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Creative Problem Posing: Analysis of the Problems Posed Towards Different Strategies by Prospective Mathematics Teachers

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Abstract

The purpose of this study is to analyze the problems posed by prospective elementary mathematics teachers towards different strategies in the scope of creativity. The participants in the study are 36 prospective teachers who are taking the course "Problem Solving Strategies". In this course, they are studying problem-solving strategies. At the end of the course, they were asked to pose three problems suitable for each of the nine problem-solving strategies. Each participant posed a total of 27 problems. The problems posed by participants were analyzed in terms of the indicators of fluency, flexibility, and originality. The chi-square independence test was applied to determine whether the creativity of problem posing depends on the strategies used. It was observed that fluency had the highest average among all strategies, excluding the conscious guessing and control strategy. The drawing strategy had the highest average among the strategies in terms of flexibility, and the conscious guess and control strategy had the highest average among the strategies in terms of originality. Furthermore, it was observed that the creativity levels of participants for various strategies were usually high and, in some cases, in the higher echelons of the medium category. This small variation was found to be statistically significant.

Keywords: Problem posing, problem solving strategies, creativity, mathematical creativity

Yaratıcı Problem Kurma: Matematik Öğretmeni Adaylarının Farklı Stratejilere Yönelik Kurdukları Problemlerin Analizi

Öz

Bu çalışmanın amacı, ilköğretim matematik öğretmeni adaylarının farklı stratejilere yönelik kurdukları problemlerin yaratıcılık bağlamında incelenmesidir. Araştırmanın katılımcıları "Problem Çözme Stratejileri" dersini alan 36 öğretmen adayıdır. Bu ders kapsamında problem çözme stratejilerine yönelik eğitim verilmektedir. Dersin sonunda katılımcılardan stratejilere uygun üçer problem kurmaları istenmiştir. Bu bağlamda her katılımcı, ele alınan 9 problem çözme stratejisinin her biri için üç problem olmak üzere toplam 27 problem kurmuştur. Katılımcıların kurdukları problemler akıcılık, esneklik ve özgünlük göstergeleri açısından analiz edilmiş ve problem kurma yaratıcılığının stratejilere bağlı olup olmadığını belirlemek için ki-kare bağımsızlık testi uygulanmıştır. Çalışma sonunda, esneklik bağlamında en yüksek ortalamaya sahip stratejinin çizim yapma stratejisi olduğu, özgünlük bağlamında ise en yüksek ortalamaya sahip stratejinin bilinçli tahmin ve kontrol stratejisi olduğu görülmüştür. Bunun yanı sıra, katılımcıların çeşitli stratejilere yönelik problem kurma yaratıcılıklarının genel olarak iyi düzeyde olduğu, bazı stratejiler için ise yüksek düzeyden az farkla orta düzeyde olduğu görülmüştür. Bu küçük varyasyon ise istatistiksel olarak anlamlı bulunmuştur.

Anahtar kelimeler: Problem kurma, problem çözme stratejileri, yaratıcılık, matematiksel yaratıcılık

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INTRODUCTION

Studies that investigate the contributions of problem posing in the wider context of mathematics education (e.g., Kilpatrick, 1987; English, Fox & Watters, 2005) ensure that problem posing occupies a central position in curricula (National Council of Teachers of Mathematics [NCTM], 2000). During problem posing, students can develop authentic and challenging perspectives and produce significant insights about the issue. Through the problem posing process, students think about mathematical operations, employ mathematical concepts, and consider how to solve the posed problems, developing different thinking perspectives in the process. Problem posing helps enhance students' critical thinking as they strive to pose even better problems and come up with original ideas through each problem posing activity and register concrete improvements on the creativity front (English, 1997). Numerous studies suggest that problem posing helps to develop an in-depth thinking perspective (e.g., Arıkan, 2013). Moreover, problem posing can be thought of as a tool that provides teachers with a perspective on students' thoughts (Cildir & Sezen, 2011). However, studies show that teachers are inexperienced in problem-posing activities and have difficulties in such activities (Leung, 2013). The teachers' low levels of proficiency in this area would, expectedly, result in a failure to achieve the learning outcomes expected from problem posing. In this context, improving the problem posing skills of teachers as well as prospective teachers should be a priority. Experience with problem-solving strategies is known to have a positive impact on problem solving skills (Collins et al., 1989; Gencer, 2019; Göktaş, 2019; Verschaffel et al., 1999). Therefore, teachers' ability to pose problems with distinct strategies in mind is crucial in terms of providing experiences of these strategies to the students. Lastly, one should note that the ultimate goal of designing and implementing curricula is to equip students equipped with the skills of the 21st Century (Ministry of National Education [MoNE], 2018). Creativity is certainly among those skills (Pásztor et al., 2015). Problem posing often requires creative ideas, and presenting new and interesting problems facilitates and fosters creative environments (Daher & Anabousy, 2018). Therefore, teachers' efforts to pose creative problems are certainly crucial in terms of providing creative learning environments. A glance at the literature reveals a number of studies evaluating problem posing activities conducive to distinct strategies (e.g., English, 1997; Mestre, 2002; Leung, 2013) and assessing creativity in the context of problem posing (e.g., Daher & Anabousy, 2018; Shriki, 2013; Taşkın, 2016). However, no study has been found that reveals the creativity of problems posed according to problem-solving strategies. The findings reached through such a study would provide insights into the requirements of teacher training by shedding some light on the level of creativity prospective mathematics teachers have in terms of posing problems in tune with specific strategies. In this context, the present study aims to investigate the creativity aspect of the problem posing activity that prospective elementary school mathematics teachers engage in with respect to distinct strategies.

Research Questions

For this purpose, the following research questions were investigated:

1. How does the creativity of problems posed by prospective elementary school mathematics teachers vary according to different strategies?

2. Is the creativity level of prospective elementary school mathematics teachers in problem posing dependent on the problem solution strategies involved?

Theoretical Framework

Problem Posing

Problem posing refers to the formulation of a new problem based on given conditions or experiences (NCTM, 2000). Based on this definition, the term problem posing can be used to describe the activity of generating a question to be explored with respect to a given event or condition. Before handling a real-life situation, event or problem, students should first become aware of the problems involved. That is why it is crucial for students to have the skill of noticing and solving problems. Problem posing plays a central role in ensuring that students notice the problems they come across in real life. In this context, it would not be an exaggeration to argue that problem posing is often more challenging than solving them (Mestre, 2002). There are various instructional applications for students to gain experience in this challenging skill. One can discuss educational practices for problem posing in essentially three categories: unstructured, semi-structured, and structured practices (Stoyanova & Ellerton, 1996). In unstructured problem posing activities, no problem is provided, and students are asked to come up with their own problems with reference to a natural situation. In the case of semi-structured problem posing activities, students are given a specific set of conditions, and they are asked to discover the structure or pose a problem in tune with it, making use of their existing knowledge, skills, concepts and mathematics experiences. Finally, in the

case of structured problem posing activities, students are expected to formulate a problem based on an existing one (Stoyanova, 2003). In the present study, unstructured problem posing activities defined by Stoyanova and Ellerton (1996) were implemented. The underlying reason is the desire to avoid any contextual restrictions that may curb creativity.

Factors Affecting the Problem-Solving Skills

Problem solving skills enable the individual to become aware of her own emotions as well as those of others, to define the problem, to identify and choose objectives, to develop an alternative solution, to review the results, to choose the optimal solution, to develop an action plan, to check for any obstacles, and to employ these insights into any future problem-solving activities (Elias & Weissberg, 2000). In this context, multiple factors affect the students' problem-solving skills. Even though a number of distinct categorizations were embraced by various researchers, it was often argued that problem solving skills were affected by the students' knowledge about the topic and the contents, and experience with similar problems (e.g. Charles & Lester, 1982; Schoenfeld, 1985; Collins et al., 1989), their heuristics to approach a given problem (Schoenfeld, 1985), ability to identify the optimal strategy for solving the problem (Collins et al., 1989), control strategies regulating the problem solving processes (Schoenfeld, 1985; Collins et al., 1989) and the students' beliefs in problem solving (Charles & Lester, 1982; Schoenfeld, 1985). When the factors affecting the problem-solving process are examined, it is seen that all factors are actually related to experience. At this junction, the teachers are expected to provide the groundworks for the students gain required experience. Therefore, the teachers' ability to pose problems with distinct strategies in mind is crucial in terms of providing experiences of these strategies to the students. Moreover, in the context of the classes they take, the participants get experience with problem solving strategies. Against this background, the results presented are also crucial in terms of understanding whether the experience with problem solving strategies is implicitly associated with problem posing skills and creativity, and what kind of an effect the experience factor would have on problem posing processes.

21st Century Skills and Creativity

As a recent addition to modern societies' vocabulary, the 21st century skills refer to the specific skills the children from younger generations would need to face the problems of the new world that is taking shape (Sing, 1991). Even though one can perceive a general trend in the literature about the specifics of the 21st century skills, there are dissenting voices as well. The literature describes the framework presented in Figure 1 and called the Partnership for 21st Century Skills (P21), to provide a general perspective regarding these skills.

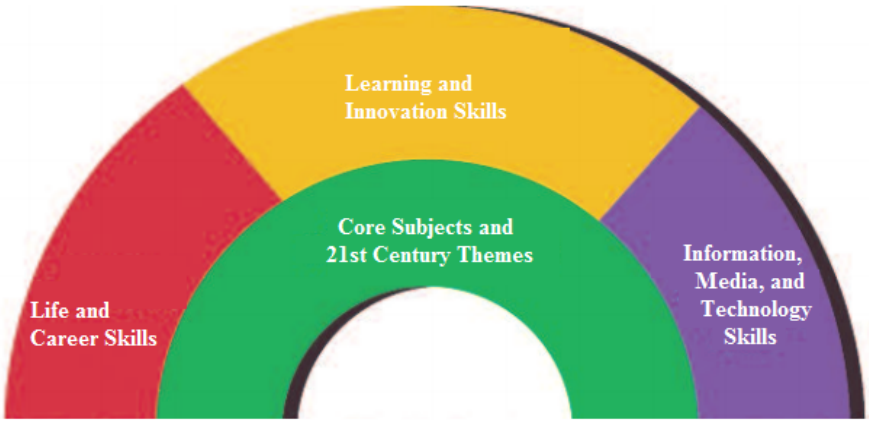

Figure 1. *P21 Framework for 21st century learning (Partnership for 21st Century Learning, 2009, p.3)*

The learning and innovation skills presented in Figure 1 are composed of four competencies (called 4C): (i) critical thinking, (ii) communication, (iii) collaboration, (iv) creativity (Partnership for 21st Century Learning, 2009). The present study specifically focuses on creativity. Due to the complex nature of creativity, a universally accepted definition has yet to be formulated. While some researchers focus on the product while defining creativity, while others consider the process dimension (Taşkın, 2016). Torrance (1968) defines creative thought as the process of perceiving gaps and uncomfortable shortcomings, stating views or formulating hypotheses about them, testing such hypotheses, presenting the results, and revising or refuting such hypotheses where necessary. Moreover, the literature in general emphasizes four major elements of creativity: fluency, flexibility, originality, and elaboration (Guilford, 1967). In this context, fluency refers to expressing a wealth of thought, organized work, and engaging in production; flexibility, in turn, entails embracing different perspectives towards situations and

developments, and expressing distinctive lines of thought. Originality is about producing new or technical yet authentic thought, making inventions or discoveries, or producing priceless works (Balka, 1974). Finally, elaboration refers to enriching and extending thought, providing details, and consolidating ideas (Ersoy & Başer, 2008).

In discussing the descriptors of these indicators, it was observed that there may be different descriptors specific to the field, and the concept of creativity in mathematics was put forward. Like general creativity, creativity in mathematics also lacks a universally accepted definition. Still, generally speaking, creativity in mathematics in school contexts often refers to coming up with unusual and clear solutions which express an in-depth understanding of the problem, regardless of the level of complexity involved, and formulating new questions and/or possibilities to enable an approach from a new angle for an old problem (Sriraman, 2005). Looking at this definition, it should be evident that the problem-solving and problem-posing activities are essentially tools that enable individuals to exhibit their creativity in mathematics. There is a growing consensus regarding creativity in mathematics, embracing the problem posing and problem-solving processes as the primary axis of any creative act (Silver, 1997). Shriki (2013) states that through posing problems on their own, students benefit from the development of reasoning as well as different and flexible thought, expand and reinforce their knowledge and problem-solving skills, and thus evolve into innovative, creative and active learners. In other words, problem-posing often requires creative ideas, and presenting new and interesting problems facilitates and fosters creative environments (Daher & Anabousy, 2018). In the present study, the participants' creativity was assessed with reference to their problem-posing activities.

On the other hand, there is a certain level of consensus in terms of analyzing creativity associated with mathematics with reference to three main elements: fluency, flexibility, and originality (e.g. Balka, 1974; Haavold, 2013). In the context of creativity in mathematics, fluency refers to the skill of developing multiple alternative yet applicable solutions for a given problem; flexibility refers to the skill of switching to a new approach in the solution of mathematics problems requiring distinct strategies; originality refers to the skill of developing new or special solutions (Torrance, 1968). The present study also approaches creativity in mathematics through the lens of these three main elements.

METHOD

The study adopts a mixed method that includes both qualitative and quantitative analysis. The data were collected during the spring semester of the 2018-2019 academic year.

Setting and Participants

Thirty-six prospective teachers participated in this study as part of the Elementary School Mathematics Teaching Program. They enrolled in the study voluntarily from among the wider set of prospective teachers who took the "Problem-Solving Strategies" course. The course lasted 14 weeks, with two hours of instruction per week. During the course, the first part focused on theoretical aspects of problem-solving and problem-posing in the curriculums, and factors affecting problem-solving processes. In the second part, problem-solving strategies (Working Backwards, Finding a Pattern, Adopting a Different Point of View, Solving a Simpler Analogous Problem, Organizing Data, Guessing and Testing, Making a Drawing, Accounting for All Possibilities, and Considering Extreme Cases) and problem-solving processes for each strategy were covered. Each week, a different problem-solving strategy was focused, and the instructor provided approximately 8-10 problems that were suitable for the focused strategy. The problems were presented one by one to prospective teachers, who were asked to come up with a relevant solution. Once enough time was granted for each problem, a prospective teacher who volunteered for the problem was asked to present the solution. Then, the class had a discussion of the solution, as well as different solution strategies. After solving the problems related to the relevant strategy, the pre-service teachers were asked to review the solution process of all the problems in the course they were in. They were expected to recognize the common solution approach and name the strategy employed. Information about the strategy was presented by the lecturer after this stage. At the end of this process, pre-service teachers were asked to pose three problems related to the relevant strategy. Some of these problems were explored and discussed in the next lesson, in order to preserve the problematic nature of the addressed problems. Then, a similar process was started for the new strategy. Before taking this course, the participant prospective teachers had no prior experience with problem-solving strategies and problem-posing.

Data Collection

At the end of each week when strategies were taught, the prospective teachers were asked to pose three problems that were suitable for the problem-solving strategy covered that week, along with their solutions. There

were no restrictions other than compliance with the given strategy in problem posing. In other words, the tasks were unstructured problem posing practices. The solutions provided an opportunity to check the mathematical correctness of the posed problems. They also allowed for the evaluation of the indicator of "Poses problems with more than one applicable solution". For this reason, the pre-service teachers were advised to provide solutions for the problems they posed. The prospective teachers were required to pose the problems outside of the lesson times and before the next lesson (one week later). It was emphasized that the problems should align with a learning outcome that the prospective teachers would choose from the curriculum. This is because the Ministry of Education expects teachers to align their activities with the learning outcomes. During the problem-posing process, the prospective teachers were provided with the option to look at the curriculum and textbooks. The instructor then collected the problems and their solutions in written form. By the end of the 14-weeks, each prospective teacher had posed a total of 27 problems, three for each of the nine problem-solving strategies. The present study is based on the data set comprising the problems posed by prospective teachers through this process.

Data Analysis

Creativity Scores Analysis

The literature emphasizes that an answer could be highly extraordinary or original, yet it should also be mathematically correct (Haavold, 2013; cited in Taşkın, 2016). Similarly, it is possible that the problems posed by prospective teachers can be extraordinary and original, yet mathematically unreasonable. Thus, the analysis of the problems posed first checked whether the problems were mathematically reasonable and solvable. This process was carried out by two researchers engaging in discussions in accordance with the co-decision procedure.

The reasonable problems posed by prospective teachers were then analyzed in the context of creativity in mathematics, with reference to the fluency, flexibility, and originality indicators discussed in the theoretical framework above. In this context, a literature review was carried out to identify the descriptors of these indicators. A theoretical framework was developed by Taşkın (2016) to analyze creativity in mathematics in the context of problem-posing, based on the theoretical groundwork developed by Amaral and Carreira (2012), seeking to assess creativity in the mathematical modeling process. In his study, Taşkın (2016) discussed the descriptors associated with each indicator of creativity, in the context of problem-posing. The theoretical structure presented by Taşkın (2016) was used in this present study because it covers the descriptors associated with each indicator and offers the most detailed and current structure to analyze creativity in the context of problem-posing. The theoretical framework is summarized in Table 1.

Table 1. The Theoretical Framework Used for the Analysis of Creativity in the Problem-posing (Taşkın, 2016)

Indicators	Descriptors
Fluency (FL)	FL1) Contains an appropriate problem statement that requires the use of mathematical concepts and procedures. FL2) Poses an appropriate problem that requires the development and discovery of mathematical concepts and procedures. FL3) Presents the variables and concepts used in the problem statement in a clear and consistent manner FL4) Communicates (expresses) the problem statement by organizing the variables/data
Flexibility (F)	F1) Poses an appropriate mathematical problem using various variables. F2) Poses problems with more than one applicable solution. F3) Poses problems that require the association of the variables involved in the scenario with each other, in line with the defining purpose. F4) Poses problems entailing the assessment of various cases concerning the variables involved in the scenario. F5) Poses a different problem by reformulating a previously posed problem.
Originality (O)	O1) Develops authentic shapes, diagrams, tables etc., and formulates problems for their interpretation. O2) Poses problems that require the use of extraordinary and authentic strategies. O3) Poses extraordinary and authentic problems by applying different perspectives to existing data.

In the present study, prospective teacher was asked to pose three problems for each strategy, and the descriptors in the problems posed by each prospective teacher were scored as follows:

• If the new problem created by a prospective teacher candidate is different from the other problems created by all participants, and each descriptor of each indicator in that problem is assigned a score of 10.

• If the problem posed by a prospective teacher is based on a structure that is similar or the same as another problem(s), each descriptor of each indicator in that problem is assigned a score of 0.

Taşkın (2016) scored the indicators as 10, 1, and 0.1. For detailed information, Taşkın (2016) can be consulted. This scoring system provides meaningful information for interpreting the originality of a single problem. However, when considering the tendency of creativity of large groups (i.e., when calculating the average score), it does not provide meaningful information. The numbers after the decimal point lose their meaning, and evaluating the presence and absence of indicators as 1 and 0, respectively, also makes it difficult to interpret the averages. Therefore, the presence of indicators was scored as 10 points, and their absence was as 0 points.

The total scores are calculated as follows (Taşkın, 2016):

Fluency score (FL): The total score obtained by adding up the individual scores for descriptors associated with the fluency indicator in all problems posed by prospective teachers is divided by four (There are four descriptors.).

Flexibility score (F): The total score obtained by adding up the individual scores for descriptors associated with the flexibility indicator in all problems posed by prospective teachers is divided by five (There are five descriptors.).

Originality score (O): The total score obtained by adding up the individual scores for descriptors associated with the originality indicator in all problems posed by prospective teachers is divided by three (There are three descriptors).

Creativity score: FL+F+O

The analyzing process was applied by two researchers working separately. Thereafter, they compared their scores, and the discussion provided an opportunity to make a decision about the final scores. In this perspective, the lowest and highest possible scores for fluency, flexibility and originality indicators for one problem posed with respect to each strategy were 0 and 10, respectively (0 and 30 for three problems), whereas the total creativity score for one problem was in the 0 to 30 range (0 to 90 for three problems). The fluency, flexibility, and originality scores and then the total creativity score for each prospective teacher, were calculated, to serve as input for the participants' average creativity scores. Creativity scores in the 0-30 range were evaluated as low, while scores in the 31-60 range were evaluated as medium, and scores in the 61-90 range were evaluated as high level. Two researchers and an expert analyzed approximately 20% of the data independently to ensure analysis reliability. The analyses were compared, and differences were discussed until a 90% consensus was reached. Then, one researcher conducted all the remaining data analysis and interpretation.

Statistical Analysis

The second research problem covered in the study is to determine whether creativity in problem posing is dependent on the problem-solving strategies or not. In this context, the total creativity scores of prospective teachers for each strategy were calculated. If we want to determine the existence of a relationship between two categorical variables, the chi-square independence test (Can, 2018) is necessary. To examine whether there is a statistically significant difference in scores between different strategies, the Chi-Squared test was applied. The variables examined in the study, namely 'problem-solving strategies' and 'creativity levels (low, medium and high)' are categorical variables. Therefore, the Chi-Square test was appropriate for analysis.

Research Ethics

All participants voluntarily participated in the research, and no harmful practices were applied to them. During the research, each participant received the same information about the research processes, and their personal information was kept confidential.

FINDINGS

Creativity of Problems According to Different Strategies

It was observed that since prospective teachers were asked to solve the problem, they paid attention to posing solvable problems. All problems were mathematically reasonable and solvable. The section below first presents qualitative results regarding the problems posed by prospective teachers with reference to the making drawing strategy, and then quantitative findings were interpreted.

All problems posed were in Turkish and translated into English by the researchers. One problem posed by Participant 24 (P24) with respect to the making drawing strategy is presented in Figure 2.

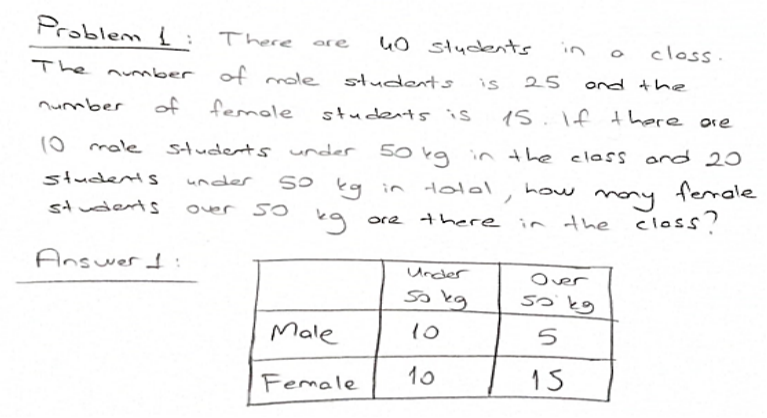

Figure 2. *The first problem posed by P24 and its solution*

When the problem was analyzed in terms of fluency, it was seen that the problem required the use of mathematical tables, so FL1 was revealed. The variables were presented in a clear and consistent manner, so FL3 was revealed. The problem statement provided some information about the arrangement of the variables, so FL4 was revealed. Besides, the problem did not enable further exploration of mathematical concepts and procedures, so FL2 was not revealed. In the light of this analysis, the prospective teacher was assigned a score of 7.5 (30/4) in terms of fluency. In the review of the problem in terms of flexibility, the problem took a multitude of variables into account, so F1 was revealed. The problem required the association of the students' characteristics with each other and in line with a specific goal, so F3 was revealed. The problem was essentially a revised statement of a similarly posed problem, so F5 was revealed. As the problem did not have multiple solutions, so F2 was not revealed. Similarly, the focus limited to weight and gender, disregarding distinct cases concerning the variables, F4 was also not revealed. In the light of this analysis, the prospective teacher was assigned a score of 6.0 (30/5) in terms of flexibility. In terms of originality, even though the solution to the problem required only a simple step, the problem required the development and interpretation of a unique table, so O1 was revealed. However, as such tables represent the most frequently used model of the making drawing strategy, one could argue that it did not represent a highly extraordinary and original strategy perspective. In this context, O2 and O3 were not revealed. In the light of this analysis, the prospective teacher was assigned a score of 3.3 (10/3) in terms of originality. Therefore, the prospective teacher received a total creativity score of 16.8 (7.5+6.0+3.3).

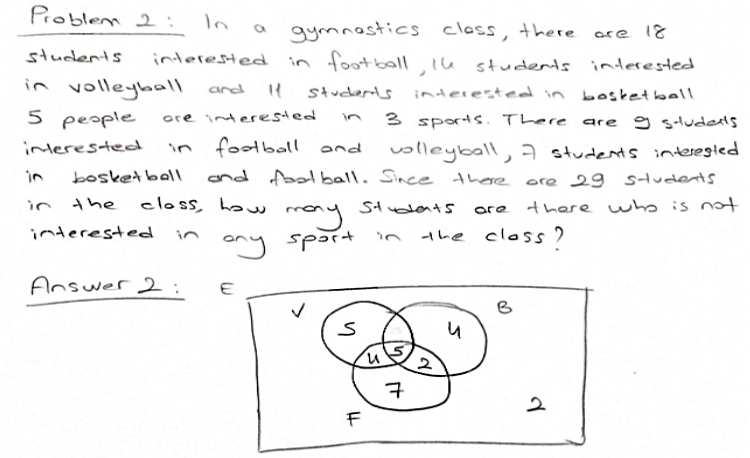

Figure 3. *The second problem posed by P24 and its solution*

When the problem is analyzed in terms of fluency, it can be seen that the problem is a mathematical one that can be solved through the use of applicable drawings and procedures, so FL1 is revealed. The variables are presented in a clear and consistent manner, so FL3 is revealed. The problem provides some information about the arrangement of the variables provided, so FL4 is revealed. However, the problem does not provide a setting conducive to the development of applicable drawings and procedures, so FL2 is not revealed. In the light of this analysis, the prospective teacher was assigned a score of 7.5 (30/4) in terms of fluency. In terms of flexibility, the problem takes into account a multitude of variables, so F1 is revealed. The problem requires the association of the number of students and the branches of sports with each other and in line with the purported goal, so F3 is revealed. Various cases linked with the number of individuals are taken into account, so F4 is revealed. The

problem is essentially a revised statement of an ordinary problem, so F5 is revealed. However, as the problem does not have more than one applicable solution, F2 is not revealed. In the light of this analysis, the prospective teacher was assigned a score of 8.0 (40/5) in terms of flexibility. In terms of originality, the making drawing presents a different perspective towards existing data, so O3 is revealed. The presentation in the form of sets is not original, and as the 'making drawing' strategy cannot be considered an extraordinary strategy for the solution of the problem, O1 and O2 are not revealed. In the light of this analysis, the prospective teacher was assigned a score of 3.3 (10/4) in terms of originality. Therefore, the prospective teacher received a total creativity score of 18.8 (7.5+8.0+3.3).

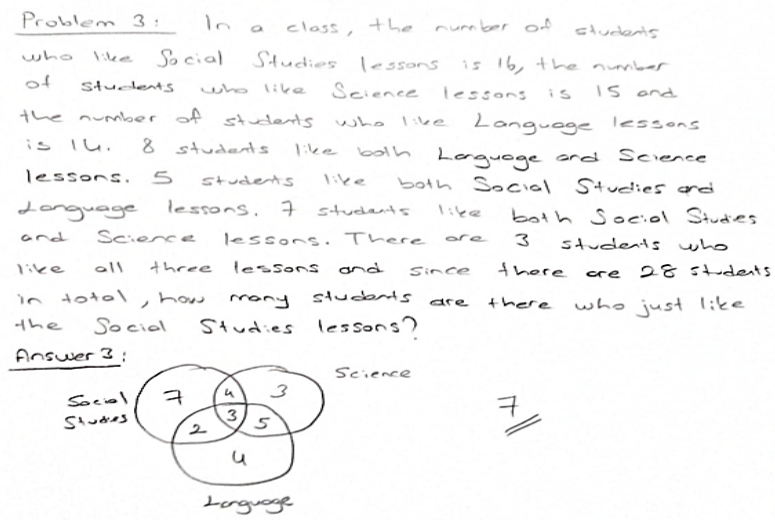

Figure 4. *The third problem posed by P24 and its solution*

In terms of creativity, the problem received a score of 0 as none of the descriptors associated with each of the indicators of creativity applied. This is because the problem is similar to the second problem posed by P24, involving the same variables and essentially the same steps for the solution, with only a slight difference entailing an additional operation and the use of an additional concept. Against this background, the prospective teacher was assigned a score of 0 for the fluency, flexibility, and originality indicators. Therefore, the prospective teacher received a total creativity score of 0.

Taken together, the scores P24 received for the problems she posed for the 'making drawing' strategy are 5 ((7.5+7.5+0)/3) for fluency, 4.7 ((6+8+0)/3) for flexibility, 2.2 ((3.3+3.3+0)/3) for originality. Total creativity score is 11.9 ((16.8+18.8+0)/3). In Figure 5, the average (rounded up) scores for the fluency, flexibility, and originality indicators in the context of problem-solving strategies with reference to the problems posed by the prospective teachers are presented in Figure 5.

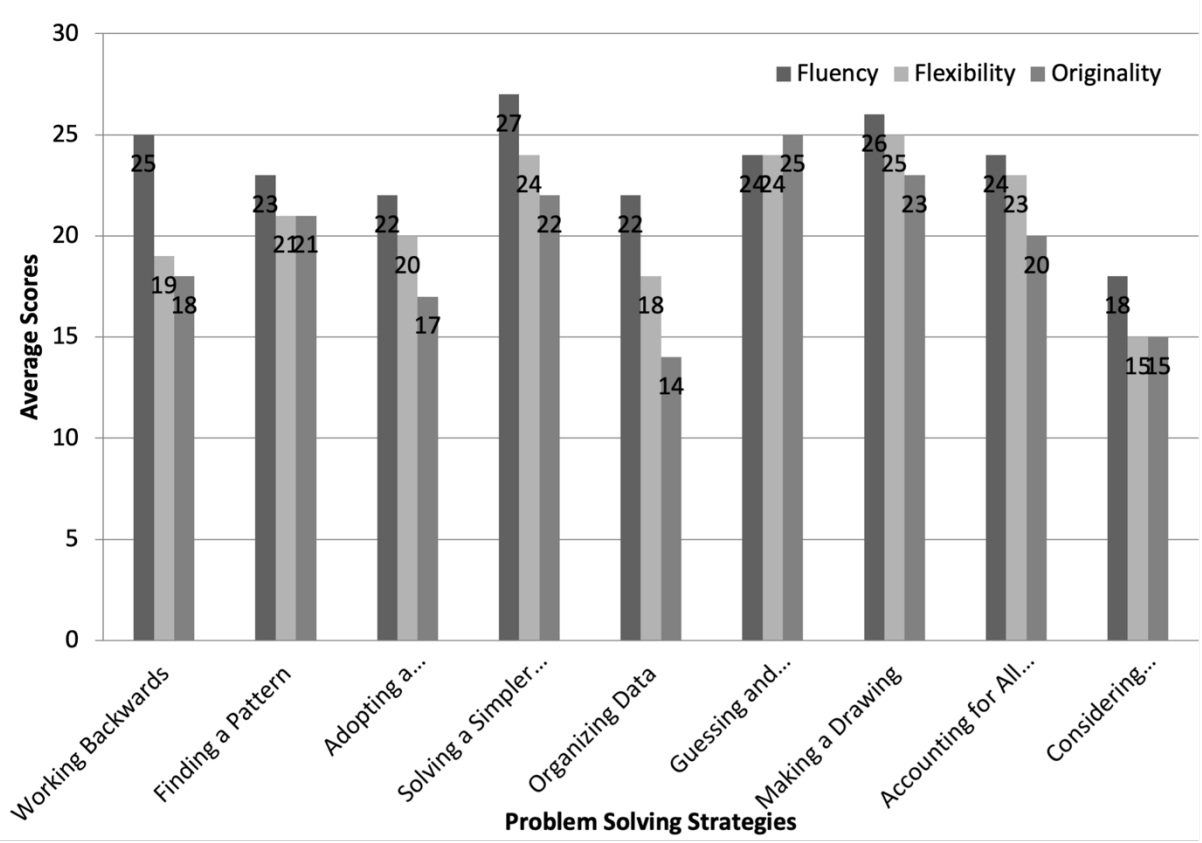

Figure 5. *The average originality, flexibility, and fluency scores for various strategies*

When Figure 5 is examined, it shows that the indicator with the highest average is the fluency in all strategies except conscious guessing and testing strategy. This is followed by flexibility and originality. Moreover, in the case of the strategies of considering extreme cases and finding a pattern, the average scores for originality and flexibility are equal to each other. The same applies for the flexibility and fluency indicators for the informed guessing and testing strategy. The comparison of the prospective teachers' creativity according to fluency reveals that the solving a simpler analogous problem strategy has highest average score among all strategies. The comparison of the prospective teachers' creativity according to flexibility reveals that the making drawing strategy has the highest average score among all strategies. The comparison of the prospective teachers' creativity according to originality reveals that the guessing and testing strategy has the highest average score among all strategies.

The prospective teachers' average total creativity scores (rounded up) are presented in Figure 6.

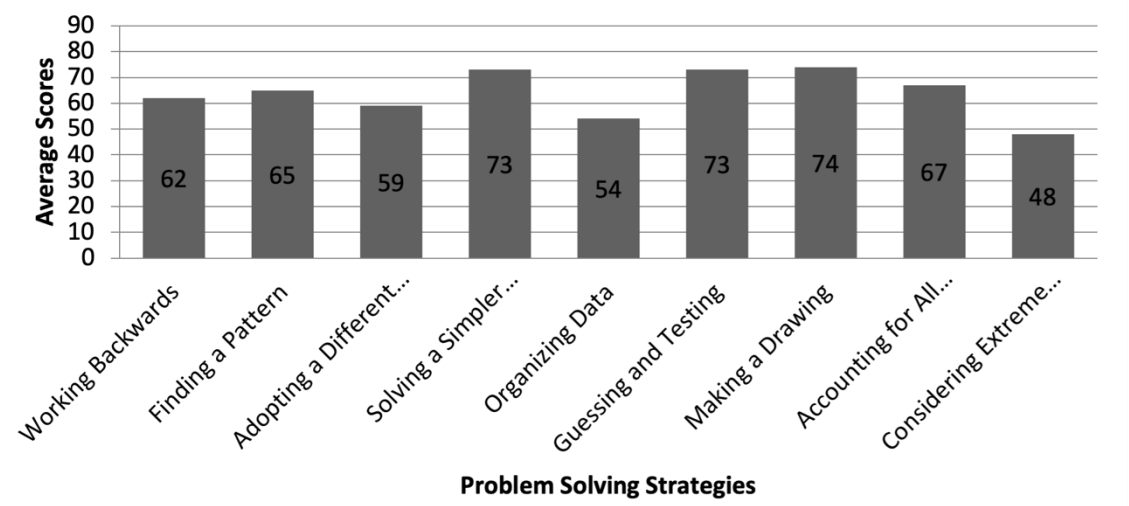

Figure 6. *The average total creativity scores for various strategies*

A glance at the average creativity scores presented in Figure 6 reveals that the highest average score is achieved with the making drawing strategy, while the lowest average score is associated with the considering extreme cases strategy. It is apparent that prospective teachers may not be able to produce different and creative ideas while posing problems using organizing data, adopting a different point of view, and considering extreme cases strategies. Another observation is that the average scores range from 48 to 74. Therefore, one can argue that the prospective teachers' creativity levels can be considered mediocre. The numbers of participants associated with each category for the evaluation of creativity levels are presented in Table 2.

Table 2. Creativity Levels Associated with each Strategy

Creativity Levels / Strategies	Low (0-30 points)		Medium (31-60 points)		High (61-90 points)	
	f	%	f	%	f	%
Working Backwards	0	0.00	20	55.56	16	44.44
Finding a Pattern	2	5.56	7	19.45	27	75.01
Adopting a Different Point of View	1	5.56	15	41.66	20	55.56
Solving a Simpler Analogous Problem	0	0.00	12	33.34	24	66.66
Organizing Data	2	5.56	18	50.00	16	44.44
Guessing and Testing	0	0.00	1	2.78	35	97.23
Making Drawing	0	0.00	5	13.89	31	85.62
Accounting for All Possibilities	1	2.78	12	33.34	23	63.88
Considering Extreme Cases	0	0.00	12	33.33	24	66.67

The finding that the "low" performance category had the lowest frequency of scores for any strategy suggests that, in general, the participants' creativity levels are not low. Creativity levels generally accumulate in the "high" category. Thus, it can be argued that the creativity levels of the prospective teachers do not vary widely, and their creativity levels regarding each strategy are generally high.

Relationship between Creativity Levels and Problem-Solving Strategies

The results of the Chi-Square test applied to determine if there is a statistically significant variance in the scores from one strategy to another are presented in Table 3.

Table 3. Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	40.500[a]	8	.000
Likelihood Ratio	46.689	8	.000
Linear-by-Linear Association	4.021	1	.045
N of Valid Cases	324		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 12.00.

As seen in Table 3, there are no expected frequencies less than 5 and the minimum expected frequency value is 12.00. Therefore, the Chi-Square analysis is deemed appropriate. In the analysis, the Chi-Square value was calculated as X^2= 40.500, the degrees of freedom were determined df=8, and the significance level was determined as p=0.000. Based on these results, the null hypothesis "H_0=There is no significant relationship" was rejected since the p value is less than the significance level of 0.05, and the alternative hypothesis "H_1=There is a significant relationship" was accepted. This indicates that there is a significant relationship between problem-solving strategies and creativity levels. To determine the strength of the relationship, the correlation coefficient value in Table 4 was examined.

Table 4. Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Contingency Coefficient	.333	.000
N of Valid Cases		.324	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

As seen in the table, the Contingency Coefficient value was determined as 0.333. This value showed that there is a moderate relationship between the two variables, problem-solving strategies and creativity. In other words, the prospective teachers' creativity levels in terms of posing problems are correlated with the strategies they pose the problem with.

DISCUSSION & CONCLUSION

The study aimed to assess the creativity levels of prospective teachers, with reference to the problems they posed with respect to various strategies. In conclusion, it was observed that the problems posed with distinct strategies helped reveal the creativity. Indeed, the literature is rich in terms of suggestions that problem posing activities could help bring out the students' creativity in mathematics (e.g. Balka, 1974; Shriki, 2013; Taşkın, 2016). Otherwise, asking the prospective teachers to provide also the solutions for the problems they posed allowed a most detailed analysis of the problems' structures. Yet, some studies argue that such an attitude also poses its share of disadvantages, as the participants in the study would refrain from posing problems harder to solve, given the possibility that they may fail to solve them (Taşkın, 2016). Even though the present study certain advantages as well as disadvantages of asking for solutions for the problems posed were still noted, and discussed in the relevant sections.

In this study it was found that the indicator with the highest average is the fluency in all strategies except conscious guessing and testing strategy. Flexibility and originality ranked second and third respectively, in this context. Other studies in the literature, performed with various groups with the use of various tools of assessment also found that fluency ranks at the top among all indicators of creativity (Ersoy & Başer, 2009). In studies focusing on quantity (eg Akgül, 2014; Balka, 1974; Haavold, 2013), this result is an expected result. Also, as the studies (e.g. Amaral & Carreira, 2012; Baltacı et al., 2014) focusing on quality emphasize the descriptors associated with the fluency's role in "problem posing requiring the use of mathematical concepts and procedures, and presenting the variables/concepts in a clear and consistent manner", this observation would again not be a surprising one. In the present study, even though a quantity limit of just three problems was applied, the prospective teachers' ability to make appropriate use of the mathematical concepts often associated with secondary school level mathematics courses, as well as their consistent use of the variables should not be surprising. In other words, the fluency scores can be expected to be high. In this context, one can argue that the creativity of the prospective teachers is mostly a function of the flexibility and the originality indicators. The observation that the score for the fluency indicator is higher than those of the other indicators suggests that the prospective teachers are able to pose problems in tune with mathematical concepts and procedures, but somewhat fall behind in terms of presenting a truly extraordinary perspective towards various strategies.

The comparison of the prospective teachers' creativity according to fluency revealed that the strategy of solving a simpler analogous problem had the highest average score among all strategies. This is may be associated with the fact that this strategy enables the development and discovery of different mathematical concepts and procedures during the process of "conversion of the problems posed to simpler analogous structures" (Posamentier & Krulik, 1998). On the other hand, the studies in the literature have found that the strategy of solving a simpler analogous problem is more frequently utilized by gifted children (Yıldız et. al, 2012). Even though the prospective teachers who participated in the study were not selected from among gifted students, they were able to exhibit creative behavior in terms of associations between mathematical concepts as they were asked to pose secondary school level problems. Their relatively high fluency scores may be related with this fact. The comparison of the prospective teachers' creativity according to flexibility revealed that the strategy essentially entails making associations between the variables in line with the objective, aiming to come up with a drawing that would lead to the solution (Posamentier & Krulik, 1998). The observations that the prospective teachers took care to employ distinct drawings for the solution of the problem, enabling the review of distinct cases concerning the variables

involved in the scenario on which the drawing is based, help explain the high average flexibility scores for the making drawing strategy. The comparison of the prospective teachers' creativity according to originality revealed that the strategy of guessing and testing strategy had the highest average score among all strategies. Thinking about "a logical answer with respect to the solution" (Posamentier & Krulik, 1998) of the problems posed with reference to this strategy enables and facilitates the use of extraordinary strategies for the solution and the embrace of wider perspectives in this process. Studies in the literature suggest that the guessing and testing strategy is the most widely used one (Özcan, 2005) and the students' level of familiarity with activities can have an impact on their creativity (Leikin & Lev; 2007). Based on that point, one can argue that the prospective teachers may have put more thought into the problems they had posed for that strategy, with which they are more familiar, leading to the generation of more original problems. In other words, the solution strategy applicable to the problem has an impact on the originality exhibited. As Amaral and Carreira (2012) underline, even though originality is considered more closely associated with creativity, it is not enough on its own for creativity to arise.

The present study found that the average creativity scores for the problems posed with reference to specific problem-solving strategies ranged between 48 and 74. Therefore, one can argue that the prospective teachers' creativity levels and associated scores can be considered mediocre and not as high as expected. The comparison of average creativity scores revealed that the highest average scores occurred with the making drawing, solving a simpler analogous problem, guessing, and testing strategies, whereas the lowest average scores occurred with the considering extreme cases strategy. It was seen that prospective teachers seem to be inadequate in producing different and creative ideas while posing problems using organizing data, adopting a different point of view, considering extreme cases strategies. Studies show that creativity in mathematics may vary with the activities (Leikin & Lev, 2007; Taşkın, 2016). Therefore, it can be expected that the prospective teachers exhibit different creativity scores for different strategies. A discussion can be conducted about why the creativity score for a specific strategy is higher or lower than the others. Due to the reasons discussed above, the flexibility scores were higher for the problems posed around the making drawing strategy, whereas the fluency scores for the problems posed around the solving a simpler analogous problem strategy, and the originality scores for the problems posed around the guessing and testing strategy were similarly higher. These results led to higher overall creativity scores compared to the other strategies. Otherwise, these strategies are also easier to reach solutions for students (e.g. Gür & Hangül, 2015, Intaros et al., 2014). According to these points, the prospective teachers may have focused on and spend more time for posing a extraordinary problem, instead of focusing on the solution. And this may have brought about a higher creativity score. The lower creativity scores for the organizing data strategy, are due to the pretty low originality score compared to those of the other strategies. The organizing data strategy is about using certain forms of organization of data to come up with systematic solutions (Posamentier & Krulik, 1998). Even though this strategy enables a wide range of organization, it is not easy to plan for it. (Yıldız et al., 2012). That is why the prospective teachers may have opted for rather ordinary organization, instead of trying to come up with truly original and extraordinary forms of data organization. This, in turn, may lead to a lack of extraordinary and original problems. The 'adopting a different point of view' strategy is about applying a different perspective towards the problem, by solving it through means other than the obvious way (Posamentier & Krulik, 1998). Embracing different perspectives regarding a given situation and focusing on variables other than the clearly given ones is not easy for everyone. In this context, students may have difficulty solving problems associated with this strategy. (e.g. Çeker & Ev Çimen, 2017). As the prospective teachers were asked to also provide the solutions for the problems, they may have focused on posing problems they are rather familiar with, as they had a harder time in solving the problems associated with this strategy. This may have led to low creativity scores on all indicators. The considering extreme cases strategy is about using extreme cases for one of the variables, while keeping the other one fixed (Posamentier & Krulik, 1998). This strategy requires the individual to focus on the extreme cases regarding a situation. Therefore, one should make a robust analysis of the extreme cases and make the true decisions. In this context, the prospective teachers may have chosen to pose problems comparable to the ones they had already been familiar with, to make their task of defining the extreme case easier. This may have led to low creativity scores on all indicators.

Based on a ranking of the scores in the low, medium and high-performance categories, it is evident that the creativity levels in problem posing for various strategies are usually high, and in some cases in the higher echelons of the medium category. The problem-solving strategies have a medium effect in the prospective teachers' creativity. This result is consistent with previous research that has shown how creativity in mathematics can vary across different activities. (Leikin & Lev, 2007; Taşkın, 2016). These studies assessed creativity using different activities, including problem posing, multiple solution activities, and model development. In this study, problem posing activities were focused, but the solution strategies of the posed problems were diversified. In other words,

although the study began with the same set of problem posing activities, the variations in strategies had an impact on creativity.

The study analyzed the creativity regarding the problems posed with various strategies. The creativity, in turn, was assessed with reference to just three problems posed for each strategy. Moreover, the creativity was examined through written documents presenting the problems posed and the solutions associated with those problems. The discussion is based on estimated and probable arguments. The thoughts of the prospective teachers, about why a problem has an original, fluent, or flexible structure and the other has not, have not been investigated. Interviews with the participants could have helped on that front, to come up with a detailed analysis with their thoughts and leading to a rather in-depth assessment of the descriptors associated with relevant indicators. Future studies are recommended to take these limitations into account.

Statements of Publication Ethics

The researchers declare that they have followed the principles of publication ethics. The data used in this study belonged to before 2020. Therefore, there is no approval of ethics committee for this study.

Researchers' Contribution Rate

All authors contributed equally rate to the research.

Conflict of Interest

We confirm that there are no conflicts of interest associated with this study.

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