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Mathematical Problem Solving and Its Teaching: Study from Indonesian Preservice Teachers

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ABSTRACT

This research aims to explore the understanding of preservice mathematics teachers in Indonesia regarding mathematics problems, problem-solving, and learning to develop problem-solving. The research used an exploratory sequential design which consists of two stages, involving quantitative and qualitative. The quantitative stage was carried out through a survey of 124 preservice mathematics teachers. Data was collected using a questionnaire given via Google Forms. Data was analyzed using descriptive statistics and an independent sample t-test. The qualitative stage was carried out through semi-structured interviews with 20 participants. Qualitative analysis adapting the Bogdan and Biklen technique, through data reduction, looking for themes and relationships between themes, and concluding. The results showed that the understanding of preservice mathematics teachers in Indonesia regarding problem solving and learning is in the sufficient category. The results of the independent sample t-test show that students who have studied for more than two years have a better understanding than those who have studied for less than two years. Several lecture activities that influence their understanding are project learning, exercises, and discussions. The result gave considered higher education or universities in providing an accommodating curriculum for students to develop their understanding of problem-solving and its teaching.

Kata Kunci:
Calon guru,
Matematika,
Pembelajaran,
Pemecahan masalah,

ABSTRAK

Penelitian ini bertujuan untuk mengekplorasi pemahaman calon guru matematika di Indonesia terkait masalah matematika, pemecahan masalah, dan pembelajaran untuk mengembangkan pemecahan masalah. Penelitian menggunakan exploratory sequential design yang terdiri dari dua tahap, yaitu kuantitatif dan kualitatif. Tahap kuantitatif dilakukan melalui survei pada 124 mahasiswa calon guru matematika. Data dikumpulkan menggunakan angket yang diberikan melalui google form. Analisis data dilakukan dengan statistik deskriptif dan uji independent sample t-test. Tahap kualitatif dilakukan melalui wawancara semi terstruktur pada 20 mahasiswa calon guru matematika. Analisis kualitatif dilakukan dengan mengadaptasi teknik Bogdan and Biklen, melalui tahapan reduksi data, mencari tema dan hubungan antar tema, dan menyimpulkan. Hasil penelitian menunjukkan bahwa secara umum pemahaman calon guru matematika di Indonesia terkait pemecahan masalah dan pembelajarannya berada pada kategori cukup. Hasil uji independent sample t-test menunjukkan bahwa mahasiswa yang telah menempuh pendidikan lebih dari dua tahun memiliki pemahaman yang lebih baik dibandingkan yang menempuh pendidikan kurang dari dua tahun. Beberapa aktivitas perkuliahan yang mempengaruhi pengembangan pemahaman mahasiswa calon guru matematika diuraikan secara mendalam dalam diskusi penelitian ini, meliputi pembelajaran proyek, latihan, dan diskusi. Temuan dalam penelitian ini diharapkan menjadi pertimbangan pendidikan tinggi untuk memberikan kurikulum yang akomodatif bagi mahasiswa untuk mengembangkan pemahaman pemecahan masalah dan pembelajarannya.

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Introduction

Mathematics is one of the core subjects in schools, partly because it plays a crucial role in science, technology, and engineering (Rozgonjuk et al., 2020). For an individual to thrive, it is essential to possess adequate mathematical skills (Skagerlund et al., 2019). Solving math problems helps students deepen their understanding of mathematics (Munzar et al., 2021). Furthermore, consistently solving problems contributes to the development and refinement of mathematical knowledge (Mason, 2016). Therefore, teachers should provide students with ample opportunities to solve as many mathematical problems as possible.

Mathematical problem solving has been a major agenda in the development of mathematics education for the past four decades (Santos-Trigo, 2024). Problem solving influences the development of mathematics curricula and strategies to support learning environments worldwide (Toh et al., 2023). Mathematical problems can be interpreted as new questions that require previously unknown solution strategies, thus encouraging students to think critically and creatively to develop innovative solutions (Getenet, 2024). Mathematical problems related to everyday life are often challenging for students because they require the application of various skills, such as reading comprehension, mathematical reasoning, and problem-solving strategies (Verschaffel et al., 2020). To be able to solve problems effectively, students need skills to identify relevant information, plan and implement problem-solving strategies, monitor progress, and evaluate solutions (Getenet, 2024; Verschaffel et al., 2020).

Teachers play an important role in developing students' problem-solving skills. Even in the early years of a child's education, teachers need to develop students' problem-solving skills (Szabo et al., 2020). Teachers' beliefs about mathematics have an impact on the learning that will be carried out (Lester & Cai, 2016). Teachers play an important role in developing an affective atmosphere and social interactions in the classroom (Pehkonen et al., 2016) which will affect the success of learning. Teachers need to accustom students to being able to use and develop various problem-solving strategies. This allows students to develop self-confidence and resilience when solving problems (Reys et al., 2021). Therefore, teachers need to have a good understanding of mathematical problem solving and its learning.

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To be able to improve teachers' ability in teaching mathematical problem solving requires a study of mathematical problem solving and its teaching according to prospective teachers (Jiang et al., 2022). Prospective teachers must understand mathematics, teaching, and pedagogy (Register et al., 2022). However, research shows that many prospective teachers have false beliefs about the nature of mathematics, fail to realize that mathematics stimulates analytical thinking skills and creativity (Paolucci, 2015), and have difficulty in solving problems (Mallart et al., 2018). Understanding mathematics, mathematical problem solving, and its teaching are important parts of teacher quality that effectively direct future learning to be better.

Exploring the understanding of prospective mathematics teachers in Indonesia regarding mathematical problem solving and learning is an important thing to do. This is an effort to ensure that future Indonesian mathematics teachers are ready to develop students' problem-solving abilities. In the practice of mathematics education in Indonesia, many teachers prefer a memorization-oriented mathematics learning process, using routine procedures by explaining formulas, giving examples of problems and giving exercises that are usually almost the same as the examples given previously (Hendriani & Marsyidin, 2023). Often, teachers focus more on providing knowledge or subject matter, rather than providing scenarios that prioritize the development of problem-solving abilities (Mulyati, 2011). Based on this, this study seeks to explore how prospective mathematics teachers in Indonesia understand mathematical problems, problem solving, and mathematics learning to develop problem-solving abilities.

Method

The study used explanatory sequential design which was conducted through quantitative stages and continued with qualitative stages. The quantitative stage was conducted through a survey using a questionnaire to see how prospective teachers in Indonesia understand problem solving and learning. After that, it was continued with a qualitative stage through interviews. This stage focuses on describing in depth the findings of the quantitative analysis that had been conducted previously.

In the quantitative stage, 124 prospective mathematics teacher students were involved in the study. Participants came from 5 universities in Indonesia. The detailed demographics of the research subjects can be seen in Table 1.

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Table 1. Demographics of Research Subjects

Aspect	Number of participants	Percentage
Gender		
Male	27	22 %
Female	97	78 %
Years of Education		
Less than 2 years	79	64 %
More than 2 years	45	36 %

In the qualitative stage, participants were selected using purposive sampling considering their willingness to be interviewed and follow the research until the end. A total of 20 participants were involved in this stage which were then coded as S1 to S20.

Data collection was conducted using questionnaires and semi-structured interviews. The questionnaire consisted of 15 statements with five alternative answers in the form of a google form. The questionnaire will measure three main aspects, namely 1) prospective teachers' understanding of mathematical problems, 2) prospective teachers' understanding of mathematical problem solving, and 3) prospective teachers' understanding of problem-solving learning. The questionnaire was given to the research subjects via google form. Each participant filled out the questionnaire within 15-20 minutes.

Semi-structured interviews were conducted in 20-30 minutes for each participant in turn. Each participant has agreed that the interview process will be recorded and documented. The questionnaire instrument and interview questions have been reviewed by two experts.

The questionnaire data were analyzed descriptively to see the understanding of prospective mathematics teachers in Indonesia related to mathematics problems, problem solving, and learning to develop problem-solving skills. The understanding of prospective teachers will be categorized based on the average achievement of the teacher questionnaire. The understanding of prospective teachers is categorized into very high, high, sufficient, low, and very low. The analysis was continued by looking at the comparison of the understanding of prospective mathematics teachers who have studied for more than two years and less than two years using the independent sample t-test. The test was carried out at a significance level of 95% with the help of SPSS. The results of the quantitative analysis were then interpreted and continued with qualitative data analysis.

Interview data were analyzed qualitatively by adapting the analysis steps (Bogdan & Biklen, 1998), including 1) data reduction, 2) finding themes and relationships between themes, and 3) drawing conclusions. To ensure that the research runs well,

the researcher ensures credibility, confirmability, dependability, and transferability (Lincoln & Guba, 1985). Credibility in the study was achieved through triangulation of data collection methods, namely questionnaires and interviews. Confirmability and dependability in research are achieved through continuous involvement of researchers with data and data verification by all members of the research team. Meanwhile, to ensure transferability, researchers provide detailed explanations for each part of the research.

Result and Discussion

This study will describe two main topics, namely 1) the profile of understanding of prospective teachers in Indonesia related to mathematical problems, mathematical problem solving, and problem-solving learning; and 2) a comparison of the understanding of prospective mathematics teachers who have studied for more than two years and less than two years.

Preservice Teachers' Understanding of Problem Solving and Its Teaching

The results of descriptive statistics show that the average understanding of prospective teachers about problem solving and learning is 3.17 in the sufficient category. Meanwhile, each aspect can be observed in Figure 1. The findings of this study indicate that prospective mathematics teachers understand the meaning of problem-solving, problem-solving procedures, and learning designs that can be implemented in developing problem solving skills. However, prospective teachers do not understand mathematics problems well.

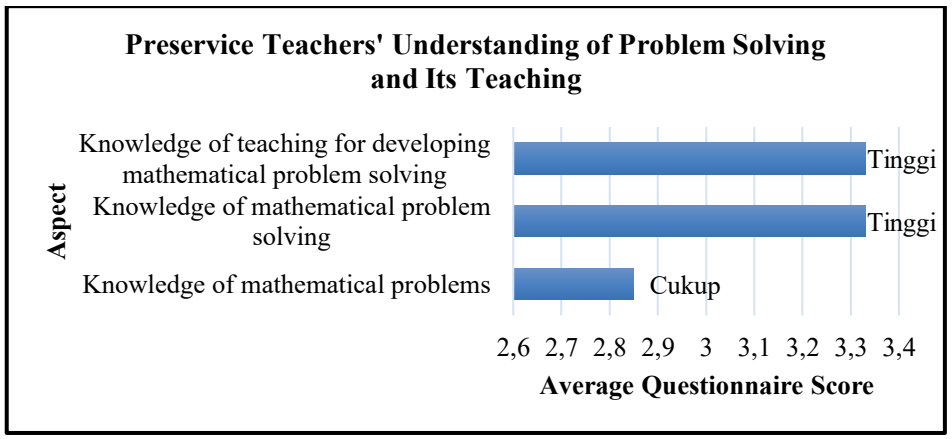

Figure 1. Preservice Teachers' Understanding of Problem Solving and Its Teaching

The category of sufficient understanding of prospective teachers in Indonesia regarding problem solving and learning is different from the results of previous studies. Research conducted by (Jiang et al., 2022) showed that prospective mathematics teachers in China understand mathematical problems, problem solving, and teaching problem solving well. This condition shows the importance of higher education in preparing a more accommodating curriculum in the

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development of problem solving and learning in Indonesia. Problem-solving training for prospective mathematics teachers is the core of mathematics teacher education (dos Santos Morais, 2020).

The Impact of Lectures Towards Understanding of Problem Solving and Its Teaching

The analysis continued by looking at whether the length of lectures had a significant effect on prospective teachers' understanding of mathematical problem solving and learning. The results of the independent sample t-test (Table 2) showed that the length of lectures had a significant effect on prospective teachers' understanding of mathematical problems, mathematical problem solving, and learning mathematical problem solving. This shows that the experience experienced by a person affects their understanding. The findings of this study confirm previous research that prospective mathematics teacher education is effective in teaching problem solving (Jiang et al., 2022).

Table 2. Independent Sample T-Test Results

Aspect	Sig. (2-tailed)	H_0	Conclusion
Understanding mathematical problems	0.003	Rejected	There is a significant difference in the average understanding of mathematical problems of prospective mathematics teachers between those who have studied for more than two years compared to those who have studied for less than two years.
Understanding mathematical problem solving	0.018	Rejected	There is a significant difference in the average understanding of mathematical problem solving of prospective mathematics teachers who have studied for more than two years compared to those who have studied for less than two years.
Understanding problem solving learning	0.006	Rejected	There is a significant difference in the average understanding of mathematical problem-solving learning of prospective mathematics teachers between those who have studied for more than two years compared to those who have studied for less than two years.

The results of the interviews conducted describe several factors that are predicted to influence the development of prospective teachers' understanding of problem solving and learning. Lecture experiences that are predicted to influence prospective mathematics teachers' understanding include 1) Project-based learning; 2) problem-solving practice questions; and 3) group discussions. Complete details can be observed in Table 3.

Table 3. Lecture Experiences That Impact Prospective Teachers' Understanding

Results	Theme
The project task is to go into the field to overcome or provide solutions related to student problems in learning mathematics (S2) Through project work activities and group assignments (S3, S10, S12, S15) Through research project activities such as social projects related to mathematics (S18, S20) Through case study activities that must be completed through project work. The case must be solved or resolved with strong evidence, so as to produce the best solution (S17)	Project Work
Through practice questions during lectures (S6, S7, S9, S11, S18) which are graded from easy to difficult (S14, S16). Through practice questions and several applications of mathematical material in the form of story problems (S13) The lecturer gave practice questions that were quite different from the questions that had been discussed during the lecture. So we students need creativity and learn to solve problems (S5) Through practice questions that combine several related materials in one question (S4, S8, S17, S19)	Problem solving practice questions
Through discussion activities in solving mathematical problems (S1, S3) Through discussion activities and linking problems in everyday life (S6, S8, S12)	Group discussion

The interview results revealed that project-based learning during lectures was able to develop prospective teachers' understanding of problem solving and learning. Several main characteristics of problem-solving abilities, such as problems originating from real situations, the complexity and challenges of the problem-solving process, and the need for active student participation, are all related to the characteristics and advantages of project-based learning (Ruslan et al., 2021). Project-based learning differs from traditional learning because it seeks to develop students as active learners who take the initiative to acquire the knowledge needed to solve problems that arise in the project, rather than as passive recipients. These results strengthen the argument that project-based learning is a common approach to developing problem-solving abilities (Ling et al., 2024).

Problem-solving exercises are also believed to be able to develop the understanding of prospective teachers. The exercises presented have several criteria, namely they are graded from easy to difficult, varied, related to real problems and related to various lecture materials. This form of problem-solving exercise can be part of deliberate practice. Deliberate practice is an act of repeated practice to be able to increase a person's capacity (Davis et al., 2016; Lehtinen et al., 2017). In mathematics

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education, it is very important to provide opportunities for students to engage in more complex forms of practice that encourage them to develop emerging skills and knowledge structures, not just routine practice with the skills they have (Lehtinen et al., 2017). By involving prospective teacher students in deliberate practice, it will support the automation of increasingly complex activities. This will support student performance in increasingly complex tasks in the future kompleks (McMullen et al., 2023).

Group discussions have also been suggested to influence the development of pre-service teachers' understanding of their problem-solving and learning skills. To use active learning methods in universities, lecturers must use adult learning principles including providing autonomy and respect to students and students must have the opportunity to discuss (Kumar et al., 2021). Discussion skills include the ability to exchange information in groups for purposes such as problem solving. Overall, discussions offer students a space to externalize ideas, obtain feedback, and resolve differences of opinion while completing the problem-solving process (Tawfik et al., 2017). In case-based learning, discussions provide students with a space to understand complex topics by combining their previous knowledge and experiences with information from their peers (Koehler et al., 2020). It is through these discussions that pre-service teachers develop awareness of their understanding and performance when completing certain learning tasks.

Conclusion

The results of the study indicate that overall the understanding of prospective teachers regarding mathematical problem solving and learning is in the sufficient category. The results of the independent sample t-test indicate that lecture experience has a significant effect on the understanding of prospective teachers. The findings of this study are expected to be the basis for consideration by universities to develop an accommodating curriculum in developing prospective teachers' understanding of problem solving. In addition, sustainable programs need to be pursued so as to provide more space for prospective mathematics teachers to be able to develop their abilities.

This study used limited subjects with backgrounds that were not yet diverse. Based on this condition, it is expected that future research can consider the number and diversity of research subjects' backgrounds so that the research results are more comprehensive. In addition, research in the qualitative phase only focuses on exploring lecture activities that affect the understanding of prospective mathematics teachers. Future research is expected to conduct in-depth qualitative studies to reveal the obstacles to the development of problem-solving skills in Indonesia.

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