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IDENTIFYING EFFECTIVENESS OF ONLINE GROUP STUDY ON MATHEMATICAL PROBLEM SOLVING ATTITUDE: A COMPARATIVE STUDY

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Abstract:
Designing a group study enables students to develop critical thinking, effective team work; appreciation and respect for other views, techniques and problem-solving methods by promoting active learning environment. The purpose of this quantitative study examined the effects of online collaboration on the pre-service teachers' mathematical problem solving attitude. Specifically, the study examined the effects of group working to the mathematical word problem solving tasks alone. Forty-two pre-service teachers enrolled in the study which were divided into three groups: Synchronous online (n=12), face-to-face (n=15) and individual (n=15). Students in each group were required to solve four ill-structured problems under problem solving sessions over a six-week period. It is used a quantitative analysis of data. To measure the change in problem solving attitude, a pre and post-test problem solving attitude questionnaire administered to measure attitude change. The results indicate that, whether synchronous online or face-to-face group based problem solving processes resulted with more positive attitude than individual study. It is also revealed that students' problem solving attitudes were increased in all groups, however, F2F group students' showed positive higher difference than those SO and IND students.

Keywords: collaborative group study, online collaboration, problem solving, attitude

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1. Introduction

In today's learning environment, having learners' engagement by carrying out collective learning activities is crucial factor for emerging meaningful learning outcomes. That's why it is important to propose learning dynamisms by incorporating critical thinking, problem solving and group based learning activities in the classroom. Based on the constructivism theory (Driscoll, 2005; Duffy & Cunningham, 1996), students could construct their knowledge and promote ideas by active participation on learning activities (Campisi & Finn, 2012; Rosen & Salomon, 2007; Tam, 2000). Discourse based activities help students to share ideas, construct their understandings by having arguments and expressing their mathematical thinking (Chi, 2009). Thus, it is crucial factor for learners in groups to engage with related tasks and responsible to other group members to pursue a goal.

According to Jonassen and Kwon (2001), learning settings could be more effective when learners are active by sharing and discussing their experiences. Current standards in teaching and learning mathematics have emphasized the importance of group based studies for students during mathematics education (NCTM, 2000). Engagement of various student ideas within a group enable students to overcome mathematical problem solving exercises by providing explanations, exchanging ideas and clarifying each other's statements (Chi, 2009; Gillies, 2000; Webb, 1991). One of the suggested method is the online systems that enable students to share knowledge and interact with their classmates and teachers through interactive learning settings (Stahl, Kochmann & Suthers, 2006; Liu & Tsai, 2008; Stacey, 1998; Sendağ & Odabasi, 2009; Wikeley & Muschamp, 2004). These online facilities, students have the opportunity to broaden their learnings by joining collaborative group activities, participating mathematical discussions and promote each of their understanding (Stahl, 2009).

Depends on the collaborative settings, activities and experiences take place during collaboration mode have a positive effect on participants' academic and social performances (Barkley et al., 2005; Carini, Kuh, & Klein, 2006; Gillies, 2004; Gunawardena et al., 2001). With the transformation of in-class CPS setting to computerized environment it is crucial to reveal its effectiveness on affective factors. Waxman, Lin & Michko (2003) stated that technology based teaching and learning has a positive and non-significant effect on participants' affective outcomes. While online cooperative learning has been found to be an effective pedagogical tool on a different subject area, limited research explores affective outcomes of online collaborative problem solving. It is interested in the study that how a collaborative problem solving setting affects students' learning outcomes. Thus, the current study aimed to reveal

effectiveness of synchronous online (SO) and in-class (F2F) collaborative group settings with individual (IND) study on pre-service teachers' problem solving attitude. The following research questions (RQ) were considered to address the purpose of the study:

RQ 1. What is the level of pre-service mathematics teachers' pre- and post-test attitudes towards mathematical problem solving in terms of the SO, F2F and IND groups?

RQ 2. Is there a statistically significant difference between the pre- and post-test attitude scores of the SO, F2F and IND groups?

RQ 3. Is there a statistically significant interaction between the grouping and treatment factors on the problem solving attitude?

2. Conceptual Framework

2.1. Collaborative Problem Solving

Critical explanations after a debate on mathematical argumentation play an important role in students' mathematic performance. Therefore, building a collaborative learning setting which supports to construct new knowledge and related experiences is a critical factor. According to Johnson and Johnson (1990) students have the opportunity to think and develop ideas by communicating mathematically. One of the ways this can be done through working collaboratively as a group (NCTM, 2000). During a mathematical collaborative study, participants could overcome given problem situations by sharing, building and contributing each of their experience. Collaborative problem solving (CPS) refers to problem solving activities that involve active participation of group members to build shared understandings by exchanging ideas (Dillenbourg & Traum, 2006; Hesse et al., 2015; Lazakidou & Retails, 2010; OECD, 2013; O'Neil, Chuang, & Baker, 2010; O'Shea & Leavy, 2013).

During a CPS setting students have many advantages. Active participation of group members supports more interaction as mathematical communication and reasoning (Jansen, 2006). Students who has lower mathematical abilities tended to involve in problem solving activities and this situation makes them more confident (Nebesniak, 2007). Collaboration improved learner performance regarding higher-order thinking activities when learners actively discussed and suggested alternative solutions to the problem situations (Mergendoller et al., 2000). Students who try to solve problem exercises as a group can see solution strategies from different perspectives and able to offer alternative ideas by criticizing each other's statements (Gillies, 2000; Hoek & Seegers, 2005; Kolawole & Ilugbusi, 2007; Pear & Crone-Tood, 2002).

In several studies which analyzed effects of collaboration on problem solving support that collaborative settings are more effective on mathematical performance and provide higher order thinking skills than individual work (Cohen et al., 2002; Ge & Land, 2003). Lin et al. (2015) showed that CPS based STEM settings have an effect on establishing shared understandings on problem situations by well-established team organizations. In their study Carlan, Rubin and Morgan (2005) resulted that students became more reluctant on mathematical problem solving by obtaining alternative ideas. With the growth of computer and internet technologies it is possible to provide further insights to adapt CPS activities via computer supported collaborative learning environments. One way to enhance student mathematical collaboration performance is to integrate technology as a creative and interactive scaffold to help students' mathematical thinking.

2.2. Computer Supported Collaborative Problem Solving

With the increase interest for recent years computer supported collaborative learning (CSCL) settings have gained importance in supporting group based teaching and learning activities (Dillenbourg et al., 2009; Kochmann, 1996; Stahl et al., 2006). It is possible for participants to expand their learning by sharing and discussing through CSCL environments (De Corte, 2000; Mukama, 2010). Recent internet and communication technologies offer various dimensions to the structure of traditional classrooms (Wang, 2008). Based on the CSCL paradigm, one of the suggested method is the web-based collaborative learning (WBCL) setting (Koschmann, 1996; Hron & Frederich, 2003; Raes, Schellens & De Weber, 2014; Zhang et al., 2014). According to Bates (2005), students have access to internet have a chance to participate courses through online technologies. With the use of internet, students have their learning experiences by interacting with their teacher, other learners and course content (Ally, 2008; Anderson & Dron, 2011; Dede, 2010; Alvarez et. al., 2013).

Moving traditional collaborative learning settings to web based systems offers more flexible environments that enable students to construct their knowledge without time and place allowance (Garrison, Anderson & Archer, 2000; Rovai, 2002; Hurme & Järvelä, 2005; Liaw et al., 2008; Lord & Lomicka, 2008; Oliveira, Tinoca, & Pereira, 2011). WBCL systems have made it possible for learners to collaborate through asynchronous (Rovy & Essex, 2001) and synchronous (Romiszowski & Mason, 2004) communication modes that enable students to enhance their knowledge by collaborative written assignments, group discussions and chats (Wang, 2009; Zhu, 2012).

Recent researches showed that collaboration mode via electronic environments have positive effects on students' mathematical development and thinking. Jonassen

and Kwon (2001) investigated the effects of face-to-face and computer-mediated collaboration on problem solving activities. As a result of their study, more task oriented interactions and qualified outcomes were revealed on behalf of computer-mediated group studies. Hurme and Järvelä (2005) also supported that CSCL based mathematical problem solving environments encourage students to think mathematically and promotes them to use mathematical knowledge effectively. As a result of another experimental study showed that students who studied in online asynchronous algebraic problem solving sessions performed more positive mathematical skills and better math scores than individual problem solvers (Kosiak, 2004).

3. Methodology

3.1. Design of the Study

In this study the pre- and post-test two treatment quasi experimental design (Cohen, Manion & Morrison, 2007) was performed as outlined in Table-1.

Table 1: Research design of the study

Group	Pre-test	Treatment	Post-test
Experimental_1	PSAQ	SO	PSAQ
Experimental_2	PSAQ	F2F	PSAQ
Control	PSAQ	IND	PSAQ

SO: Synchronous online; F2F: Face-to-Face; IND: Individual;
PSAQ: Problem solving attitude questionnaire

3.2. Participants

Participants of this study composed of 42 pre-service teachers who enrolled in a Calculus-II course in an Elementary Education Program at a Turkish state university in northeastern part of Turkey. There were 23 (54.8%) female and 19 (45.2%) male students participated in the study. Participants were all freshman and their ages were around 18-20. Due to the design of the study all participants were placed to groups as SO (n = 12), F2F (n = 15) and IND (n = 15).

3.3. Data Collection Tool

Problem Solving Attitude Questionnaire (PSAQ) was utilized as the data collection tool which was developed by Charles, Lester & O'Daffer (1987) in order to identify participants' attitudes towards problem solving. There are 20 items in PSAQ including 11 positive and 9 negative. This instrument just like five point Likert type questionnaire

and each items classified as: "strongly disagree", "disagree", "neutral", "agree" and "strongly agree". The researcher translated the PSAQ's items into Turkish and its translation appropriateness was controlled by English and Turkish language instructors. After conducting the PSAQ to participants it shows high reliability as the overall Cronbach Alpha coefficient value was found as 0.87.

3.4. Data Analysis

PSAQ employs as a 5 point Likert type questionnaire and they are scored as 1=Strongly Disagree; 2=Disagree; 3=Not Sure; 4=Agree and 5=Strongly Agree. The scoring is reversed depends on the negative items. Upon completion of the test 20 would be the minimum and 100 would be the maximum scoring labels. Data was analyzed using SPSS 17.0. Descriptive statistics were calculated including mean and standard deviation for each PSAQ scores of the groups. It was also performed one-way ANOVA to study the differences between SO, F2F and IND students' attitudes on behalf of their pre-and post-test scores. Next two-way ANOVA was conducted to study the significant level of difference on the problem solving attitude between treatment type and groups. The two independent variables in this study are grouping (SO, F2F and IND) and treatment type (pre and post-test). The dependent variable is the problem solving attitude score. An alpha level of .05 was used for the initial analyses.

3.5. Procedure

In the present study, three mathematical problem solving sessions were carried out as synchronous online (SO), face-to-face (F2F) collaborative groups and individual (IND) settings. After having official permission from the university administration a pre-treatment meeting was held to explain the purpose and procedure of the study with the participation of students and math instructor. At first, explanation of their groups were announced to all participants. By bringing three students in each, four groups were formed for the online and five groups were formed for the in-class groups and fifteen students were placed for the individual studies. In order to maintain the heterogeneity status, gender and previous Calculus-I course grades were considered for assigning students to relevant groups. At that time PSAQ was utilized as a pre-test.

After revising all procedures above treatment phase of this study was carried out within six-week period. Online group based problem solving sessions were carried out through learning management system under the supervision of the researcher. Adobe Connect system was used for the online group activities. Within the possibilities of the online system, students were allowed to use audio and visual mediums to communicate with each other. Each group members were also provided with digital pen devices to

filling out the questions on problem solving worksheets. The researcher did not intervene in any group processes, except for answering student questions in relation to technical problems. Face-to-face group based problem solving sessions were carried out inside a classroom environment under the supervision of the course instructor. Individual problem solving sessions were held inside a separate classroom setting under the supervision of a faculty stuff. Four ill-structured mathematical problem scenarios were implemented based on scheduled weeks. These problems were related with "Functions", "Equations", "Plenary shapes and their area" and "Solids and their area" concepts. At the end of the treatment, all participants were asked to complete the PSAQ as the post-test.

4. Findings

In order to generate information about the assumption of normality of obtained pre- and post-test scores of PSAQ Shapiro-Wilks test was employed. The value of this test was 0.95 and p=0.11 indicating that the attitude scores on the dependent variables are normally distributed in the sample.

In order to explore the first research question, descriptive statistics (mean and standart deviation) for the problem solving attitude scores of two factors are presented in Table 2.

Table 2: Mean and Standard Deviations of Problem Solving Attitude Scores

Group	N	Pre-test		Post-test	
		Mean	SD	Mean	SD
SO	12	39.92	2.64	50.75	6.24
F2F	15	35.8	2.62	47.93	9.13
IND	15	36.67	5.15	43.2	7.87

According to the results in Table 2, attitude scores of all three groups are presented on the basis of treatment type. In general, mean scores for all three groups have increased in favor of the post-test. Based on the experimental study it is obvious to see that both SO and F2F collaborative groups' post-test attitude scores have more increased than individual study. When two collaborative groups' (SO and F2F) pre and post-test attitude scores were compared between each other it can be seen that F2F group students have experienced more increment than SO ones.

Based on the second research question, one-way ANOVA test was conducted to reveal whether SO, F2F and IND students' problem solving attitude scores statistically

differed with treatment process. The test results of one-way ANOVA are presented in Table 3.

Table 3: Summary of one-way Anova test scores

Treatment	Source	Sum of Squares	df	Mean of Squares	F	p
Pre-test	Between Groups	121.92	2	60.7	4.37	.01
	Within Groups	544.7	39	13.9		
	Total	666.6	41			
Post-test	Between Groups	398.32	2	199.2	3.16	.05
	Within Groups	2461.58	39	63.1		
	Total	2859.91	41			

The results for the one-way ANOVA revealed a significant difference for SO, F2F and IND group students' problem solving attitudes on behalf of both pre ($F_{(1,40)} = 4,37$, $p < 0.05$) and post-test ($F_{(1,40)} = 3,16$, $p <= 0.05$) treatment process.

Regarding to the third research question, independent two-way Anova test was conducted to determine whether mean differences of SO, F2F and IND groups' attitude scores are statistically significant or not. Results of two-way Anova test are provided in Table 4.

Table 4: Summary of two-way Anova test scores

Source	Sum of Squares	df	Mean of Squares	F	p	N^2
Treatment (6 week period)	2008.27	1	200.27	52.11	.000	.4
Group (SO, F2F, IND)	393	2	196.5	5.10	.008	.12
Treatment X Group	127.24	2	63.62	1.65	.2	.04

N^2: Partial Eta Squared

Based on the results in Table 4, there is no significant interaction between treatment and grouping, $F_{(2,40)}=1.65$, $p>0.05$, indicating that any differences between the treatment process were not dependent upon which groups were studied in and that any differences between SO, F2F and IND groups were not dependent upon which treatment process was conducted. Since there wasn't an interaction, it was needed to test main effects of both treatment and grouping independent variables separately on the problem solving attitude. The results in Table 4 indicated a significant main effect for treatment ($F_{(1,40)} = 52.11$, $p < 0.05$) and a significant main effect for grouping ($F_{(2,40)} = 5.1$, $p < 0.05$) on the problem solving attitude.

When partial eta squared scores of the two independent variables were compared, it is obvious to see that treatment has the highest effect size ($N^2 = .4$) than grouping ($N^2 = .12$). This situation indicates that treatment process which took place

within six week period was much more effective on the increment on mathematical problem solving attitude than grouping factor. The difference of problem solving attitude scores between group and treatment process variables is shown in Figure 1.

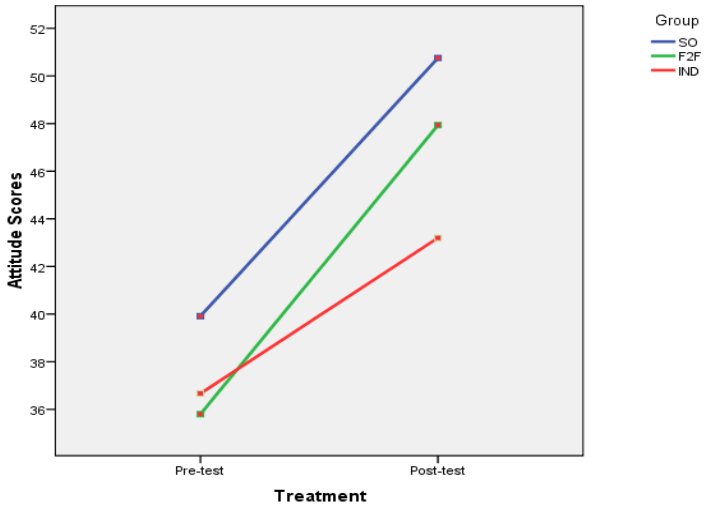

Figure 1: Comparison of Problem Solving Attitude Scores between Groups and Treatment

5. Discussion

The purpose of this study was to investigate the impact of incorporating synchronous online and face-to-face collaborative group studies on the attitude of mathematical problem solving. In order to address this aim, two research questions were developed and tested with the help of statistical analysis techniques. This section include discussion and conclusion of two research questions. Furthermore, it concludes with limitation of the study and some recommendations for future research.

5.1. Group Studies Have More Positive Attitude than Individual Work

The first research question was related to reveal the differences for the pre and post-test problem solving attitude mean scores between students in a synchronous online face-to-face collaborative group study with individual working settings. Both pre and post descriptive statistics of PSAQ test scores were calculated to compare the difference between them. As a result of the findings that aroused from the first research question, it is obvious to see that all SO, F2F and IND students' post-test attitude scores were increased when it is compared to their pre-test results. However, students who were part of group sessions (SO and F2F) performed more increment on behalf of mathematical problem solving attitude than individual study. This difference aroused from group study based environment that enables students to overcome problem

solving steps more systematically with the help of multiple ideas within group members.

In literature it is obvious to see in many studies that studying as a group has a positive influence on solving mathematical problems (Eric, 2011; Ifamuyiwa & Akinsola, 2008; Laughlin et al., 2006; Wismath & Orr, 2015; Zakaria, Chin & Daud, 2010). In their study Portia and Dimabuya (2005) and Marchis (2014) investigated effectiveness of peer and group based problem solving processes on problem solving attitude as resulting positive significant difference on behalf of collaborative group studies. They concluded the reason of this difference aroused from engagement level which encouraged students to exchange their ideas and help their understandings more productively.

In terms of our study it can be said for the IND students that working by themselves without a sense of responsibility (Ellis, 2003; Gokhale, 1995; O' Donnell, 1999) and lack of solidarity (Rocca, 2010) affected negatively on affective outcomes. As stated in the study of Freitas and colleagues (2004), students' passive way of participation on problem solving not only caused fear or anxiety but also it gives rise to show negative attitudes on a given tasks. To conclude, studying alone gives rise to students could not put forth more contributions on their studies.

5.2. Attitude Scores Differ between Collaborative Groups

The second research question was related to reveal the difference of attitude scores of SO, F2F and IND group students whether they are statistically significant or not. When it is compared with pre-test scores there was an increment on behalf of post-test attitude scores for both SO and F2F group students, however, this increase was found a little bit higher for F2F students than SO ones. The negative aspects of the technology played an important in the emergence of this situation.

In this study, all group based problem solving activities in SO were held via online synchronized communication mode. That's why, some uncontrolled issues like having difficulty with the internet speed had affected negatively on SO students online interoperability performances. In some cases

Although online collaboration process allowed SO students to communicate with written and oral features they faced some barriers during this process. For instance, failure on accessing to other group members such as being unable to communicate and restrictions on sharing written expressions to other group members caused some deficiencies and this situation led some of SO students to reflect anxious type discourses. In their study Wang and Woo (2007) expressed that face-to-face gestures and facial expressions make communication process easier and more natural than

online interaction. That's why, being in a face-to-face environment enabled F2F group members to communicate with each other more comfortably. It is thought that, ineffective video communication process was the main challenge that reflects negatively on online group performances (Sam et al., 2007; Tiene, 2000; Thompson & Ku, 2006).

In some cases, low internet speed was the main reason of this problem and this situation caused some deficiencies on transmission of verbal comments between SO members. In literature some researchers have reported the same situations as our study. As a result of the research (Park & Bonk, 2007) that examines students' experiences within an online collaboration highlighted the importance of problems on audio transmission between students due to low internet speed. Schultz (2003) also revealed that having internet problems during online collaborative study caused a decline in the success when compared with in-class discussions.

Inexperienced and challenged situations when using digital pen device to filling out problem solving worksheets have also another reason for the decline of SO students' attitudes. As signs and symbols are uses as the main elements for mathematical thinking (Van Oers, 2001) SO students had challenges to transmit written expressions via graphic tablet devices to other group members. In this study, even though some pre-treatment sessions were held for adapting digital pen usage on tablets, it was observed that SO students need more effort and more time to get used to it.

By considering the three features; confidence, hesitation and self-control that reflect the attitude towards problem solving (Heppner & Peterson, 1982), showing less self-confidence (Liaw, 2007) and poor enactment (Roberts & McInnerney, 2007) caused some disadvantages to contribute group studies for SO students. It can be concluded that, communication problems and technological deficiencies which occurred during student-student and student-content interaction process affect negatively on affective outcomes.

5.3. Limitations

Although the research was carefully planned, it has some limitations. First, all treatments in this study were took place in a 6-week period along with the one semester long (14 week) Calculus-II course. More time should be required in order to observe all students' affective performance. Therefore, it would be better to re-conduct this study in a more time allocated situations. Besides these, during this research researchers faced with technological issues. Therefore, technological features should be well equipped to maintain successful online learning settings.

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