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# Preservice Mathematics Teachers' Views on the Process of Mathematics Literacy Problem Writing

**Hatice Kübra Güler Selek**
*Bursa Uludag University, Turkey*
*https://orcid.org/0000-0002-6262-8421*

**Abstract**
*Connecting mathematical concepts to real-life situations is a crucial skill in math class. Using mathematical literacy problems in classes may be an option to make connections with real life. In this context, the aim of this research is to reveal the experiences of preservice mathematics teachers in the process of writing mathematical literacy problems and to determine the difficulties they encountered. The participants of the research were 28 preservice teachers who were taking the mathematical literacy elective course in the 2022-2023 spring semester. In this qualitative research design, preservice teachers were provided with essential theoretical information on mathematical literacy over nine-weeks. They were then presented with mathematical literacy questions and their analyses were conducted. Following five weeks, participants worked in groups of 3-4 individuals, each group creating four mathematical literacy problems relating various content areas. At the end of their studies, in order to determine their experience regarding problem posing process, preservice teachers were given a survey consisting of open-ended questions. As a result of the analysis of the data obtained from the survey, it was seen that the issues in which the preservice mathematics teachers found themselves inadequate were more than the issues in which they found themselves competent. It was observed that participants focused on choosing context and writing the problem in accordance with the real life. While one group found themselves very competent in this regard, the other group found themselves quite inadequate. In addition, preservice teachers thought that they needed to examine more mathematical literacy questions and made writing attempts in order to pose qualified mathematical literacy problems.*
**Keywords: Preservice Mathematics Teachers, Mathematical Literacy, Problem Posing**

## Introduction

Mathematics is perceived as a problem-solving activity based on modeling real life, rather than just an algorithmic rule (De Corte, 2004). Mathematics plays a crucial role for young people as they tackle a diverse array of issues and challenges across different aspects of their lives (OECD, 2023). From this perspective, it is important to teach mathematics by associating it with real life in order for students to find it valuable. OECD (2023) defines mathematical literacy as 'Mathematical literacy is an individual's capacity to reason mathematically and to formulate, employ, and interpret mathematics to solve problems in a variety of real-world contexts. It includes concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to know the role that mathematics plays in the world and to make the well-founded judgements and decisions needed by constructive, engaged and reflective 21st Century citizens'. In this definition, it is emphasized that mathematical literacy is the capacity to solve real life problems and is related to various competencies. At this point, the notion that mathematical literacy problems can be employed in math classes to establish a connection with real-life situations is apparent. However, in order for teachers to use mathematical literacy problems in their classes, they must know the characteristics of these problems, be able to analyze

whether a problem is a mathematical literacy problem or not. And ultimately, they are able to write a mathematical literacy problem. Due to this requirement, mathematics literacy course was offered as an elective to preservice mathematics teachers and the research was conducted within this scope. The aim of this research is to reveal the experiences of preservice mathematics teachers in the process of writing mathematical literacy problems and to determine the difficulties they encountered.

**Review of Literature**

Mathematical literacy is the individual's capacity to formulate, apply and interpret mathematics in various ways in living environments (OECD, 2017). As seen in the definition, the process of solving mathematical literacy problems has three components. These components are stated as 'Formulating situations mathematically', 'Employing mathematical concepts, facts and procedures' and 'Interpreting, applying and evaluating mathematical outcomes' (OECD 2017; 2023). These skills include the processes of establishing a relationship between real life and mathematical problems, solving the problem using mathematical knowledge, and interpreting the obtained mathematical results as an answer to the real life problem. Students are required to have a variety of competencies while they carry out these mathematical process. These competencies are 'communication; mathematisation; representation; reasoning and argument; devising strategies; using symbolic, formal and technical language and operations; and using mathematical tools' (OECD, 2017; 2023). As can be understood from the definition, mathematical literacy is important for the ability to use the various competencies acquired in school to be used in real life and is emphasized in the literature as a skill that students should acquire in mathematics classes (Firdaus et al., 2017; Sitopu et al., 2024; Stacey & Turner, 2015).

There are various studies in the literature on the mathematical literacy levels of teachers and teacher candidates (Güler & Arslan, 2019; Kabael & Barak, 2016; Sáenz, 2009; Suharta & Suarjana, 2018; Widjaja, 2011). However, while there are various studies on the problem posing processes of teachers or teacher candidates (Crespo, 2003; Patáková, 2013; Stickles, 2011; Silber & Cai, 2017; Yao et al., 2021), there are limited studies focusing on the process of writing mathematical literacy problems (Demir, 2019; Özgen, 2019; Sahin & Basgul, 2018). Sahin and Basgul (2018) investigated mathematics pre-service teachers' problem posing skills appropriateness to the nature of PISA. Their findings showed that many of the problems that pre-service teachers posed are appropriate to the nature of PISA. Similarly, Özgen (2019) examined the problems developed by teachers and teacher candidates for mathematical literacy in terms of their type, difficulty level, context, mathematical content, topics and processes. In both studies, the problems written by the participants were analyzed within the framework of PISA, but the participants' views on the problem writing process were not included. Demir (2019) conducted a qualitative study to determine the actions of preservice teachers in the problem posing processes. However, in this study, preservice teachers' views and experiences regarding problem writing processes were not discussed. Gürbüz (2014) gave mathematics literacy courses to preservice mathematics teachers and then conducted a question writing exercise. In his study, he received the views of the preservice teachers regarding the courses provided, but did not present any data regarding their views on process of writing mathematical literacy problems. Demir and Altun (2018) provided mathematics literacy problem writing courses to preservice mathematics teachers. In addition to evaluating the problems they wrote within the framework of mathematical literacy, they also identified the opportunities and difficulties encountered by the participants in choosing and writing problems. While preservice teachers considered writing problems based on their own experiences and using situations they encountered in daily life as an opportunity; they considered the difficulty of writing problems, lack of time to write problems, not being able to write original questions, and confusing mathematical literacy problems with intelligence questions as difficulties. In the current study, unlike the studies in the literature, it is focused on the issues that preservice mathematics teachers consider themselves competent and insufficient in the process of writing mathematical literacy

problems and what they need to write more qualified problems.

## Methodology

The holistic single case design examines only one situation from a single context (Yin, 2018). The current study only focused on the preservice mathematics teachers who were taking the mathematical literacy course evaluating themselves after writing mathematical literacy problem tasks. Because of this reason, the research structured based on holistic single case design.

The participants of the research are 28 preservice mathematics teachers who were taking the mathematics literacy elective course in the 2022-2023 spring semester. 14 of the mathematics teacher candidates were second grade, 10 were third grade and four were fourth grade. They were coded as PT1, PT2, …, PT28.

**Table 1 Grades of the Preservice Mathematics Teachers (PT)**

| Grade | PT | Frequency (f) |
|---|---|---|
| 2nd | PT1, PT3, PT4, PT6, PT8, PT12, PT13, PT16, PT17, PT20, PT22, PT23, PT24, PT25 | 14 |
| 3nd | PT2, PT5, PT7, PT11, PT18, PT19, PT21, PT26, PT27, PT28 | 10 |
| 4rd | PT9, PT10, PT14, PT15 | 4 |

In this qualitative research, theoretical framework of mathematical literacy was represented to preservice teachers for nine weeks and mathematical literacy problems were introduced. Mathematical literacy problems were analyzed in the context of the mathematical processes and mathematical competencies. For five weeks, participants were asked to work in groups of 3-4 people and write at least one mathematical literacy problem for each content area (Uncertainty and data, space and shapte, quantity, change and relationships). At the end of their studies, they were asked to evaluate their problem writing task individually and for this purpose they were given a survey consisting of open-ended questions. After the survey was prepared, expert opinion was taken. A pilot study was conducted with 10 students who were taking the same course and were not included in the research. The validity and reliability of the data collection tool were ensured through expert opinions and pilot applications. Subsequently, the questions were finalized. The questions in the survey are as follows:

1. Which course(s) do you think were most helpful to you in writing mathematical literacy problems?
2. What do you consider yourself competent in writing mathematical literacy problems?
3. What do you consider yourself inadequate in writing mathematical literacy problems?
4. 'To write more qualified mathematical literacy problems, one must have …' How would you fill in the blank in the sentence?

The participants' answers to the survey were analyzed using the content analysis method. The codes obtained during the analysis process were shared with the students and confirmation was obtained. In this way, validity was tried to be ensured for the data analysis process.

## Results

As a result of the analysis of the answers given by the preservice teachers, most of them stated that mathematical literacy, problem solving and problem posing courses were among the courses they benefited from in writing mathematical literacy problems. Only two participants stated that pure mathematics courses contributed to mathematical literacy problem writing.

**Table 2 The Courses from Which Preservice Teachers Benefited When Writing Mathematical Literacy Problems**

| Grade | PT | f |
|---|---|---|
| Mathematical literacy | PT4, PT8, PT14, PT15, PT19, PT20, PT21, PT22, PT28 | 9 |
| Problem solving | PT4, PT5, PT6, PT10, PT11, PT15, PT21, PT22, PT28 | 9 |
| Problem posing | PT5, PT11, PT13, PT15, PT21, PT23, PT24, PT26, PT28 | 9 |
| Connection | PT3, PT10, PT25, PT27 | 4 |
| Methods of teaching and learning mathematics | PT12, PT17, PT23, PT25 | 4 |

| | | |
|---|---|---|
| Developing activities in mathematics education | PT3, PT18, PT23 | 3 |
| Evaluation and assessment | PT3, PT16, PT25 | 3 |
| Mathematical modelling | PT10, PT21, PT28 | 3 |
| Investigating mathematics textbook | PT7, PT11 | 2 |
| Pure mathematics courses | PT8, PT14 | 2 |

While 20 of the participants considered themselves competent in various aspects of writing mathematical literacy problems, eight of them considered themselves completely inadequate. PTs' views on the points at which they considered themselves competent were come under three categories: theoretical knowledge, skills and individual factors. PTs generally considered themselves competent in choosing the appropriate context and writing problems appropriate to real life. In addition, PTs considered themselves competent in writing mathematical literacy problems for a competency or mathematical process. One PT stated that s/he was able to relate problem content to other fields (skill category). Another one stated that s/he could write more current problems because s/he followed current news and topics (personnel factor category). One PT explained that s/he was sufficient in writing problem content (knowledge category) because he had a good level of mathematics knowledge. The most codes were seen in the skill category. The categories and codes regarding PTs' competencies can be seen in Table 3.

**Table 3 Issues in which PTs find themselves Competent**

| Category | Competency | PT | f |
|---|---|---|---|
| Skill | Writing problems appropriate to real life | PT1, PT8, PT11, PT12, PT13, PT28 | 6 |
| | Choosing the appropriate context | PT7, PT10, PT11, PT13, PT18, PT22 | 6 |
| | Writing problems appropriate to chosen competency | PT19, PT21, PT22, PT26 | 4 |
| | Writing problems appropriate to chosen mathematical process | PT13, PT19, PT21, PT22 | 4 |
| Skill | Writing problems clearly | PT2, PT9, PT15 | 3 |
| Theoretical Knowledge | Writing problems appropriate to content | PT22, PT25 | 2 |

PT2 expressed that s/he was competent in terms of writing clearly with the following sentence.

PT2: What I feel I am good at is being able to express the question clearly…. I pay attention to grammar rules and to avoid any errors in expression.

PT5 and PT10 stated that they were sufficient in finding context with the following sentences.

PT5: I think I have no trouble finding context.

PT10: I think I'm creative in finding context.

PT19 stated that s/he learned the mathematical processes in mathematical literacy very well and did not have difficulty in writing problems about the processes.

PT19: The thing I improved most was creating problems suitable for the desired process.

All of PTs feel inadequate in various aspects when writing mathematical literacy problems. PTs' views on the points at which they considered themselves inadequate were come under three categories: experience, theoretical knowledge, skills and prejudice. They often felt inadequate in being creative, finding the context appropriate to real life, and structuring the problem. These three cases were grouped under the skill category. Four participants stated that they had difficulty in determining mathematical processes and competencies in mathematical literacy problems. They stated that by examining more problems, they would gain experience in determining competence and process; and will begin to feel themselves as more competent. Three students had a prejudice that writing mathematical literacy problems was difficult. Only two participants stated that not having taken the problem posing and problem solving course was a disadvantage for them in writing mathematical literacy problems, and they stated that they would feel more competent if the missing pure mathematics and mathematics education courses were completed. One participants stated that s/he had difficulty writing problems in a scientific context (PT25), and another participant stated that s/he sometimes went off the purpose because s/he had no experience in writing questions (PT24).

**Table 4 Issues in which PTs find hemselves Inadequate**

| Category | Inadequacy | PT | f |
|---|---|---|---|
| Skill | Finding context | PT5, PT9, PT14, PT15, PT26, PT28 | 6 |
| | Inability to structure the problem | PT11, PT12, PT14, PT16, PT23, PT26 | 6 |
| | Inability to be creative | PT2, PT6, PT16, PT22, PT23, PT27 | 6 |
| | Inability to write problems appropriate to real life | PT7, PT14, PT20, PT26 | 4 |
| | Inability to determine competence and process | PT4, PT6, PT21, PT28 | 4 |
| | Inability to distinguish mathematical literacy problems from new generation questions* | PT1, PT8 | 2 |
| | Inability to write appropriately for every content area | PT20, PT22 | 2 |
| | Inability to write problems for more than one competency at the same time | PT13, PT19 | 2 |
| | Inability to write problems for interpretation-evaluation processes | PT5, PT10 | 2 |
| Experience | Need to review more problems | PT2, PT16 | 2 |
| Theoretical Knowledge | Lack of mathematical knowledge | PT18, PT24, PT26 | 3 |
| | Not having taken the problem solving/ posing courses | PT3, PT18 | 2 |
| Prejudice | Difficulty of the problem writing process | PT3, PT4, PT17 | 3 |

PT2 stated that s/he felt his/her own in creativity, PT8 stated that s/he had difficulties in structuring the problem, and PT18 expressed his/her lack of mathematical knowledge with the following sentences.

PT2:…In short, creativity is an issue, I find myself inadequate.

PT11:…I reconstruct the question sentence over and over again to make it look the way I intended. This is where I have difficulty in writing the problem.

PT18: I think that in order to write better problems, I need to increase my theoretical knowledge in all areas of mathematics and improve myself by practicing.

In the country where the study was conducted, there are problems presented in the context of what is called 'new generation questions*' in the national curriculum. Although these problems are similar to mathematical literacy because there is a context, they are not mathematical literacy questions in terms of competence and processes.PT1 and PT8 drew attention to this issue and stated that they confused these two problem types. PT8's statement regarding this issue is as follows:

PT8: My biggest weakness might be the inability to escape the influence of new generation questions.

PTs statements about what was required to write a qualified mathematical literacy problem were come under four categories: experience, theoretical knowledge, skill and individual factors. They especially emphasized that in order to write more qualified mathematical literacy problems, it was necessary to be experienced in adapting real life problems, to write and examine more mathematical literacy problems, to have a wide imagination. Only one participant stated that problems that did not have the characteristics of mathematical literacy problems should also be examined. This can be considered as an indication that the PT in question focuses on conceptual learning. In addition, one PT's each statement 'must have knowledge of the content area' (PT1), 'knowledge is required' (PT3), 'knowledge of question writing techniques' (PT4), 'examples that do not comply with mathematical literacy should be examined' (PT13) were included in the theoretical knowledge category; 'looking at life through mathematical eyes' (PT7), 'having 21th century skills' (PT20), 'having connection skills' (PT26) were skill categories; 'Assimilating mathematics' (PT7) and 'having experience' (PT25) were coded under the experience category.

**Table 5 Issues that PTs consider Necessary for Writing more Qualified Mathematical Literacy Problems**

| Category | Necessity | PT | f |
|---|---|---|---|
| Experience | Further review and write mathematical literacy problems | PT2, PT4, PT6, PT13, PT17, PT22, PT24 | 7 |
| | Experience in writing real life problems | PT1, PT21, PT22, PT23, PT28 | 5 |
| | More training on mathematical literacy | PT2, PT17 | 2 |
| Skill | Find appropriate context | PT10, PT11, PT18, PT20, PT21 | 5 |
| | Using the language correctly | PT8, PT9, PT18, PT23 | 4 |
| | Having a wide imagination | PT15, PT16, PT22, PT27 | 4 |
| | Thought provoking problem writing | PT10, PT11 | 2 |
| | Reasoning power | PT3, PT18 | 2 |
| Knowledge | Knowledge of mathematical process/ competency | PT5, PT11, PT19, PT20 | 4 |
| | Considering the student's level and needs | PT4, PT9, PT27 | 3 |
| | Mastering on theoretical knowledge | PT17, PT20 | 2 |
| | Knowledge of technology | PT4, PT12 | 2 |
| Personal Factor | Reading book | PT6, PT15 | 2 |
| | Knowledge of current events | PT4, PT12 | 2 |

## Conclusion, Discussion and Suggestions

As a result of this study, which was carried out to reveal the experiences of preservice mathematics teachers in the process of writing mathematical literacy problems and to determine the difficulties they encountered in this process, it was seen that the courses that they used in the problem writing process differed, and the issues in which they found themselves inadequate were more than those in which they found themselves competent. The courses that PTs benefit most from are mathematical literacy, problem solving and problem posing courses. Ultimately, writing a mathematical literacy problem can also be considered as a problem posing activity. Therefore, taking these courses was seen as a necessity by PTs in order to write a mathematical literacy problem. While finding context was a very easy task for a group of participant, it was found to be a difficult task for some other participants. Considering the grade levels of these students, it was determined that most of the students who considered themselves competent in finding context were second graders, while those who considered themselves inadequate were mostly third graders. However, it was seen that the students who have difficulty in posing the problem were generally second graders. These differences between grade levels may be related to the courses students took during their undergraduate education, their experiences or areas of interest.

Demir and Altun (2018) stated that preservice teachers considered writing problems based on their own experiences and being able to use situations they encountered in daily life for mathematical literacy problems as an opportunity. In the current study, the issues that PTs considered themselves most competent in were writing problems appropriate to real life and finding an appropriate context. However, one of the main issues that PTs found themselves inadequate in was finding context. The skill, 'finding context', which was felt to be both competent and inadequate, might be related to the extent to which PTs looked at their daily lives mathematically. When looking at their grade levels, it was determined that most of the students who considered themselves competent in finding context were second graders, while those who considered themselves inadequate were mostly third graders. In this case, problem writing might be an advantage for some PTs, based on their own experiences expressed

by Demir and Altun (2018). However, some could not turn this situation to their advantage. In Demir and Altun's (2018) study, PTs considered the difficulty of writing problems, lack of time to write problems, not being able to write original problems, and confusing mathematical literacy problems with intelligence questions as difficulties. In the current study, it was determined that PTs found themselves inadequate in terms of creativity and had a prejudice that writing problems was difficult. Van Harpen and Sriraman (2013) also stated in their problem posing study with high school senior and university freshman students that the students had difficulty in posing qualified and creative problems. In addition, in the current study, PTs stated that they confused mathematical literacy problems with the problems called 'new generation questions' in the curriculum in their country, and this situation coincides with the confusion of problem types identified in the study of Demir and Altun (2018).

Pre-service teachers emphasized the importance of experience in order to write more qualified mathematical literacy problems. Stickles (2011) and Patáková, (2013) also determined in their studies with teachers that experience was effective on problem posing success. Additionally, Stickles (2011) stated that there was no significant difference between teacher candidates and one- or two-year teachers in terms of problem posing success. Crespo (2003) also found in his study that in a series of problem posing tasks, teacher candidates were able to pose more qualified problems in subsequent tasks. The second problems posed by teacher candidates were more complex, unfamiliar and difficult. In this respect, the results of the current study coincide with the results of Crespo (2003).

Based on the results obtained from the study, it can be said that appropriate activities should be developed for preservice teachers to gain more experience in writing mathematical literacy problems. Preservice teachers' awareness about mathematics in life should be improved so that they can write more qualified mathematical literacy problems. Although the participants generally had the needed knowledge, they had difficulty in thinking in an organized way about problem writing. Therefore, to support preservice teachers in gaining more experience, more emphasis can be placed on analyzing and writing questions in classes.

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**Author Details**

**Hatice Kübra Güler Selek,** *Bursa Uludag University, Turkey,* ***Email ID****: hkguler@uludag.edu.tr*