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Investigating Undergraduate Students' Mathematical Problem-Solving Techniques in Mathematics Education

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ABSTRACT

The study aims to investigate the methods used by undergraduate students studying mathematics education to solve mathematical problems. The researcher used a survey questionnaire to carry out a quantitative study design. This survey covered a range of approaches used by the student teachers before, during, and after problem-solving. According to the study's findings, the respondents use cognitive and metacognitive strategies when tackling mathematical problems. The organizing, elaboration, and rehearsal processes are all included in cognitive procedures. However, metacognitive abilities demonstrate that self-control and critical thinking are helpful strategies for solving mathematical problems. The methods utilized to solve mathematical problems before, during, and after determining the solution are also examined in this study. After responding to the problem-solving question, the responders used organization, elaboration, rehearsal, and critical thinking. Respondents also use monitoring and organization while addressing the issue. Moreover, in solving mathematical problems, students also apply self-control, critical thinking, and monitoring. This study's results show that student teachers know the different strategies for solving mathematical problems. However, they find it challenging to apply in a real scenario, which results in low scores.

INTRODUCTION

In this generation, teaching students how to solve problems is a critical thinking skill they must develop. It involves the capacity to recognize the type of problem, evaluate it, and create a plan of action that will successfully resolve the issues it brings up in real life. It comprises the ability to identify the problem, evaluate it, and develop a plan that will effectively address the issues it brings up in everyday life. This suggests that when it comes to problem-solving, thinking is more critical than information (Carson, 2007). The cognitive process of problem-solving includes both higher-order thinking abilities and the development and execution of plans to achieve objectives (Md, 2019; Sutarno *et al.*, 2017). Students' practical skills are developed using this strategy, which improves their cognitive capacities and knowledge acquisition while preparing them to handle problems in the real world. Additionally, it promotes teamwork, interpersonal contact, the sharing of fresh concepts, the development of critical thinking abilities, and the creation of innovative ideas (Sinaga *et al.*, 2023).

Students must have a solid foundation in mathematics knowledge, skills, and principles to pursue further studies in the modern, technologically advanced world (Albay, 2020). According to the country's educational framework, developing critical thinking and problem-solving skills is the cornerstone of mathematics education in the Philippines (SEI-DOST & MATHTED, 2011). Through improving critical thinking and analytical skills, students can solve problems and become persons with high mathematical proficiency. Students can use their acquired knowledge and problem-solving abilities in situations from the real world. This is because general problem-solving strategies and mathematical problem-solving procedures are identical (Arson, 2007).

The Philippines' performance in mathematics education has fallen short of expectations despite the Department of Education's goal of improving Filipino students' mathematical abilities to broaden their skill set. Less than 20% of Filipino students achieved Level 2 in mathematics on the 2018 Programme for International Student Assessment (PISA), while more than 50% fell below Level 1(Bernardo *et al.*, 2022). Although more than half of the participants lacked sufficient skills, this suggests a significant gap in mathematical Education. Additionally, statistics showed issues with the nation's math instruction and students' enthusiasm for the subject.

Many students believe mathematics is difficult to understand, contributing to poor academic performance (Isack, 2015). Furthermore, students frequently experience anxiety and trepidation due to the abstract character of mathematical concepts (Olango, 2016). However, the students' attitude is not the only factor contributing to their poor performance in mathematics. Teacher characteristics can also influence students' attitudes and performance in mathematics classes (Mazana *et al.*, 2019). However, the challenges do not stop there; many students still need to acquire the skills required to become more proficient in solving mathematical problems. Acquiring additional "math facts" is insufficient; students must also be able to use these facts to enhance their cognitive skills (Stramel, 2021).

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To improve their abilities and comprehension through mathematical problem-solving, undergraduate students—especially student instructors in mathematics education—need great assistance and instruction (Yow, 2009; Aquino & Gurat, 2023), with a special emphasis on problem-solving (Gurat, 2018). The capacity of curriculum and educational programs to successfully incorporate and convey innovations and changes is one of its desirable qualities (Aquino, 2024). This is among the causes of the ongoing changes in educational curricula. Teachers are vital to the success and usefulness of these programs.

Teachers modify their teaching strategies according to their professional knowledge (Aquino & Gurat, 2023; Deasmin & Paglinawan, 2024; Guler & Celik, 2016). The country's mathematical education obligation has now been placed on aspiring teachers. To effectively teach mathematics, these student teachers need to develop their mathematical and analytical thinking skills. Their preparedness, knowledge, comprehension, and abilities are how each student's future problem-solving skills might be improved. However, they must first learn how to solve problems before teaching learners this skill.

One of the abilities children must develop to be problem solvers is the capacity to comprehend and grasp before responding. To become a good problem solver, one needs to be a heuristic. Heuristics is a systematic approach to mathematical problem-solving established irrespective of context (Gurat, 2018). Furthermore, a heuristic method can help establish links between mathematical ideas by looking at specific scenarios, generating visual representations, considering specific solutions, and developing generalizations.

Two types of mathematical problem-solving may be distinguished. O e is problem comprehension, which most students struggle with since most math teachers mainly concentrate on the second kind of problem-solving, namely issue solution (Behera, 2021). This was demonstrated in research by Kaitera and Harmoinen (2022), in which fifth-grade students were taught general heuristics, which were thought helpful resources for handling challenging arithmetic problems. They explained that it was evident at the start of the school year that many students struggled with arithmetic tasks, especially when putting their problem-solving approaches into writing. In this situation, they clarified that students must use the right approach to problem-solving to offer an acceptable solution to mathematical difficulties.

According to Özreçberoğlu and Çağanağa (2018), some of the most difficult problem-solving techniques include estimating, methodical listing, finding correlations, drawing diagrams, formulating equations or inequalities, using solutions from similar situations through reflection, and drawing conclusions from table analysis. These mathematics education students may soon be unable to teach problem-solving techniques to other students if they cannot comprehend and absorb them.

Therefore, improving students' analytical and problem-solving skills—especially for those who hope to become teachers in the future—is the goal of mathematics education in the Philippines. Additionally, the main goal of this research is to thoroughly understand the methods aspiring math teachers use to solve problems. Improving higher Education, especially in math instruction, requires this study. Additionally, this study can be used to create treatments that will improve future teachers' capacity to solve mathematical problems.

MATERIALS AND METHODS

Thirty students enrolled in the Bachelor of Secondary Education program with a mathematics specialization at Isabela State University's Angadanan Campus were included to achieve the study's objectives. The tool used in this study to evaluate undergraduate mathematics education students' problem-solving skills approach is the Mathematical Problem-Solving Set (MPSS), which comprises multiple problem sets for the participant to solve (Gurat, 2018). Arithmetic, algebra, trigonometry, geometry, sets, probability, number theory, and puzzle problems/logic are the various mathematical disciplines that make up the MPSS. The participant's problem-solving approach was ascertained by analyzing and comprehending their accurate problem-solving outputs. This study also used a checklist of the Mathematics Motivated Strategies Learning Questionnaires (MMSLQ) developed by Liu and Lian (2010), which was also utilized in the study of Gurat (2018). The purpose of this checklist is to ascertain their approach both before they begin to solve the problem and after they have come up with a solution.

Additionally, Gurat (2018) employed a semi-structured interview and a videotape to triangulate their response and gain a more thorough comprehension and analysis of their approach to problem-solving. The researcher used the Constant Comparative Approach (CCA) to examine the collected data. Before addressing the problems and finding solutions, CCA was utilized to compare the collected data to identify commonalities and discrepancies and formulate significant hypotheses based on the results. Descriptive analysis is another tool the researcher employs to ascertain the frequency and proportion of responses from the respondents.

RESULTS AND DISCUSSION

Table 1: Score of Mathematics Students in the Problem-Solving

Respondents	Mean	Standard Deviation	Remarks
Third Year	5.85	3.60	High
Fourth Year	6.57	4.51	High

Table 1 shows, third-year students studying mathematics education achieved an average score of 5.85 with a standard deviation of 3.60. Participants' scores show a high degree of proximity. In contrast, fourth-year mathematics education students received an average score of 6.57 with an SD of 4.51. Additionally, the data shows that the respondents' scores are very close. However, the average score of third-year students studying mathematics education is so high that, when added to the overall score, the average score of fourth-year students falls short of the minimum passing threshold.

Mathematics-Motivated Strategies Learning Questionnaires (MMSLQ)

According to Gurat's (2018) study and the MMSLQ students participated in, the respondents employed cognitive, metacognitive, and other methods.

Cognitive Strategies

Pfannenstiel *et al.* (2014) state that the educational method includes teaching students how to solve specific types of word problems using cognitive strategies like strategy and visual strategy. A cognitive approach is essential for helping students process information effectively and enhance their understanding of the structural elements found in various word problem types. The framework of cognitive strategies includes organization, elaboration, and rehearsal as effective mathematical problem-solving techniques (Gurat, 2018).

Rehearsal

According to Arjmandnia *et al.* (2012), a rehearsal strategy uses the technique of repeated practice to learn new material. Students usually use the rote memorization technique, which is repeating the information aloud when presented with specific material they must know, like a list.

Table 2: Students' Cognitive Rehearsal Techniques for Solving Mathematical Problems

Cognitive Strategies (Rehearsal)	**1 - never or only rarely valid in me**		**2 - sometimes true of me**		**3 - true of me, about half of the time**		**4 - frequently true to me**		**5 - always or almost always true of me**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
I repeatedly examine the problem.	0	0	2	7.1%	7	25.0%	6	21%	13	46%
I rehearse the same kinds of questions over and over.	0	0	1	3.6%	9	32.1%	11	39.3%	7	25.0%
I constantly review the textbook and class notes.	0	0	6	21.4%	12	42.9%	8	28.6%	2	7.1%
I put the essential math formulas to memory to help me remember the most crucial aspects of my math class.	0	0	5	17.9%	8	28.6%	8	28.6%	7	25.0%
I remember how to solve problems.	0	0	9	32.1%	12	42.9%	4	14.3%	3	10.7%
I rehearse the same kinds of questions over and over.	0	0	6	21.4%	7	25.0%	9	32.1%	6	21.4%

Table 2 shows the cognitive rehearsal strategies used by the participants to solve the mathematical issue. It suggests that the majority of student teachers use rehearsal-focused cognitive techniques. According to their responses, they practice, recall, read aloud several times, and analyze difficulties in-depth almost constantly. Elaboration. This method was illustrated by highlighting and selecting essential details, like the problem's terms, and using self-reflection to help with problem-solving (Gurat, 2018). Product development is turning an original idea into an accurate result. Essentially, if a procedure does not result in any invention, it cannot be considered creative (Liljedahl *et al.*, 2016).

Table 3: Students Use Cognitive Elaboration Strategies to Solve Mathematical Problems

Cognitive Strategies (Rehearsal)	**1 - never or only rarely valid in me**		**2 - sometimes true of me**		**3 - true of me, about half of the time**		**4 - frequently true to me**		**5 - always or almost always true of me**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
I check my comprehension of the content of the mathematical materials by asking myself questions.	0	0	2	7.1%	7	25.0%	6	21%	13	46%

To increase my comprehension, I make connections between the lecture notes and examples from the textbook.	0	0	1	3.6%	9	32.1%	11	39.3%	7	25.0%
I connect the learning resources with what I already know.	0	0	6	21.4%	12	42.9%	8	28.6%	2	7.1%
I make connections between related math and other disciplines.	0	0	5	17.9%	8	28.6%	8	28.6%	7	25.0%
I will look for everyday examples to connect to math materials.	0	0	9	32.1%	12	42.9%	4	14.3%	3	10.7%

Table 3 displays the results of an analysis of the cognitive elaboration techniques used by the participants to solve mathematical problems. According to the statistics, the participants' attitudes regarding cognitive elaboration techniques appear neutral. This is demonstrated by the fact that a significant percentage of participants stated that they used elaboration to solve mathematical problems roughly 50% of the time. This result can also be inferred from the student's answer to the open-ended question. Respondent 2 often assesses how well her response fits the particular context of the problem or topic.

Organization. One strategy the students employed to solve mathematical issues was methodically building the provided problem. This method is commonly used to create methodical solutions (Aydın Güç & Daltaban, 2021). The math education students presented the problem statement, made a clear graphic, and meticulously broke the problem down into digestible parts to illustrate this method.

Table 4: Cognitive Strategies of Organization Used by Students in Solving Mathematics Problems

Cognitive Strategies (Rehearsal)	**1 - never or only rarely valid in me**		**2 - sometimes true of me**		**3 - true of me, about half of the time**		**4 - frequently true to me**		**5 - always or almost always true of me**	
	f	%	f	%	f	%	f	%	f	%
In order to organize the concept, I highlight the most important lines.	0	0	3	10.77%	10	35.7%	10	35.7%	5	17.9%
I highlight key terms in the word problem.	1	3.6%	6	21.4%	9	32.1%	9	32.1%	3	10.7%
I follow the plan methodically.	0	0	5	17.9%	11	39.3%	8	28.6%	4	14.3%
I spend time creating a plan of action before doing any calculations.	0	0	2	7.1%	9	32.1%	13	46.4%	4	14.3%
I choose appropriate tools to address the problem.	0	0	1	3.6%	9	32.1%	11	39.3%	7	25.0%
I go over the textbook and class notes and										
discover the most important elements.	0	0	4	14.3%	10	35.7%	11	39.3%	3	10.7%
I went over the class notes and underlined the key points.	0	0	4	14.3%	9	32.1%	11	39.3%	4	14.3%
For each exam, I classify the easy and complex questions.	0	0	2	7.1%	11	39.3%	10	35.7%	5	17.9%
I systematically record the steps involved in solving problems.	0	0	3	10.7%	7	25.0%	13	46.4%	5	17.9%
I create basic charts and tables to keep my math lesson materials organized.	1	3.6%	2	7.1%	12	42.9%	10	35.7%	3	10.7%
I choose the computations required to resolve the problem and project a potential result.	0	0	2	7.1%	9	32.1%	12	42.9%	5	17.9%
I execute the plan.	0	0	2	7.1%	16	57.1%	8	28.6%	2	7.1%
I adhere to the processes for systematically solving problems.	1	3.6%	3	10.7%	12	42.9%	9	32.1%	3	10.7%
I investigated to see where the problem was.	0	0	1	3.6%	11	39.3%	11	39.3%	5	17.9%

When solving mathematical problems, most respondents organize the problems with a frequency ranging from half the time to often, as shown in Table 4. This is further illustrated by Participant 7's response to the open-ended question/interview, in which he states that one of his methods for resolving mathematical problems is to identify the subject's key elements and devise a methodical plan to address the issue at hand. Furthermore, the student did not follow the sequential problem-solving processes methodically, did not highlight the important terms in the word problem, and did not make simple charts and tables to help the learner organize the math lesson materials.

Meta-cognitive Strategies

Meta-cognition refers to a person's awareness and control over their cognitive processes, such as thinking techniques, monitoring, and regulation (Güner & Erbay, 2021). It refers to the awareness and understanding one's cognitive processes and fundamental patterns. Based on Liu and Lin's (2010) Mathematics Motivated Techniques Learning Questionnaires, Gurat (2018) identified two categories of metacognitive techniques that students can use. The following ideas are crucial: self-control and critical thinking.

Critical Thinking

The student teacher illustrated this approach by presenting expected outcomes, relating difficulties to real-world situations, picking out important figures or aspects of a problem, and assessing the response's plausibility.

Table 5: Meta-cognitive Strategies of Critical Thinking Used by Students in Solving Mathematics Problems

Cognitive Strategies (Rehearsal)	**1 - never or only rarely valid in me**		**2 - sometimes true of me**		**3 - true of me, about half of the time**		**4 - frequently true to me**		**5 - always or almost always true of me**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
I make connections between the present problem and other issues.	2	7.1%	2	7.1%	11	39.3%	7	25.0%	6	21.4%
I compare the content of the textbook with the teacher's explanation.	2	7.1%	2	7.1%	7	25.0%	11	39.3%	6	21.4%
I start with the math class materials and work to establish my perspective on the subjects.	0	0	6	21.4%	8	28.6%	12	42.9%	2	7.1%
I choose appropriate tools to address the problem.	0	0	1	3.6%	9	32.1%	11	39.3%	7	25.0%
I take notes about the problem.	0	0	2	7.1%	9	32.1%	13	46.4%	4	14.3%
I incorporate my thoughts into the lessons I study in math class.	0	0	2	7.1%	11	39.3%	11	39.3%	4	14.3%
When I hear a solution or a suggestion, I devise another effective strategy to deal with the problem.	0	0	3	10.7%	7	25.0%	11	39.3%	7	25.0%
I identify a possible problem.	0	0	3	10.7%	14	50.0%	9	32.1%	2	7.1%
I typically evaluate whether the material is convincing by challenging what I have heard or learned in math class.	0	0	2	7.1%	15	53.6%	9	32.1%	2	7.1%
I use units appropriately.	1	3.6%	6	21.4%	10	35.7%	9	32.1%	2	7.1%
I monitor the continuous problem-solving procedure and adjust the plan as needed.	0	0	4	14.3%	14	50.0%	8	28.6%	2	7.1%
I consider the answer and summarize it.	1	3.6%	24	14.3%	11	39.3%	7	25.0%	5	17.9%
I make an assumption based on the task.	2	7.1%	3	10.7%	11	39.3%	10	35.7%	2	7.1%
I validate the math concept result with a real-world example.	0	0	4	14.3%	6	21.4%	15	53.6%	3	10.7%

According to Table 5, some students could not make connections between the given problem and other problems, distinguish between the teacher's explanation and the material in the textbook, correctly use units, summarize and consider the outcome, and draw conclusions based on the assignment. This suggests that some students are still unaware of how to approach mathematical problems using critical thinking. However, only a tiny percentage of the class made appropriate use of the knowledge they had received in math class while solving problems when it came to relating a possible difficulty in the future and asking about the relevance of what they had learned. The survey respondents showed they used critical thinking when solving mathematical issues.

Self-regulation is the process of monitoring and assessing one's comprehension of problems and then modifying learning strategies to reach the required degree of proficiency. It also involves how confident pupils are in their answers.

Table 6: Meta-cognitive Strategies of Self-regulation Used by Students in Solving Mathematics Problems

Metacognitive Strategies (Self-regulation)	**1 - never or only rarely valid in me**		**2 - sometimes true of me**		**3 - true of me, about half of the time**		**4 - frequently true to me**		**5 - always or almost always true of me**	
	f	%	f	%	f	%	f	%	f	%
After class, I reorganized and clarified the unclear parts.	0	0	3	10.7%	8	28.6%	15	53.6%	2	7.1%
I establish my goal and stick to my plan.	2	7.1%	2	7.1%	9	32.1%	11	39.3%	4	14.3%
I start by listing related formulas.	0	0	2	7.1%	8	28.6%	13	46.4%	5	17.9%
My calculations are accurate.	1	3.6%	8	28.6%	15	53.6%	4	14.3%	0	0
I attempt to see where the problem is.	0	0	1	3.6%	11	39.3%	11	39.3%	5	17.9%
I will clarify whether my incorrect calculation solutions result from a miscalculation or a conceptual error.	0	0	2	7.1%	10	35.7%	9	32.1%	7	25.0%
I consider what worked and how the tasks were completed.	0	0	1	3.6%	9	32.1%	12	42.9%	6	21.4%
I double-check my computation.	0	0	1	3.6%	9	32.1%	12	42.9%	6	21.4%
After answering the question, I double-check my answer.	0	0	1	3.6%	5	17.9%	13	46.4%	9	32.1%
I compare the response to the predicted result.	0	0	1	3.6%	12	42.9%	11	39.3%	4	14.3%

As Table 6 demonstrates, most student teachers commonly answer "sometimes" when questioned about their level of participation. On the other hand, two students seldom try to establish and adhere to their own objectives. Furthermore, none of the students selected "always true" on this question, indicating that most lack confidence in their problem-solving capacity.

Other Strategies

Gurat (2018) found that students may use planning, monitoring, evaluation, and prediction/orientation strategies. The students' answers to this study's open-ended questions and questionnaire demonstrate these strategies.

Forecast/Orientation

Students read a mathematical problem several times to find hints and supporting information to help them respond to the given question and guess the answer correctly.

Table 7: Prediction/Orientation Used by Students in Solving Mathematics Problems

Other Strategies (Prediction/Orientation)	**1 - never or only rarely valid in me**		**2 - sometimes true of me**		**3 - true of me, about half of the time**		**4 - frequently true to me**		**5 - always or almost always true of me**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
I highlight important words in the word problem.	1	3.6%	6	21.4%	9	32.1%	9	32.1%	3	10.7%
I have some theories or predictions about what might happen.	0	0	1	3.6%	15	53.6%	9	32.1%	3	10.7%
To better understand the task, I reread it.	0	0	1	3.6%	9	32.1%	6	21.4%	12	42.9%

I write out what has been asked in my own words.	0	0	6	21.4%	9	32.1%	6	21.4%	7	25.0%
I chose the necessary information required to solve the problem.	0	0	1	3.6%	11	39.3%	8	28.6%	8	28.6%
I write down what I already know in my own words.	0	0	5	17.9%	9	32.1%	9	32.1%	5	17.9%
I choose appropriate steps to address the problem.	0	0	2	7.1%	9	32.1%	14	50.0%	3	10.7%
I drew an illustration of the problem.	1	3.6%	6	21.4%	12	42.9%	5	17.9%	4	14.3%
I combined the facts required to address the problem.	0	0	2	7.1%	11	39.3%	10	35.7%	5	17.9%
I consider my work carefully, moving slowly on challenging exercises and quickly on simple ones.	0	0	3	10.7%	15	53.6%	7	25.0%	3	10.7%

Table 7 demonstrates that when tackling mathematical issues, a sizable percentage, if not the majority, of the student teachers frequently used orientation or prediction strategies. Moreover, either one or no respondent reported never using orientation or prediction as a tactic. Making plans. Before diving into the problem's answer, student teachers usually do some planning. This is demonstrated by applying critical thinking skills and using classification. One instance is when students identify an issue's important features and determine the challenge's possible conclusion.

Table 8: Other Strategies (Planning)

Other Strategies (Planning)	**1 - never or only rarely valid in me**		**2 - sometimes true of me**		**3 - true of me, about half of the time**		**4 - frequently true to me**		**5 - always or almost always true of me**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
I choose appropriate data and numbers to address the problem.	0	0	1	3.6%	7	25.0%	15	53.6%	5	17.9%
I spend time creating a plan of action before doing any calculations.	0	0	2	7.1%	9	32.1%	13	46.4%	4	14.3%
I choose appropriate tools to address the problem.	0	0	1	3.6%	9	32.1%	11	39.3%	7	25.0%
I choose the computations required to solve the problem and anticipate a potential result.	0	0	2	7.1%	9	32.1%	12	42.9%	5	17.9%

Table 8 indicates that most respondents use regular planning when solving mathematical problems. The student instructors regularly answered "true to me" or "frequently true to me," while none of them answered "rarely true to me." Observing. When students use the rehearsing technique, they solve mathematical problems meticulously, following a step-by-step procedure. They deliberately address a particular issue once more while actively remembering whether they have previously faced a comparable issue.

Table 9: Monitoring Used by Students in Solving Mathematics Problems

Other Strategies (Monitoring)	**1 - never or only rarely valid in me**		**2 - sometimes true of me**		**3 - true of me, about half of the time**		**4 - frequently true to me**		**5 - always or almost always true of me**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
I follow the plan methodically.	0	0	5	17.9%	11	39.3%	8	28.6%	4	14.3%
I take notes about the problem.	0	0	2	7.1%	9	32.1%	13	46.4%	4	14.3%
I systematically record the steps involved in solving problems.	0	0	3	10.7%	7	25.0%	13	46.4%	5	17.9%
I follow the plan.	0	0	2	7.1%	16	57.1%	8	28.6%	2	7.1%
My calculations are accurate.	1	3.6%	8	28.6%	15	53.6%	4	14.3%	0	0
I make correct use of units	1	3.6%	6	21.4%	10	35.7%	9	32.1%	2	7.1%
I do not forget problem-solving steps	0	0	9	32.1%	12	42.9%	4	14.3%	3	10.7%
I follow the sequences of problem-solving steps in an orderly	1	3.6%	3	10.7%	12	42.9%	9	32.1%	3	10.7%
I monitor the ongoing problem-solving process and change the plan if necessary	0	0	4	14.3%	14	50.0%	8	28.6%	2	7.1%
I reflect on the answer, and only if all are checked, giving a clear, exact, and precise answer	0	0	1	3.6%	11	39.3%	13	46.4%	3	10.7
I check my calculation again	0	0	1	3.6%	9	32.1%	12	42.9%	6	21.4%
I recheck my answer after I finish the question.	0	0	1	3.6%	5	17.9%	13	46.4%	9	32.1%

As shown in Table 9, most respondents use the tie method's monitoring phase as a typical approach to solving mathematical problems. Furthermore, some students hardly ever use monitoring as a tactic.

Assessment. Students practice self-reflection by analyzing their performance, using past knowledge to solve problems, judging the consistency of their responses, and determining whether they have faced comparable circumstances. This is related to the organizational, analytical, and elaborative skills used to solve the mathematical issues based on the earlier findings.

Table 10: Evaluation Used by Students in Solving Mathematics Problems

Other Strategies (Evaluation)	**1 - never or only rarely valid in me**		**2 - sometimes true of me**		**3 - true of me, about half of the time**		**4 - frequently true to me**		**5 - always or almost always true of me**	
	f	%	f	%	f	%	f	%	f	%
I relate the given problem to other problems	2	7.1%	2	7.1%	11	39.3%	7	25.0%	6	21.4%
I relate future problems	0	0	3	10.7%	14	50.0%	9	32.1%	2	7.1%
I summarize the answer and reflect on the answer	1	3.6%	4	14.3%	11	39.3%	7	25.0%	5	17.9%
I draw a conclusion referring to the task	2	7.1%	3	10.7%	11	39.3%	10	35.7%	2	7.1%
I reflect on what went well and how the tasks were solved	0	0	1	3.6%	9	32.1%	12	42.9%	6	21.4%
I recheck my answer after I finish the question.	0	0	1	3.6%	5	17.9%	13	46.4%	9	32.1%

According to Table 10, most respondents frequently use the assessment method as a common approach to mathematical problem-solving. Additionally, particular students hardly ever use evaluation as a tactical tool.

Techniques Employed Prior to Solving the Mathematical Problem

One of the study's objectives is to find out how student instructors approach solving mathematical problems. Table 11 shows the abilities that students use before engaging in problem-solving tasks.

Table 11: Mean score of the strategies before answering mathematical problem-solving

Before Solving a Problem	**MEAN**
I repeatedly analyze the problem.	4.07
I mark up the important lines for concept organization.	3.61
I underline important words in the word problem	3.25
I select relevant numbers/data to solve the problem	3.86
I adhere to the plan systematically	3.39
I relate the given problem to other problems	3.46
I take time to design an action plan before actually calculating	3.68
I have some ideas or estimates of the possible outcome	3.50
I compare the difference between the teacher's explanation and textbook content.	3.61
I ask questions to myself to make sure that I understand the math materials' content	4.00
I repeatedly practice similar question types.	3.86
I study the class notes and textbook again and again.	3.21
I make the math class materials a starting point and try to self-develop my viewpoint.	3.36
I reorganized and clarified the confusing points after class.	3.57
I try searching for patterns or symmetry to find the correct answer, like thinking of a more manageable problem than doing the given task.	3.89
I reread the task to comprehend it better	4.04
I select relevant materials to solve the problem.	3.86
I make notes related to the problem	3.68
I write down in my own words what was asked for	3.50
I select the relevant information needed to solve the problem	3.82
I combine my ideas into the math class.	3.61
I memorize the important and key math formulas to remind me of the important part of my math class	3.61
I link the class notes to textbook examples to improve my understanding.	3.25
I read the class notes and textbook and found the most important parts.	3.46
I read through the class notes and marked up the important parts.	3.54
I categorize the easy-hard questions for every exam.	3.64
When I hear of some idea or solution, I find another efficient way to solve the problem.	3.79
I set up my target and followed the agenda I made.	3.46
I list related formulas first.	3.75
I divide the problems into parts, or I solve them in general.	3.43
I write down in my own words what I already know	3.50
I select relevant steps to solve the problem	3.64
I orderly take note of problem-solving steps	3.71
I relate future problems	3.36
I made a drawing related to the problem	3.18
I put the information needed to solve the problem together	3.64
Total	3.61

As indicated in Table 11, students usually practice, elaborate, organize, and exercise critical thinking before solving the mathematical problem. One of the most important strategies is that students typically conduct several analyses of the issue before offering a solution. In order to gain a deeper understanding of the first problem, students must also examine it multiple times before answering it.

Techniques Employed in Solving Mathematical Problems

Another study goal is to discover student teachers' methods to solve mathematical problems. Table 12 shows the skills that students use when working on problem-solving exercises.

Table 12: Mean score of the strategies while answering mathematical problem-solving

While Solving a Problem	MEAN
I usually question what I hear or what I earn in math class and judge whether this information is persuasive.	3.39
I know how and when to add, subtract, multiply, and divide.	4.29
I used trial and error when I did not know the formula of the problem.	4.21
I have my tactics for solving a problem	3.46
In order to get the correct answer, I have to follow the method step by step.	4.04
I combine my own known knowledge with the learning materials.	3.89
I make simple charts and tables to help me organize my math class materials.	3.43
I am aware of what "borrowing" means when subtracting numbers.	4.18
I select the calculations that will be needed to solve the problem and estimate a possible outcome	3.71
I visualize the scenario in the problem by drawing, hoping to see what is asked about the problem.	3.25
I know how to manipulate the general formula to arrive at a specific formula for getting what is missing in the problem.	3.21
I use arithmetic to solve the problem.	3.39
I know what "carrying" means and how to use it.	4.00
I use strategies that provide a definite way to reach a goal.	3.61
I use different strategies like guessing and checking, diagrams, and others to solve problems, trying to bring out the even if I am unsure of my answer	3.43
I act according to the plan	3.36
I am correct in my calculations	2.79
I reflect on work carefully and slowly on challenging exercises and fast on easy parts	3.36
I make correct use of units	3.18
I remember how to solve problems.	3.04
I follow all the processes for systematically solving problems.	3.36
I keep an eye on the continuous process of problem-solving and adjust	3.29
Total	3.54

Based on the results, Table 12 demonstrates that most students use monitoring and organization strategies when tackling mathematical problems. When responding, they also exhibit critical thought, self-control, practice, and prediction. Student teachers carefully consider and follow a methodical approach to problem-solving. They also successfully organize their answer to reach the intended outcome. Additionally, students clearly understand when to use fundamental operations while solving mathematical problems, as seen by its highest mean score. Additionally, student teachers use a trial-and-error method when unsure of which formula to apply while solving a problem. However, most individuals still lack confidence in their final calculation or response.

Techniques Employed Following the Solution of the Mathematical Problem

This study aims to determine how student teachers approach solving mathematical problems. Table 13 shows the skills that students used following problem-solving exercises.

Table 13: Mean score of the strategies after answering mathematical problem-solving

After Solving a Problem	MEAN
I link relative portions of math and other subjects.	3.68
I look to find out where the problem is.	3.71
I analyze my answer and summarize it.	3.39
I reflect on my answer.	3.64
I check whether this is a conceptual mistake or a miscalculation when I answer incorrectly.	3.75

I make an assumption based on the problem given.	3.25
I consider what worked and how the tasks were completed.	3.82
I check my calculation again	3.82
After answering the question, I go back and review my response.	4.07
I validate the math theory result with a real-world example.	3.61
I review the formula and key ideas on my own.	3.64
I can find any samples in daily life that link with math materials.	3.36
I compare the response to the anticipated result.	3.64
I practice the same kinds of questions over and over.	3.54
Total	3.64

After completing the mathematical exercise, Table 13 demonstrates that students use monitoring, self-regulation, and critical thinking. Once they have their final response, I advise them to participate in verification. According to the data, individuals who checked their responses after responding to the question had the highest average. They also reassess to see if their answer makes sense and suits the task. However, students' capacity to conclude from the provided information is lacking.

CONCLUSION

Students pursuing a bachelor's degree in mathematics education use cognitive and metacognitive problem-solving approaches. The student instructors tackle difficulties using cognitive strategies like planning, elaboration, and rehearsing. The student teachers also use metacognitive techniques like self-control and critical thinking to deal with difficulties. They employ other tactics, such as preparation, observation, and assessment. The study found that student teachers in mathematics education are familiar with various approaches to solving mathematical issues. It indicates that they will impart the skills they have learned to their future students. It is commendable that math teachers at the undergraduate level use tactics before, during, and after problem-solving. The study's results indicate that while people know these strategies, they do not always apply them effectively when solving mathematical problems, leading to low scores. With an emphasis on problem-solving strategies that produce precise and ideal answers, future studies might examine applying practical approaches in mathematics education for student teachers. Future studies should look into the factors, particularly problem-solving skills, that affect pupils' performance in mathematics.

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