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Abstract

This study aims to investigate the impact that teaching incorporating free problem posing activities has on elementary freshmen's attitudes toward mathematics. As such, this study employs an embedded mixed methods design which includes quasi-experimental design. The participants of this study consisted of 33 elementary freshmen at a university in the Marmara region of Turkey during the fall semester of the 2017-2018 school year. The participants were selected using convenience sampling. The study's data were collected using two instruments: the mathematical problem posing performance file and the mathematics attitudes scale. Quantitative data of the study were analyzed using descriptive and inferential statistic while qualitative data were analyzed using content analysis. Quantitative findings revealed there to be a statistically significant difference between the pretest and the posttest scores for the entire mathematics attitudes scale and for the interest-love sub factor. The qualitative findings, however, indicated that freshmen's opinions could be grouped into two main categories: the affective dimension and the cognitive dimension.

Key words: Embedded mixed method, free problem posing activities, mathematics attitudes, elementary school freshmen.

Introduction

In the 21st century, where global competition is intense, the importance of mathematics is emphasized more. In line with the scores obtained from international exams, countries can prove to what extent they have a voice this century. Accordingly, other countries follow the mathematics education programs of successful countries closely and make updates in their national education programs. Turkey step by step in the math curriculum for trying to improve the math achievement in international exam updates are go (Baş, 2017). In 2005, the education, which took the place of traditional education as the center of the constructivist approach, was adopted and it was last updated in 2018 with 1-8. Mathematics curriculum for the classes started to be implemented. In this program, 1-4. classes are elementary school levels and there are 229 attainments in total, which students are expected to gain. 9.2% of these attainments are based on mathematical problems (the number of gains determined as "…pose…" for the determination of these attainments) and 13% are related to mathematical problem solving skills (while determining these attainments, the words "… solve problems" are counted) (see Ministry of National Education [in Turkish: MEB], MEB, 2018). Therefore, the ability to solve mathematical problems and to pose mathematical problems has a rate higher than one-fifth of the attainments. In this context, the study aimed to determine whether elementary freshmen's attitudes towards mathematics course have changed due to problem posing and to examine their thoughts about problem posing skills. Therefore, both quantitative and qualitative data were collected and analyzed in the study.

Mathematical Problems

A problem can be defined as a difficulty that one wants to overcome but whose solution is not clearly seen (see Hoosain, 2004; Kilpatrick, 1985). A similar definition can also be made for the problems encountered in math classes. Schoenfeld (1992) stated that straightforward and simple techniques cannot be used to solve math problems. In fact, even understanding those upon initial encounter can be difficult. Math problems can be classified as being either routine or non-routine. While routine problems can be close-ended questions with a single correct answer, non-routine problems can be open-ended with more than one correct answer (Filiz & Abay, 2017). Therefore, non-routine problems are a type to which students are generally unaccustomed. However, students' habitual solving of close-ended problems with a single correct answer may prevent them from acquiring sufficient information about their own thought processes. Therefore, students should also be

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given the opportunity to define and solve non-routine problems (Işık & Kar, 2011; Türnüklü & Yeşildere, 2014). One example of a non-routine problem is: "How many different ways can 16 apples be placed in four baskets, each with a different number?" (Altun et al., 2007).

Mathematical Problem Solving

In order to overcome a challenge, individuals make plans, determine strategies, and then seek to implement them. If one is still unable to solve the problem following these steps, s/he has not completely understood the challenge and is required to address it using completely different methods. This type of procedure resulting in reaching a solution constitutes problem solving. Similarly, students studying mathematics may develop a sense of curiosity upon encountering a challenge needing to be solved. If students are able to solve different types of problems, they get experience and learn how and where to begin working even if they have not previously encountered a similar problem (Altun, 2015). In this process, students share their attempted solutions with their peers and teachers in class and discuss the strong and weak points of their attempts. Accordingly, problem solving is an indispensable part of teaching mathematics as it allows students to establish relationships between concepts and operations while seeking solutions to problems (National Council of Teachers of Mathematics [NCTM], 2000). However, acquiring problem solving skills may not be easy for students, who often experience difficulties in the face of mathematical problems. Aside from being able to solve math problems, students must also be allowed to learn how to act systematically while solving problems. Polya (1957) standardized the problem solving process. Although there are different types of problems, these steps are: (i) gaining a general understanding of the problem, (ii) planning, determining, (iii) applying a strategy, and (iv) checking one's solution. According to these steps, problem posing activities are also stated to be instrumental in aiding individuals develop problem solving skills (see Abu-Elwan, 2002).

Relationship between Problem Posing and Problem Solving

Despite the importance of problem solving mentioned above, having only problem solving skills may not always be sufficient for students. Consequently, mathematical problem posing activities have begun to be included alongside mathematical problem solving activities since the 1990s (see Dede & Yaman, 2005; Gonzales, 1994; Silver, 1995; Tuska, 2003). This is because problem posing is seen as a mirror that reflects the nature and characteristics of students' mathematical experiences (see Van den Brink, 1987) and can also be used as a tool for determining how students think and understand while learning mathematics skills (Cai & Hwang, 2003; Silver, 1994). In addition, problem posing develops flexible thinking skills and creative thinking skills in students (see Kilpatrick, 1985; Silver, 1997; Yuan & Sriraman, 2010) and can also facilitate students' determining skills and assist them in eliminating prejudices and misconceptions about learning math (English, 1997). As such, teachers should emphasize changes in conditions and aspects of problems so that students may understand what to do and why to do it while solving problems and to be able to follow the process more efficiently. Additionally, aside from helping students develop problem solving skills to better deal with problems, having them construct problems themselves is stated to facilitate their mathematical development (see Dede & Yaman, 2005). Additionally, dealing with problem posing activities may also aid students in becoming increasingly familiar with open-ended situations. For this reason, the problem posing process, similar to the problem solving process, is held by researchers to be a central topic of mathematics teaching (see Silver, 1994) because it requires problem solving competences (see Grundmeier, 2003).

Addressing a problem from different angles or constructing new problems from its solution is possible. However, it not necessary to produce new problems solely from previous problems in problem posing; problems can also be produced from open- ended and close-ended situations. While posing the problem, one completes its construction by simultaneously calculating how the problem may be solved (Cai, 1998; English, 1997; Grundmeier, 2003). On the other hand, one of the most-controversial issues in the related literature is whether or not a clear connection exists between problem posing and problem solving. Even though the literature includes studies indicating no close relationship to exist between these two concepts (see Crespo, 2003; Silver et al., 1996), one encounters studies attesting the existence of a close relationship between these two concepts more frequently (see Cai & Hwang, 2002; Cankoy & Darbaz, 2010; Dickerson, 1999; Arıkan, 2014). For example, Dickerson (1999) argued that problem posing activities are an effective technique to increase students' success with solving problems. Similarly, Cankoy & Darbaz (2010) also determined at the end of one experimental study that problem solving based on problem posing positively affects students' understanding of the problem. In a related vein, Fidan (2008) stated that providing opportunities for students to form their own problems through their own expressions positively contributes to the development of students' problem solving skills.

Types of Mathematical Problem Posing

Silver (1994) stated that problem posing activities can be handled in three different ways together with problem solving activities: (i) pre solution posing, (i) in-solution posing, and (iii) post solution posing (Kılıç, 2015). Brown and Walter (2005) proposed the problem posing strategy as “what-if-not”. According to this strategy, they stated that problems can be posed by replacing a situation, condition, or the given/desired pair. Here, Brown and Walter’s (2005) what-if-not problem posing strategy can be said to show similarity in form to Silver’s (1994) post solution posing strategy by changing the conditions or the data. Meanwhile, Stoyanova and Ellerton (1996) addressed problem posing strategies in three categories: (i) structured, (ii) semi- structured, and (iii) free problem posing strategies. Brief descriptions regarding these three strategies are given as follows:

Structured problem posing strategy. The strategy is to form new problems by using data from an existing problem. The following is an example of this strategy:

Example 1:

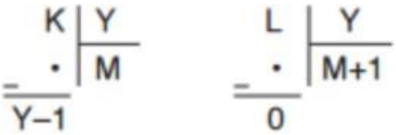


Figure 1. An example for free problem posing strategy

From the K in the figure, find the total of K + L using the adjacent division function (Turkish Student Selection Exam [ÖSS], 1991). Pose as many problems as possible using the data from this problem (Kılıç, 2013).

Semi-structured problem posing strategy. One clear case is the problem posing strategy aimed at exploring relationships over limitations that are made or an incomplete problem and posing new relationships. The following is an example of this strategy:

Example 2:
8 × 5 = 40
90 – 40 = 50
Pose problems that are appropriate to the given operations (Arıkan & Ünal, 2013).

Free problem posing strategy. This is a flexible and creative problem posing strategy that poses as few restrictions as possible. Some examples of this strategy are:

Example 3:
Pose a problem related to real life (Işık & Kar, 2012).
Pose a problem with a challenging solution (Bayazit & Kırnap-Dönmez, 2017). Form a problem that can be segmented (Kılıç, 2013).
From the above expressions and questions, the free problem posing strategy is considered the most flexible problem posing strategy that allows students the opportunity to think using the problem posing strategies proposed by Silver and Cai (1996) and Brown and Walter (2005). Accordingly, the free problem posing strategy is the focus of the current study.

The Relationship of Attitudes toward Mathematics and Mathematical Problem Solving and Problem Posing

Attitude, under its simplest universally accepted definition, is a term that outlines the case of an intention being appreciated or disliked (see Hannula, 2002). However, defining attitude only as the like or dislike of any one thing can become the reason for overlooking the attitude’s formation process. Therefore, the process of attitude formation should be questioned and considered accordingly over a comprehensive definition. When examining the related literature, different perspectives are seen on attitudes. For example, while İnceoğlu (2010) stated that attitude transforms into behavior through personality traits, cultural/social environment, and individual experiences, Ekici (2002) stated that attitudes do not just contain affective and behavioral characteristics but also cognitive characteristics. Similarly, Karagöz et al. (2016) has asserted that while attitudes are composed of cognitive, affective, and behavioral elements, affective elements are more prominent in mathematics teaching.

Similarly, Hannula (2002) highlighted that when cases where positive emotions develop while progressing toward the result when solving/manufacturing a math problem and progress toward the goal are blocked, negative feelings such as fear, sadness, and anger are triggered because of mathematical attitude's having four dimensions: (i) emotions felt while doing math, (ii) giving value to math, (iii) the formation of expectations about the benefit math provides for careers and one's future, and (iv) the associations that come to mind upon math's mention. Kadijevich (2008) evaluates mathematical attitudes under three dimensions: (i) self-confidence in learning math, (ii) love of math, and (iii) the usefulness of math. Therefore, while students with positive attitudes toward math prefer math-oriented professions (Yıldız, 2006), students who generally do not consider math a worthy occupation because they have difficulty associating math with real-life applications choose professions where math is not heavily used (see Tarım & Dinç-Artut, 2016). This is because affective variables like attitude are a significant factor in the process of learning math and play a dominant role in whether students' future career goals include mathematics or not (Dede & Uysal, 2012). In this context, the current study examines mathematical attitudes as a synthesis of the views of Hannula (2002) and Kadijevich (2008) regarding mathematical attitudes in terms of enjoying math, the usefulness of math, giving value to math, and anxiety about math. The following are brief explanations related to these attitude dimensions:

Like, interest and enjoyment to mathematics. Including mathematics in more than a single activity indicates a predilection toward math (Aksu, 2010).

Occupational and daily importance. Students' attitudes toward needing to use math in daily life and in their future professions (see Dossey & McCrone, 2007; Fennema & Sherman, 1976). Believing that math is important is the case of dealing with the proofs of mathematical theorems, researching historical information about math, and being curious about the nature of math (Eccles & Wigfield (1995).

Confidence and anxiety about math. Negative attitudes about learning math can be handled as a combination of low self-confidence, test pressure, and fear of failure. According to this, mathematical anxiety contains affective and cognitive components (Bessant, 1995).

Interest, like and enjoyment. Take pleasure in dealing with a process, and that approaching it with an intrinsic motivation (Warner, 1980).

Problem Solving, Problem Posing, and Mathematical Attitude in the Turkish Mathematics Curriculum

When looking at the updates made in recent years to the mathematics teaching program in Turkey, properly analyzing the problem solving process, developing positive attitudes related to mathematics, and giving value to mathematics are frequently included under the program's objectives (see MEB, 2005, 2013).

Similarly, the current mathematics curriculum enacted in 2018 in Turkey (see MEB, 2018a, 2018b) aims for three things: (i) for students to be able to express their own solutions and the strategies they use in their own words in the problem solving process, (ii) for individuals to be educated in such a way that they possess the ability to determine their own deficiencies in the problem solving process, and (iii) for them to be able to examine each stage of the problem solving process. At the same time, problem solving skills are also included in the curriculum as one of the fundamental skills specific to mathematics. In this context, for example, space is included in the elementary school mathematics curriculum standards between grades 1 and 4 directed at completing problem solving and problem posing exercises. Of these standards expected to be acquired by students, 21 are associated with problem posing and 30 with problem solving (see MEB, 2018a).

The Special Aims of the Mathematics Curriculum for 1-4 graders, moreover, encourages developing positive attitudes toward math class by using students' own experiences, approaching math problems with self-confidence, and doing exercises that increase the value of mathematics in students' eyes. The expression for developing a positive attitude towards mathematics in the curriculum is exactly as follows: "*The impact on mathematical success of developing positive attitudes toward math cannot be ignored. Mathematical games should be included in sections related to units' content as deemed appropriate*" (MEB, 2018a, p. 15). In fact, studies revealing the positive impact that problem posing activities have on students' affective tendencies toward math in general and their attitudes toward math in particular are often noted in the literature (e.g., Fetterly, 2010).

Purpose and Importance of the Research

The liking or dislike of mathematics, the tendency to engage in or abstain from mathematical activities, the belief that someone is good or bad in mathematics, and the belief that mathematics is useful or useless summarizes one's attitude towards mathematics Neale (1969).

The current research seeks to examine the impact that instruction incorporating free problem posing activities has on freshmen's attitudes toward mathematics. In fact, teachers' attitudes and beliefs directly impact those of their students (Schoenfeld, 1992). Accordingly, a teacher with advanced problem posing skills can create problems relevant to students' current realities and can transfer their own attitudes toward math to students because s/he is familiar with their students' interests and experiences (Albayrak et al., 2006). Vionita and Purboningsih (2017) stated that students can be allowed to exhibit positive attitudes toward learning math through enjoyable, easy-to-understand, and relatable activities, emphasizing that problem posing activities need to be frequently used in learning environments. Similarly, Altun (2015) highlighted the importance of providing space for different mathematical problem posing activities suitable to students' experiences and skills in classroom environments at various grade levels. Therefore, determining and developing elementary freshmen's attitudes and skills toward problem posing activities (free problem posing activities in particular) can make significant contributions both to their students and their own future professional careers.

In particular, elementary freshmen's possessing more knowledge about and experience doing problem posing activities (especially free problem posing activities) before entering the profession is integral to improving students' cognitive levels and attitudes toward mathematics. This is because freshmen are able to develop positive attitudes toward math through problem posing activities and to transfer these positive attitudes to their students in their future teaching experiences (see Albayrak, İpek, & Işık, 2006). In this context, in the current study, it is thought that problem posing will make a significant contribution to the development of positive attitude to mathematics and the theoretical framework is built on it. In addition, if the mathematics net of the freshmen who participated in this study were examined, it was determined that they achieved success under 50% success (Council of Higher Education, 2017). In this case, this study was intended to be carried out considering that some of the freshmen had a negative attitude towards mathematics before they settled in the University. For this purpose, the contribution of problem posing to the development of positive attitude towards mathematics course was examined quantitatively by comparing the pretest posttest with the Math Attitude Scale scores.

Qualitative data were collected to support quantitative data.

The purpose of this study is to investigate the impact that teaching incorporating free problem posing activities has on elementary freshmen's attitudes toward mathematics. For this reason, we sought answers to these questions:

- Does learning environment enriched with free problem posing activities influence elementary freshmen's attitudes toward mathematics?
- What are elementary freshmen's opinions related to problem posing about their experiences before, during and after problem posing?

Research Design

In the study, embedded mixed methods design was used. The main idea in this design is that either quantitative or qualitative data is handled in a wider design and these data sets have a supportive position over the entire methods design (Creswell, 2012). In this context, quasi-experimental design was used as the main design in the present study. In this design, measurements are made on the study group before and after the experimental design. In the experimental process, the qualitative data collected have a supportive position over the entire design (Creswell & Plano Clark, 2014).

The Study Group

The study group of this research consisted of 33 elementary freshmen attending a foundation university in the Marmara region during the fall semester of the 2017- 2018 school year. The convenience sampling method was used to select freshmen. The sample consists of 6 males and 27 females. The lessons included in the freshman classroom-teaching curriculum are mathematics (Basic Mathematics 1 & 2), education courses (Introduction to Educational Science and Educational Psychology), and general culture courses (Turkish Language 1 & 2, Introduction to Computers 1 & 2, English 1 & 2, and Ataturk's Principles and the History of the Turkish Revolution 1 & 2).

Data Collection Tools

The study uses the mathematical Problem Posing Performance File and the Mathematical Attitudes Scale. Information on these data collection tools is summarized below.

Problem Posing Performance File contains 10 different mathematics topics formed which based on the free problem posing strategies classified by Stoyanova and Ellerton (1996). The items were prepared in-line with the content of students' Basic Mathematics 1 class. The scope validity of the test appears in a U shape. Items included in the Problem Posing Test are listed below:
Pose a problem related to divisibility.
Pose a problem concerning the least common multiple (LCM) and the greatest common divisor (GCD).

- ✓ Pose a problem related to proportions and ratios.
- ✓ Pose a problem related to relations.
- ✓ Pose a problem related to functions.
- ✓ Pose a problem related to parabolas.
- ✓ Pose a problem related to operations.
- ✓ Pose a problem related to graphing data.
- ✓ Pose a problem related to measuring central tendency.
- ✓ Pose a problem related to measuring central dispersion.

Mathematical Attitudes Scale. This study uses the Mathematical Attitudes Scale developed by Duatepe and Çilesiz (1999) for the university level and is a Likert- type scale formed of a total of 38 items. The scale mainly reflects the affective component. The reason for this scale was chosen as both validity and reliability study of the first- year students at the university and the affective attitude towards mathematics course. The scale's items are scored from 1 = totally disagree to 5 = totally agree, and negative items are reverse scored. The Mathematical Attitudes Scale has 22 negatively scored items (Items 5, 7, 10, 12, 13, 14, 15, 16, 20, 22, 23, 26, 28, 30, 31, 32, 33, 34, 35, 36, 37, & 38) and 16 positively scored ones (Items 1, 2, 3, 4, 6, 8, 9, 10, 11, 17, 18, 19, 21, 24, 25, 27, & 29). The scale contains the following sub-factors: fear-confidence (Items 1, 18, 20, 22, 26, 27, 33, 35, & 36), interest-love (Items 2, 5, 8, 9, 10, 13, 15, 28, 30, 31, 32, 33, 34, & 38), profession and giving importance (Items 4, 7, 12, 14, 17, 21, 25, & 37), and pleasure (Items 3, 6, 11, 16, 19, 23, 24, & 29). The Cronbach's alpha of reliability for the overall scale is 0.96 and between 0.87 and 0.94 for the sub-dimensions (Duatepe & Çilesiz, 1999). The maximum score obtainable is 190 and the minimum is 38. Here, when examining the results report of the Trends in International Mathematics and Science Study (TIMSS) published in Turkish by the Ministry of National Education (MEB) in 2016, the sub-factors of the scale show general similarities with the sub-factors used to measure attitudes toward mathematics classes. This is because in 2015, the TIMSS measured the four sub-factors as: attitudinal components toward mathematics lessons, interest in math class, liking to learn math, self-confidence in math class, and giving value to math class. Example items for each sub-factor have been presented in Table 1.

Table 1. Sub-Factors and Examples from the Mathematical Attitudes Scale

Factor	Example Items
Fear-Confidence	I am enthusiastic toward math. (27) Math is one of my most feared classes. (35) I feel very helpless when studying math. (36)
Interest-Love	I continue to strive hard until I find the answer when faced with an unusual question while studying math. (11) I like to solve the problems I encounter using math. (21) Math confuses my head. (33)
Profession and Giving Importance	I will use math in many places throughout my life (4) Being successful in math class is important to me (25)
Pleasure	I want to study math (3) It's hard to stop once I start studying math (16) Dealing in class with math problems with half-finished solutions gives me pleasure. (24)

The Procedure

This study is an embedded mixed-methods design that uses a quasi-experimental design (a quantitative research method). Accordingly, the single-group pretest-posttest design has been used in the quantitative part of the study. The group, comprised completely of freshmen, was subject to an experimental procedure based on problem posing activities for two hours once a week over 10 weeks within the scope of their Basic Mathematics 1 course.

During the experiment's first four weeks of implementation, the students were first introduced (It took 4 × 2 = 8 hours) to problems, math problems, problem solving in math and its strategies, and problem posing in math and its strategies. These strategies are exemplified through sample problem posing activities related to certain basic mathematical concepts. These basic topics are the rules of division, the lowest common multiple, the greatest common divisor, ratios/fractions, correlations, equivalence, the order of operations, functions, showing data on the graph, graph types, measuring central tendency, and measuring central dispersion. The fifth week includes problem posing activities aimed in particular at free problem posing strategies. At the end of the first 5-week period, at least two problem posing items for two of the above-mentioned ten basic mathematical concepts were requested each week beginning in the sixth week. This way, the number of problems to be posed at the end of the 10th week was determined to be at least 10 per person. The problems posed during the experiment's implementation were initially discussed in small groups during class and then as a large group in which the entire class participated. Additionally, the study group was subject to the above-mentioned Mathematical Attitudes Scale as a pretest prior to the experiment's execution and as a posttest afterward. Moreover, freshmen's views regarding the pre-experimental procedure (being able to make the necessary plans and arrangements, determining the study group, determining, and examining the measuring tools, and determining the details of the experimental process), the experimental process (understanding it), and the post-experimental process (explaining the results, determining the study group's responses, determining the long-term effects of the experimental process) were recorded in writing. In other words, in order to learn the attitudes of pre-service teachers about mathematics course during the problem posing activity process and at the end of the problem posing activity, "What is your expectation from teaching based on free problem posing activities? Do you think it will contribute to you?" was asked to the freshmen and freshmen's thought to be used to explain the quantitative findings.

Data Analysis

As stated above, this study is of an embedded mixed-methods design that incorporates a semi-experimental design. In this context, the study analyzes the quantitative and qualitative data separately (Creswell, 2012). Accordingly, the study first analyzes the quantitative data (experimental process) and discusses whether the quantitative results obtained as a result of the analysis are supported by the qualitative data.

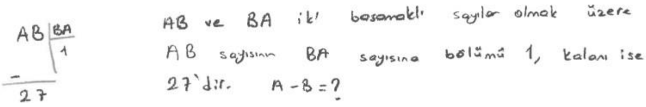
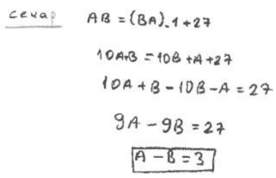
Quantitative data analysis. First, freshmen's answer sheets were coded as S1, S2, …, S33, and these codes were used throughout the entire study. Analyses of the scores from the Mathematical Attitudes Scale that the freshmen completed as a pre and posttest were done using a statistical package program, and both descriptive and predictive statistical analyses have been included in the data analysis. A Shapiro-Wilk test for normality was first conducted, which revealed that the scores obtained from the Mathematical Attitudes Scale had normal distribution ($p > .05$). A dependent t-test was then used to compare the mathematical attitude pre and posttest scores. Additionally, in order to study the experiment's ability to determine the statistically significant difference from the entire scale and its sub-factors, the partial effect size values (η^2) were also calculated. Meanwhile, in scoring the Problem Posing Performance File, 10 problems chosen by the freshmen from among what they had posed related to the above-mentioned basic mathematical concepts (one from each concept) were evaluated, each one worth 10 points for a total of 100 points. Here the evaluation criteria and scoring are as follows: (i) explaining the problems clearly and understandably/language usage (writing factor) = 3 points, (ii) posing mathematical logic (Fiction factor) = 3 points, (iii) posing a topic-appropriate problem (topic factor) = 2 points, and (iv) solving the problem (solving factor) = 2 points.

Table 2. Problem Posing Evaluation Criteria Table

Writing Factor (If the problem is…)	Fiction Factor	Topic Factor	Solving Factor
Mathematical (1 point)	Having logical plot (1 point)	Posing the problem on the desired topic (1 point)	Solving the created problem completely (1 point)
Clear (1 point)	Mathematical fluency (1 point)	Paying attention to the attainments of the topic (1 point)	Solving the created problem partially (1 point)
Not only math operation (1 point)	Real life compliance as much as possible (1 point)		

A problem posing performance file was created for each coded freshman and these files were examined by individual researchers. Additionally, in addition to the researchers, one freshman, one math teacher, and one mathematics educator with a doctorate in problem posing each scored the test independently. A consensus between the researchers and experts was sought. Table 2 depicts the process of evaluating a problem that one freshman posed during the problem posing activity related to division and divisibility that received a score of 9.

Table 3. Evaluating the Problem Posed by Freshman S9

Topic: Division-Divisibility	The problem posed by the freshman: 
Writing factor/ The problem is expressed clearly and understandably - language usage (3 points)	Operations was asked directly in the last sentence. Therefore, no points were given from this sub-factor (2 points)
Fiction factor/ Posing mathematical logic (3 points)	The problem contains no logical contradictions (3 points)
Topic factor/ The problem is appropriate to the topic (2 points)	The problem is appropriate to division-divisibility (2 points)
Solving factor/ Solving the problem (2 points)	 The problem is appropriately solved (2 points)

The scores earned on the problem depicted in Table 2 were statistically analyzed using the total score that freshmen received from the problem posing activity. The Shapiro-Wilk test for normality was conducted for freshmen's problem posing test scores, which revealed the data from the test to be normally distributed ($p > .05$).

Qualitative data analysis. Before, during, and after the experiment, the previously mentioned open-ended questions were asked to the freshmen to identify and understand the impact of the experiment on their mathematical attitudes and free problem posing strategy. The data collected were analyzed using content analysis.

Validity of the Data

Validity of the quantitative data. The study's quantitative data were obtained during the experiment. The measures taken in the study on the internal and external factors that threaten the validity of the experimental procedures have been summarized as follows:

A study group was formed in order to determine which individuals were appropriate for the study. Since the participants included in the sample at the beginning of the study remained unchanged, the number of participants in the study remained the same. Due to the 10-week period between the Mathematical Attitude Scale's pre and posttest execution, the subjects were considered to have little familiarity with the items on the scale. Moreover, a performance test was not used here. Instead, in order to determine the participants' natural reactions to the items included on the Mathematic Attitude Scale, they were informed that their answers would not be used to calculate their course grade. Performing any process that could lead to statistical manipulation of the data was not an issue because there was no control group. Additionally, because the experiment continued for 10 weeks, participants' maturation and possibility of experiencing burnout were also considered.

Furthermore, understanding the impact of the open-ended questions directed at the subjects has been attempted during the experimental process, and some corrections have also been made according to the feedback.

Validity of the qualitative data. In the qualitative data analysis, participants' answers to the open-ended questions were read several times, no changes were made regarding their statements, and the written texts were presented to participants for their approval. This was done to allow participant control over the data (Creswell, 1998). Additionally, peer assessment was also benefitted from in identifying categories (Lincoln & Guba, 1985). Additionally, broad space was given to the freshmen's statements in the study in order to provide readers with the feeling of having experienced part of the current study themselves (Creswell & Miller 2000).

Results

The qualitative and quantitative findings obtained in the study are presented separately.

Quantitative Findings

Here, the study's quantitative data are presented under two headings: problem posing and attitude scores.

Problem Posing Scores

At the start of the instruction based on free problem posing activities, freshmen were first provided with some necessary theoretical information regarding the previously mentioned application. Afterward, the topics from the Basic Mathematics 1 class were handled with an instruction incorporating free problem posing activities. Ten problems that had been posed in each of the 10 weeks, especially from the 6th week onward, chosen by the freshmen themselves were collected and each problem was scored on a basis of 10 points. This way, the highest obtainable score on the test was 100 points. When examining the scores' distribution, 9 freshmen were found to have scored 90 or higher, 14 to have scored between 80 and 90, and 10 to have scored between 70 and 79. The arithmetic means of freshmen's problem posing scores are shown in Figure 1 by topic.

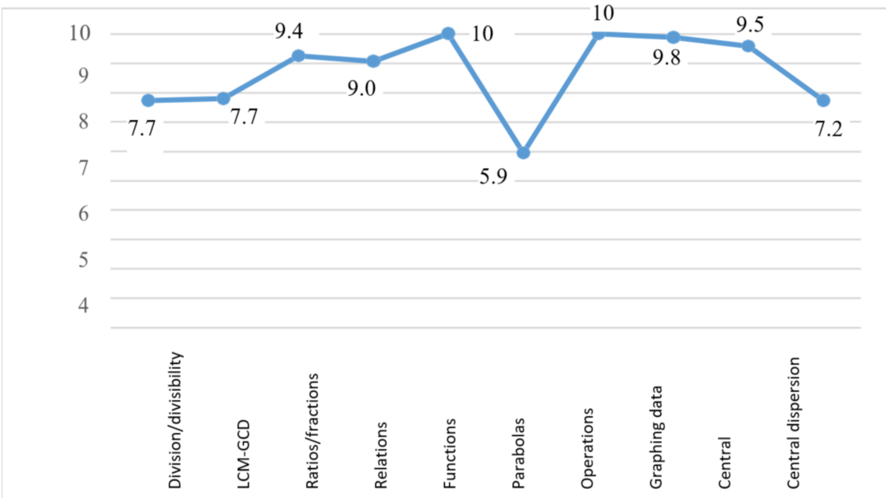


Figure 1. Arithmetic mean of problem posing scores according to topic.

As shown in Figure 1, freshmen's arithmetic means by topic (Division-divisibility to Central dispersion) are 7.72, 7.78, 9.24, 9.06, 10, 5.93, 10, 9.87, 9.57, and 7.72, respectively. Students experienced the greatest difficulty in posing proper problems related to parabolas (mean = 5.93). Meanwhile, functions (m = 10) and operations (m = 10) were determined to have the highest scores in terms of problem posing. Of course, these scores should be noted to have been given without regard to the difficulty level of the problems posed to the freshmen. Moreover, the difference in efficiency posing problems addressing such intertwined concepts as functions, polynomials, and operations constitutes another interesting, albeit separate area of study.

Attitude scores

The normality coefficients for the Mathematical Attitudes Scales pre and posttest were first examined and were found to have normal distribution (α1= 0.57; α2 = 0.165). The dependent t-test results for the Mathematical Attitudes Scale pretest and posttest scores are presented in Table 4.

Table 4. Dependent t-test Results for the Factors Included in the Mathematical Attitudes Scale Mathematical Attitudes Scale pretest and posttest scores

	Pretest			*Posttest*			*Comparison Statistics*			
Measure	Mean	SD	n	Mean	SD	n	*df*	*t*	*p*	η^2
Fear-Trust	33.27	10.19	33	34.03	8.78	33	32	.41	.67	0.00
Interest-Love	44.27	11.47	33	50.48	13.42	33	32	-4.06	.00	0.34
Profession and Importance	32.06	5.18	33	33.36	4.64	33	32	-1.10	.27	0.03
Pleasure	28.42	6.97	33	27.69	6.57	33	32	.70	.48	0.01
Overall Scale	138.03	28.24	33	145.57	27.32	33	32	-2.06	.04	0.11

As seen in Table 4, the dependent samples' *t*-test results show the existence of a statistically significant difference between the pretest and posttest scores for the overall scale and the sub-factor of interest-love $t(32) = -2.06$, $p = 0.04$; $t(32) = -4.06$, $p = 0.000$). Here the effect has been determined to be at a medium level for the overall scale ($\eta^2 = 0.11$) and at a high level for the sub-factor of interest-love ($\eta^2 = 0.34$). Meanwhile, no statistically significant difference was found between the pre and posttests of the other sub-factors on the Mathematical Attitude Scale: $t(32)= -.41$, $p= 0.67$ for fear-trust, $t(32) = -1.10$, $p = 0.28$ for profession and giving importance, and $t(32) = 0.70$, $p = 0.48$ for pleasure.

Qualitative Findings

The freshmen's views were collected in writing during the various stages of the experimental process (before, during, and after), and some adjustments were made to the experimental process based on their views. Approximately 70% of participants' views were similar. For example, 10 freshmen stated that they wanted to know more about how problem posing would be done after receiving general information about it. Accordingly, the definition of problem posing and how it would be done were addressed in greater detail. Throughout the experiment, the freshmen's feedback focused on needing more practice with problem posing activities. At the end of the experiment, their feedback was concentrated on how to use more things in the problem posing process, such as games, materials, and creative ideas. Freshmen's statements fell under two main categories: the affective and the cognitive dimension. Explanations regarding these dimensions are as follows:

Affective dimension.

Before the experiment, some participants stated their inability pose problems whereas others admitted to being afraid of math class. Their views changed over the course of the experiment. By the end, they stated that their self-confidence had increased, that math class had become enjoyable, and that their belief in needing to make use of problem posing activities as a teacher had become stronger. These statements indicate that the experiment had been a positive impact on the freshmen's affective tendencies, such as self-confidence, attitude (enjoyment/taking pleasure), and being dutiful/responsible. These findings indicate that the statistically significant difference between pre and posttest scores on the attitude scale in favor of posttest scores are not random. For example, statements from freshmen S12, S15, and S30 have been summarized as follows:

Freshman S12's views:
I do not suppose I will be able to pose problems because I am scared of math and my foundation is insufficient. I start biting my nails when I hear the word math. (Pre-experimental process)
I enjoy math but am unable to do it. (During the experimental process)
I have become more able to do mathematical problem posing. (Post experimental process)

Freshman S15's views:
Math classes are boring. I do not think this will change with problem posing. (Pre-experimental process)
I consider problem posing to be important for my profession. (During the experimental process)
Math classes are no longer boring. (Post-experimental process)

Freshman S30's views:
I was not able to do math in high school. I do not believe I will have any success. I might need to know a lot of math to be an elementary school teacher. (Pre-experimental process)
Problem posing will help me be a good teacher. (During the experimental process)
I see the value in posing proper problems. I think my prejudices toward mathematics have decreased. (Post-experimental process)

Cognitive dimension.

Prior to the experiment, the freshmen stated that they expected to gain a more clear and concrete understanding upon completion of the problem posing activities and that math problems should be more logically consistent and mathematical operational fit into the logical framework. Additionally, some freshmen argued that math had no application in real life and that problem posing was therefore unnecessary (i.e., Freshmen S1, S4, S7, S10, S11, S12, S27, & S32) prior to the experiment. Freshman S11's statement is a salient example reflecting the general views held by freshmen.

I do not love math, and I do not think I'll be able to do any math-related activities. (Freshman S11, pre-experiment)

Prior to the experiment, six freshmen stated that a variety of opportunities and resources were available for professional life and that problem posing was therefore unnecessary (i.e., Freshman S16). Additionally, freshman S20 stated that problem posing contributes nothing to mental development. Short statements from freshman S16 and S20 are provided below:

I believe problem posing is unnecessary. Many resources are already available on the market for elementary school teachers. (Freshman S16, pre-experiment)

I do not like math, but I must use it for my profession. I do not think problem posing will contribute to my students' mental development. (Freshman S20, pre-experiment)

Freshmen's views were determined to have changed following the experiment's execution. During the experiment, freshmen began to be able to pose problems such that notice individual differences of their students' level, to have developed complex thinking, and to be able to notice students' mistakes (Freshman S21, freshman S22). In addition, they said that they had developed problem solving skills, were able to think analytically, had gained pre-teaching experience, learned how information depended on students' own levels, had gained greater mastery of the subjects, and had reinforced what they learned (Freshman S13, freshman S17). For example, the following statements made by freshmen S31 and S33 offer a general summary of the aggregate of participants' views:

While posing a problem, I need to be able to solve that problem and think logically. (Freshmen S31, during the experimental application process)

I feel I cannot create any questions using numbers. While creating problems, the information needs to be used logically and consistently, and must be appropriate to real life. (Freshman S33, during the experimental application process)

The freshmen stated that as a result of the experiment and problem solving activities, they had become able to associate mathematics with everyday life and had overcome their prejudices toward mathematics. In addition, they also stated that they had gained experience in their profession by using free problem posing while teaching, had learned how to identify students by the problems they themselves had posed, and were able to pose problems in-line with their interests and abilities. The views of freshmen S10, S31, and S6 summarize the above statements:

I can pose problems by using concrete concepts appropriate to real life. (Freshman S10, at the end of the experimental process)

I noticed that my problem solving skills had improved, and I had a developed a positive attitude toward both math and problem posing. (Freshman S31, at the end of the experimental process)

I think I have gained different points of view. As such, I believe I can pose different problems that address different levels and different learning types. By identifying with my students, I can form problems aligned with their interests. (Freshman S6, at the end of the experimental process)

Freshman S13's statements are included below to exemplify participants' cognitive experiences and development during the experimental process:

Math courses are now more active. Thanks to problem posing, I can see the mathematical relationship between information, and I have learned new concepts. (Pre-experimental process)

*I can pose problems by changing the numbers, but I want to find original ideas. (*During the experimental application process)

*The mathematical relationship among information needs to be established while posing problems (*Post-experimental process).

Discussion, Conclusion, Recommendations

Problem solving and, thus, problem posing skills are among 21st-century skills (Ananiadou & Claro, 2009). Owing to their importance, these skills are therefore expected by teachers to help students learn these skills. A similar situation also naturally applies to freshmen, which requires them to acquire these skills. However, the relevant literature frequently finds that freshmen are insufficiently versed in problem solving and problem posing (Dede & Yaman, 2005; Gonzales, 1994). In order to overcome this problem, it is recommended that freshmen be trained in dynamic teaching environments that incorporate problem solving activities so as to provide them the opportunity to think flexibly instead of undergoing a textbook-based education (see Gonzales, 1994). Moreover, research in the literature (see Frey, 2010; Özgen et al., 2017) shows problem posing skills to have a positive impact on attitude.

Problem posing activities are found in the mathematics curriculum of many countries owing to its importance (Silver, 2013) and have also been included in both middle school and high school mathematics teaching curriculum (Grades 1-8 and 9-12) in Turkey (see MEB, 2005, 2013, 2018a). Accordingly, it is further recommended that problem posing studies also be included in the attainments of elementary and high school mathematics curricula in Turkey (see MEB, 2018a; 2018b). Moreover, studies have also found problem posing teaching programs to aid in the positive development of a few affective tendencies, such as attitudes toward math, self-confidence, and in decreasing mathematical anxiety. Therefore, problem posing activities have been given precedence in the current study, and the effect that their incorporation in teaching has on freshmen's attitudes and opinions toward mathematics has been researched. The reason for this MEB considers teachers' attitudes to be among the general competencies of the teaching profession in addition to teachers' professional knowledge and skills (see MEB, 2017). Moreover, considering those studies indicating that teachers' attitudes toward mathematics have an impact on students' own behaviors and attitudes (e.g., Savaş et al., 2010), it is essential that freshmen develop positive attitudes toward their own math classes so that their future students may do the same. Accordingly, the finding that a teaching environment incorporating problem posing activities leads to a statistically significant difference in freshmen's overall scores on the Attitudes Toward Math Scale and their scores on its sub-factor of interest-love in favor of the posttest is important because teachers' attitudes toward teaching math shape their approach to math and how they design their units and lessons. In turn, students' attitudes toward mathematics are influenced (Aiken, 1970).

Additionally, the current study has found there to be no difference between the pre and posttest scores of the other sub-factors on the attitude scale. For example, freshmen's average pre and posttest scores on the fear-confidence subscale were 33 and 34, respectively. The source of freshmen's anxiety toward mathematics stems from their early years as students, as identified in their written responses, and this may be the reason for the closeness between scores. This is because the freshmen sometimes experience irritation during the experiment, because they knew where and how to start the problem posing activities, establishing relationships between concepts and operations, and assessing the accuracy of all the posed problems' processes. Anxiety toward math comprises both cognitive and affective components, with individuals stating to feel helplessness, intense frustration, and mental failure (Ashcraft & Faust, 1994). Moreover, the literature also indicated that Turkish had high levels of math anxiety regardless of grade level (see Dede & Dursun, 2008; MEB, 2005). It is therefore imprudent to expect all traces of negative past cognitive and affective experiences to be eliminated after a single learning experience incorporating short-term problem posing activities.

The average pre and posttest scores from the Attitudes Toward Math's *profession and giving* importance subscale were 32 and 33, respectively. Accordingly, the present study indicates no noteworthy change in scores related to freshmen's views on the usefulness of mathematics in their daily lives and in other disciplines, on knowing math well enough to be able to contribute to one's future professional life, and on considering math to be important. One reason for this could be because participants considered it important to understand mathematics prior to the problem posing study. The average pre and posttest scores from the attitude scale's pleasure subscale were 28 and 27, respectively. Considering that the highest score that can be obtained from this sub-dimension is 40, it is seen that pre-service teachers like mathematics in general because of problem posing activity (although the profession and materiality subscale is not at the level of pretest and posttest scores). Probably, they found the problem posing activities simple and enjoyable at the beginning of the experiment. When taking another look at the freshmen during the experiment (e.g., the 7th week), although they stated problem posing to be difficult, they also admitted that mathematics in general and problem posing in particular had become a fun endeavor.

The qualitative data corroborates this. For example, most freshmen stated problem posing to be an indispensable part of their professional lives and that problem posing helped improve their understanding of mathematics' real-life application (e.g., freshman S16). Freshmen's views in this vein are important, and freshmen holding such opinions are expected to exhibit this kind of a teaching approach in their future professional careers. This is also important for students' own development because mathematics' usefulness is not restricted to using real-life examples in math classes. Its importance extends to facilitating increased mathematical knowledge and contemplation during one's daily activities. This way, students gain the opportunity to understand and evaluate the world's economic, physical, and social dimensions (Atweh, 2007).

Lastly, the current study has determined that freshmen tended to pose problems containing superficial and simple relationships. For example, freshmen posed problems at basic levels, generally giving f(x) when f(a) is desired or giving g(x) when finding the resultant function of f(g(x)) is desired. Although this case shows that the participants implemented their problem posing requirements at the minimum level, they were expected to employ as many original ideas as possible, especially in free problem posing activities. This is because only when mathematical problem posing activities are carried out from an original point of view can they open the doors to flexibility and creativity (Arıkan, 2017). An implicit relationship was found between mathematical problem posing and creativity, and information about problem posing skills compared to creativity levels or also creativity levels compared to problem posing skills can be acquired (Krutetskii, 1969; Ellerton, 1986). Elementary freshmen wrote easily identifiable problems in any mathematics book, so they could not present original problems, and presented problems in the form of an exercise question. Bonotto (2013) reached a similar conclusion in his study in which Grade 5 students participated with a semi-structured problem posing strategy. However, considering the age of the participants and the problem posing strategy used was a little more difficult, considering the participants in our study to be teachers in the future, the problems posed in our study would be expected to be unique. On the other hand, due to the first-time participants were trained in problem posing, the dimension of originality was disabled in the evaluation of the problems in our study. The study has also determined freshmen to experience some serious problems associating quadratic equations and their graphs (parabolas) and making problems based on these. Conducting further research to identify and resolve the reasons for this and similar cases is recommended.

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