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Examining the Problem-Posing Skills of Prospective Classroom Teachers

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The study investigates the integration of problem-posing techniques within mathematics pedagogy. The aim is to examine the competencies in posing problems by prospective fourth-grade classroom teachers during lesson preparation and figure out what changes need to be made. We designed this research as a quasi-experimental design involving 50 teacher candidates enrolled at a public university during the academic year of 2021-2022 in Turkey. We delved into the effects of problem-posing instruction by giving it to 25 prospective teachers who volunteered to be in the experimental group. We used the Problem-Posing Test as the data collection tool. The Problem-Posing Test consists of 12 distinct scenarios for posing problems, ranging from highly structured to semi-structures, and extending to open-ended problem posing situations. We collected the quantitative data using a rubric developed to evaluate the Problem Posing-Test. We employed the T-test and the Mann-Whitney U test for the analysis of quantitative data. Based on the pre-test results of problem posing, the prospective teachers' problem-posing skills in the measurement and learning areas were insufficient. However, both groups were able to use the daily life contexts to address the problems they posed. The experimental group demonstrated a notable advantage in problem-posing skills on the post-test administered after receiving problem-posing instruction. We also concluded that problem-posing instruction positively affected the problems posed by prospective classroom teachers in the measurement and learning area. In this regard, offering an elective course on problem posing for the classroom teacher training program in education faculties would be beneficial.

Introduction

Problem posing is defined as the creation of new problems or posing of a specific problem (Tichá & Hošpesová, 2009). Problem posing is an important activity in mathematics curricula (Crespo & Sinclair, 2008; Örnek, 2020). In order to include these activities in the classroom, teachers need to have knowledge and skills about problem posing (Kar, 2014).

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Problem-posing activities will have a positive effect on students' problem-posing skills as well as enable teachers or prospective classroom teachers to establish qualified problems by ensuring their development in problem-posing situations (Demirci, 2018; Örnek, 2020). Problem posing, which enriches both teaching and learning, contributes to meaningful learning of mathematical concepts (Ticha & Hospesova, 2009). Lin (2004) emphasized in his study with classroom teachers that problem-posing activities can be used as an assessment tool to reveal students' mathematical understanding. At the same time, it provides teachers with an idea about students' skills and conceptual learning for a situation and allows them to correct mistakes (Kar, 2014; Lin, 2004). For this reason, problem posing should be included more in mathematics teaching courses in faculties of education for prospective teachers to gain experience (Şengül & Katrancı, 2015).

The content in textbooks that contribute to student achievement in mathematics teaching is very important (Özer & İncikabı, 2019; Usta & İpek, 2019). Usta and İpek (2019) stated that the quality of the problems in mathematics textbooks will have a positive effect on teaching. However, they stated that the problems related to multiplication and division in the primary school mathematics textbooks they examined were not sufficiently associated with daily life and were in mathematical form and cognitively simple. Özer and İncikabı (2019) stated that the problems related to fractions in primary school mathematics textbooks are simple, routine and closed-ended. Teachers, who are the implementers of mathematics teaching, have duties to complete the deficiencies in the textbooks (Usta & İpek, 2019). After the activities that enable students to learn the subject matter, teachers should set up quality problems that allow students to gain mathematical process skills and ask these problems (Kar, 2014; Van de Walle et al., 2012, p.34). Therefore, it is thought that teachers should have the ability to construct quality problems in order to eliminate the problems in textbooks and increase the quality of mathematics teaching.

An examination of the previous literature has provided evidence that problem posing contributes to the active use of individuals' thinking processes and improves their creativity skills (Cai & Hwang, 2002; Bonotto & Dal Santo, 2015; Hošpesová & Tichá, 2015), increases problem-solving skills (Cai & Hwang, 2002; Ellerton et al., 2015), allows students to associate mathematics with daily life (Abu-Elwan, 2002; Lin, 2004; Tichá & Hošpesová, 2009), and can be used as an assessment tool to reveal their learning and misconceptions (Hošpesová & Tichá, 2015; Kar, 2014; Lin, 2004; Örnek, 2020; Xie & Masingila, 2017). Studies indicate that mathematics and prospective classroom teachers' problem-posing skills are inadequate (Bayazit & Kırnap-Dönmez, 2017; Ellerton, 2013; Hošpesová & Tichá, 2015; Işık & Kar, 2012; Örnek, 2020, Özdemir Yıldız, 2019; Tekin-Sitrava & Işık, 2018; Tichá & Hošpesová, 2009; Zehir, 2013). In addition, there are fewer studies conducted with classroom teachers and prospective classroom teachers (Hošpesová & Tichá, 2015; Leavy & Hourigan, 2019; Lin, 2004; Serin, 2019; Tekin-Sitrava & Işık, 2018; Tichá & Hošpesová, 2009).

In recent years, there has been an increasing interest and emphasis on research related to problem-posing, which is a significant component of mathematics curricula in many countries (Cai, 2022). The Ministry of National Education (MoNE) includes objectives in the mathematics curriculum that require students to solve and pose problems in every learning area (MoNE, 2018). Measurement, which is an important learning area in mathematics, presents challenges in terms of learning and teaching. Although it is easy to relate measurement to daily life, it remains a complex concept (Durmaz, 2019; Pesen, 2019). There are studies indicating that both learners and educators face difficulties in the area of measurement (Drake, 2013; Divrik & Pilten, 2021; Doğan-Coşkun, 2017; Kamii & Russel, 2012; Şimşek & Boz, 2015). Teachers generally pose problems to help their students develop mathematical knowledge and skills (Cai et al., 2020; Lin, 2004). More research is needed to understand how capable teachers are in creating significant and valuable mathematical problems based on different problem situations (Cai et al., 2020; Christou et al., 2024).

Considering that prospective teachers, who are the teachers of the future, act as guides in achieving the objectives of the mathematics curriculum, it is essential to pay attention to the quality of the problems they will use in their lessons. Given the inadequacy of the quality of some problems in textbooks and the necessity of incorporating problem-posing activities into the mathematics curriculum, it is important for prospective classroom teachers to possess problem-posing skills. This study is considered valuable in providing insights to prospective teachers on the necessary features of high-quality problems. Moreover, when problem-posing is viewed as an assessment tool, it can reveal the comprehension and application levels of prospective classroom teachers regarding the concepts and objectives of the measurement learning area. Considering the contribution of problem-posing to teaching, examining the problem-posing situations of prospective classroom teachers in the measurement learning area is of great importance. The research problem has been defined as 'What are the problem-posing success levels of prospective classroom teachers before and after problem-posing instruction?' In this context, the following questions have been investigated:

(1) What are the problem-posing success levels of prospective classroom teachers before problem-posing instruction?
(2) What are the problem-posing success levels of prospective classroom teachers after problem-posing instruction?
(3) How are the problem-posing processes of prospective classroom teachers?

Method

Research Design

The research employed a quasi-experimental design, one of the experimental designs. In the pretest/posttest control group quasi-experimental design, both groups are given a pretest for measurement. Subsequently, the experimental group undergoes an intervention. After the intervention, a posttest is administered to both groups under equal conditions for measurement (Çepni, 2010; Karasar, 2018). In this study, the experimental and control groups consisted of prospective classroom teachers studying in two different sections at a state university. In quasi-experimental research, it is not possible to create the experimental and control groups randomly. When forming the groups, volunteers from among the prospective teachers who were willing to participate in problem-posing instruction were assigned to the experimental group. After administering the pretest to both groups, problem-posing instruction was given as an independent variable to the experimental group. The research, which lasted 10 weeks, began with a pretest in the first week and concluded with a posttest in the tenth week. The problem-posing instruction, which lasted 8 weeks with two hours per week, started by asking participants for feedback on their thoughts about problems, problem-posing, and their problem-posing situations. The relevant concepts were explained based on their responses. In the second lesson, the focus was on the types of problems. Participants were provided with theoretical knowledge about the structures of problems according to their types. In the second week, participants were allowed to examine the changes in the objectives of the measurement learning area from the first to the fourth grade. One of the sub-learning areas, length measurement, was explained in terms of how it should be taught at different grade levels. Both standard and non-standard measurement tools were introduced, and standard measurement units along with their symbols were demonstrated. It was explained to participants that fourth-grade students should understand the relationship between millimeters and other measurement units, and that they need to be able to convert between mm-cm, cm-m, and m-km units. Concepts such as perimeter, time, mass, and weight in the measurement learning area were explained, and the unit symbols for the measurement learning area were shown. It was observed that participants had difficulties distinguishing between the concepts of mass and weight. These concepts, along with their units, were clarified to resolve any uncertainties. Additionally, many participants indicated that they knew the symbol for grams, which is 'g', as 'gr'. To prevent such misunderstandings, the symbols for length measurement units, time measurement units, mass measurement units, and liquid measurement units were shown. In the third week, the qualities of problems, such as mathematical accuracy, language and expression, directive and data quality, appropriateness to objectives, solvability, and contextuality, were explained with examples. For each criterion, one example met the criterion while another did not. Incorrect examples were discussed to raise participants' awareness. Problems with errors were corrected through discussion, and participants indicated that they became aware of their mistakes by the end of the lesson. Some participants noted that they recognized errors in problems by the end of the lesson that they had not noticed before the lesson. In the fourth week, participants were taught mathematical process skills. Example problems were analyzed with participants in terms of communication skills, association skills, and reasoning skills. To help participants relate problems to different disciplines, examples of different contextual situations that could be used in problems were taken from fourth-grade textbooks in Turkish, social studies, and science. In the fifth week, a structured problem-posing worksheet prepared by the researcher was distributed to participants. The session began with solving the given problems, followed by classroom discussions on the problems posed by participants. Deficiencies were addressed to help participants gain experience. In the sixth week, semi-structured problem-posing worksheets were distributed to participants. The problems posed by participants based on the given problem-posing situations were read aloud in class, and any deficiencies were examined. The quality of the problems posed by participants was discussed and resolved. During the lessons, the researcher provided feedback by checking the problems posed by each participant. In the first lesson hour of the seventh week, some of the semi-structured problems posed by participants were written on the board. After discussing and correcting the problems with participants, the solutions were provided. The second lesson hour was devoted to free problem-posing activities. In the eighth week, the free problem-posing activities continued, and some of the problems posed by participants were written on the board. After discussing and correcting the problems with participants, the solutions were provided. Some participants received feedback and made corrections from their seats. Despite no intervention in the control group, it is assumed that they would possess problem-posing skills due to taking mathematics teaching courses during their undergraduate education. A posttest was administered to the groups at the end of the problem-posing instruction.

Study Group

The sample of the study consists of fourth-year students enrolled in the elementary education program at a state university during the fall semester of the 2021-2022 academic year. Out of 65 prospective teachers, 31 volunteers were assigned to the experimental group. The remaining students were randomly assigned to the control group. Six prospective teachers indicated that they could not participate in the instruction due to Covid-19 and personal reasons. Thus, the experimental group consisted of 25 prospective teachers. One disadvantage of quasi-experimental studies is that the groups may not be similar in characteristics before the intervention. It is crucial to create equivalent groups by ensuring that participants are as similar as possible (Çepni, 2010). The control group was intended to be matched with the experimental group based on the pretest scores of the prospective teachers who participated in the pretest. Therefore, the control group was formed by matching the pretest scores of 25 prospective teachers from the experimental group.

Data Collection

Written Problem Posing Test (PPT*)*

The study utilized a Written Problem Posing Test (PPT) for gathering data. This PPT adhered to three distinct categories of problem-posing scenarios—structured, semi-structured, and free—as delineated by Stoyanova and Ellerton in their 1996 study. The PPT's structured segment required students to reorganize pre-existing problems. The semi-structured segment involved completing partially formed problems and crafting new ones using provided images, tables, and equations. For the free segment, students had the liberty to devise problems without any predefined constraints (Stoyanova & Ellerton, 1996).

In preparing the Problem Posing Test (PPT), the measurement learning area in the fourth-grade mathematics curriculum was taken into consideration. According to the research problem, 12 problem-posing situations were designed based on four objectives in the measurement learning area to reveal the problem-posing situations of prospective classroom teachers. Each of the three sections of the PPT contains four problem-posing situations. These problem-posing situations involve calculating the perimeter lengths of shapes, using time measurement units, using weight measurement units, and using liquid measurement units. PPT1 consists of structured problem-posing situations, PPT2 consists of semi-structured problem-posing situations, and PPT3 consists of free problem-posing situations. To determine the content validity of the prepared test, the opinions of three classroom teachers working in institutions affiliated with the Ministry of National Education were initially sought. Additionally, to meet the expert opinion criterion necessary for test preparation, the views of three faculty members, who have academic work related to mathematics education and have either written or supervised theses on this subject, were consulted. The problems were analyzed according to the rubric created as a result of the literature review. In terms of quality, mathematicality (Şengül & Katrancı, 2015; Kanbur, 2017; Karaaslan, 2018; Rosli et al., 2015; Örnek, 2020; Özdemir Yıldız, 2019; Özgen et al., 2017; Yıldız, 2014), language and expression (Çomarlı, 2018; Şengül & Katrancı, 2015; Kanbur, 2017; Örnek, 2020; Özdemir Yıldız, 2019; Özgen et al, 2017; Yıldız, 2014), instruction and data quality (Kanbur, 2017; Özgen et al., 2017; Yıldız, 2014), conformity to the outcome (Özgen et al., 2017), solvability (Şengül & Katrancı, 2015; Kanbur, 2017; Örnek, 2020; Özgen et al., 2017; Yıldız, 2014) and contextuality (Çomarlı, 2018; Karaaslan, 2018; Özdemir Yıldız, 2019). The rubric was scored as 0, 1, 2 and 3. The sum of the scores obtained from each sub-dimension was used in the evaluation of the problems. Problem-posing evaluation criteria were created according to the fourth-grade mathematics curriculum.

Reliability

The reliability of the measurements from the rubric evaluation of the Problem Posing Test (PPT) was obtained by calculating the Kendall's W coefficient of concordance. This value was found to be 0.93 in the pilot study. To test consistency, the data collection tools used in the analysis of the data were retained by the researcher.

Validity

In the study, the PPT was prepared according to the fourth-grade objectives of the primary school mathematics course, utilizing expert opinions. Thus, efforts were made to ensure the content and face validity of the PPT. Conditions that hinder validity, which is divided into internal and external validity, should be eliminated in the study. Internal validity ensures that the change in the dependent variable is solely caused by the independent variable, while external validity ensures the generalizability to similar situations (Creswell, 2012; Özmen, 2019). To ensure internal validity, factors such as time, subject selection, pretest effect, and measurement tools were considered. From the start to the end of the study, only the experimental group was involved in the intervention. During the teaching process, participants in the experimental group were instructed not to share information and documents with those in the control group. Volunteers from the prospective teachers were assigned to the experimental group. Subsequently, the control group was formed by matching based on pretest results. It is considered that sufficient time elapsed before administering the same test to the sample a second time due to the problem-posing instruction. The same measurement tool was used for both the pretest and posttest. The research process, lasting eight weeks, involved long-term interaction with the prospective teachers, and expert opinions were sought while preparing the PPT and worksheets to be used in the study. For external validity, the selection of participants, application time, and setting were considered. Participants were chosen to reflect similar characteristics to the population. The group participating in the study was assigned from volunteers and matched to form similar groups. Thus, the aim was to ensure that the research results could be generalized. It was thought that the exam anxiety of fourth-year prospective teachers, who were preparing for the Public Personnel Selection Examination, could negatively affect the generalizability of the results obtained at the end of the year. Therefore, the application was carried out in the first term, when exam anxiety was considered to be lower. The setting of the research was the classrooms where prospective teachers conducted their lessons at the university, thus avoiding an artificial environment. The research process was detailed and described thoroughly. Direct quotations were included to support transferability.

Data Analysis

A rubric was developed by the researcher to evaluate the problems posed by the prospective teachers in the experimental and control groups regarding the measurement learning area in the PPT. The problems posed for the PPT were analyzed according to this developed rubric. The obtained data were entered into the MS Excel 2010 program. The success scores for the problem-posing test were created by summing the scores each candidate received from the 12 problems. These success scores were transferred to the IBM SPSS 22.0 program for statistical analysis. During the analysis process, it was first examined whether the data showed a normal distribution. The normality of the distribution was assessed based on the skewness value. To evaluate the assumption of normality, the skewness and kurtosis values of each group were checked to see if they fell between -1 and +1. If the skewness values fall within this range, it indicates that the distribution does not deviate significantly from a normal distribution or is reasonably consistent with a normal distribution (Büyüköztürk, 2018). One of the methods used in the analysis of the research data is the Kolmogorov-Smirnov and Shapiro-Wilk tests. When the number of data points is 50 or less, it is appropriate to use the Shapiro-Wilk test to check whether the data show a normal distribution (Büyüköztürk, 2018; Kilmen, 2015).

The SPSS table showing the normality values of the pretest scores of the control and experimental groups is presented in Figure 1.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	GrupD	Statistic	df	Sig.	Statistic	df	Sig.
öntest	kontrol	.103	25	.200*	.971	25	.680
	Deney	.125	25	.200*	.948	25	.221

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 1. Normality Test for Pretest Scores

When Figure 1 is examined, it can be stated that the data are normally distributed, as the significance (sig.=p) value obtained for the pretest results of the control and experimental groups is greater than .05.

The SPSS table showing the normality values of the posttest scores of the control and experimental groups is presented in Figure 2.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	GrupD	Statistic	df	Sig.	Statistic	df	Sig.
sontest	kontrol	.126	25	.200*	.948	25	.223
	Deney	.183	25	.031	.870	25	.004

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 2. Normality Test for Posttest Scores

When Figure 2 is examined, it can be stated that the data are not normally distributed, as the significance (sig.=p) value obtained for the posttest results of the control and experimental groups is greater than .05.

The normality of the data can be examined by checking whether the skewness and kurtosis values fall between -1 and +1. If the skewness and kurtosis values are between -1 and +1, it can be stated that the data are normally distributed (Büyüköztürk, 2018; Hair et al., 2013). In this study, the assumption of normality was evaluated based on whether the skewness and kurtosis values of the data fell between -1 and +1. The skewness values for the pre-and post-test achievement scores of the problem-posing test for both the experimental and control groups were detailed in Table 1.

Table 1. Skewness and Kurtosis Values of Pre/Post Test in Control and Experimental Groups

Total/Sub-Dimension	Group	Pre-test		Post-test	
		Skewness	Kurtosis	Skewness	Kurtosis
Mathematicalness	Control	.16	-.91	-.84	1.14
	Experimental	.18	1,71	-1.42	2.03
Language and Expression	Control	.11	-1.16	-.45	-.48
	Experimental	.12	-1.04	-1.42	2.03
Instruction and Data Quality	Control	-.19	-.72	-.33	-.48
	Experimental	-.61	.88	-2.09	5.62
Appropriateness to Objectives	Control	-.51	-.38	-.64	.28
	Experimental	-.45	-.11	-1.76	3.65
Solvability	Control	-.04	-.34	-.24	-1.03
	Experimental	-.55	-.54	-1.24	1.08
Contextuality	Control	-.72	-.35	-.67	-.38
	Experimental	-.63	-.99	-3.07	10.73
Total	Control	-.32	-.03	-.64	.11
	Experimental	-.60	-.26	-1.29	1.54

When Table 1 is examined, it is observed that the skewness and kurtosis values of the total pretest success scores obtained in the problem-posing test, as well as the subdimensions of directive and data quality, appropriateness to objectives, solvability, and contextuality, are between -1 and +1. Accordingly, it can be stated that the total pretest success scores and the scores of the subdimensions of directive and data quality, appropriateness to objectives, solvability, and contextuality for the experimental and control groups are normally distributed. However, it can be said that the subdimensions of mathematical accuracy, language, and expression do not show a normal distribution. For comparing data that show a normal distribution in groups, the independent samples t-test, a parametric test, was used. For comparing data that do not show a normal distribution, the Mann-Whitney U test was used. Since the skewness and kurtosis values of the total posttest success and subdimension scores are not between -1 and +1, the data distribution of the experimental and control groups does not show normality. Therefore, the non-parametric Mann-Whitney U test was used to compare the posttest measurement results of these two groups. To explain the magnitude of the difference between the groups according to the results of the Mann-Whitney U test, the formula $r=Z/(\sqrt{n})$ used by Field (2009) and Pallant (2007) was employed to calculate the effect size of the independent variable. According to Cohen (1988), if the absolute value of the coefficient is between 0.1 and 0.3, it indicates a small effect; if it is between 0.3 and 0.5, it indicates a medium effect; and if it is 0.5 or higher, it indicates a large effect.

Ethics Committee Decision

Ethics committee permission for this research was obtained from Amasya University Social Sciences Ethics Committee on 01.04.2021 with document number 11554.

Findings

Findings Related to the First Sub-Problem

The following findings were obtained from the analysis of the quantitative data from the PPT conducted to answer the research question, "What are the problem-posing success levels of prospective classroom teachers before problem-posing instruction?"

Since the pretest data of the experimental and control groups, except for the subdimensions of mathematical accuracy and language and expression, were normally distributed, an independent samples t-test was used to analyze the total PPT and other subdimension average success scores. For the analysis of the pretest data of the subdimensions of mathematical accuracy and language and expression, the Mann-Whitney U test was used. The test results based on the pretest total and subdimension average success scores of the control and experimental groups are presented in Table 2.

Table 2. PPT Pre-test Results of Control and Experimental Groups

Total/Sub-Dimension	Group	N	$\bar{X}$	S	Rank Average	Test Results	p
Mathematicalness		25	19.64	4.99	25.46	U= 311.50	.98
	Control	25	19.28	4.67	25.54		
Language and Expression	Experimental	25	26.40	4.34	25.60	U= 310.00	.96
	Control	25	26.36	4.59	25.40		
Instruction and Data Quality	Experimental	25	19.52	4.61	-	t= -.54	.59
	Control	25	20.24	4.80			
Appropriateness to Objectives	Experimental	25	23.20	5.46	-	t= .89	.37
	Control	25	21.76	5.88			
Solvability	Experimental	25	17.76	5.37	-	t= -1.99	.05
	Control	25	20.72	5.09			
Contextuality	Experimental	25	30.96	4.59	-	t= .16	.87
	Control	25	30.76	4.21			
Total	Experimental	25	137.40	22.07	-	t= -.04	.96
	Control	25	137.68	23.66			

Upon examining Table 2, it was observed that the mean pre-test achievement scores of the prospective classroom teachers in both the control and experimental groups, as measured by the Problem Posing Test (PPT), did not show any notable differences (t48=-.04, p>.05). When the PPT pre-test achievement mean scores of the control group ($\bar{X}$ =137.40; S=22.07) and the experimental group ($\bar{X}$ =137.68; S=23.66) were examined. Our analysis revealed that the average scores were closely aligned. Given that the highest possible score on the Problem Posing Test (PPT) is 216, the average pre-test scores of the prospective teachers in both groups indicate a moderate proficiency level. Based on these pre-test averages, the proficiency of the prospective teachers in problem-posing scenarios is around 63%.In the pre-test of the PPT of the experimental and control groups, mathematical (U=311.50, p>.05), language and expression (U=310.0, p>.05), instruction and data quality (t48=-.54, p>.05), conformity to the outcome (t48=.89, p>.05), solvability (t48=-1.99, p>.05) and contextuality (t48=.16, p>.05) sub-dimensions.

Findings Related to the Second Sub-Problem

The outcomes derived from analyzing the quantitative data from the Problem Posing Test (PPT), which was aimed at determining the post-instructional problem-posing abilities of prospective classroom teachers, are summarized as follows. The post-test mean scores, both overall and across sub-dimensions, evaluated using the problem-posing rubric in the PPT, did not exhibit a normal distribution in either the experimental or control groups. Consequently, the Mann Whitney-U test was utilized for the analysis, with the findings detailed in Table 3.

Table 3. PPT Post-test Mann Whitney-U Test Results of Control and Experimental Groups

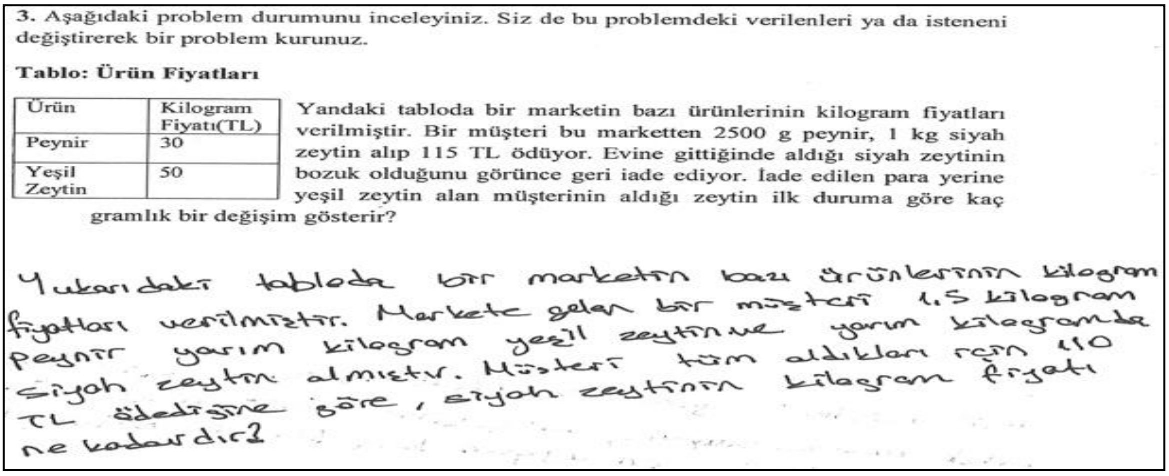
Total/Sub-Dimension	Group	N	Rank Average	Rank Total	U	p	r
Mathematicalness	Control	25	13.88	347.00	22.00	.00*	.79
	Experimental	25	37.12	928.00			
Language and Expression	Control	25	15.56	389.00	64.00	.00*	.68
	Experimental	25	35.44	886.00			
Instruction and Data Quality	Control	25	14.66	366.50	41.50	.00*	.74
	Experimental	25	36.34	908.50			
Appropriateness to Objectives	Control	25	14.68	367.00	42.00	.00*	.74
	Experimental	25	36.32	908.00			
Solvability	Control	25	14.68	367.00	42.00	.00*	.74
	Experimental	25	36.32	908.00			
Contextuality	Control	25	16.86	421.50	96.50	.00*	.64
	Experimental	25	34.14	853.50			
Total	Control	25	14.02	350.50	-25.50	.00*	.78
	Experimental	25	36.98	924.50			

*p<.05

An examination of Table 3 reveals a statistically significant difference in the rank mean scores of the post-test for the Problem Posing Test (PPT) between the prospective classroom teachers in the experimental and control groups, with significant statistical values (U=-25.50, z=-5.57, p<.05, r=.78). This suggests that the experimental group outperformed the control group in problem-posing abilities. The influence of problem-posing instruction on the experimental group is evident and significant when looking at the rank averages. The 'r' formula was used to determine the effect size of the change in mean achievement scores, indicating a substantial impact of the problem-posing instruction on the experimental group's success. The post-test results across various sub-dimensions, including mathematical ability, language and expression, instruction and data quality, relevance to the outcome, solvability, and contextuality, all favored the experimental group with significant values (U=22.00, p<.05 for mathematical ability; U=64.00, p<.05 for language and expression, and so forth).

Findings Related to the Third Sub-Problem

The findings obtained from the analysis of the qualitative data from the PPT conducted to answer the research question, “What are the problem-posing processes of prospective classroom teachers?” are presented. An example from the pre-application phase of the structured problem-posing situation in the first section of the PPT is shown in Figure 3.



3. Aşağıdaki problem durumunu inceleyiniz. Siz de bu problemdeki verilenleri ya da isteneni değiştirerek bir problem kurunuz.

Tablo: Ürün Fiyatları

Ürün	Kilogram Fiyatı(TL)
Peynir	30
Yeşil Zeytin	50

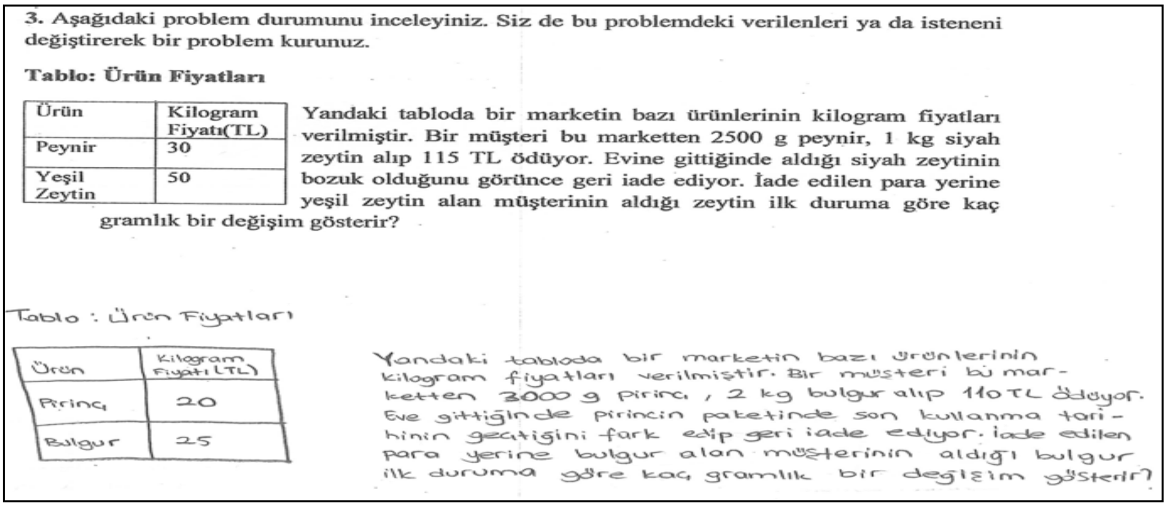
Yandaki tabloda bir marketin bazı ürünlerinin kilogram fiyatları verilmiştir. Bir müşteri bu marketten 2500 g peynir, 1 kg siyah zeytin alıp 115 TL ödüyor. Evine gittiğinde aldığı siyah zeytinin bozuk olduğunu görünce geri iade ediyor. İade edilen para yerine yeşil zeytin alan müşterinin aldığı zeytin ilk duruma göre kaç gramlık bir değişim gösterir?

Yukarıdaki tabloda bir marketin bazı ürünlerinin kilogram fiyatları verilmiştir. Markete gelen bir müşteri 1,5 kilogram peynir yarım kilogram yeşil zeytin ve yarım kilogramda siyah zeytin almıştır. Müşteri tüm aldıkları için 110 TL ödediğine göre, siyah zeytinin kilogram fiyatı ne kadardır?

Figure 3. Example of Structured Problem Posing

In Figure 3, it can be seen that the decimal notation used as data in the problem posed by D10 before the application is not suitable for the 4th-grade curriculum. Since there is no decimal notation at the primary school 4th-grade level, the problem cannot be solved at the primary school level. It is evident that D10 was unable to use appropriate data in the problem.

An example from the post-application phase of the structured problem-posing situation is shown in Figure 4.



3. Aşağıdaki problem durumunu inceleyiniz. Siz de bu problemdeki verilenleri ya da isteneni değiştirerek bir problem kurunuz.

Tablo: Ürün Fiyatları

Ürün	Kilogram Fiyatı(TL)
Peynir	30
Yeşil Zeytin	50

Yandaki tabloda bir marketin bazı ürünlerinin kilogram fiyatları verilmiştir. Bir müşteri bu marketten 2500 g peynir, 1 kg siyah zeytin alıp 115 TL ödüyor. Evine gittiğinde aldığı siyah zeytinin bozuk olduğunu görünce geri iade ediyor. İade edilen para yerine yeşil zeytin alan müşterinin aldığı zeytin ilk duruma göre kaç gramlık bir değişim gösterir?

Tablo : Ürün Fiyatları

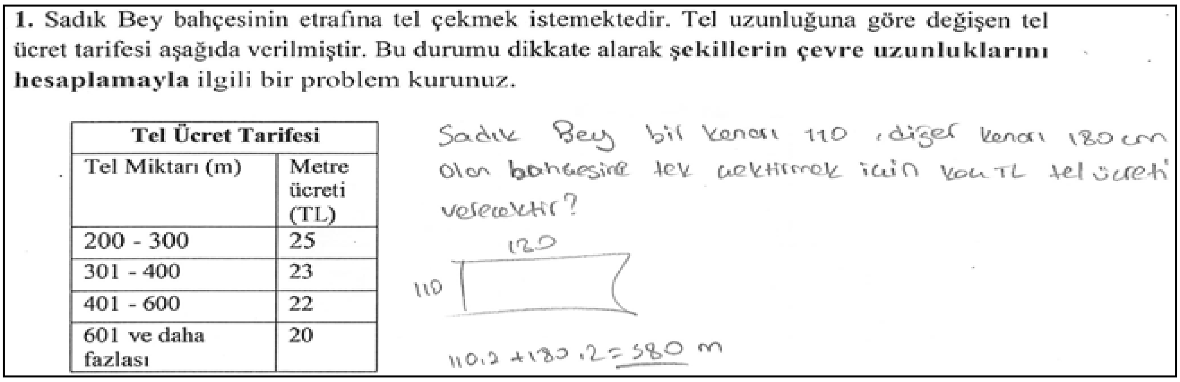
Ürün	Kilogram Fiyatı (TL)
Pirinç	20
Bulgur	25

Yandaki tabloda bir marketin bazı ürünlerinin kilogram fiyatları verilmiştir. Bir müşteri bu marketten 3000 g pirinç, 2 kg bulgur alıp 110 TL ödüyor. Eve gittiğinde pirincin paketinde son kullanma tarihinin geçtiğini fark edip geri iade ediyor. İade edilen para yerine bulgur alan müşterinin aldığı bulgur ilk duruma göre kaç gramlık bir değişim gösterir?

Figure 4. Example of Structured Problem Posing

In Figure 4, it can be seen that D9 correctly used mathematical concepts and data appropriate for the grade level in the problem posed after the application. The problem is understandable in terms of language and expression and is related to real-life context. Additionally, it is appropriate to the objective and solvable.

An example from the pre-application phase of the semi-structured problem-posing situation in the second section of the PPT is shown in Figure 5.


1. Sadık Bey bahçesinin etrafına tel çekmek istemektedir. Tel uzunluğuna göre değişen tel ücret tarifesi aşağıda verilmiştir. Bu durumu dikkate alarak **şekillerin çevre uzunluklarını hesaplamayla** ilgili bir problem kurunuz.

Tel Ücret Tarifesi	
Tel Miktarı (m)	Metre ücreti (TL)
200 - 300	25
301 - 400	23
401 - 600	22
601 ve daha fazlası	20

Sadık Bey bil kenarı 110 , diğer kenarı 180 cm olan bahçesine tek çektirmek için kaç TL tel ücreti verecektir?

120

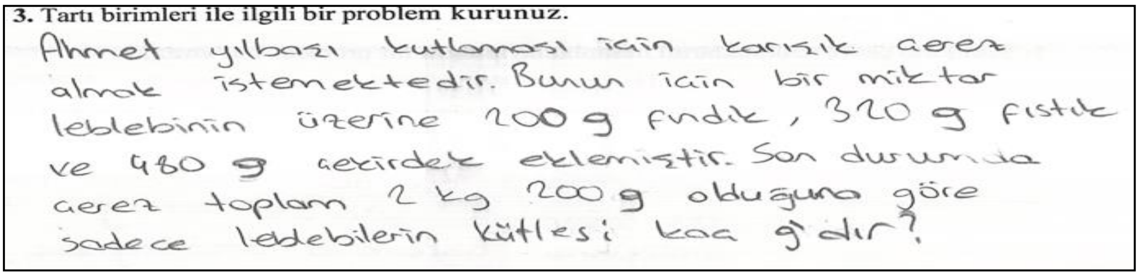
110

110.2 + 180.2 = 580 m

Figure 5. Example of Semi-Structured Problem Posing

In Figure 5, it is observed that D16 had deficiencies in the use of mathematical concepts and units in the problem posed before the application. The geometric shape of the garden was not specified in the problem. Although a real-life context was used in the problem, it was unsolvable due to insufficient instructions.

An example from the post-application phase of the semi-structured problem-posing situation is shown in Figure 6.


3. Tartı birimleri ile ilgili bir problem kurunuz.

Ahmet yılbaşı kutlaması için karışık çerez almak istemektedir. Bunun için bir miktar leblebinin üzerine 200 g fındık, 320 g fıstık ve 480 g çekirdek eklemiştir. Son durumda çerez toplam 2 kg 200 g olduğuna göre sadece leblebilerin kütlesi kaç g'dır?

Figure 6. Example of Semi-Structured Problem Posing

In Figure 6, it is observed that D9 correctly expressed mathematical concepts and symbols and provided sufficient data for solving the problem in the semi-structured problem posed after the application. The problem, appropriate to the objective, is clearly expressed with a real-life context.

An example from the pre-application phase of the free problem-posing situation in the third section of the PPT is shown in Figure 7.

1. Sadık Bey bahçesinin etrafına tel çekmek istemektedir. Tel uzunluğuna göre değişen tel ücret tarifesi aşağıda verilmiştir. Bu durumu dikkate alarak **şekillerin çevre uzunluklarını hesaplamayla** ilgili bir problem kurunuz.

Tel Ücret Tarifesi	
Tel Miktarı (m)	Metre ücreti (TL)
200 - 300	25
301 - 400	23
401 - 600	22
601 ve daha fazlası	20

Sadık Bey yanda tel ucret tarifesi verilen tablodaki tel ucretlerine bakıp bahcesinin etrafını tel ile dolamak istiyor. Bahcesi kısa kenarı 30 m ,uzun kenarı 45 m olan bir dikdörtgen şeklindedir.
Sadık Bey bahcesinin etrafına iki kere tel Çekerse bunun için ne kadar ücret öder?

Figure 7. Example of Free Problem Posing

In Figure 7, it is observed that D11 incorrectly expressed mathematical units, and there were insufficient instructions and data for solving the problem posed before the application. Although the problem was related to a real-life context, it was inadequate in terms of language and expression.

An example from the post-application phase of the free problem-posing situation is shown in Figure 8.

2. Zaman ölçme birimlerinin kullanıldığı bir problem kurunuz.

Bir araba A noktasından B noktasına her 20 km'ini 5 dk mda vererek 4 saat 40 d varmıştır buna göre A ve B noktaları arasındaki mesafe kaç km'dir?

Figure 8. Example of Free Problem Posing

In Figure 8, it is observed that D14 correctly used conceptual expressions and units, and provided sufficient instructions and data in the problem posed after the application. The problem is adequate in terms of language and expression, solvable, and related to a real-life context. Additionally, it is appropriate for the 4th-grade mathematics curriculum objective.

When posing structured problems, some participants changed the data while others changed the requirements. It was observed that participants were actively engaged in structured problem-posing situations where the constraints were high. Participants found semi-structured problem-posing situations more challenging compared to structured ones. They had difficulties relating tables, graphs, and verbal representations. Before the problem-posing instruction, some participants found free problem-posing easier. Very few participants posed problems that were not related to real-life contexts, and this was observed mostly when calculating the perimeter lengths of shapes. Some participants had issues ensuring the appropriateness of the problems to the objectives. The most common error was using decimal notations in the problems. Overall, it can be said that the errors in using mathematical concepts, symbols, and expressions decreased in the problems posed by the prospective teachers after the problem-posing instruction.

Discussion

In this study, we investigated the problem-posing abilities of prospective primary school teachers in relation to four specific outcomes within the fourth-grade measurement learning domain of primary education. The initial test results revealed no significant difference in the mean achievement scores between the experimental and control groups, indicating their comparable and moderate level of problem-posing skills. The observation that these prospective teachers in both groups were not adequately proficient in problem-posing prior to the instruction aligns with the findings of similar research by Crespo and Sinclair (2008), Kanbur (2017), Örnek and Soylu (2021), Tekin-Sitrava and Işık (2018), Tichá and Hošpesová (2009), and Yıldız (2014). Tekin-Sitrava and Işık (2018) observed that the ability of prospective classroom teachers to pose problems freely was inadequate. Similarly, Yıldız (2014) identified challenges among prospective teachers in problem-posing tasks, particularly noting their low proficiency in the 'geometry and measurement' learning domain. Örnek and Soylu (2021) pointed out that the competency of prospective teachers in formulating problems involving addition and subtraction of fractions fell short of the desired level. Furthermore, Demirci (2018) attributed the shortcomings of prospective teachers in creating probability-related problems to a lack of conceptual understanding and practical experience in the field.

Prior to the intervention, the mathematical sub-dimension was a challenging area for the prospective classroom teachers. Several studies in the field indicate that gaps in conceptual knowledge adversely impact problem-posing abilities (Demirci, 2018; Ellerton, 2013; Hošpesová & Tichá, 2015; Kar, 2014; Örnek & Soylu, 2021; Tekin-Sitrava & Işık, 2018; Yıldız, 2014; Zehir, 2013). Zehir (2013) highlighted that a lack of conceptual knowledge led prospective teachers to commit errors in problem construction, particularly in the area of unit confusion. Kar (2014) linked the conceptual mistakes of secondary school mathematics teachers to deficiencies in their subject knowledge. Ellerton (2013) emphasized that insufficient mathematical knowledge in prospective teachers detrimentally affects their capacity to pose problems. Similarly, Hošpesová and Tichá (2015) identified that a shortfall in classroom and prospective teachers' conceptual understanding often resulted in problem-posing difficulties. The recurring issues with incorrect application of concepts, symbols, and units by prospective teachers in problem-posing could be attributed to their inadequate mathematics subject matter knowledge.

Before starting the intervention, our analysis showed that the prospective classroom teachers generally scored well in the language and expression dimension. This finding is in line with several studies that have documented grammar and expression mistakes among prospective teachers (Çomarlı, 2018; Hošpesová & Tichá, 2015; Karaaslan, 2018; Işık & Kar, 2012; Örnek & Soylu, 2021; Xie & Masingila, 2017; Yıldız, 2014). Işık and Kar (2012) noted that prospective classroom teachers faced challenges in formulating verbal problems. Çomarlı (2018) observed that teachers struggled to frame problem sentences correctly according to the rules of the Turkish language. In their research involving 10 prospective teachers, Xie and Masingila (2017) found that these teachers had difficulties in clearly expressing problems and understanding the problem situations conceptually. Additionally, Hošpesová and Tichá (2015) identified issues with the clarity and comprehensibility of problems created by classroom teachers and prospective teachers.

In the pre-implementation phase, the prospective classroom teachers' average performance in the 'instruction and data quality' sub-dimension was found to be moderate. Similar challenges in handling instructions and data have been noted in other studies (Boyraz, 2019; Hošpesová & Tichá, 2015; Işık, Kar, et al., 2012; Kanbur, 2017; Yıldız, 2014). For instance, Yıldız

(2014) observed that prospective teachers struggled with integrating text and visuals in graphically presented questions and often used illogical or unrealistic data. Kanbur (2017) pointed out the absence of clear instructions in some problems to define shapes and contexts. Boyraz (2019) found that the data used by prospective teachers were often incomplete and illogical, straying from real-life scenarios. Işık, Kar, et al. (2012) noted issues in the selection of appropriate data for problems involving graphs. Hošpesová and Tichá (2015) found that prospective classroom teachers had more difficulty in using realistic data compared to practicing classroom teachers.

Before the implementation, the initial assessments indicated that the average ability of prospective classroom teachers in aligning their problem-solving with targeted educational outcomes was moderately developed. This suggests that these teacher candidates across different groups, often developed mathematical problems that were not adequately tailored to the specified grade level, either being too advanced or too simplistic. This trend points to a potential gap in their understanding of the mathematics curriculum. Supporting this view, research by Tekin-Sitrava and Işık (2018) highlighted that prospective teachers often deviate from intended educational outcomes in their problem construction. Similarly, Serin (2019) observed a misalignment between the complexity of the problems and the students' academic level, and Hošpesová and Tichá (2015) identified a lack of consideration for grade-appropriate problem construction. These findings collectively underscore a possible deficiency in the prospective teachers’ grasp of the mathematics curriculum.

In our preliminary assessment before the project's start, it was noted that the proficiency of prospective classroom teachers in crafting solvable mathematical problems was generally moderate. The solvability assessment, based on the researchers' own problem-solving attempts, helped identify specific challenges. Additionally, problems that were either devoid of clear instructions or contained irrelevant data were often deemed unsolvable. This insufficiency in guidance could lead to a superficial approach to problem-solving, resulting in lower solvability scores. Problems that required understanding of advanced mathematical concepts were also frequently labeled as unsolvable. Parallel findings in the realm of problem solvability have been noted in similar research. For instance, Işık and Kar (2012), as well as Örnek and Soylu (2021), observed instances of solutions that did not align with the proposed mathematical operations. Moreover, Yıldız (2014) and Örnek and Soylu (2021) highlighted issues with unsolvable problems stemming from errors in the application of mathematical concepts.

Before the implementation, our observations showed that the ability of prospective classroom teachers to incorporate real-life contexts into their problem constructions was notably strong. This was evident in both groups we examined, indicating a proficiency in integrating everyday scenarios into their mathematical problems. This observation aligns with the findings of Çomarlı (2018), who also reported that teachers frequently utilize real-world contexts in their problem posing.

Following the intervention focused on problem-posing techniques, we noted a marked enhancement in the problem-posing abilities within the experimental group. Conversely, the control group did not exhibit a statistically significant change in their problem-posing skills, indicating no cross-effect between the groups in terms of the instructional intervention. The experimental group's improvement can be attributed to their hands-on experience in problem posing. Supporting this observation, various studies (Abu-Elwan, 2002; Crespo & Sinclair, 2008; Demirci, 2018; Yıldız, 2014) have demonstrated that experiential learning plays a crucial role in honing the problem-posing abilities of prospective teachers. This practical experience seems pivotal for the development of their skills in this area. The link between the prospective teachers' enhanced problem-posing capabilities and their growing understanding of concepts and curriculum was evident. We noted a reduction in conceptual mistakes and a tendency to create problems more suited to the fourth-grade level. Parallel findings in the literature (Crespo & Sinclair, 2008; Demirci, 2018; Işık & Kar, 2012; Zehir, 2013) suggest that an increase in conceptual knowledge is a key factor in improving problem-posing skills. Specifically, Demirci (2018) found that a specially designed problem-posing instructional approach led to improvements in prospective teachers' abilities, as evidenced in focus group interviews.

Post-implementation, a significant improvement was observed in the mathematical precision of the prospective teachers. Such advancements suggest that the instruction on problem-posing played a pivotal role in enhancing the mathematical aspect of their skills within the experimental group. This observation is in line with the findings of Örnek (2020) and Rosli et al. (2015), who reported a notable enhancement in the correct application of mathematical concepts and symbols in groups of prospective teachers who received problem-posing training. However, Karaaslan (2018) encountered a contrasting scenario in his study with seventh graders, noting difficulties in the correct application and expression of mathematical concepts, despite integrating problem-posing into their curriculum. This discrepancy might stem from the novelty of the subject matter to the students and the limited duration of instructional time. Therefore, it can be inferred that for learners to effectively utilize mathematical concepts and symbols, these elements need to be thoroughly integrated and given adequate time during problem-posing instruction.

Following the intervention, a notable improvement was observed in the language and expression skills of the prospective teachers, as evidenced by a statistically significant rise in this area. This finding aligns with Örnek's (2020) results, where problem-posing training significantly enhanced the grammatical correctness in problem construction by prospective teachers. In contrast, Yıldız (2014) noted no significant improvement in language and expression among prospective mathematics teachers after similar training. Additionally, Karaaslan (2018) found that students still struggled with creating understandable problems even after the training had concluded. Alongside these findings, it was also observed that there was an increase in the response rate to the Problem-Posing Test (PPT) among the control group participants.

After the implementation, prospective teachers showed a statistically significant improvement in the prospective teachers' skills related to the quality of instruction and data, as evidenced by significant statistical improvements. These observations suggest that the problem-posing instruction had a positive impact on the experimental group in terms of their proficiency in the instruction and data quality aspect.

The post-implementation phase revealed a significant enhancement in the prospective teachers' ability to align their problems with the intended outcomes, particularly in terms of grade level appropriateness. This suggests that they were able to design problems that were well-suited to the specific grade levels they were targeting. This finding echoes the results of Hošpesová and Tichá (2015), who found that classroom teachers and prospective teachers were more adept at creating grade-level appropriate problems following instructional guidance. In contrast, members of the control group were observed to continue creating problems that were not consistently aligned with the appropriate grade level, often deviating above or below the intended outcome.

The results post-implementation indicated a significant improvement in the prospective teachers' performance in the aspect of problem solvability. This improvement within the experimental group was attributed to the efficacy of the problem-posing instruction. Similar enhancements in solvability following problem-posing instruction were also reported by Örnek (2020). The prospective teachers' enhanced capability in this regard was linked to their judicious selection of relevant data and their proficient use of mathematical language in constructing problems Consequently, the experimental group showed notable advancements in mathematicality, the quality of instructions and data, and alignment with intended outcomes, leading to their overall success in problem solvability. This finding aligns with Yıldız's (2014) study with prospective elementary mathematics teachers, where the solvability aspect was found to be influenced by factors such as mathematicality, the quality of instruction and data, and language and expression. Yıldız (2014) also observed that mistakes in the use of units and concepts within problems adversely impacted their solvability.

Following the intervention, there was a noteworthy improvement in the ability of the prospective teachers to incorporate real-life contexts into their problem constructions, particularly in the experimental group. This was evidenced by a significant statistical increase in the contextualization sub-dimension in the post-test. Interestingly, despite not receiving specialized problem-posing instruction, the control group also demonstrated a considerable aptitude in integrating everyday life contexts into their problems. This trend aligns with findings from similar research, such as Örnek (2020) and Özdemir-Yıldız (2019), where the use of daily life scenarios in problem posing was prevalent. Örnek (2020) categorized the problems from both groups under the 'realism dimension,' observing that both groups consistently included daily life elements in their problem constructions pre- and post-intervention. However, in contrast, Serin (2019) noted that prospective classroom teachers faced challenges in creating problems related to everyday life. The proficiency of prospective teachers in embedding real-life contexts might be attributed to the choice of the 'measurement learning domain' for problem construction, which naturally lends itself to real-world applications. This suggests that the problem-posing instruction was particularly effective in enhancing the contextualization skills of the experimental group.

Before the problem-posing instruction, it can be said that the prospective teachers made errors in the symbols and units they used in their problems, used mathematical concepts that were not suitable for the student level, and did not include units. When examining the language and expression scores of the prospective teachers, it can be said that although there were spelling and punctuation errors, the problems they posed were understandable. Accordingly, it can be stated that there was a lack of transfer between the text and the visual/table/steps, the data were not realistic, and the data and instructions were either too much or too little. There are similar studies in the literature that report issues related to data and instructions (Boyraz, 2019; Hošpesová & Tichá, 2015; Kanbur, 2017; Yıldız, 2014). Additionally, examples were found where prospective teachers could not pose problems appropriate to the objectives before the instruction. Errors in mathematical concepts and the absence or inaccuracy of units negatively affected the solutions to the problems posed. The lack of or inappropriate data made the problems unsolvable. The lack of instructions led to problems being evaluated with lower solvability scores since it caused formal issues in solving the problems.

After the instruction, it was observed that the experimental group started using mathematical concepts, symbols, units, and representation types correctly in their problems, and included mathematical concepts suitable for the student level. Similar studies have noted that an increase in knowledge of mathematical concepts and curriculum positively reflected in the problems posed (Demirci, 2018; Örnek, 2020; Rosli et al., 2015). They also paid more attention to writing rules and punctuation, resulting in more understandable problems. Likewise, Örnek (2020) stated that the problems posed after problem-posing instruction became more comprehensible in terms of language and expression. However, Yıldız (2014) found no improvement in language and expression after problem-posing instruction. It can be said that there was progress in correctly transferring between text and visual/table/steps, using realistic data, and avoiding excessive instructions/data. The correct use of units and concepts, meaningful data, and clear language and expression resulted in solvable problems due to the problem-posing instruction. The instruction helped prospective teachers improve in posing problems appropriate to the objectives and using real-life contexts. Hošpesová and Tichá (2015) similarly reported progress in posing problems appropriate to the objectives in their study. There are similar studies where real-life contexts were used in the problems posed (Örnek, 2020; Özdemir-Yıldız, 2019). Örnek (2020) mentioned that participants posed realistic real-life-related problems. Conversely, Serin (2019) reported that prospective classroom teachers had difficulties using real-life contexts.

Conclusion

Prior to introducing problem-posing techniques, our analysis indicated that both the control and experimental groups of prospective teachers exhibited inadequate proficiency in formulating problems within the realm of measurement learning. In our analysis, we observed no notable differences in the initial average scores of the prospective teachers when it came to various aspects of problem quality. These aspects included mathematical accuracy, use of language, instructional clarity, data relevance, outcome pertinence, problem-solving feasibility, and contextual relevance. Despite incorporating real-life scenarios in their problem posing, these prospective teachers showed challenges in correctly implementing mathematical concepts, language accuracy, outcome alignment, and problem-solving effectiveness. Our findings also highlighted that, in both the control and experimental groups, there was a lack of proficiency regarding mathematics knowledge and understanding of the mathematics curriculum, specifically in the area of measurement learning, prior to the commencement of our study. Following the instruction on problem-posing, those in the experimental group demonstrated a notable improvement in their utilization of mathematical concepts, symbols, and expressions, leading to the creation of more understandable problems. The problems they developed were typically solvable, relevant to everyday scenarios, aligned with instructional quality and data accuracy, and met the intended achievement standards. Our analysis indicated that the prospective teachers adeptly incorporated real-life contexts into their problem posing. Post-intervention, the experimental group outperformed the control group significantly in problem-posing skills. This led us to determine that the instruction in problem-posing had a marked positive impact on the performance of participants in the experimental group.

Limitations and Recommendations for Future Research

We are aware that our research has some limitations. The first is the homogeneity of groups. The initial assessment revealed no statistically significant variations in pre-test results between the control and experimental groups. Regarding this, future research should explore a wider range of participants with varying levels of initial proficiency to understand the impact of problem-posing instruction across a broader spectrum of abilities. The second is the quantitative focus. The study primarily relied on quantitative measures (e.g., test scores) to assess problem-posing abilities. Incorporating qualitative methods, such as in-depth interviews or participant observations, could provide richer insights into the cognitive processes and pedagogical strategies of prospective teachers.

Future research should include a more diverse range of prospective teachers, potentially with different educational backgrounds or at various stages of their teacher education programs, to understand how these variables influence problem-posing skills. Further, there could be a focus on developing and evaluating specific curriculum designs and instructional strategies that enhance problem-posing abilities, particularly in areas where prospective teachers showed weaknesses, such as conceptual knowledge and mathematicality. Comparative studies should also be carried out as comparing the effectiveness of different problem-posing instructional approaches or comparing problem-posing skills across different educational systems could yield valuable insights. What is more, since artificial intelligence has penetrated into different aspects of education, investigating the role of technology in facilitating problem-posing instruction and practice could provide insights into innovative teaching methods. Finally, future research could also focus on the role of ongoing professional development in enhancing in-service teachers' problem-posing abilities, thereby contributing to their professional growth and classroom practices.

Implications

Based on the findings of this present research, we believe that our research has potential to some theoretical and practical implications.

Theoretical Implications

This research contributes to the theoretical understanding of the existing competencies of prospective teachers in problem-posing, particularly in the measurement learning domain. This adds to the body of literature indicating that prospective teachers often have gaps in their subject matter knowledge and problem-posing skills. These findings provide a new perspective on understanding of problem-posing skills. So much so that the study underscores the complexity of this skill, which not only involves mathematical knowledge but also requires the ability to contextualize problems, use appropriate language, and ensure solvability. Our findings support the theory that a lack of conceptual knowledge in mathematics impacts the ability to pose effective and relevant mathematical problems. This aligns with previous research that emphasizes the importance of strong subject matter knowledge for effective teaching.

Practical Implications

Practically, this study offers insights for curriculum development, teacher training, enhanced teaching methods, assessment and feedback mechanisms, real-world contextualization, as well as policy and educational reform. First, our results suggest a need for curriculum revisions in teacher education programs to strengthen problem-posing skills. This can include focusing more on developing conceptual understanding of mathematics, as well as training in constructing problems that are relevant, solvable, and appropriate to students’ grade levels. Second, these results have significant implications for the development of teacher training programs for prospective teachers should include dedicated modules or workshops on problem-posing, emphasizing not only the mathematical concepts but also the pedagogical aspects like language use, instruction quality, and contextualization. Third, our findings also offer practical solutions to teaching process. In this sende, we argue that experiential learning methods, such as hands-on problem-posing exercises, can be significantly beneficial. This aligns with the observed improvement in the experimental group, suggesting that practical, experience-based learning is effective. Problem-posing teaching can be included as an elective course in the undergraduate program of classroom teaching. When it comes to evaluation and assessment, our study highlights the importance of regular assessment and feedback in teacher training programs. By identifying specific areas of weakness in problem-posing, teachers can provide targeted support to prospective teachers. For the real-world contextualization, given the high scores in contextualization, teacher training should continue to emphasize the importance of relating mathematical problems to real-world scenarios, which can enhance student engagement and understanding. Further, our findings can inform educational policymakers about the areas of focus for improving mathematics education at the primary level, particularly in terms of teacher preparedness and curriculum design.

Author Contribution

The authors contributed equally to the study.

Ethical statement

During the planning, data collection, analysis and reporting of this research, the ethical principles and rules in the "Directive on Scientific Research and Publication Ethics of Higher Education Institutions" were followed. No application contrary to Scientific Research and Publication Ethics was made and informed consent was obtained from all individual participants participating in the research.

Declaration of interest

The authors declare that there is no conflict of interest with any institution or person within the scope of the study.

This research is derived from the first author's doctoral thesis titled 'The Effectiveness of Skill-Based Problem Posing Education'.

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