The Outcomes of Collaborative Learning in Design Studio Courses

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Abstract: The most effective learning in industrial design education takes place in the studio courses, in which the students can explore, analyse, practice and observe the outcomes of the design project. In studio courses, occasionally, students are encouraged to take part in collaborative learning by working together in a group and submitting a joint project that results from the group work. The collaborative learning projects commonly end up with discussions, confusions and conflicts between the group members and the instructors. The basic problems are especially declared by group members as not choosing their partners by themselves, and working on a design project that does not interest them. In accordance with this information, a study was conducted by integrating the collaborative learning system to the industrial design studio course. In this paper, the outcomes of collaborative learning will be evaluated in light of the project conducted in a design studio course with undergraduate students. The study will be interpreted by the context of the dynamics of collaborative learning, the common problems observed during collaborative learning, and novice designer properties featured by the students.

Keywords: collaborative learning; studio course; design project; board game design; design education

1 Introduction

Industrial design education is usually conducted in an industrial design studio, which is the heart of most industrial design curricula and is a place where students learn to think as designers. In studio courses, students can work individually or as a part of a group. Thompson (2002, p. 42) states that collaborative learning or group-based assessment can be a practical, valuable and cost-effective strategy in design education, which is often used as an exigent strategy rather than an explicit development of the curriculum. Through collaborative learning experiences in studio courses, problems can be observed in the subjects such as the formation of groups, in-group communication and in-group assessments; therefore, a pilot study was conducted in the spring semester of 2013-2014, in order to analyse the collaborative learning environment dynamics and to enhance the collaborative learning process. The pilot study was evaluated and the common problems faced by the students were listed. In order to eliminate the problems, a second study was conducted in the spring semester of 2015-2016 by shifting the factors of the collaborative learning environment.

The aim of the research is to present the contribution of a collaborative learning environment to design studio courses, to eliminate the common problems observed in collaborative learning, and to form suggestions for conducting collaborative learning in design studio courses.

2 Characteristics of Collaborative Learning

Collaborative learning can be defined as a "situation in which two or more people learn or attempt to learn something together" (Dillenbourg, 1999, p. 1). Collaborative learning promotes the development of critical thinking skills, co-creation of knowledge and meaning, reflection and transformative learning (Palloff & Pratt, 2010, p. 4). Collaborative learning is a common method used in studio courses of industrial product design undergraduate education to bind students together, to gain different perspectives on the topic, to develop critical thinking and to gain experience of working with different people. Hocaoğlu (2016) refers to collaborative learning "as an improving learning system due to its character that allows students to negotiate and manage their design concepts with other group members. It is also a great opportunity for individuals to find solutions to the complicated problems in collaborative works" (p. 2). Lahti, Seitamaa-Hakkarainen and Hakkarainen (2004) state that collaborative design plays a particularly important role during the conceptual phase of designing, i.e., while generating and articulating design through searching for new information that would help to determine design constraints and produce a satisfactory design.

Cross and Clayburn Cross (1995) remark the importance of teamwork in professional design activity and also highlight the problems and possibilities concomitant to working as a member of a team as follows: roles and relationships; planning and acting; information gathering and sharing; problem analysing and understanding; concept generating and adopting; conflict avoiding and resolving (p. 144).

Slavin (as cited in Kreijns, Kirschner & Jochems, 2003, p. 337) states that collaborative learning has been used generally in ill-structured learning environments. As design action is inherently associated with ill-structured problems (Simon, 1973), collaborative learning appears to be an effective method for students to cope with these problems, but there are major problems in practice. One of the basic problems that occur during collaborative learning is the formation of groups. Hocaoğlu (2015) suggests that "if the instructor forms the groups and determines the group members, then the groups have to be determined at the beginning of the semester and enough time has to be given to groups to socialize and know each other's skills" (p. 1811). Roberts and McInnerney (2007) also state that "in cases where students participate in group work without any prior formal training in group skills, a minimum of two weeks at the beginning of the course should be devoted entirely to the core advantages and benefits of group learning, and the skills required" (p. 261).

Thompson (2002) mentions that one of the biggest problems encountered with collaborative learning is the students' perception of fairness. Latch Craig and Zimring (2000) note that students may be afraid to expose their fledgling ideas, since they compete for grades and status. Hocaoğlu (2016) presents the results of a collaborative work between undergraduate students of Interior Architecture and Industrial Design programmes that aimed to encourage students for collaborative learning from different professions. She noted threats of a collaborative learning environment in the design process as being a single-handed, conflicted, frustrating and assessing method, and the opportunities as professional business life experience and gaining awareness on group dynamics.

Roberts and McInnerney (2007) list the seven most common problems of group learning found in the literature as follows:

   P.1. student antipathy towards group work
   P.2. the selection of the groups
   P.3. a lack of essential group-work skills
   P.4. the free-rider
   P.5. possible inequalities of student abilities
   P.6. the withdrawal of group members
   P.7. the assessment of individuals within the groups.

This study will be evaluated based on these seven most common problems of group learning presented by Roberts and McInnery; therefore, terms and definitions of the problems will be explained in the further sections.

3 Properties of Novice Designers

The designers' experience on design, affects their attitude towards the design process. Dorst (2010, p. 136), based on the study of Dreyfus (2004), categorizes seven types of designers as novice, advanced beginner, competent, proficient, expert, master, and visionary. Undergraduate students, as novice designers, are on the bottom level who are trying to understand the meaning of design and the *rules of the game*. Newstetter and McCracken (2001, p. 67), based on their observations on student behaviour, describe features of novice design activity as ideation without substance, design arrogance, design shutdown, design jumps, and design routinisation. Based on the studies of Cross (2006) and Newstetter and McCracken (2001), properties of novice designers can be listed as follows:

- Ideation without substance: Students get the wrong idea about design that it is only coming with good ideas, and they underestimate analysis, evaluation or realisation steps (Newstetter & McCracken, 2001).
- Design arrogance: Students do not analyse user profile or environment, and they often design for themselves (Newstetter & McCracken, 2001).
- Design shutdown: Students tend to focus on an initial idea and stop considering alternatives (Newstetter & McCracken, 2001).
- Design jumps: Students are inclined to think too generally or too detailed; they do not move between these spaces (Newstetter & McCracken, 2001).
- Design routinisation: Students often see the design problem as a linear algebra problem. They do not make iterations, revisit past decisions or evaluate alternatives (Newstetter & McCracken, 2001).
- Problem focused strategy: Before starting to generate solutions, novice designers often get stuck in attempts to understand the design problem (Cross, 2006).
- Depth-first approach: Novices often show a depth-first approach to a design problem and try to generate numerous sub-solutions in depth (Cross, 2006).
- Design fixation: Novice designers can also become fixated on a solution. Experts usually show a breadth-first approach, top-down strategies, and reject being liable for early solutions (Cross, 2006).

In this study, the findings of the research also will be evaluated in terms of the properties of novice designers that are determined by Cross (2006) and Newstetter and McCracken (2001). The evaluation will be just performed based on the novice designers' attitudes; the qualification of their designs will not be considered.

4 The Research Study

4.1 Scope of the Research

This study is based on the research of a collaborative learning system that was integrated into an industrial design studio course. The scope of the research comprises evaluating the intra-group dynamics of collaborative learning, while the qualifications of the projects that students carried out, were excluded.

The research was conducted under two cycles: the first project as a pilot study and the second one as a workshop. It assigns two different project briefs to the students. The first cycle was a pilot study for observing the attitudes of the students during the collaborative work. In order to observe the benefits and problematical sides of collaborative learning, in the pilot study, groups were determined by the instructors, and in the workshop the groups were formed by the students. In the pilot study, the design project topic was determined by the instructor, but in order to eliminate the prejudice of the students against the project topic, the topic of the workshop was determined by the students. The attitudes of students during the collaborative work, the formation of the groups in the second cycle, and the projects that were submitted, were evaluated to gain an understanding in the situation of collaborative learning in design studio courses.

4.2 Research Method

4.2.1 First Cycle: Organizing Groups and Determining the Topic of the Pilot Study
In the 2013-2014 spring semester, the collaborative learning environment was tested at Doğuş University, Department of Industrial Product Design, in the design studio course. The project was given for a semi-period (seven weeks) and was conducted with twenty-five students in five groups; seventeen students from the Project Year 2, six students from the Project Year 3 and two students from the Project Year 4 (Table 1).

The principles of organising the groups were classified below as:

- The groups were formed by the instructors.
- In order to create equal groups in the studio year of students, friendship (restraining close friends taking part in the same group), age, gender, design development skills and computer aided design skills were taken into consideration.
- The students were selected from the ones who had never done a group project before to eliminate the positive and negative prejudices against collaborative work.

Table 1. Distribution of students per groups in pilot study

Group	Students			
	Project 2	Project 3	Project 4	Gender
Group 1	4 students	1 student	-	2 male, 3 female
Group 2	4 students	1 student	-	3 male, 2 female
Group 3	3 students	1 student	1 student	2 male, 3 female
Group 4	3 students	2 students	-	4 male, 1 female
Group 5	3 students	1 student	1 student	4 male, 1 female

4.2.2 Second Cycle: Organising Groups and Determining the Topic of the Workshop

In the second cycle it was planned to organise a short, one-week workshop, as only group formation variables would be observed. In the first cycle, the students had also disagreed on the topic of the design project; therefore, in order to eliminate the objections of the students related to the project topic of the first cycle, students were asked to select the workshop topic.

Five project topics that could encourage collaborative learning were selected among the topics that the students had previously wanted to study and were presented to the students. The students chose the board game among the five project topics presented to them. This topic is also an advantage for collaborative learning due to the nature of the *board game*. "Game", a word originating from German and with the same meaning in English, refers to learning by observing and practicing (Kaszap, Ferland & Stan, 2013). The game has been dealt with as an important issue in every period in society, as it is part of human life and allows for the formation of culture (Huizinga, 1955). In addition to supporting learning, game is also fun and fair for both children and adults and develops their open-mindedness (Sutton-Smith, 1997).

While the game encourages learning by observation and practice, it also shows how complexity could emerge in the game as a result of simple rules (Holland, 1998). In traditional game theory, games are divided into two basic categories: competitive or collaborative. Competitive games require players to create strategies that directly oppose other players in the game. As in many traditional board games such as chess and checkers, the goals of the players are diametrically opposed (Jones, 2000). In contrast, a cooperative game models a situation where two or more players have interests that are "neither completely opposed nor completely coincident" (Nash, 2002, p. 99). There are opportunities for winners to work together to achieve a win-win situation.

Although not accepted in game theory, cooperative games also appear as a third category (Table 2). In such games, all participants act together as a team, and if the team wins or loses at the end, everyone wins or loses. A collaborative board game has a set of static goals and rules to provide only obstacles and counter strategies. As a result, after multiple play sessions, players adapt better to the game and use their abilities. Over time, the game becomes easy because the team can easily beat it. Therefore, unlike competitive games such as chess, collaborative games must be adapted to the abilities of the players in order to sustain the replay ability (Zagal, Jochen & Hsi, 2006).

The selection of the project topic was notably coherent with collaborative learning in terms of playing the game with more than two people and sometimes players/students behaving more as a collaborator, sometimes behaving more dominant and causing conflicts. In the later stages of the project, collaborations among students, discussions, and the observation of situations such as leaving the group made the project resemble real life situations.

One of the problems that cause conflict among group members is grading, and in order to eliminate this problem observed in in-group grade assessments, it was decided that absence would be graded instead of the projects designed in the workshop. In this way, students were motivated to participate in the workshop.

The workshop was held in the 2015-2016 fall semester at Doğuş University, Department of Industrial Products Design. The workshop was conducted with sixteen students in four groups; fifteen students from the Project Year 3, one student from the Project Year 4 (irregular class) (Table 3).

Table 2. Comparison between different types of board games

Games	Type	Category	Players
Chess	abstract strategy and mind game	competitive	2
Risk	strategy game	cooperative	2-6
Go	abstract strategy and mind game	competitive	2
Monopoly	fast-dealing property trading game	cooperative	2-6
Backgammon	abstract strategy and mind game	competitive	2
Scrabble	word game	competitive	2-4
Lord of the Rings	action role-playing game	collaborative	2-5

Table 3. Distribution of students per group in the second cycle

	Students		
Group	Project 3	Project 4	Gender
Group 1	3 students	1 student	4 male
Group 2	4 students	-	4 female
Group 3	4 students	-	4 male
Group 4	4 students	-	2 male, 2 female

The workshop was held for four days, with sixteen hours of design time and two hours of jury time. In addition, the students prepared models and layouts for the jury in their leisure time. Students came to the workshop being aware of the topic of the project. According to Richards (2009), the size of the group is directly proportional to the complexity level of the study topic but working groups of 4-5 people are ideal in non-complex subjects; therefore, students were asked to form groups of four. Close friends had formed three groups by choosing each other, and compulsorily the remaining four people formed the fourth group. At the end of the project, four different project concepts were determined: mountain climbing, brainstorming, desert strike, and legend (Table 4).

Table 4. Properties of the board games

	Properties of the Board Games Designed			
Group	Project Concept	Type of Board Game	Category of Board Game	Players
Group 1	Mountain Climbing/Board Game	Strategy game	Competitive	2-4
Group 2	Brainstorming/Board Game	Mind game	Competitive	2-6
Group 3	Desert Strike/Board Game	Strategy and action role-playing game	Competitive	2-4
Group 4	Legend/Board Game	Abstract, strategy and action role-playing game	Competitive	2-4

5 Results and Discussion

5.1 Outcomes of the Collaborative Learning

In the first cycle, the students were demoralised after the formation of groups, and the instructors needed to create in-group communication. A course hour was spent outside of the classroom with group inclusion activities; but in-group conflicts continued. Two of the five groups had adapted and carried out the collaborative study; the other two of the five groups could not adapt to the group work and were able to manage the process with the support of the instructors; and the last group could not adapt to group work in any way and was dissolved.

5

In the pilot study, collaborative learning dynamics had been determined for research, whereas appearance of an unexpected situation, such as the dissolution of a group, came into question, and the focus of the research was changed. The main factor in the dissolution of the group was the formation of groups by the instructors and the unwillingness of the students to work together. Therefore, in order to observe the group formation variable, the second cycle of the study was performed.

In the second cycle, with the observation of the workshop process of the students, the problems they faced were examined in the context of Roberts and McInnerney's study (2007), and the novice designer properties featured by the students were interpreted based on the studies of Cross (2006) and Newstetter and McCracken (2001) (Table 5).

When Table 5, the table of common problems of group learning encountered during the workshop, was analysed, it was seen that problems 1 (student antipathy towards group work) and 2 (the selection of the groups) were not observed in any group. Students did not complain about group work or the way of selecting the groups as they formed their own groups (Table 5).

Table 5. Dynamics of groups and problems observed during the collaborative work (P.1. student antipathy towards group work, P.2. the selection of the groups, P.3. a lack of essential group-work skills, P.4. the free-rider, P.5. possible inequalities of student abilities, P.6. the withdrawal of group members, P.7. the assessment of individuals within the groups)

| Group | Dynamics of the Group | | | Common Problems Generally Observed at Colloborative Learning | | | | | | |
	Relationship	Strengths	Weakness	P.1	P.2	P.3	P.4	P.5	P.6	P.7
1	Classmate and friends	Intermediate Design Capabilities	1 Dominant Character	☺	☺	☹	☹	☹	☹	☺
2	Classmate and best friends	Intermediate Design Capabilities	2 Dominant Characters	☺	☺	☹	☺	☺	☺	☺
3	Classmate and best friends	Strong Communication Skills Best Friends Strong Design Capabilities	Best Friends 1 Dominant Character	☺	☺	☹	☺	☺	☺	☺
4	Classmate	Heterogeneous Group Strong Design Capabilities	Weak Communication Skills	☺	☺	☺	☺	☺	☺	☺

The third problem (a lack of essential group-work skills) was observed in all groups except for the fourth group. None of the students participating in the workshop had any experience in group work. Although Roberts and McInnerney (2007) suggested a minimum of two weeks at the beginning of the course for students without any prior formal training in group skills, as the fourteen-week training process was intensively planned, a two-week time period could not be allocated.

The first three groups were homogeneous groups of close friends; the first and third groups had one dominant character in each group, and the second group had two dominant characters in the group. The second group, which had two dominant characters in the group, fell into disagreement on project concepts and were divided into two groups on the second day. The group lost a day until the participants of the group made a joint decision and continued with the project. The third group was composed of four best friends. They could not develop design alternatives since they approved each idea of the dominant character of the group. No difficulties were observed in the group work of the fourth group.

The fourth problem (the free rider) was only observed in the first group. The free-rider effect, mentioned in the fourth problem refers to group motivation losses, when a group member or members do not participate in group work and decrease group performance (Kerr & Bruun, 1983). In the first group, only one student had strong design skills, while the other three students had low design skills, and their participation in the class was minor. When they formed a group as friends, the student with strong design skills became the dominant character of the group and the other students handed over the responsibility of the project to the dominant student. For this problem Roberts and McInnerney (2007, p. 261) suggest that the instructor can use pressure on the free riders. Although the instructors tried to interfere with the group to give responsibilities to the free-rider members, the dominant character of the group defended those friends and argued that they did not pose a problem.

As a consequence of the relationships and the abilities of the free riders, the fifth problem (possible inequalities of student abilities) was also observed in the first group. Kerr and Bruun (1983) state that there is always the possibility

that the most capable student(s) within a group may fall victim to what has become known as the *sucker effect*, which in many ways may be the reverse of the free-rider effect. In this study, this person in the group was the dominant character who had strong design capabilities and attendance to the class; and was therefore left to carry the bulk of the workload.

Therefore, the sixth problem (the withdrawal of group members) was also observed only in the first group. As a result of the *free-rider* and *sucker effect* relationships, the dominant character designed the whole project. The other students joined the workshop at a minimum level. The seventh problem (the assessment of individuals within the groups) was not observed in any group because at the beginning of the workshop it was stated that participation in the workshop, not the projects designed, would be graded.

Referring generally to Table 5, only in group 4, which was formed compulsorily, was no problem observed. The fourth group was composed of two male and two female classmates, who had different backgrounds. Kagan (2015) defines this kind of mixed groups as heterogeneous groups, in which participants are mixed by student ability level, sex and race; and states that heterogeneous groups can be advantageous, because of the different perspectives brought to the group. Besides being a heterogeneous group, the coming together of people with strong design skills was another strong side of the fourth group. The group had weak communication skills and could not conduct the brainstorming process at first on their own. The process of brainstorming began with the support of the instructors.

5.2 Evaluation of Novice Designers' Attitudes

All attitudes of the students who participated in the workshop were also evaluated by considering the properties of novice designers, based on the studies of Cross (2006) and Newstetter and McCracken (2001). Properties of novice designers are; ideation without substance, design arrogance, design shutdown, design jumps, design routinisation, problem focused strategy, depth-first approach, and design fixation (Newstetter and McCracken, 2001; Cross, 2006).

As seen in Table 6, *design jumps* and *design routinisation* were observed in all groups as they were third year novice students. Alongside these properties, design arrogance has also been observed in all groups except for the fourth group. This property is associated with the designer who designs for him/herself, rather than analysing the user profile. The three groups that had *design arrogance* were homogeneous groups of close friends with common tastes and interests, and were same sex groups. Since the whole group had common tastes, the diversity of ideas could not be established, and students could not go beyond their interests. In addition to the properties mentioned so far, the third group had *design shutdown* and *depth-first* attitudes. This group of friends, who had common interests, stuck to their initial design ideas, ignored instructors' critiques and began to elaborate on this initial design idea. They were so obsessed with their first ideas that they did not accept the critiques of the instructors even in the jury of the workshop.

Table 6. Evaluation of groups according to Cross's (2006) and Newstetter and McCracken's (2001) classification of novice designer properties.

| Group | Dynamics of the Group | | | Common Problems Generally Observed at Collaborative Learning |
	Relationship	Strengths	Weakness	
Group 1	Classmate and friends	Intermediate Design Capabilities	1 Dominant Character	Design arrogance Design jumps Design routinisation
Group 2	Classmate and best friends	Intermediate Design Capabilities	2 Dominant Characters	Design arrogance Design jumps Design routinization
Group 3	Classmate and best friends	Strong Communication Skills Best Friends Strong Design Capabilities	Best Friends 1 Dominant Character	Design arrogance Design shutdown Design jumps Design routinisation Depth first approach Design fixation
Group 4	Classmate	Heterogeneous Group Strong Design Capabilities	Weak Communication Skills	Design jumps Design routinisation

At the end of the workshop, four groups submitted four design projects that had different board game concepts. As was mentioned at the beginning of the workshop, students were evaluated according to their absence and all students—except one—got full marks.

6 Conclusion

Although collaborative learning is a frequently applied method in design education, there are still problems that need to be overcome. In the literature, it is stated that the students are inclined to be in a group with close friends, but this tendency is not very favourable in forming groups for collaborative learning environments. It is stated that it is a more efficient approach for the instructor to create heterogeneous groups by considering certain criteria (Johnson, Johnson & Smith, 2007; Roberts & McInnerney, 2007; Ergulec, 2017).

In the pilot study (first cycle) summarized in the paper, heterogeneous groups were formed by instructors, considering certain criteria; unfortunately, conflicts arose from in-group communication which the instructors could not predict. In the first cycle, one of the five groups was dissolved and the group could not complete the collaborative study. Based on this outcome, the second cycle was carried out to examine the effects of the group formation. In the second cycle, the group choices were left to the students completely and a one-week workshop was organized in order to observe the effect of group selection. Thereupon, the second cycle was carried out to examine the instructors' necessity of heterogeneous group formation. The students were allowed to choose the project topic for the workshop. Also, to avoid problems related to in-group grade assessment they were informed that they would be graded according to presence or absence in the workshop. Twelve students formed three groups of four as best friends and the remaining four students compulsorily formed the fourth group. Through the observation of the workshop process of students, the problems they faced were examined in the context of Roberts and McInnerney's study (2007) and the novice designer properties featured by the students were interpreted based on the studies of Cross (2006) and Newstetter and McCracken (2001). Unexpectedly, in the first three groups various problems were observed although they worked on their chosen project topic and with friends of their choice; no problems were observed in the fourth group that came together compulsorily but composed a heterogeneous group incidentally.

In this study, the attitudes of participants observed by researchers were summarised as below:

- Homogeneous groups tend to design for themselves or their own interests when they are the same sex, and have the same interests or backgrounds.
- Homogeneous groups could show design arrogance.
- Although it is important for group members to have strong communication with each other, forming the group with best friends narrowed the viewpoints of the group members and prevented the development of critical thinking.
- Different sex and different interests in a heterogeneous group provide a different perspective to the project topic.
- Heterogeneous groups face fewer problems in collaborative studies.
- In spite of everything, unexpected situations could be observed during the collaborative work due to the bilateral relations.

In this study, it was seen that when the groups were organised by the instructors, groups could dissolve because of in-group communication. Taking into consideration in-group communication as criteria at forming heterogeneous groups could be regarded as impossible for instructors. At this point, as Roberts and McInnerney (2007) note, spending more time on group-inclusion activities may transform in-group communication from negative to positive. In further research, it is possible to study group-inclusion activities in order to familiarise students with group work in design education.

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