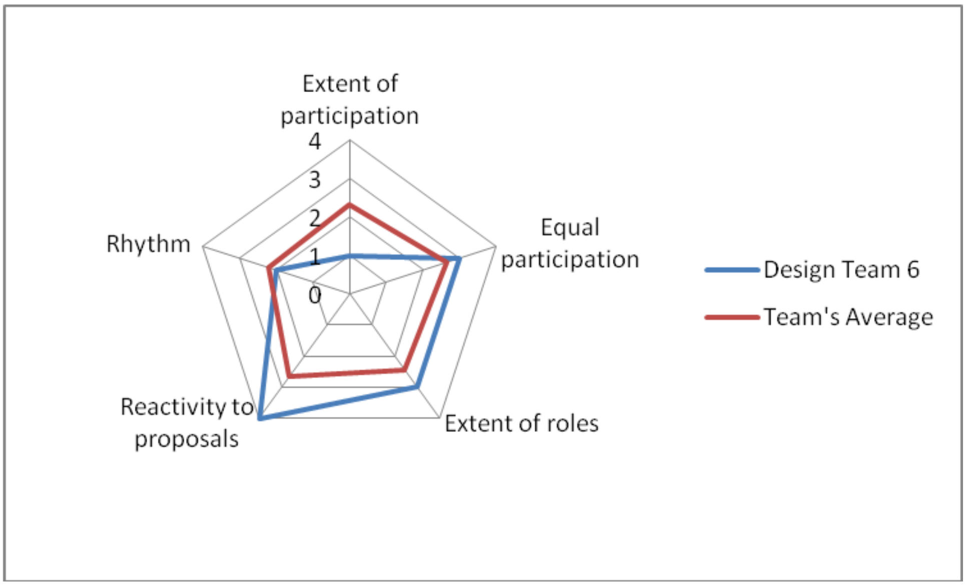

Figure 5.14 Design team 6 indicators of collaboration analysis

The design team 7 is above the average for equal participation, extent of participation and reactivity of proposals variables (Figure 5.15). Extent of roles and rhythm scores are below the average score. The team members generated forum posts; however, flexibility of taking different responsibilities is weak in the team.

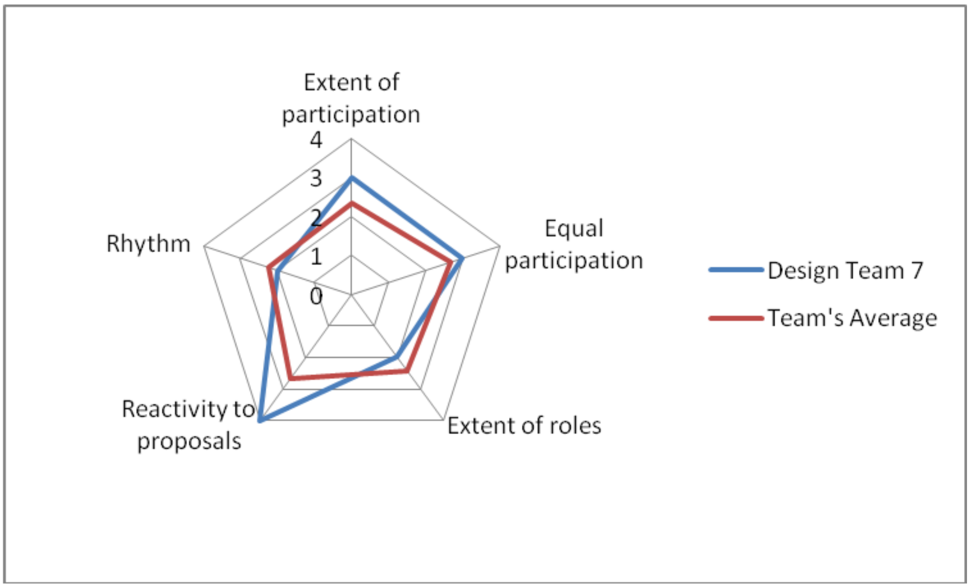

Figure 5.15 Design team 7 indicators of collaboration analysis

The design team 8 is above the average for all indicators (Figure 5.16). The rhythm score is noteworthy, indicates that the design team members routinely participated the collaborative process. Other indicator scores are also above the average score, the team had an effective collaborative process.

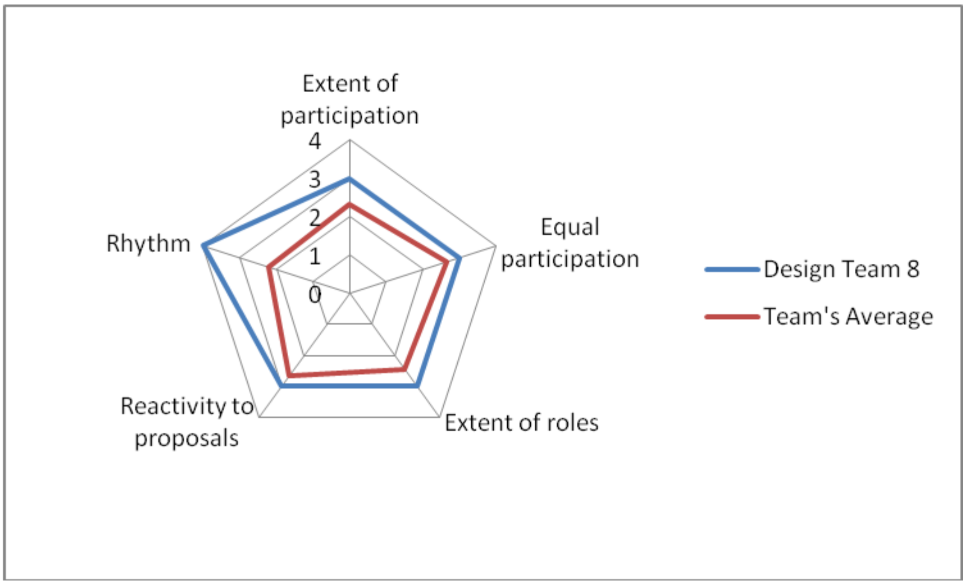

Figure 5.16 Design team 8 indicators of collaboration analysis

The design team 9 is below the average score for all indicators (Figure 5.17). The team gets the weakest points; each indicator is in the first quartile. There is no collaborative activity observed in design team 9.

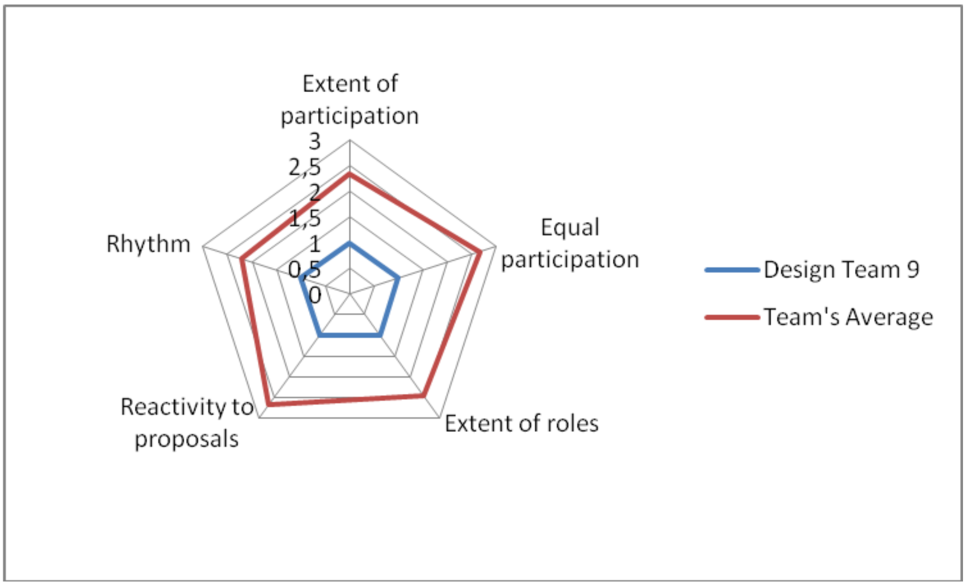

Figure 5.17 Design team 9 indicators of collaboration analysis

The integrated radar graphic shows all design team values according to indicators of collaboration (Figure 5.18). The graph demonstrates that design teams 1 and 2 have high level of extent of participation. Since the design team members of 4, 6 and 7 express their critical evaluations to new ideas and follow group discussions, their reactivity to proposals indicator values are 4. Only design team 8 gets 4 points from rhythm because their number of collaborative sessions is higher than other groups. According to graph, equal participation is observed mostly on the design team 4. On the other hand, the design team 9 gets the lowest points from each indicator; they show no collaborative activities throughout the study.

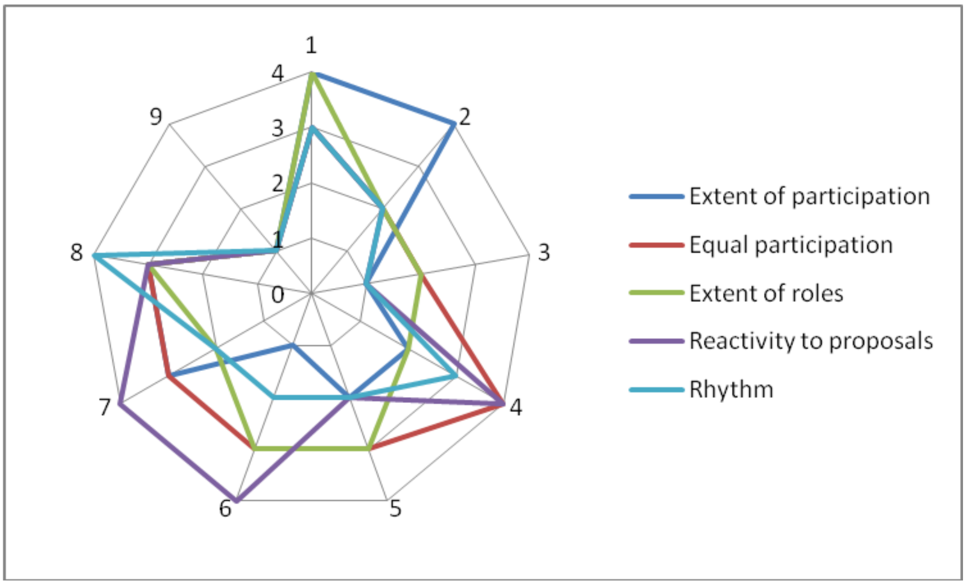

Figure 5.18 Integrated radar graphic of indicators of collaboration analysis

5.6. Discussion

This part is based on both quantitative and qualitative data analysis. Textual data from the MOODLE forums was analyzed through communication patterns, segmentation of the forum posts and interpretation of semi-structured interviews in addition to the quantitative data in this part. Mainly two characteristics of the study were evaluated; support of creativity process and support of collaboration process of the design students. The results of the study indicated that the CCST was helpful not only in analyzing the design problems and generating alternative solutions, but also, in sharing of information about design problem, in reflecting their design ideas and in generating multiple perspectives. Design process, decision process, time spent on the MOODLE forums, number of sessions, number of synchronous sessions, number of posts, indicators of creativity and indicators of collaboration were analyzed by using the SPSS software.

5.6.1. Discussion on Questionnaires

The findings demonstrated that all design students had their computers and the Internet connections both at home and at studio. Also, the design students were experienced in using computers, the Internet and CAD tools (see Figure 5.4). In line with this, the findings indicated that students were also familiar with the collaborative study and in using MOODLE. The design team members were also friends, they were spending time together after class hours and they were studying together (see Figure 5.6). In the light of the findings of questionnaire 1, the students do not have a familiarity problem neither with the technological infrastructure nor the team members. The findings of questionnaire 2 indicated that the students were satisfied with the support tool. Both creativity and collaboration activities were supported, as a result of this, their learning process and product development has been improved (see Chapter 5.7.1).

In line with the MOODLE forum posts, the most active forum contributors got high scores from questionnaire 3. Only one team member, Subject 9 rated her contribution and participation as unsatisfactory. Other team members rated their contribution and participation as satisfactory or excellent. According to the results of questionnaire 3, the team member's contributions were satisfactory.

Although team leaders were observed in design teams T2 and T4, their team members did not recognize T2S4 and T4S11 as team leaders. These students were considered as team leaders, since they attended every discussion, asked questions to instructors and generated new ideas. Since, their team members were not active enough and did not participate in design process, they might be afraid of having low grades if they have recognized a team leader. Instead of pointing out one student as team leader, they have preferred to ignore the leader's effort and declared that every student paid the same effort, even the team leader herself.

Twenty-five students out of twenty-six rated their contribution as satisfactory and the two students rated their contribution as unsatisfactory. Twenty-four students were rated as satisfactory by their team members; this demonstrates that participation level and contribution of the team members were high.

5.6.2. Discussion on Decision Process

This study assessed creativity in terms of *creative decision process.* The creative process is analyzed regarding individual and collaborative creativity issues (see proposed system model, Figure 4.1). The individual creativity test was analyzed in the design student was analyzing the design problem; generating sketches by using Google SketchUp and deciding up on a final design solution.

The findings of the semi-structured interviews indicated that using Google SketchUp allows design students to generate multiple 3D models easily and they can decide on the final design solution among many alternatives. The correlation between the number of sessions on the MOODLE forums and creative activities can be explained as a result of the speed and capabilities of the computer in use that enhances creativity of designers while expressing their design acts easily (Table 5.6).

Table 5.6 Correlation table of decision process

			Problem Solving Activities				Time	Communication Activities		
			group	sessions	synch	posts	time	problem	solution	orientation
Decision Process	social inf	Pearson Correlation	-,474	,290	,199	,960**	,671*	,547	,909**	,906**
		Sig. (2-tailed)	,198	,448	,608	,000	,048	,127	,001	,001
		N	9	9	9	9	9	9	9	9
	info share	Pearson Correlation	-,491	-,144	-,318	,695*	,313	,992**	,499	,399
		Sig. (2-tailed)	,180	,712	,404	,038	,413	,000	,171	,288
		N	9	9	9	9	9	9	9	9
	reflectivity	Pearson Correlation	-,266	,577	,560	,871**	,871**	,411	,969**	,803**
		Sig. (2-tailed)	,489	,104	,117	,002	,002	,272	,000	,009
		N	9	9	9	9	9	9	9	9
	convergent	Pearson Correlation	-,537	,554	,470	,910**	,870**	,448	,911**	,972**
		Sig. (2-tailed)	,136	,122	,202	,001	,002	,226	,001	,000
		N	9	9	9	9	9	9	9	9
	divergent	Pearson Correlation	-,636	,334	,209	,954**	,716*	,661	,873**	,924**
		Sig. (2-tailed)	,066	,379	,589	,000	,030	,053	,002	,000
		N	9	9	9	9	9	9	9	9

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Social influence segments were significantly correlated with solution (r=0.909 at the 0.01 level) and orientation (r=0.906 at the 0.01 level) action categories (Table 5.6). This finding indicates that when the design teams are socialized, they generate more alternative design solutions and able to orient the team member for better design solutions.

Reflectivity segments of design teams were significantly correlated with the number of posts (r=0.871 at the 0.01 level) and the solution (r=0.969 at the 0.01 level) action categories (Table 5.6). It is clear that the more reflective design teams had more posts and they easily generate alternative solutions to the design problems.

Information sharing segments were significantly correlated with the number of posts (r=0.695 at the 0.05 level) and the problem (r=0.992 at the 0.01 level) action categories (Table 5.6). When design students share their research or background knowledge, they try to analyze the design problem or give critiques to the defined design problem.

There were some significant correlations between group actions according to correlation analysis. In Table 5.6, number of sessions and number of synchronous sessions were highly correlated (r=0.887 at the 0.01 level). This means the number of discussion sessions increase in direct proportion with the number of synchronous sessions. Also, the number of sessions were highly correlated with the time spent on the MOODLE forums (r=0.815 at the 0.01 level).

In this study, the design students were guided by the CCST to represent and manipulate the alternative design ideas easily. In the study, significantly correlation of the *number of forum posts* and *reflection segments* indicated that design ideas were easily generated and developed with team members towards a better alternative design solution. The design students easily downloaded a Google Sketch Up file, made necessary modifications and re-upload to the MOODLE forums as a reflection of a design idea.

Hewett et al. (2005) pointed out the importance of computer systems that allow multiple representation formats by providing a kind of virtual notepad to generate ideas easily. In this study, the MOODLE forums facilitated the design process as a virtual notepad. The design students could easily follow the written critiques from the *database* of *knowledge domain* where ideas were stored.

Moreover, 3D modeling software supported the creativity acts of users by providing different camera angles, versatile modify tools and rapid simulation capabilities. Thus, this study supported the creative process of design students in terms providing information from different sources, communicating this information with the other team members, creating new design solutions and distributing the new ideas to other design students.

Design projects were developed according to the given critiques and new ideas. CCST supported the *creative process* and reflections of the new ideas enhanced the design projects in a positive way. Consequently, recorded ideas can easily be traced and necessary implementations and modifications can be done.

5.6.3. Discussion on Problem Solving Process

This study analyzed creativity as a social activity (Csikszentmihalyi, 1996). As a social activity, being creative involves communicating with others, sharing ideas and generating multiple perspectives. In this study, the design students collaborated during a design process. Individual design students interacted with the other design students in evaluating interpreting and integrating new ideas into *knowledge domain* (see proposed system model, Figure 4.1).

The findings of the questionnaire 3 demonstrated that the students were mostly satisfied with the collaborative process, although the major complaint was about difficulty of getting together in an online environment without an exact appointment time. However, some students were pleased with this situation.

The findings of Sagun's (2003) study indicated that "the more the students are encouraged to think on design solutions, the more the solution of design problem is developed" (p.130). In line with this, the findings of this study support that the correlation is statistically significant between time spent and reflection segments (see Table 5.7).

Table 5.7 Correlation table of problem solving activities

			Time	Communication Activities			Decision Process				
			time	problem	solution	orientation	social inf	info share	reflectivity	convergent	divergent
Problem Solving Activities	group	Pearson Correlation	,342	-,503	-,357	-,565	-,474	-,491	-,266	-,537	-,636
		Sig. (2-tailed)	,367	,168	,346	,113	,198	,180	,489	,136	,066
		N	9	9	9	9	9	9	9	9	9
	sessions	Pearson Correlation	,815**	-,133	,505	,582	,290	-,144	,577	,554	,334
		Sig. (2-tailed)	,007	,733	,166	,100	,448	,712	,104	,122	,379
		N	9	9	9	9	9	9	9	9	9
	synch	Pearson Correlation	,761*	-,339	,474	,485	,199	-,318	,560	,470	,209
		Sig. (2-tailed)	,017	,372	,198	,186	,608	,404	,117	,202	,589
		N	9	9	9	9	9	9	9	9	9
	posts	Pearson Correlation	,744*	,665	,949**	,892**	,960**	,695*	,871**	,910**	,954**
		Sig. (2-tailed)	,022	,051	0	,001	,000	,038	,002	,001	,000
		N	9	9	9	9	9	9	9	9	9

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Increase in the number of discussion sessions leaded to spending more time on the MOODLE forums. This indicates as the design students are able to communicate with each other; they can support or criticize each other's design ideas on the online setting. In line with this, the number of synchronous sessions and time spent also were significantly correlated (r=0.761 at the 0.01 level) (Table 5.7).

The number of MOODLE posts were significantly correlated both with design and decision process. When a design group's number of post increase, there is an increase in the number of solution segments (r=0.949 at the 0.01 level). This correlation demonstrates that using the MOODLE forums leaded to more solution segments for design problems. Also, orientation (r=0.892 at the 0.01 level), social influence (r=0.960 at the 0.01 level), information sharing (r=0.695 at the 0.01 level), convergent thinking (r=0.910 at the 0.01 level) and divergent thinking (r=0.954 at the 0.01 level) were significantly correlated with number of MOODLE forum posts. This statistical analysis demonstrates CCST supports both collaborative and creative processes (Table 5.7).

The total number of posts on MOODLE forums was another important issue in collaborative activities; students believed that an increase in the number of forum posts would make them more productive. This situation is supported by the correlation between the number of segments and number of reflections (see Table 5.7).

In an online setting, socialization levels of the design students can influence the quality and quantity of interaction, enthusiasm and participation. As mentioned before, creativity is a social phenomenon, it is expected that design students take action well to working and discussing with others online. The findings of the study indicated that (Table 5.7) the *number of forum posts* and *social influence segments* were significantly correlated (r=0.960 at the 0.01 level). In that case, the CCST supported socialization levels of the design groups and the design teams throughout the study.

Collaborative process requires interactions between design team members to make design students more productive in terms of their creative process. In Table 5.7, correlation between *number of forum post* and *solution development segments* indicated that using the CCST provided an interactive design field (r=0.949 at the 0.01 level).

5.6.4. Discussion on Communication Activities

Collaborative model of the online setting is important, since Eastmond (1995) stated that students in the same course may have diverse learning experiences. The findings demonstrated that the student groups of the study were acquainted with each other and they have worked together before. This study was designed as a *multiple viewpoint current working knowledge model* (see Figure 2.5). In the study, the design students formalized knowledge within the viewpoints of the other design students.

The communication patterns of the design groups indicated that the more time spent in the MOODLE forums resulted the more effective communication pattern as *problem analysis- solution development - solution acceptance* phases. This communication pattern provides a causal link relation across discrete perspectives and design ideas.

Online social relations between student-student and student-instructor may affect the quality of the learning experience (Demirbaş & Demirkan, 2003). In the literature, there are some arguments about technology that tend to dehumanize the teaching/learning process (Braslavsky & Fumagalli, 2004; Nistorescu et al., 2006). However, some researchers believe that students can establish online relations with their team members as with face-to-face teaching, based on common interests and beliefs (Drennan et al., 2005; Reushle et al. 2008).

Since communication is important in collaborative creative process, the MOODLE forums supported communication of design students. While the design students were exchanging their ideas electronically, a creativity pool for ideas was developed where the design groups submitted discussion (Table 5.8).

Table 5.8 Correlation table communication activities

			Problem Solving Activities				Time	Decision Process				
			group	sessions	synch	posts	time	social inf	info share	reflectivity	convergent	divergent
Communication Activities	problem	Pearson Correlation	-,503	-,133	-,339	,665	,292	,547	,992**	,411	,448	,661
		Sig. (2-tailed)	,168	,733	,372	,051	,440	,127	,000	,272	,226	,053
		N	9	9	9	9	9	9	9	9	9	9
	solution	Pearson Correlation	-,357	,505	,474	,949**	,856**	,909**	,499	,969**	,911**	,873**
		Sig. (2-tailed)	,346	,166	,198	,000	,003	,001	,171	,000	,001	,002
		N	9	9	9	9	9	9	9	9	9	9
	orientation	Pearson Correlation	-,565	,582	,485	,892**	,836**	,906**	,399	,803**	,972**	,924**
		Sig. (2-tailed)	,113	,100	,186	,001	,005	,001	,288	,009	,000	,000
		N	9	9	9	9	9	9,	9	9	9	9

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

According to Table 5.8, problem segments and information sharing segments were significantly correlated (r=0.992 at the 0.01 level). This finding indicates that when design students share their views and information with other students, this situation influence their problem solving activities positively. Also, the number of forum posts and solution segments were significantly correlated (r=0.949 at the level 0.01 level), this indicated that the more productive design students created the more solutions to the design problem and oriented their team members (r=0.892 at the 0.01 level).

The reflectivity segments were highly correlated with solution segments (r=0.969 at the 0.01 level), reflection on each design critique leaded alternative solutions for the design problem. Solution segments were also correlated significantly with convergent (r=0.911 at the 0.01 level) and divergent (r=0.873 at the 0.01 level) thinking segments, the design students could produce solutions in both ways of thinking (Table 5.8).

5.6.5. Discussion on Indicators of Creativity

Analysis of indicators of creativity demonstrates that there is a negative correlation between generating ideas and persistence. The design teams that generate high number of MOODLE forum posts cannot develop a final design solution from the initial ideas. They had difficulty in choosing one among the many design alternatives, since each team member wanted to develop a different design proposal. On the contrary, the design teams that generated fewer ideas were able to develop the chosen alternative as the final design solution (see Table 5.9).

Another important finding of indicators of creativity analysis is there is a perfect correlation of 1.000 between group interaction and generating ideas (see Table 5.9). The more interactive design teams generated the more MOODLE forum posts, in line with this, ideas from one team member spark ideas in others and the result is a synthesis of ideas.

Table 5.9 Correlation table of indicators of creativity

		generating ideas	experi-menting	persistence	group interaction	pre-knowledge	motivation
generating ideas	Pearson Correlation	1	,618	-,122	1,000**	,472	,562
	Sig. (2-tailed)		,076	,754	,000	,200	,115
	N	9	9	9	9	9	9
experimenting	Pearson Correlation	,618	1	,229	,618	,253	,596
	Sig. (2-tailed)	,076		,553	,076	3511	,090
	N	9	9	9	9	9	9
persistence	Pearson Correlation	-,122	,229	1	-,122	,580	-,053
	Sig. (2-tailed)	,764	,553		,754	,101	,893
	N	9	9	9	9	9	9
group interaction	Pearson Correlation	1,000**	,618	-,122	1	,472	,562
	Sig. (2-tailed)	,000	,076	,754		,200	,115
	N	9	9	9	9	9	9
pre-knowledge	Pearson Correlation	,472	,253	,580	,472	1	,399
	Sig. (2-tailed)	,200	,511	,101	,200		,287
	N	9	9	9	9	9	9
motivation	Pearson Correlation	,562	,596	-,053	,562	,399	1
	Sig. (2-tailed)	,115	,090	,893	,115	,287	
	N	9	9	9	9	9	9

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

5.6.6. Discussion on Indicators of Collaboration

The design team activities through proposed system model indicated effective activities in terms of collaboration. The design teams that use support tools effectively get higher scores in extent of participation, rhythm and reactivity to proposals (Table 5.5). The main negative clauses in the analysis result from scarce participation of the team members. Scarcity of participation leads design teams to show low degree of proposing attitude and reactivity to proposals of other team members.

A good social atmosphere makes design groups more productive in terms of extent of participation. Observations throughout the study indicate design teams whose members are familiar with each other generate more ideas than other design teams. Also, these team members worked together before the study.

Rhythm is observed in the design teams that team members' participation is more synchronous. Designated meeting times encourage the team members to contribute the design project development. In asynchronous sessions, one team member may dominate decision process due to lack of participation of other members.

Table 5.10 demonstrates that equal participation in the design team and rhythm is correlated ($r=0.693$ at the 0.05 level), harmonious groups participate design process more equally, design team members participate regularly.

Reactivity to proposals indicator is highly correlated with equal participation (r=0.825 at the 0.01 level), substantiates that well-balanced design teams is important for criticizing and developing alternative design solutions (Table 5.10).

Table 5.10 Correlation table of indicators of collaboration

		ext. of participation	equal participation	ext. of roles	reactivity to proposals	rhythm
ext. of participation	Pearson Correlation	1	,236	,424	,250	,560
	Sig. (2-tailed)		,542	,255	,516	,117
	N	9	9	9	9	9
equal participation	Pearson Correlation	,236	1	,546	,825**	,693*
	Sig. (2-tailed)	,542		,129	,006	,038
	N	9	9	9	9	9
ext. of roles	Pearson Correlation	,424	,546	1	,386	,600
	Sig. (2-tailed)	,255	,129		,305	,088
	N	9	9	9	9	9
reactivity to proposals	Pearson Correlation	,250	,825**	,386	1	,595
	Sig. (2-tailed)	,516	,006	,305		,091
	N	9	9	9	9	9
rhythm	Pearson Correlation	,560	,693*	,600	,595	1
	Sig. (2-tailed)	,117	,038	,088	,091	
	N	9	9	9	9	9

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

6. CONCLUSION

This thesis develops a support tool for a collaborative creative design process for the design students and implements it in a design studio process. This collaborative creative support tool (CCST) composes of a server side and designer side (Figure 4.1). The designer side of the model is double-sided; at the first side the design student analyzes the design problem, generate alternative solutions for the design problem with multiple sketches and decide up on a final solution after an individual creativity test. The other side is composed of other design students, design groups and instructors, called design field. In the design field, the design teams and instructors meet at a virtual place (MOODLE forums), communicate and interact to criticize the design solution alternatives and decide on a final solution together after collaborative creativity test. On the server side of the CCST, knowledge domain stores design problems and design solutions for further use and research. Knowledge domain serves the necessary documents to users, individual and collaborative creativity tests revise and modify documents and loop continues.

The study is conducted in a design studio to investigate the effectiveness of the CCST during design process. Twenty-six design students attended the study. The design students formed 9 design groups and worked together for 8 weeks. Google Sketch Up was main software and MOODLE forums were utilized as a web-based learning environment.

The results of the study indicated that the CCST supports both collaborative and creative activities of the design students. In this respect, this study asserts that not only collaborative activities make design students more creative, but also computer setup makes them more productive in terms of generating solutions and implementing different perspectives.

6.1. Summary of Results

This study explores the effectiveness of the CCST both on design and decision processes. Qualitative and quantitative analyses indicated that social creativity is important in the design process. Time spent and number of forum posts on CCST is in directly related to the number of creative segments. The design groups generated more design solutions and implemented different perspectives on design projects by using CCST.

Another result of the study is that collaboration process affects creative process. The more collaborative design groups produce the more creative segments, they shared their knowledge, influence other group members and reflect on others' ideas to develop the design project. Also, when the design students use the CCST, communication pattern of the design group started with problem analysis and ended with solution acceptance. This result demonstrates that the design groups attained final solutions together.

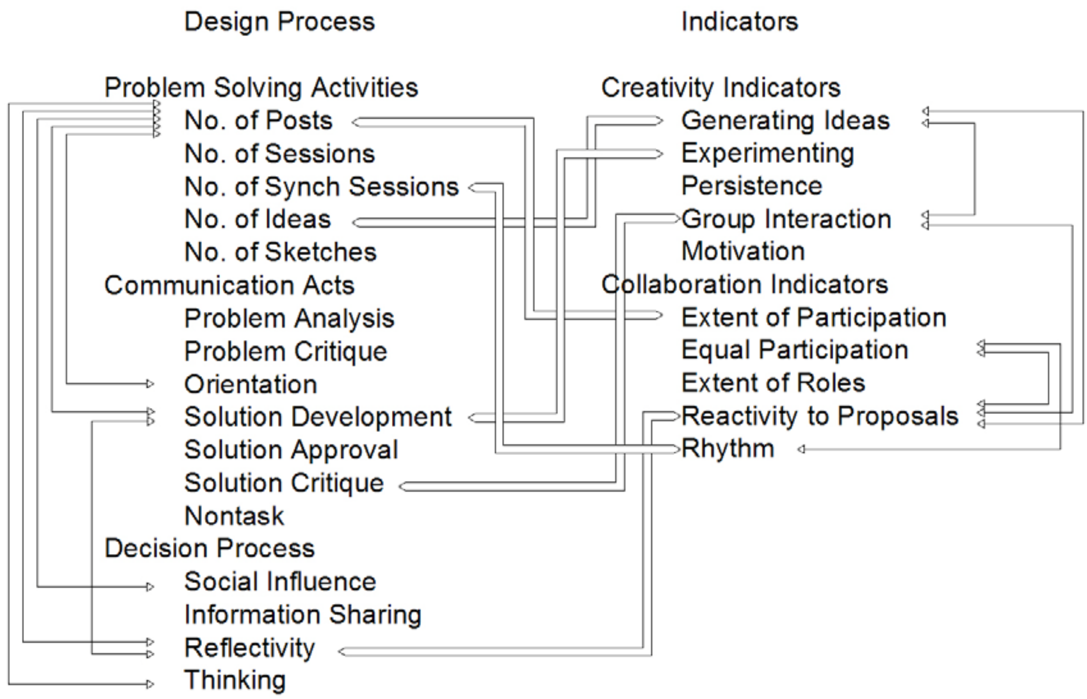

Figure 6.1 Correlation of design process and indicators

Figure 6.1 demonstrates overall correlations between design process segments and indicators of collaboration and creativity together. Number of MOODLE forum posts is correlated with both communication acts and decision process segments. This finding indicates that using MOODLE forums as a support tool enhance both collaborative and creative activities of design students. Moreover, reactivity to proposals indicator is correlated with group interaction and generating ideas creativity indicators.

Group interaction indicator is highly correlated with reactivity to proposals indicator (r=0.872 at the 0.01 level). In design process, group interaction promotes critical thinking and as a result of this, contributions to the design project are increased; new ideas and proposals are presented. Another significant correlation is between generating new ideas and reactivity to proposals (r=0.827 at the 0.01 level), when design team members generate new ideas, the team members criticize these ideas, and carry a more advanced level.

Reflectivity segments are significantly correlated with reactivity to proposals indicator, solution critique segments are significantly correlated with group interaction indicator, solution development segments are significantly correlated with group interaction indicator; these statistically significant correlations designate that collaboration process affects creative process.

6.2. Suggestions for the Further Studies

Creativity support tools will probably attract more research attention in the future. According to analysis and findings of the study, there are some important aspects for implementation of a collaborative creativity support tool for future studies. The suggestions are made on both designer and server side.

6.2.1. Suggestions on Designer Side

This study is implemented a design studio course, however this approach may not be appropriate for every design course. Design studio courses require communication/interaction between students and instructor. In this study all assignments were submitted online and design teams communicated both synchronous and asynchronous. Some design courses may require individual development of a design project and may not need to communication other design students. In a way, CCST can be used as a critique tool and a knowledge base.

The design process should include both synchronous and asynchronous communication, there should be some designated meeting times. If the design process is all asynchronous, the design team members may have difficulty in communication with their team members. Designated meeting sessions for the design process get together all the participants at the same time. Hence, team members could get benefits of synchronous communication as well.

Another suggestion for design process, as Ancona and Caldwell (1992) state, for product development team two aspects are important; first, homogeneity of organization of the design teams and second, team members' specialties. For team homogeneity frequency of communication and team integration is important. Active participation of students should be encouraged. Division of design tasks is likely to be importance in terms of development of a design project according to team members' specialties.

6.2.2. Suggestions on Server Side

Technical infrastructure is important for a web-based support tool, broad-band internet connection and up-to-date software and hardware enable design process more effective. Consequently, the design students become more focused and enthusiastic. Software compatibility is another aspect, participants should use the same version of the software to create and modify the design project.

There should be an integrated interface for the support tool, the user interface should integrate communication and drawing/sketching tolls. This study reveals that separate communication (MOODLE) and drawing tools (Google SketchUp) decrease the productivity. The participants have to use two different interfaces to develop their projects. If there is an integrated interface; loss of time, loss of motivation and loss of productivity could be prevented. Also, an integrated interface may create a better socio-technical environment for collaborative creativity support; reflectivity to other's work could be enhanced.

The support tool may have time-line applet: An applet is a small application that performs in software. Time-line tool of the support tool could display design activities in a chronological order. Design students can see a project with all phases and have a chance to edit the previous phases of the project. Also, the time-line could demonstrate relationships between design critiques; design students could easily follow development of the design project.

6.3. Limitations of the Study

As a web-based learning environment, MOODLE did not support drawing based comments. Only written comments could be given via MOODLE, modifying and re-creating of artifacts need Google SketchUp software. This situation decreases motivation of the design students. In line with this, modified projects can be uploaded to MOODLE as an attachment, design students have to download attached file to criticize or modify.

Another important limitation of the study was student sample. The study was conducted in one university and one discipline, if there could be another universities and different disciplines, grater amount of data could be collected and analyzed.

In this study, CCST is designed as a hybrid system; however a new interface could get together collaboration and creativity tools. In addition to presenting CCST framework, this study analyzes both collaborative and creative processes of the design students in a web-based environment. The relation between collaboration and creativity concepts become more definite.

On the other hand, the study was restricted by some technical issues. Following studies could develop more capable, flexible and easy to use interface for the CCST. The support tool composed of two sides and this situation led to some difficulties in the study. Integrating drawing and messaging activities into one interface may help design students. In that case, it would be possible to extend effectiveness and usefulness of the CCST. Reliability may be improved by increasing the sample size and number of raters.

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APPENDICES

APPENDIX A. Design Brief

IAED 393 Visionary and Future Environments Design Project

Space Hotel

Overview

You are required to design a space hotel for accommodation of space tourists. The space hotel will be an orbital station. The space hotel should be designed as the intersection of several modules with a public area.

Required Tools

MOODLE is the main communication tool for this project. You will be using MOODLE for all communication needs. Google Sketch Up is the only drawing and modeling tools for 2D and 3D representations. The other file extensions such as .dwg, .3ds can be imported into Google Sketch Up. Also you can download models from Sketch Up Warehouse website.

Process

Each team should be composed of 3 students and each student should use a personal computer as course requirement. All communication among the team members and instructors should be conducted through the MOODLE website.

The schedule of the project is as follows:

Time	Task
October 14th 09:40-12:30	Each team member produces a number of sketches at the initial phase of the design process.
October 14th 12:31 -October 21st 09:39	Online critiques through Forum activities.
October 21st 9:40-12:30	Team members discuss the various sketches through forum activities and decide upon a solution.
October 21st 12:31- October 28th 9:39	Online critiques through Forum activities.
October 28th 9:40-12:30	Team members discuss the various sketches through forum activities and decide upon a solution.
October 28th 12:31- November 4th 9:39	Online critiques through Forum activities
November 4th 9:40- 12:30	Team members discuss the various sketches through forum activities and decide upon a solution.
November 4th 12:31- November 11th 9:39	Online critiques through Forum activities.
November 11th 9:40- 12:30	Preliminary jury, each team provides a power point presentation.
November 11th 12:31- November 18th 9:39	Online critiques through Forum activities.
November 18th 9:40- 12:30	Team members discuss the various sketches through forum activities and decide upon a solution.
November 18th 12:31- November 25th 9:39	Online critiques through Forum activities.
November 25th 9:40- 12:30	Team members discuss the various sketches through forum activities and decide upon a solution.
November 25th 12:31- December 2nd 9:39	Online critiques through Forum activities.
December 2nd 9:40- 12:30	Team members discuss the various sketches through forum activities and decide upon a solution.
December 2nd 12:31- December 9th 9:39	Online critiques through Forum activities.
December 9th 9:40-12:30	Final Jury, Each team provides a power point presentation.

Duration

The duration of the design project is eight weeks. The design process can be conducted out of the class hours via the MOODLE website. Each week during the class hours you are required to work in class.

Design requirements

The space hotel should accommodate 6 single space tourists. One public area should be designed with the following areas to meet basic vital needs of space tourists:

- Sleeping
- Cleaning
- Eating
- Exercising
- Socializing

APPENDIX B. Demographic questionnaire

Questionnaire 1

This questionnaire is prepared for an academic purpose; please answer the questions from your point of view. If you have any questions, please ask.

Age	…………………….
Gender	Male ☐ Female ☐
Computer at home?	Yes ☐ No ☐
Linked to the Internet at home?	Yes ☐ No ☐
Years of computer experience	…………………….
Years of CAD experience	…………………….
Years of internet experience	…………………….
MOODLE experience?	Yes ☐ No ☐
E-Learning platform experience?	Yes ☐ No ☐
Collaborative study experience?	Yes ☐ No ☐
Daily hours of Internet Usage?	……………………..
Daily hours of MSN usage?	……………….……….

APPENDIX C. User satisfaction questionnaire

Questionnaire 2

Please indicate whether you agree or disagree with each statement. Use the following scale to guide your responses to each statement:

1 = Strongly disagree, 2 = Mostly disagree, 3 = Neutral, 4 = Mostly agree, 5 = Strongly agree

Web-based collaborative creative support tool of the design studio…

	Strongly disagree				Strongly agree
1. contribute positively to my learning experience……………………………..	1	2	3	4	5
2. contribute positively to the collaborative part of the project…….. ……..	1	2	3	4	5
3. contribute positively to the creative part of the project………….. ……..	1	2	3	4	5
4. contribute positively to the product development part of the project ……..	1	2	3	4	5
5. enhance my ability to understand and evaluate different viewpoints ……..	1	2	3	4	5
6. make me understand the importance of my ideas………………….. ……..	1	2	3	4	5
7. make me understand the value of others' ideas…………………….. ……..	1	2	3	4	5

APPENDIX D. Group Participation Rating Form

Questionnaire 3

Your Name______________________________

Please write the names of all of your team members, INCLUDING YOURSELF, and rate the degree to which each member fulfilled his/her responsibilities in completing the project assignments and/or in contributing to the assigned tasks of the group – as determined by the expectations developed by the group. Sign your name at the bottom. *Please be as honest as possible with your assessment. Also, please attach comments to your ratings for each individual for justification of the "grade" that you give. No comments to back up your "grade" will result in a 10% decrease in your grade (you gave yourself) and a 10% increase in the grade you gave your team members.*
The possible ratings are as follows (use numerical grades):

Excellent (90 – 100)	Consistently went above and beyond — tutored teammates, routinely went above and beyond the basic group responsibilities
Very good (80 – 89)	Consistently did what he/she was supposed to do, very well prepared and cooperative
Satisfactory (75 – 79)	Usually did what he/she was supposed to do, acceptably prepared and cooperative
Ordinary (70 – 74)	Often did what he/she was supposed to do, minimally prepared and cooperative
Marginal (60 – 69)	Sometimes failed to show up or complete assignments, rarely prepared
Deficient (50 – 59)	Often failed to show up or complete assignments, rarely prepared
Unsatisfactory (40 – 49)	Consistently failed to show up or complete assignments, unprepared
Superficial (0 – 39)	Practically no participation

These ratings should reflect *each individual's level of participation and effort and sense of responsibility*, not his or her academic ability.

Name of team member (including yourself)	Numerical Grade	Comments
YOU	________	
______________________________	________	
______________________________	________	
______________________________	________	

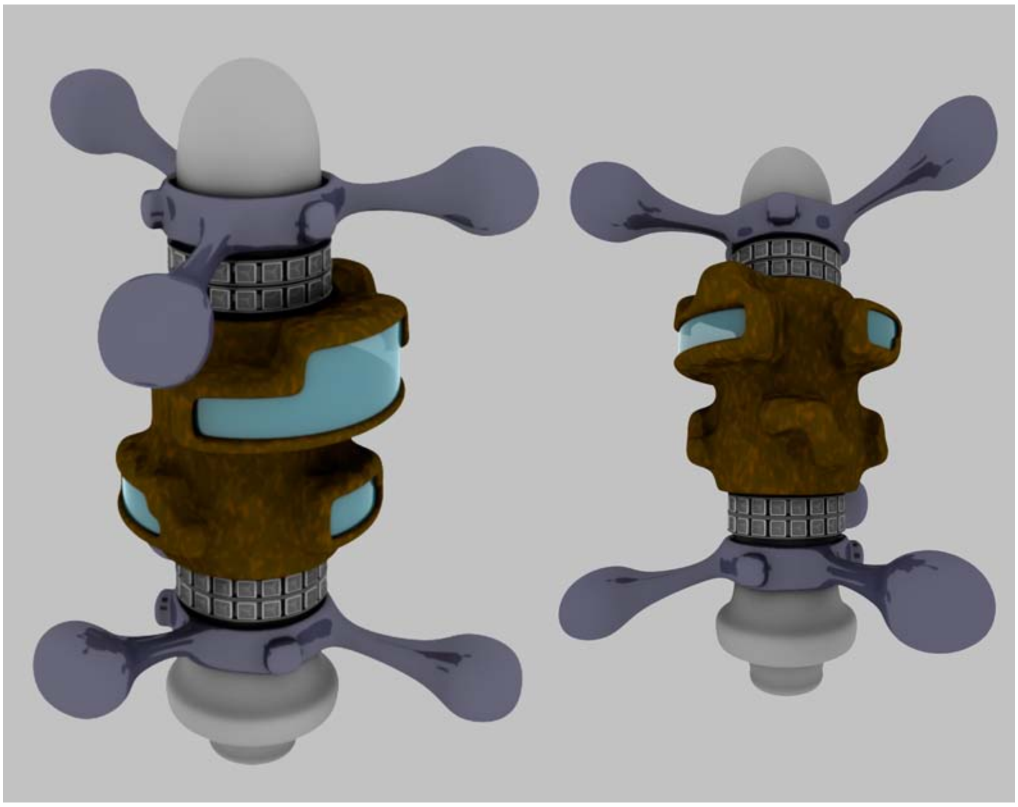
Do you spend time with team members? Yes No

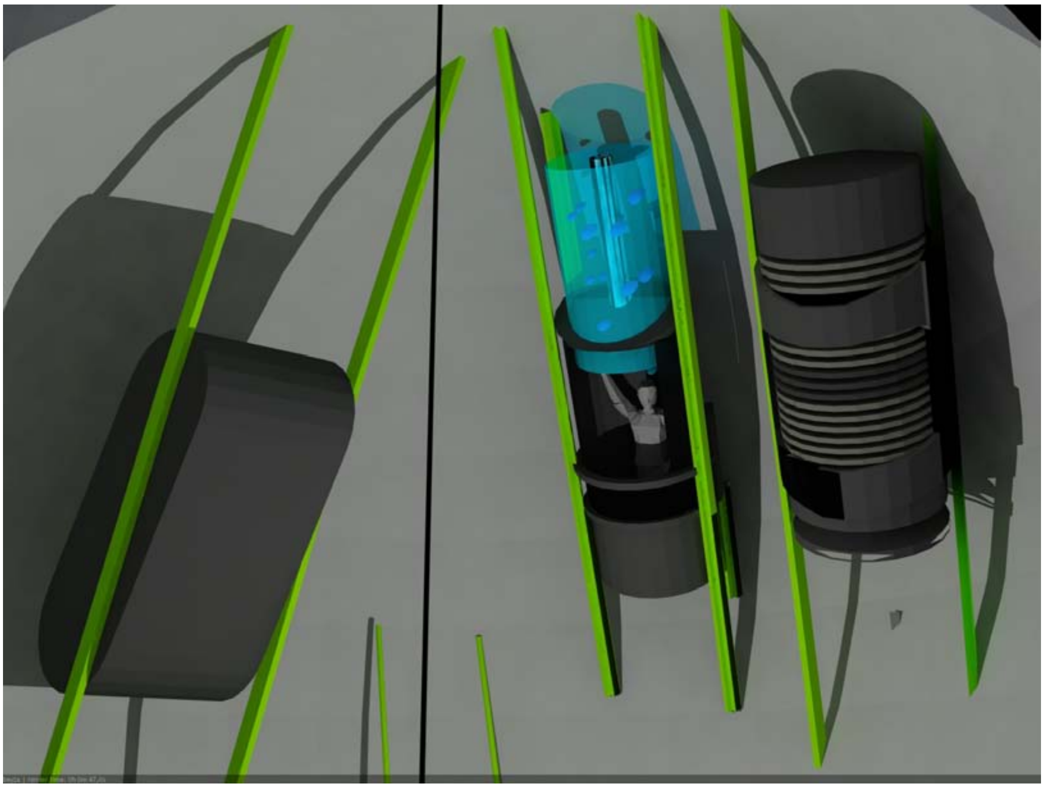
Have you previously worked together? Yes No

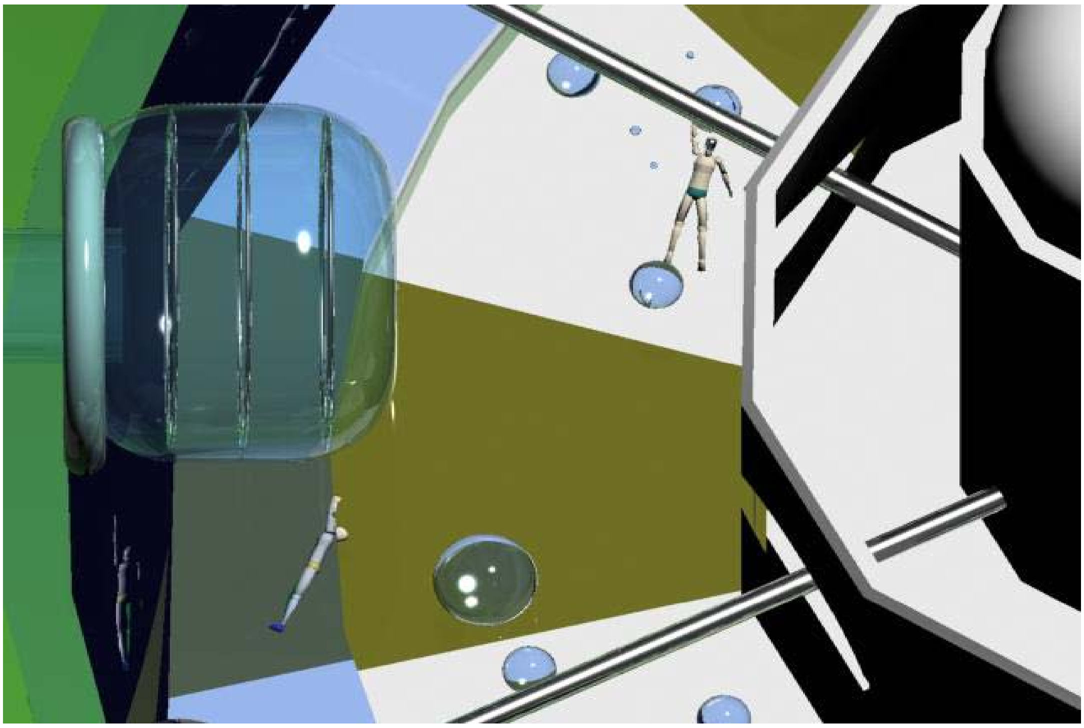
APPENDIX E. Semi-structured Interview Questions

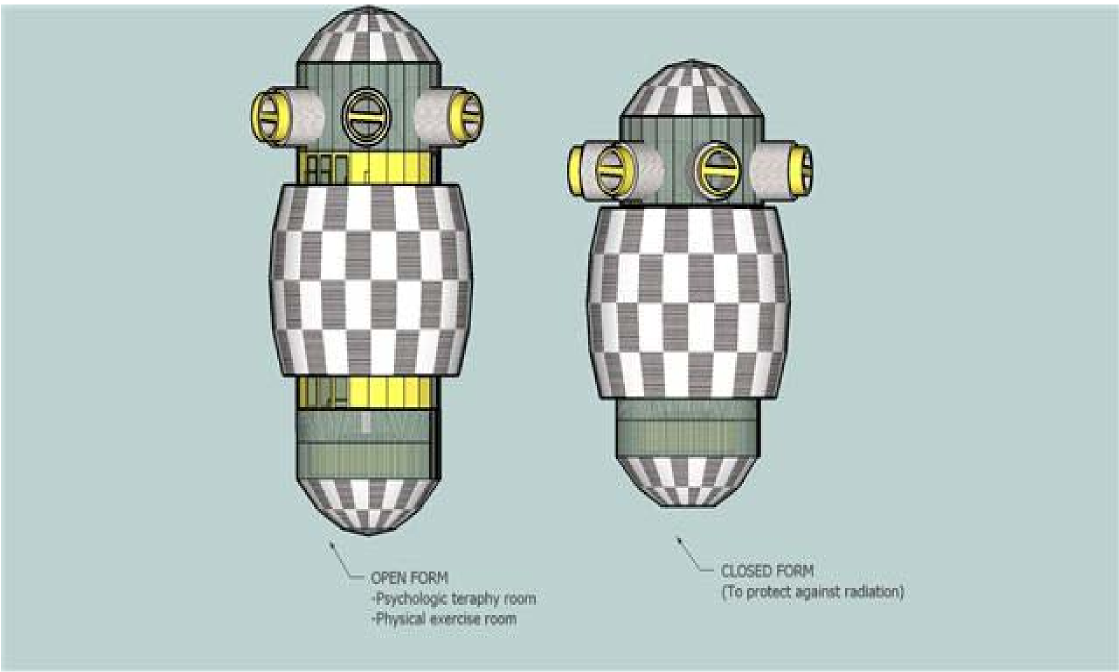
1. Was it easy to collaborate to your team members?
2. Did you communicate well with your team members?
3. Was it easy to design a space on the Internet?
4. Were the drawing and modeling tools sufficient?
5. Was the MOODLE sufficient for information sharing?
6. Was there a team leader?
7. How did you generate new ideas?
8. Did MOODLE support your creativity?
9. Did Sketch Up support your creativity?
10. Do you prefer this type of communication for your other design studio courses?
11. What were the negative aspects of the study?
12. What were the positive aspects of the study?

APPENDIX F. Sample Projects








OPEN FORM
-Psychologic teraphy room
-Physical exercise room
CLOSED FORM
(To protect against radiation)