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The Effect of Scenario-Based Probability Instruction on the Problem-Posing Skills of Secondary School Students and Their Opinions about the Application

Olasılık Konusunun Senaryo İle Öğretiminin Ortaokul Öğrencilerinin Problem Kurma Becerilerine Etkisi ve Öğrencilerin Uygulamaya İlişkin Görüşleri

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ABSTRACT

This study examined the effect of scenario-based instruction of probability, one of the eighth-grade sub-learning areas of secondary school, on students' problem-posing skills. In addition, the opinions of eighth-grade students on the use of scenarios about probability instruction were also examined. The study was carried out in the 2018-2019 academic year. The study group consisted of 39 eighth-grade students studying in a secondary school in a city North of the Black Sea Region. Data collection tools used in the study were the Equivalence test, Problem-Posing Test, scenarios and activities prepared for the experimental group, and Semi-Structured Interview Form. Quantitative and qualitative approaches were used in the study. The research model was set as a pretest-posttest quasi-experimental model with a control group. Pretest and posttest were administered on the experimental and control groups. Equivalence test results of the experimental and control groups constitute the study's quantitative data. Quantitative data were analyzed with the SPSS 22.0 statistical program. Qualitative data of the study were obtained from Problem-Posing Test and Semi-Structured Interview Form. The study's qualitative data were analyzed using descriptive and content analysis from data analysis techniques. As a result of the study, both experimental and control group students were observed to be at a better level in the semi-structured problem-posing situation that could be solved using the given visual compared to the free and structured problem-posing situations. This study concluded that scenario-based mathematics teaching contributed positively to the problem-posing skills of the students, and the application had a positive effect on the students. For this reason, it is recommended to use the scenario-based instruction method in the problem-posing process in mathematics teaching.

Keywords: Probability, problem-solving achievement, problem-posing, secondary school student, student opinion

ÖZET

Bu araştırma ile ortaokul sekizinci sınıf alt öğrenme alanlarından olan olasılık konusunun öğretiminde senaryo ile öğretimin öğrencilerin problem kurma becerilerine etkisi incelenmektedir. Ayrıca sekizinci sınıf öğrencilerinin olasılık konusunun öğretiminde senaryoların kullanımı ile ilgili görüşleri de incelenmiştir. Araştırma 2018-2019 eğitim öğretim yılında gerçekleştirilmiştir. Araştırma grubunu Karadeniz Bölgesi' nin kuzeyinde bir ilde bulunan ortaokulda öğrenim gören 39, 8. sınıf öğrencisi oluşturmaktadır. Veri toplama araçları olarak denklik testi (DT), Problem Kurma Testi (PKT), deney grubunda kullanılmak üzere hazırlanmış senaryo ve etkinlikler ve Yarı Yapılandırılmış Görüşme Formu (YYGF) kullanılmıştır. Araştırmada nicel ve nitel yaklaşımlar kullanılmıştır. Araştırmanın modeli kontrol gruplu ön test son test yarı deneysel model olarak belirlenmiştir. Araştırmada deney ve kontrol grupları kullanılarak ön test ve son test uygulamaları yapılmıştır. Araştırmanın nicel verilerini deney ve kontrol gruplarının Denklik Testi sonuçları oluşturmaktadır. Nicel verilerin analizi SPSS 22.0 istatistik programı ile analiz edilmiştir. Araştırmada nitel veriler PKT ile YYGF'den elde edilmiştir. Araştırmanın nitel verileri nitel veri analiz tekniklerinden betimsel ve içerik analizi kullanılarak çözümlenmiştir. Araştırma sonucunda deney ve kontrol grubu öğrencilerinin verilen görsele uygun çözülebilen yarı yapılandırılmış problem kurma durumunda serbest ve yapılandırılmış problem kurma durumlarına göre daha iyi düzeyde oldukları görülmüştür. Bu araştırma ile senaryo tabanlı yapılan matematik öğretiminin, öğrencilerin problem kurma becerilerine olumlu katkı sağladığı ve uygulamanın öğrenciler üzerinde çoğunlukla olumlu bir etki bıraktığı sonucuna ulaşılmıştır. Bu nedenle matematik öğretiminde senaryo tabanlı öğretim yönteminin problem kurma sürecinde kullanılması önerilmektedir.

Anahtar Kelimeler: Olasılık, problem çözme başarısı, problem kurma, ortaokul öğrencisi, öğrenci görüşü

1. INTRODUCTION

In the theory of constructivism, one of the most important theories in education, the student is at the center, and the teacher is a facilitator and guide in learning. This theory emphasizes the student's learning, transferring what is learned to different situations, producing new solutions, and socializing. This approach has also been adopted in mathematics teaching in the Turkish Education System (i.e., Ministry of National Education [MoNE], 2013, 2016, 2018). One of the main objectives of the mathematics curriculum is to develop students' higher-order thinking skills such as reasoning, communication, association, and problem-solving. One of the

methods of developing these skills is to use scenarios in teaching. Scenario-based learning is based on the constructivist approach.

In scenario-based learning, the student is active and becomes an independent learner by getting opportunities to direct their own learning. The realization of this situation is the primary purpose of learning with scenarios (Delisle, 1997; Rybarczyk, Baines, McVey, Thompson, & Wilkins, 2007). In this learning method, learning is initiated by poorly structured problems related to real life. Scenarios should be of a quality that can attract students' attention and arouse their curiosity. The problem situation given in the scenario must be created so that it opens the way for the student to reach new knowledge by using their prior knowledge (Delisle, 1997). It should be ensured that the most appropriate and best solution for the problems in the scenario is found through teamwork and independent research processes (Gallow & Grant, 2000). 2003). The scenario-based learning method reveals and develops learning, imagination, and creative thinking (Snoek, 2003).

In the scenario-based learning process, teachers should make students question their learning processes by asking questions that will activate students' higher-order thinking skills (Akins & Crichton, 2003; Gallow & Grant, 2000). In scenario-based instruction, students' learning by doing allows their knowledge to be more permanent. Because this learning/teaching method provides an environment of learning by doing and experiencing what students need (Schank, Berman, & Macperson, 1999). According to Collins (1994), presenting organized information as "content in the form of a story" in scenario-based learning, giving the responsibility of learning to the learner, increasing their self-confidence by assigning an expert role, and needing information to solve the problem in the process make this method effective in learning. (Cited: Çelen, 2008).

In studies where the scenario-based learning/teaching method is applied (Haynes, Spence, & Lenze, 2009; Siddiqui, Khan, & Akhtar, 2008), this method helped in eliminating students' misconceptions and knowledge deficiencies, ensuring the permanence of learning, acquiring social skills, increasing reading comprehension skills, understanding the whole problem and establishing the relationship between the problem and real life.

In order to carry out problem-posing studies, first of all, it is necessary to know what the problem is. Developing problem-solving skills, which is one of the main aims of education, requires a series of operations. The problem-solving process starts with the correct expression and understanding of the problem. Polya (1973) states that the second stage is to do appropriate planning for the solution, that is, to determine an appropriate solution strategy, the third stage is to implement the determined solution strategies, and the final stage is to check the significance of the solution and the accuracy of the result. These processes are intertwined with each other. Mistakes made or matters neglected at one stage affect other stages as well. For this reason, the solution process should proceed by checking each step. On the other hand, today, it is not enough to solve the problems. This process should be extended and developed towards production and creation. Gonzales (1998) emphasized the importance of problem-posing by adding another step to Polya's (1973) four-stage problem-solving process. Studies involving problem-solving and problem-posing show that these two skills support each other (Stoyanova & Ellerton, 1996). Therefore, problem-posing activities have an essential role in developing students' problem-solving skills (Akay, 2006; English, 1998; NCTM, 1989, 2000; Silver & Cai, 1996).

There are different definitions of problem-posing in the literature. Tichá and Hošpesová (2009) define problem-posing as generating new problems or recreating a given problem, Leung (1993) as rearranging a given problem. In the theoretical framework presented by Stoyanova and Ellerton (1996), problem-posing situations are divided into three; free (unstructured), semi-structured, and structured. According to Ellerton (1996), problem-posing is a process based on mathematical experiences, enabling students to add their interpretations to concrete situations and create meaningful mathematical problems. In free problem-posing situations, students are simply asked to pose problems from natural or artificial events (Stoyanova & Ellerton, 1996; Stoyanova, 1997). In semi-structured problem-posing situations, an open-ended event is given to students. They are asked to formulate the problem using their knowledge, abilities, concepts, and patterns from their mathematical experiences and pose a problem suitable for the given open-ended situation (Stoyanova & Ellerton, 1996). Semi-structured problem-posing situations involve both flexibility and limitation (Kılıç, 2013). Finally, in structured problem-posing situations, teachers ask their students to pose problems that will enable them to use the specific problem-solving strategies they have developed (Stoyanova & Ellerton, 1996). According to Ev Çimen and Yıldız (2017), problem-posing activity in structured problem-posing is related to a given problem or the solution.

Studies show that problem-solving and posing in mathematics positively affect students' mathematics achievement and attitudes towards problem-solving (Dickerson, 1999; Silver & Cai, 1996). Problem-posing is

essential for mathematics lessons and activities (Abu-Elwan, 1999; Kılıç, 2013). Problem-posing encourages students to generate new ideas and thoughts on any given topic (Brown & Walter, 1990) and is an important key to mathematical exploration (Cai, 2003). In addition, the NCTM (2000) report recommends using new approaches and techniques, especially problem solving and posing tasks, in mathematics teaching.

In previous studies, problem-posing skills are associated with association and reasoning skills (Abu-Elwan, 2002; Akay, Soybaş, & Argün, 2006; Dickerson, 1999), problem-solving skills (Kojima, Miwa, & Matsui, 2013), and creativity (Bai, 2004; Mallart, Font, & Diez, 2017; NCTM, 2000); they develop these skills, and therefore it is necessary to include problem-posing. Most of the studies on problem-posing were conducted with primary and secondary school students (Abu-Elwan, 2002; Cankoy & Darbaz, 2010; Christou, Mousoulides, Pittalis, Pitta-Pantazi, & Sriraman, 2005; Gonzales, 1994; Silver & Cai, 1996; Stoyanova. & Ellerton, 1996; Turhan & Güven, 2014; Usta, Yılmaz, Kartopu, & Kadan, 2018) and teacher candidates (Akay & Boz, 2006; Kılıç, 2013; Silber & Cai, 2017). These studies stated that problem-posing increases students' mathematics achievement, self-efficacy, and motivation and makes significant contributions to reasoning, recognizing mathematical situations, and expressing them appropriately orally or in writing.

One of the crucial objectives of mathematics education is to help individuals develop their independent and creative thinking skills. Developing this skill requires developing probability-based thinking skills, which is a fundamental way of thinking. For this reason, probability has an important place in mathematics instruction (Fischbein, 1975). However, despite the importance of probability, the desired success in teaching the subject and related concepts could not be achieved in Turkey, as in many countries, for various reasons (Gürbüz, Çatlıoğlu, Birgin, & Erdem, 2010). Kazak (2009) states that many researchers reported various difficulties in teaching probability concepts, and as a result, teaching cannot be done effectively.

The studies in the literature stated that students have various misconceptions and error types about probability. Studies have shown that students have difficulties realizing conceptual learning due to the epistemological structure of probability. O'Connell (1999) found that students' mistakes are usually due to thinking of the probability value as negative or greater than one and not understanding the relationship between the probability of an event happening and not happening. According to Gürbüz (2006), the difficulties experienced by students in probability are as follows: difficulties in linguistic understanding of probability, difficulties in transferring practical applications to a mathematical structure, difficulties caused by the lack of logical reasoning, and the lack of belief that chance events can be analyzed from particular intuitive perspectives. Regarding the studies on probability, the reasons of why probability concepts cannot be understood (Sezgin-Memnun, 2008) are the inadequacy of prior knowledge and reasoning skills, misconceptions (Dooren, Bock, Depaepe, Janssens, & Verschaffel, 2003; Hayat, 2009), teacher attitudes and negative attitudes of students.

In the Mathematics Curriculum in Turkey (2018), the probability is in the eighth grade. Understanding probability requires more qualifications than other subjects in mathematics. According to Carter (2005), these qualities are careful, critical, intuitive, and deeper thinking, making logical guesses, having a solid mathematical language, and reasoning logically. In a study in which 6 and 9-year-old children and adults' intuitions about probability were examined (Schlottmann, 2001), it was found that children can understand probability and the expected value of an event and have similar intuitions with adults. In a study examining the change of the meanings attributed to the concept of randomness by 14 and 17-year-old students according to age (Batanero & Serrano, 1999), it was stated that age was not significant in understanding the concept of randomness and that the concept is a difficult concept to understand due to its epistemological structure. Many other concepts, such as sample space, probability of an event, and comparing probabilities, should be understood to understand the concept of randomness. Korkmaz (2005) stated that students who constantly deal with classical problems in the classroom might have difficulties in the face of probabilistic situations that require reasoning. In this context, testing whether the information obtained by reasoning is correct or not depends on a good understanding of probability.

The process of learning probability brings along high-level thinking processes that require reasoning. For this reason, it is thought that it is vital to use different teaching methods in probability teaching, in which the student actively participates in the process. Moreover, it is known that curricula aim to provide students with problem-posing skills. There are studies on problem-posing skills with different methods and different samples in the literature, but they are not enough. Therefore, in this study, the effect of scenario-based probability instruction on the problem-posing skills of eighth-grade students was examined and supported with student opinions. The unique value of this study is examining the effect of using scenarios in probability teaching/learning on the problem-posing skills of secondary school students and revealing the students'

opinions about the application. In this sense, it is thought that this study will bring a different perspective for primary and secondary school teachers in teaching mathematics and thus contribute to the relevant field.

1.1. Purpose of the Study

This study examines the effect of using scenarios in teaching probability, one of the eighth grade sub-learning areas of secondary school, on students' problem-posing skills and student opinions about the application. The scenario-based instruction method was applied to the experimental group (EG). The control group (CG) was instructed according to the activities of the current mathematics curriculum (MoNE, 2018). In this direction, the sub-problems of the study are given below.

1. Is there a statistically significant difference between ET scores of EG and CG?
2. What are the problem-posing skills levels of EG and CG students before and after the application?
3. What are the opinions of EG students regarding the use of scenarios in teaching probability?

2. METHODOLOGY

2.1. Research Model

Quantitative and qualitative approaches were used in the study. The study model was set as a pretest-posttest quasi-experimental model with a control group. In the quasi-experimental model, two ready-made groups are matched over certain variables and analyzed (Büyüköztürk, 2013). The study's quantitative data were obtained from ET, and the qualitative data were obtained from PPT and SSIF. In the study, the problem-posing skills of EG and CG students were measured twice, before and after the application, using PPT. An ET was applied to both groups before the application to check the equivalence of the two groups. The quantitative data obtained from this test was analyzed with SPSS 22.0 statistical program. The data obtained from the application made to measure the problem-posing skill levels of the students was analyzed with descriptive analysis, one of the qualitative data analysis techniques, and students' opinions were analyzed with content analysis.

2.2. Study Group

The study was carried out in the 2018-2019 academic year. There were 39 students in the study group, 14 girls and 25 boys, studying in the eighth grade of a secondary school in a province of the North Black Sea Region. There were 18 (7 girls and 11 boys) students in EG and 21 (7 girls and 14 boys) students in CG.

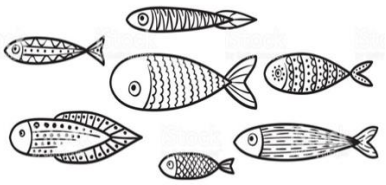
2.3. Data Collection Tools

The data collection tools used in the study consisted of the followings: the equivalence test (ET), Problem-posing Test (PPT) prepared to determine the effect of scenario-based instruction, scenarios & activities, and Semi-Structured Interview Form (SSIF) to collect the opinions of EG students about the applied method.

2.3.1. Problem-posing Test (PPT)

PPT was prepared by the researchers to evaluate students' problem-posing skills. The framework of Stoyanova and Ellerton (1996), consisting of free, semi-structured, and structured problem-posing situations, was used to create problem-posing situations. For the validity and reliability of the test, the opinions of two different experts were taken before the application, and a pilot study was conducted. PPT, which consists of 6 problems, two from each problem-posing category, has been finalized according to pilot study results and expert opinions. Students were asked to pose problems regarding the situations given in the test before and after the instruction. The problems in PPT have been prepared by the researchers, using Mathematics Teaching Program (MoNE, 2013, 2018) and mathematics teaching books (Altun, 2014; Baki, 2014, 2018; Baykul, 2014; Van De Walle, 2013). Table 1 shows the problems used in PPT. The achievements about probability in the Mathematics Curriculum (MoNE, 2018) are as follows: "identifies the probability related to an event," "distinguishes "more," "equal," "less" probable events and gives examples," "explains that in events with equal chances the value of each output is equal, and this value is 1/n", "tells that the probability of an event is between 0 and 1 (including 0 and 1)" and "calculates the probability of a simple event."

Table 1. Problem Situations Used in PPT

Free problem-posing	Semi-structured problem-posing	Structured problem-posing
Pose a problem involving equal probability and solve it.	Pose and solve a probability problem in line with the given picture. 	Aslı has 2 genuine 1 TL in her hand. Aslı tossed these coins at the same time and noted the results. Aslı, who tossed them 79 times in total, observed the following results; 25 times Tail –Tail, 17 times Tail – Heads, 23 times Heads – Heads, 17 times Tail – Heads, 23 times Heads – Heads, 14 times Heads – Tail According to these observations, what is the probability of getting heads-tail in the 80th toss? Pose and solve a problem similar to the one above.
Pose a problem related to the impossible event in probability and solve it.	Pose and solve a probability problem whose result is 0.	It is known that a quarter of 180 eggs in a basket are broken. Calculate the probability that a randomly taken egg from this basket will be broken. Pose and solve a problem similar to the one above.

2.3.2. Semi-Structured Interview Form (SSIF)

SSIF was applied to EG students to get their opinions about the application. The students were asked ten open-ended questions, and they were asked to give their answers in writing (see Appendix 1.).

2.3.3. Scenarios and Activities

Three scenarios and three activities were applied in EG to examine the effect of scenario-based probability instruction on students' problem-posing skills. Examples of scenarios and activities applied in EG are given in Appendix 2.

2.4. Experimental Work Process and Data Analysis

In determining the groups, the researchers first prepared ET consisting of 20 multiple-choice items by taking expert opinions; the item analyses of the test were made using the TAP program. The test was prepared in line with the achievements of the Mathematics Curriculum (MoNE, 2018). A pilot study was conducted with 104 eighth-grade students from a public and a private school in the Black Sea Region. Regarding pilot study results, the discrimination level of the questions was above 0.15, and it was decided to use the 20-question test as ET. The Cronbach's Alpha reliability coefficient of ET was found to be .873. After the administration of ET, two equivalent groups were determined, and one of them was set as EG and the other as CG by drawing lots. The scenarios and activities prepared by the researchers were implemented in EG by one of the researchers in mathematics lessons. The scenario-based instruction method was applied to EG. On the other hand, CG followed the activities included in the current secondary school mathematics curriculum (MoNE, 2018). The researcher attended the lessons of CG as an observer. The application was completed in 12 lesson hours for each group.

EG was divided into heterogeneous groups, with 4 or 5 students in each group. The classroom setting has been rearranged to facilitate group members' communication and let them work comfortably. Before the lesson, the students were informed about the scenario-based instruction method, and the tasks that the teacher and students should do during the study were explained. Three scenarios and three activities were carried out in EG. PPT was administered to EG and CG students twice, before and after the application, as pretest and posttest. SSIF was applied to find out the opinions of EG students about the application. 10 open-ended questions were asked to the students, and they were asked to express their answers in writing.

The study's qualitative data were analyzed using descriptive and content analysis from qualitative data analysis techniques. The main objective of content analysis is to reach the concepts and relationships that will explain the collected data. Concepts and themes missed by a descriptive approach can be discovered by content analysis. For this, data is conceptualized, logically arranged, and the themes that describe the data are identified (Yıldırım & Şimşek, 2008). SSIF was used to find out the opinions of EG students, who were taught according to scenario-based instruction, about the process. The researchers prepared the form in which the students evaluated themselves and the teaching with scenario-based instruction during the experimental study and reflected their opinions on the applied method. In order to analyze the answers given to this form, categories and subcategories were created according to student answers, and content analysis was performed. The data obtained from this study were coded separately by the researchers and divided into categories and subcategories. The agreement rate was calculated according to the Miles and Huberman formula (1994) and was 91%. For the difference, the researchers came together and reached an agreement. The questions of PPT were prepared using Stoyanova and Ellerton's (1996) framework, consisting of free, semi-structured, and

structured problem-posing strategies. The problems were analyzed by descriptive analysis, using the classification created by Ünlü and Sarpkaya Aktaş (2017). Figure 1 shows this classification.

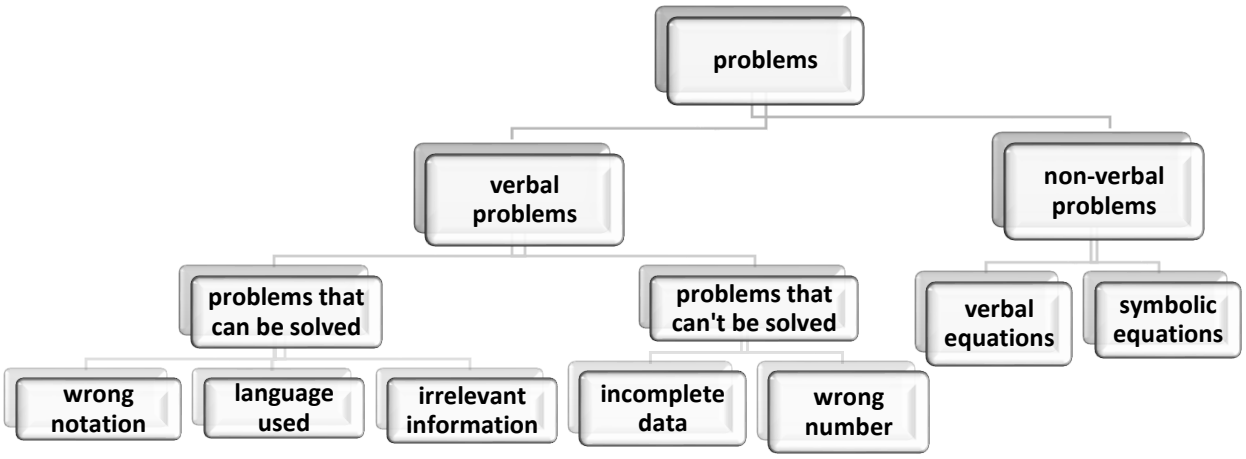


Figure 1. Ünlü and Sarpkaya Aktaş's (2017) Classification of Problems Framework

3. RESULTS and INTERPRETATION

In this part, the sub-problems of the study are presented in sections by including the findings and interpretation of the data.

3.1. Equivalence Test Results

t-test results comparing the equivalence of EG and CG are given in Table 2.

Table 2. t-test Results of EG and CG's ET scores

Group	N	$\bar{X}$	sd	t	p
CG	20	15,15	4,332	-,846	.403
EG	20	14,15	3,031		

As a result of the independent samples t-test performed between EG's and CG's ET scores, p was calculated as .403. Since the p-value is greater than .05, it was concluded that there was no significant difference between EG and CG before the application. [t (38) = -. 846, p = .403> .05]. So, it can be said that EG and CG were equivalent before applying scenario-based instruction.

3.2. Findings Related To The Second Sub-Problem And Interpretation

The second sub-problem of the study is " What are the problem-posing skills levels of EG and CG students before and after the application?". Accordingly, the findings on the answers of EG and CG students for the problem-posing situations in PPT are given below.

3.2.1. Findings of Free Problem-Posing (FPP) - Questions 3 & 5

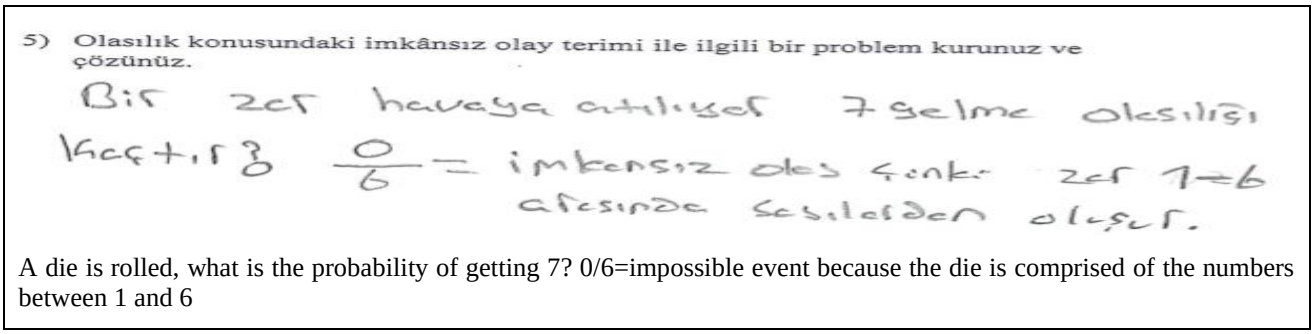
Two questions (questions 3 and 5) were asked in PPT to test FPP situations. In these questions, students were asked to freely pose problems that could be solved using probability knowledge before and after the application. Non-verbal problems were not seen in the problems posed by the students; thus, the classification included only "verbal" problems and the ones that are "not a problem." Classification of EG's and CG's' data regarding FPP situations and frequency and percentage distributions for each category are given in Table 3.

Table 3. Frequency and Percentage Distribution of EG's and CG's Pretest and Posttest Data for FPP situations

Tests	Group	FPP (ques.)	Verbal Problems								Not a Problem	
			Problems That Can Be Solved				Problems That Cannot Be Solved					
			Daily language		Wrong Notation		Incomplete Information		Incorrect Number			
			f	%	f	%	f	%	f	%	f	%
Pretest	CG	3rd	5	23.80	-	-	2	9.54	-	-	14	66.66
		5th	2	9.52	1	4.77	-	-	-	-	18	85.71
	EG	3rd	1	5.55	1	5.55	-	-	-	-	16	88.90
		5th	1	5.55	-	-	-	-	-	-	17	94.45
Posttest	CG	3rd										
		5th	3	14.30	2	9.53	-	-	3	14.30	13	61.87
	EG	3rd	8	38.09	1	4.76	-	-	1	4.76	11	52.38
		5th	13	72.22	1	5.55	-	-	-	-	4	22.22
		3rd	10	55.55	-	-	1	5.55	-	-	7	38.88

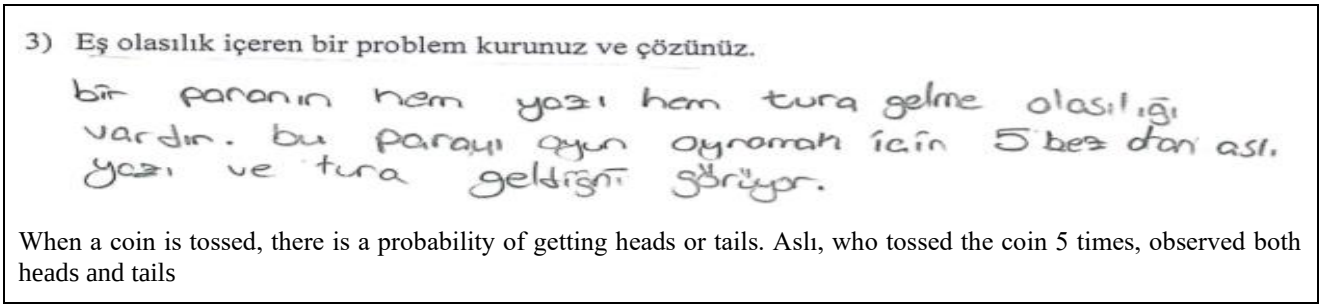
-: No data in the relevant category

The findings of the free problems posed by EG and CG students are given in Table 3. The review of Table 3 shows that the posttest data of all students in FPP situations is better than the pretest data. Besides, regarding Table 3, solvable problems posed by EG students as a result of scenario-based instruction are at a better level than the ones of CG. Similarly, a considerable decrease was observed in the number of problems that are "not a problem" and "cannot be solved" in EG's posttest data (30.55%) compared to their pretest (91.68%). From the pretest data of Table 3, it can be seen that students did not pose any non-verbal problems in FPP, but they posed verbal problems and problems that are not a problem. Regarding posttest data, 14 CG students (33.34%) and 24 EG students (66.66%) posed a solvable problem. Similarly, in the posttest, 4 students (9.53%) of CG posed unsolvable problems (sentences without problems) due to the use of incorrect numbers, and 1 student (2.77%) of EG due to the missing information. Based on these findings, it can be said that scenario-based instruction applied in EG was beneficial in enabling the FPP of the students. Figure 2 illustrates a verbal problem in daily language that can be solved, posed by one of the CG students in the posttest, and Figure 3 illustrates a problem that is not a problem posed by a CG student in the pretest.



A die is rolled, what is the probability of getting 7? 0/6=impossible event because the die is comprised of the numbers between 1 and 6

Figure 2. FPP Verbal Problem Example in Daily Language That Can Be Solved, Posed by A CG Student in The Posttest



When a coin is tossed, there is a probability of getting heads or tails. Aslı, who tossed the coin 5 times, observed both heads and tails

Figure 3. FPP Example That is not a Problem, Posed by a CG Student in The Pretest

3.2.2. Findings of Semi-Structured Problem-Posing (SSPP)- Questions 1 & 2

Two questions (questions 1 and 2) were asked in PPT to examine SSPP situations. Students were asked to pose semi-structured problems that could be solved using probability knowledge before and after the application in the SSPP situation. The problems posed by the students were classified as verbal problems, non-verbal problems, and not a problem. Frequency and percentage distributions of each category are given in Table 4.

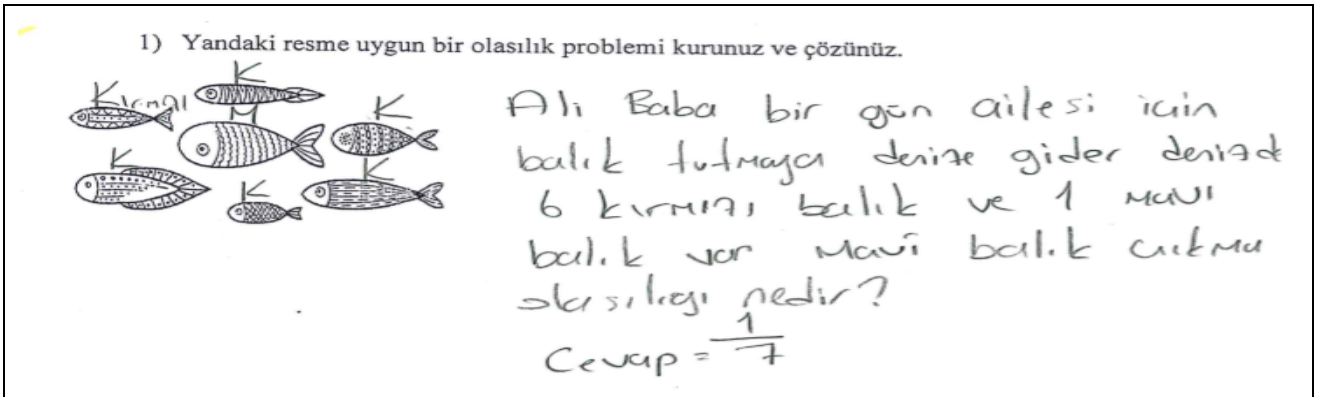
Table 4. Frequency and Percentage Distribution of EG's and CG's Pretest and Posttest Data for SSPP situations

Test	Group	SSPP (q.)	Verbal Problems												Non-Verbal Problems		Not a Problem	
			Problems That Can Be Solved								Problems That Cannot Be Solved				Verbal Equations			
			Daily language		Symbolic and daily language		Wrong Notation		Irrelevant Information		Incomplete Information		Incorrect Number					
			f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
Pre test	CG	1st	5	23.83	-	-	-	-	-	-	4	19.04	-	-	-	-	12	57.12
		2nd	8	38.10	-	-	-	-	1	4.76	1	4.76	1	4.76	1	4.76	9	42.84
	EG	1st	1	5.55	-	-	-	-	1	5.55	3	16.66	-	-	-	-	13	72.22
		2nd	2	11.11	-	-	-	-	1	5.55	1	5.55	1	5.55	-	-	13	72.22
Post test	CG	1st	-	-	5	27.77	-	-	-	-	3	16.66	-	-	1	5.55	12	66.66
		2nd	-	-	7	33.33	1	4.76	-	-	2	9.52	1	4.76	-	-	10	47.61
	EG	1st	9	50.00	-	-	-	-	3	16.66	-	-	-	-	-	-	6	33.33
		2nd	5	27.77	-	-	2	11.11	-	-	3	16.66	-	-	-	-	8	44.44

-: No data in the relevant category.

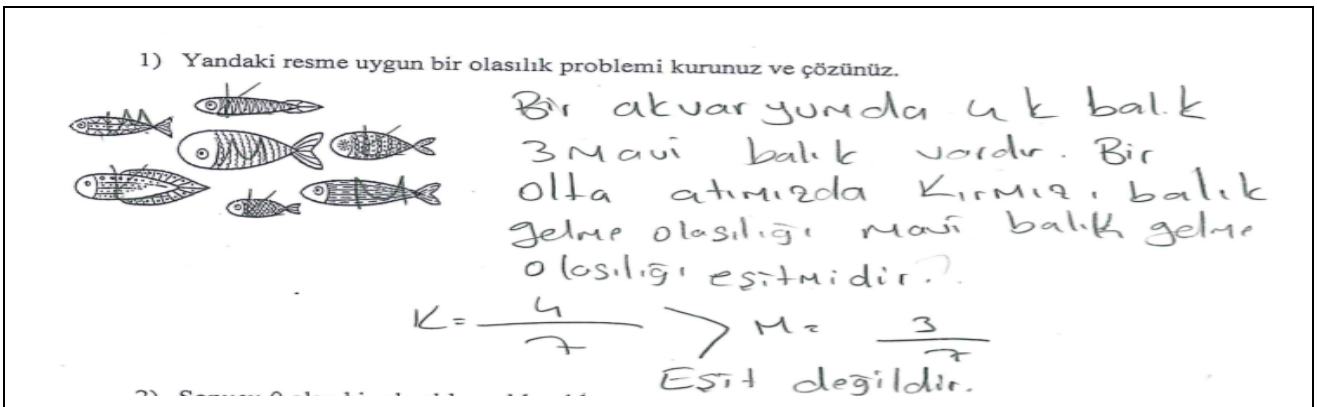
Regarding the categories of "problems that cannot be solved" and "not a problem" together in Table 4, the posttest data of EG (17 students - 47.22%) was observed to be at a better level than the pretest (31 students - 88.48%). On the other hand, the posttest data of CG (31 students- 72.60%) was similar to the pretest (27 students- 64.26%). Regarding the sum of the "problems that cannot be solved" and "not a problem" categories from Table 4, the pretest data of both groups were observed to be quite close to each other; however, improvements were observed in the posttest data of EG. Moreover, regarding posttest data of "problems that cannot be solved," 26.18% of CG students were observed to fail to pose problems due to missing information, whereas only 16.66% of EG students failed to pose problems due to missing information in the second question. The incorrect number was only observed in the second question of EG's pretest data but not in the posttest data.

According to the pretest data, the number of problems that can be solved verbally was relatively low in EG (5 students- 13.88%) compared to CG (14 students- 33.35%). However, regarding posttest data, the number of students who can pose solvable problems increased to 19 (52.77%) in EG, whereas the number of students who posed solvable problems decreased to 13 (32.93%) in CG. According to this finding, it can be said that the SSPP of EG students was better than CG students. In the light of the data in Table 4, it can be concluded that scenario-based instruction contributed to EG students' SSPP in probability. Regarding the structure and solution of the problems, they were classified as "daily language" because they were associated with daily life and narrated, and "problems that can be solved" because the numbers used and the results obtained were logical and realistic. Quotations from EG students' problems are given in Figures 4, 5, and 6. In Figure 6, the student did not check whether the problem he had posed was solvable; thus, he overlooked the missing information and could not establish a solvable problem under the given situation.



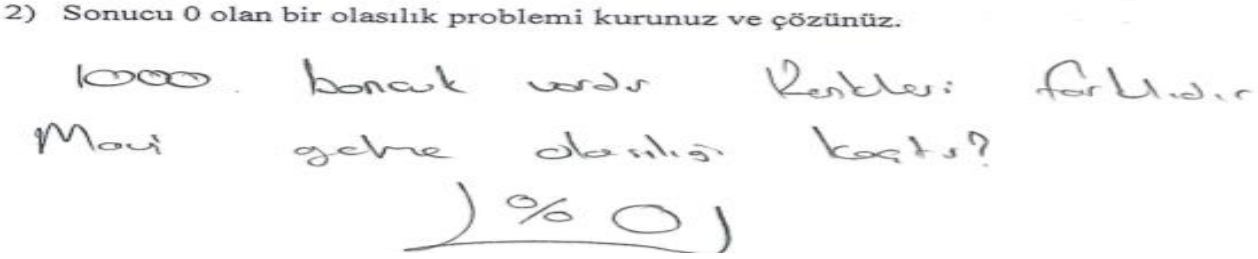
Ali Baba went to the sea to fish for his family. There are 6 red and 1 blue fish at sea. What is the probability of fishing the blue fish? Answer = 1/7

Figure 4. An Example of Verbal, Solvable, Daily Language SSPP Posed by an EG Student in The Posttest



There are 4 red and 3 blue fishes in an aquarium. When we cast a fishing pole, is the probability of getting a red fish equal to the probability of getting a blue fish. K= 4/7 > M=3/7.They are not equal.

Figure 5. An Example of Verbal, Solvable, Daily Language SSPP Posed by an EG Student in The Posttest



There are 1000 beads of different colors. What is the probability of getting a blue bead? 0%.

Figure 6. An Example of Verbal, Unsolvable, SSPP with Missing Information Posed by an EG Student in The Posttest

3.2.3. Findings of Structured Problem-Posing (SPP) - Questions 4 & 6

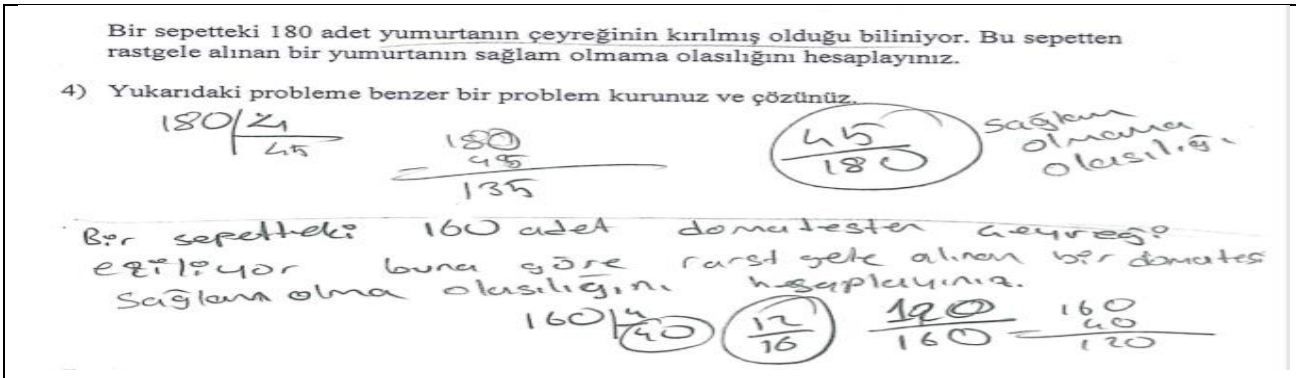
Two questions (questions 4 and 6) were asked in PPT to examine SPP situations. In these questions, students were asked to pose structured problems that could be solved using probability knowledge before and after the application. As no non-verbal problem was observed among the problems posed by the students, they were classified as "verbal problems" and "not a problem." Frequency and percentage distributions of the categories are given in Table 5.

Table 5. Frequency and Percentage Distribution of EG's and CG's Pretest and Posttest Data for SPP situations

Tests	G.	SPP(q.)	Problems That Can Be Solved						Problems That Cannot Be Solved				Not a Problem	
			Daily Language		Symbolic and daily language		Wrong Notation		Incomplete Information		Incorrect Number			
			f	%	f	%	f	%	f	%	f	%	f	%
Pretest	CG	4th	1	4.76	-	-	1	4.76	2	9.52	-	-	17	80.95
		6th	-	-	-	-	1	4.76	-	-	-	-	20	95.23
	EG	4th	-	-	2	11.11	2	11.11	-	-	1	5.55	13	72.22
		6th	-	-	1	5.55	-	-	-	-	-	-	17	94.44
Posttest	CG	4th	4	19.04	-	-	-	-	2	9.52	-	-	15	71.44
		6th	1	4.76	2	9.52	-	-	1	4.76	-	-	17	80.95
	EG	4th	6	33.35	-	-	-	-	1	5.55	1	5.55	10	55.55
		6th	7	38.88	-	-	-	-	4	22.24	-	-	7	38.88

-: No data in the relevant category.

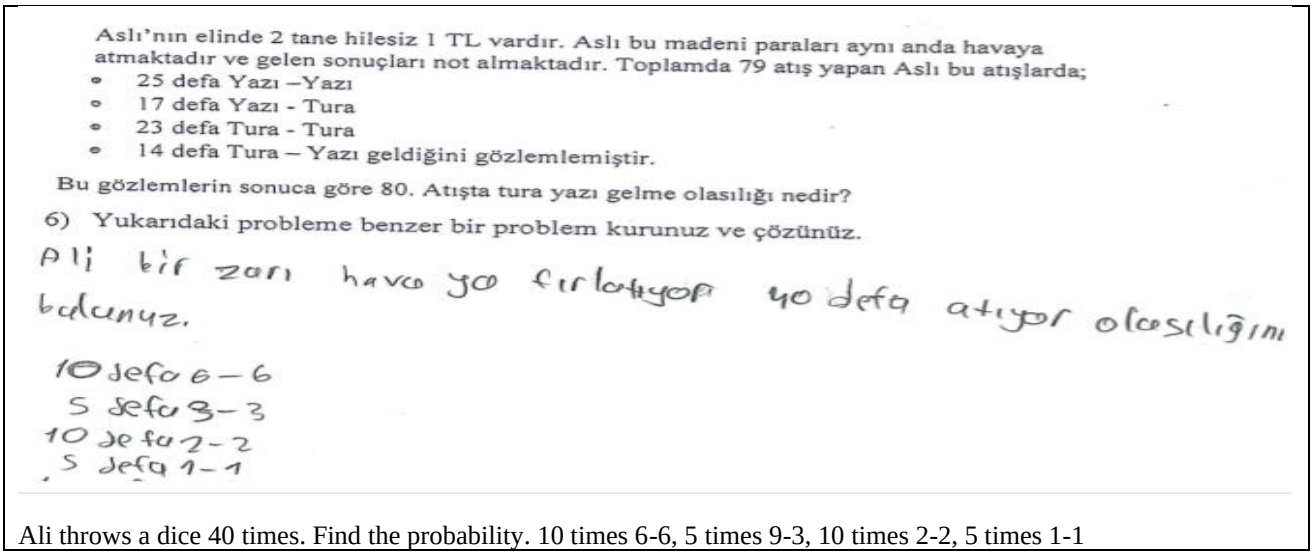
Regarding Table 5, no significant decrease was observed in "not a problem" situations between pretest (%88.1 - 37 students) and posttest (%76.20 - 32 students) of CG. Regarding pretest (83.33% - 30 students) and posttest (47.21% - 17) data of EG, an improvement was observed on the number of "not a problem" situations in the posttest; therefore, it can be said that "not a problem" situations were significantly decreased. EG's post-test data (36.11% - 13 students) was better than CG (16.66% - 7 students) regarding solvable problem situations. In EG, 2 students were observed to pose a problem using the wrong notation in the category of solvable problems in the pretest, while in the posttest data, no student posed a problem in the wrong notation category. In the posttest, 13 EG students were observed to pose structured problems in daily language, and 7 CG students posed problems in daily and symbolic language. It can be said from Table 5 that EG students are at a better level in SPP than CG students and scenario-based instruction in EG was beneficial for students on SPP. The quotation reflecting the answer of an EG student in the SPP posttest is shown in Figure 7.



A quarter of 160 tomatoes in a basket are squeezed. Accordingly, calculate the probability that a tomato randomly taken from the basket will be good

Figure 7. An example of verbal, solvable, daily language SPP posed by an EG student in the posttest

Figure 8 shows an example of a verbal problem with missing information that could not be solved posed by an EG student in the posttest. The problem was evaluated as a verbal problem as the student tried to narrate it. However, it was not understood what had been asked due to the missing information in the problem. Therefore, the problem given in Figure 8 is an example of SPP that has been evaluated in the verbal but unsolvable category due to missing information.



Ali throws a dice 40 times. Find the probability. 10 times 6-6, 5 times 9-3, 10 times 2-2, 5 times 1-1

Figure 8. An example of verbal, unsolvable, SPP with missing information posed by an EG student in the posttest

3.3. Findings of the Third Sub-Problem and Interpretation

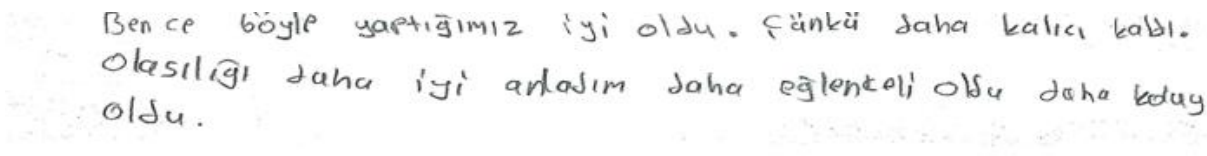
The findings obtained from " What are the opinions of EG students regarding the use of scenarios in teaching probability " are shown in Table 6.

Table 6. The opinions of students regarding the use of scenarios in the instruction of probability

Categori	Code	Sub-code	f	Overall (%)
Positive Opinions	Scenario Design	The relationship with the subject is well established	2	18 (10.46)
		Motivating, pleasant, and interesting	9	
		Fun	5	
		Illustrative	2	
	Effect on Learning the Subject	More permanent knowledge	9	21 (12.21)
		Allows to solve more questions	1	
		Good understanding of probability	11	
	Effect on Affective Learning / Socializing	Increases motivation	3	31 (18.02)
		Increases interest-enjoyable	5	
		Allows them to express better	4	
		Comfortable learning	2	
		Allows helping each other/ Sharing	8	
		Strengthens the bond between friends	2	
		Makes feel better / ask questions comfortably	4	
		Increases self-confidence / creates excitement	2	

		Increases the belief that they can solve daily life problems involving probability	1	
	Teamwork	Covers the views of all students	4	38 (22.10)
		Discussion contributes to learning / Facilitates learning	13	
		Teaches the features of teamwork and the rules to be considered in teamwork	5	
		Gaining group awareness	1	
		Working together / Deciding on solutions together	10	
		Revealing different solutions	1	
		Teamwork is fun	2	
		Allows to ask more questions to the teacher and friends in the group	2	
	Opinions on the Application and Continuation of the Application	Fun and easy to apply	3	25(14.54)
		The applications spread over a long period	3	
		Good guidance from the practitioner/ shows direction	8	
		Applying scenarios-based instruction in the instruction of other subjects of mathematics	8	
		The positive contribution of teamwork to lessons	3	
	Comparison of the Current Curriculum-based Instruction with Scenario-based Instruction	Scenarios-based instruction is more understandable	3	25 (14.53)
		Scenarios-based instruction allows discussion and expressing ideas	2	
		Previous mathematics lessons were challenging and incomprehensible	4	
		Better understood than previous subjects	3	
		Not too much writing in the notebook	2	
		Lessons are more fun	2	
		Applying scenarios-based instruction in other subjects	3	
		Teamwork and discussion of problems	2	
		Instruction of the course with daily life problems	1	
		Allows to speak and discuss	2	
		Active students	1	
Negative Opinions	Effect on Affective Learning/Socializing	Boring	2	4 (2.32)
		Not liked the sudden change of instruction style	2	
	Teamwork	Occurrence of conflicts	4	6 (3.50)
		Noise	2	
	Opinions on the Application and Continuation of the Application	Many questions should be solved	1	1 (0.58)
	Comparison of the Current Curriculum-based Instruction with Scenario-based Instruction	Mathematics lessons were more effective before the application	2	3 (1.74)
		Desiring not to teach the lessons with scenarios	1	
		Overall (%)		172 (100)

It is seen from Table 6 that 91.86% of students' opinions are positive. 22.67% of them consist of opinions about scenario design, scenario-based instruction of the course, and the contribution of the scenarios to the instruction of the subject. Students stated that the relationship between the scenarios and the subject was well established, the instruction was explanatory and understandable, and scenario-based instruction made the courses more enjoyable. In addition, other student opinions include; scenario-based instruction of the subject provides more permanent knowledge, allows to solve more questions in the lesson, and provides a good understanding of probability. A quotation supporting this is given in Figure 9.

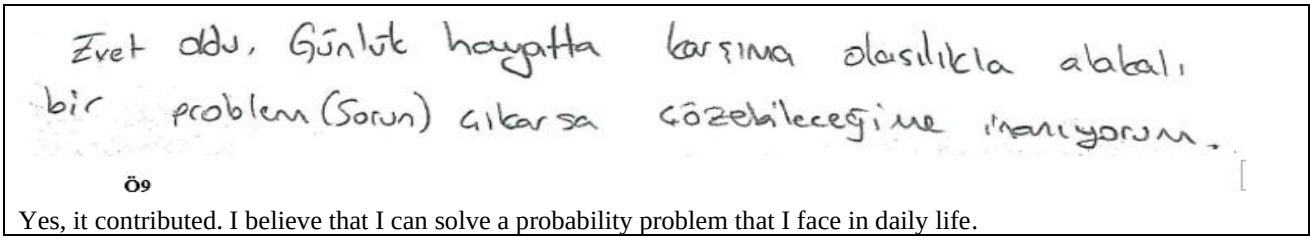


Ö2

It is good to perform in this way because it is more permanent. I understood probability better; it was more fun and more straightforward.

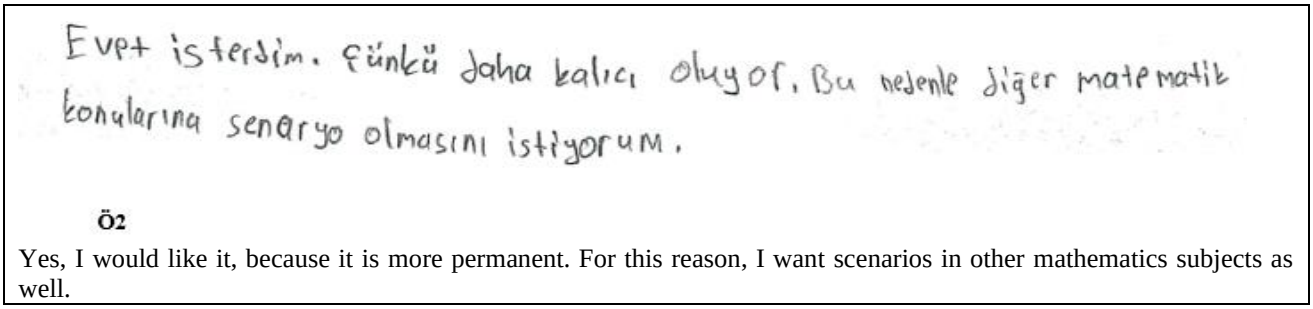
Figure 9. Positive opinion of S2

18.02% of the opinions of EG students indicate that scenario-based instruction contributes to the affective domain and socialization. The quotation illustrating this is given in Figures 10 and 11.



Yes, it contributed. I believe that I can solve a probability problem that I face in daily life.

Figure 10. Positive opinion of S9

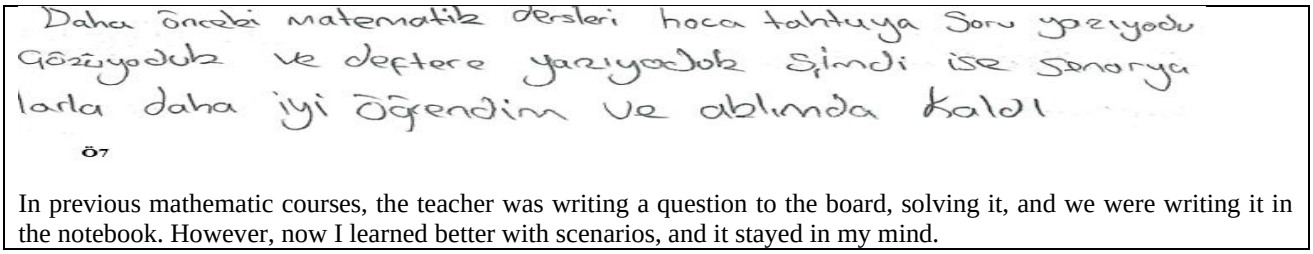


Yes, I would like it, because it is more permanent. For this reason, I want scenarios in other mathematics subjects as well.

Figure 11. Positive opinion of S2

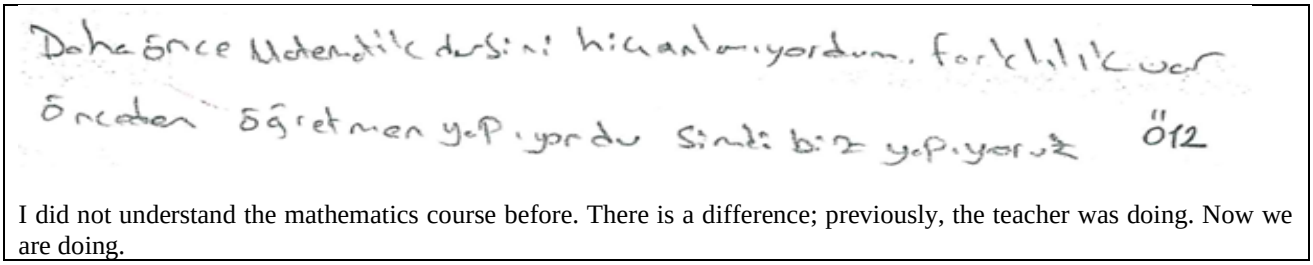
One of the positive opinions (22.10%) in Table 6 is that teamwork has made various contributions to students. Students stated that they learned being and working in a team, working together and deciding on solutions together.

29.07% of the students' opinions from Table 6 are related to the application, positive opinions regarding the program's continuation, and comparing the instruction based on the current curriculum with scenario-based instruction. Accordingly, students stated that they wanted to apply this in other mathematics subjects and allow more teamwork. Figure 12 and Figure 13 show students' quotations.



In previous mathematic courses, the teacher was writing a question to the board, solving it, and we were writing it in the notebook. However, now I learned better with scenarios, and it stayed in my mind.

Figure 12. Positive opinion of S7



I did not understand the mathematics course before. There is a difference; previously, the teacher was doing. Now we are doing.

Figure 13. Positive opinion of S12

10.14% of students' opinions in Table 6 are negative. Accordingly, students suffered from the sudden change of instruction style, the disagreements in the teamwork, and the noise, thus they were not felt positive about scenario-based instruction. However, S11 stated that he does not want to address different mathematics subjects through scenarios because *he understands the course better when narrated. However, he was unsure whether he asked for it because he was accustomed to the classical instruction of mathematics courses until now*.

4. CONCLUSION and DISCUSSION

This study aimed to examine the effect of using scenarios in teaching probability to secondary school students on their problem-posing skills. In addition, the opinions of EG students about the application were also taken. Accordingly, it is possible to summarize the results obtained from the findings of this study under two headings.

4.1. The Effect of Scenario-Based Instruction on Students' Problem-Posing Skills

In this study, the effect of the scenario-based instruction method on students' problem-posing skills was examined before and after the application. For this purpose, Stoyanova and Ellerton's (1996) framework consisted of free, semi-structured, and structured problem-posing strategies and the classification created by Ünlü and Sarpkaya Aktaş (2017) were used in the analysis of the prepared problems.

Regarding the overall evaluation of free problem-posing situations, the posttest data of both EG and CG were observed to be better than their pretest data. EG was found to be more successful than CG in the "problem that can be solved," "problem that cannot be solved," and "not a problem" categories. It was observed that both groups were able to pose verbal, solvable problems but failed to pose non-verbal problems; verbal solvable problems mainly belonged to the daily language classification, and unsolvable problems resulted from incomplete information and wrong number usage. Similar results occurred in semi-structured and structured problem-posing situations as well. Accordingly, it can be said that EG students' semi-structured and structured problem-posing status was better than CG students.

Regarding the overall effect of scenario-based instruction on students' problem-posing skills in probability, it was observed that students mostly posed verbal problems using daily language. According to the posttest data, it was found that EG students were able to establish probability problems according to the given problem situation. Regarding the problems posed by EG students, they generally consist of the problems that can be solved verbally and posed using daily language. The problems that could not be solved were generally due to incomplete information and wrong numbers usage. It can be said that this is because students did not check whether the problems they posed were solvable or not. Students often had difficulties expressing the problems they could associate with their daily lives in symbolic language. A similar result is seen in the studies of Akkan, Çakıroğlu, and Güven (2009). They reported that sixth and seventh-grade students had difficulties switching from daily language to symbolic language. EG and CG students were better at semi-structured problem-posing that can be solved according to the given image than free and structured problem-posing situations. According to these results, it can be said that scenario-based instruction has a positive effect on the problem-posing skills of EG students.

Çetinkaya (2017) stated that students wrote down the cases they encountered in their daily lives and posed problems with this information; Tertemiz (2017) reported that elementary school students could pose problems with mathematical phrases requiring four operations with natural numbers. Tertemiz and Sulak (2013) stated that students could pose problems with basic-level information. Hence, the results of the studies conducted by Çetinkaya (2017), Tertemiz (2017), and Tertemiz and Sulak (2013) are parallel to the results of this study.

In this study, it was concluded that EG and CG students could pose verbal, solvable problems. However, in the study conducted by Işık and Kar (2015), the verbal problem-posing skills of sixth-grade students were found to be low, which is a result contradictory to the results of this study.

4.2. The Effect of Scenario-based Instruction on Students' Opinions

Scenario-based instruction practice positively affected EG students' opinions about the application. The vast majority of students stated that scenario-based instruction facilitated learning, made it meaningful, and made their knowledge permanent. A similar result was reported by Schank, Berman, and Macperson (1999). Students stated that they learned more easily through teamwork, they were allowed to express themselves, they could easily ask questions to their friends in the team and teachers, and they could easily express their ideas, their motivation and interest in the course were increased, and the course was more fun and instructive (Kindley, 2002). The studies conducted by Rybarczyk et al. (2007) and Özcan (2007), in which students described themselves as active learners, support this study's result. The most striking statements of the students who compared the instruction based on the current mathematics curriculum with the application made with scenarios are as follows. "The teacher used to do it before, now we are doing it, we learn more easily with this method, now I can solve probability questions while I can't solve the questions of other subjects, I learned the role of probability in my daily life, now I come to classes more willingly and enthusiastically, I would like this method to be applied in other subjects of mathematics."

There are also very few students who had negative thoughts about the method. However, while expressing these thoughts, students stated that they could not get used to the method because it was new or thought like this because they were very used to the old method. As it can be understood from the students' opinions,

teaching with scenarios had created positive opinions on the majority of the students. Students' opinions about the application were also supported by the positive results obtained for their problem-posing skills.

5. SUGGESTIONS

This study found that scenario-based mathematics teaching positively contributed to students' problem-posing skills about probability and that the application positively affected students' opinions. For this reason, it is recommended to use the scenario-based instruction method in the problem-posing process in mathematics teaching. In addition, scenario-based learning methods can be applied in different mathematics subjects with problem-posing approaches at different grade levels, and the results can be compared.

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Appendix 1.

Semi-Structured Interview Form (SSIF)

1) What do you think about instructing probability with scenarios? Can you explain?
2) Did the use of scenarios on probability have any effect on your learning about the subject? If yes, what effect did it have? Did you like the lessons taught with scenarios? Can you explain your answer?
3) Which scenario did you like the most in this work? Can you explain why?
4) What did you learn from the teamwork?
5) Did you have difficulty in teamwork? At what stage did you struggle? Can you explain?
6) Did group work help you in any way? If so, what contribution did it make? Can you explain your answer?
7) How are math classes taught in general? Do you think there is a difference between the lesson that uses scenarios to teach probability and any mathematics lesson taught in general? What is the difference, if any? Can you explain your answer?
8) Did you encounter any challenges during the application and work? What challenges did you encounter? What do you think might be the reason for this challenge?
9) Do you want other mathematics topics to be taught with scenarios as well? Why?
10) Do you think you have learned probability? Can you explain your answer?

Appendix 2. Scenario Example

Kirklareli Trip

Mathematics School organized a trip from Ankara to Kırklareli. Beste, Büşra, Hüseyin, and İsmail are among the students who participated in the trip. These four friends, bored during the bus journey, design a game. In the game, they write the letters of KIRKLARELİ on similar cards and put them into a bag. Then, they gave their opinions on the probability of drawing each letter from the bag. They discuss until they find the correct answer. The student who makes a mistake will buy ice cream for his friends at the journey's end. Their teachers overhear the conversations of this group. The following conversations take place among the students. The teacher listens to the students until the end and then goes next to them; they evaluate each solution together and reach a common conclusion.

1) What is described in this scenario? Write your answer by sharing your thoughts with your friends.
2) The names of the students from left to right are Hüseyin, Beste, İsmail, and Büşra. Express your thoughts about the conversations between students

Hüseyin: The probabilities of drawing E and A are equal

Beste: The probability of drawing I is less than L

Ismail: The probability of drawing a vowel is less than drawing a consonant

Büşra: The probabilities of drawing K and L are equal

3) Who tells the truth among Huseyin, Beste, Ismail, and Büşra? Has anyone given a wrong answer? Explain your answer.
4) How can you help students find the correct answer? What math subject should you know?
5) If you were the teacher, how would you approach your students? How would you correct the wrong answer? If you were the teacher, how would you solve the problem, and how would you explain it to your students?
6) Imagine you are going on a trip with your group mates. What would you dream? Together create a problem situation similar to the scenario given above. How do you solve the problem you created with your group mates?
7) How is the problem you created? Is there a solution?
8) If yes, explain how you solved it and your solution.