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Problem-solving disposition as a predictor of preservice elementary teachers' problem-solving performance

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ABSTRACT

Proficiency in solving mathematical problems is essential for preservice elementary teachers, as they will teach foundational math concepts and foster problem-solving abilities among young learners. However, many studies found low problem-solving performance among preservice teachers. In line with this, the present study examined how problem-solving disposition relates to the performance of preservice elementary teachers, conducted at a selected higher education institution in Nueva Ecija, Philippines, with 134 participants. The study utilized a mathematical problem-solving disposition and beliefs scale questionnaire and a problem-solving test scored using the identify, define, explore, act, and look (IDEAL) model. Results indicated an average problem-solving disposition and high problem-solving performance among preservice teachers. Linear regression analysis showed that overall problem-solving disposition is a predictor of performance. Further, stepwise regression analysis revealed that two disposition parameters, mathematical mindset ($\beta = 2.413$, $p < 0.01$) and community of practice ($\beta = 1.866$, $p < 0.01$), significantly predicted problem-solving performance. These findings show the significance of developing a problem-solving disposition, mindset, and learning communities to improve future teachers' problem-solving ability by providing more learning opportunities, interdisciplinary problems, and social engagements.

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1. INTRODUCTION

Teaching problem-solving skills to young learners is vital to the mathematics curriculum. Cultivating problem-solving skills boosts mathematical proficiency and advances 21st-century skills, including critical thinking, creative thinking, and conceptual reasoning [1], [2]. In this sense, preservice elementary teachers must be proficient in solving math problems since they will be responsible for teaching basic math concepts and cultivating problem-solving skills among young learners. Hence, assessing the problem-solving abilities of preservice elementary teachers is crucial to determining the effectiveness of their training in developing both problem-solving skills and knowledge of teaching content [3]. This evaluation shows their proficiency in problem-solving and gives insights into how well they can engage students using inquiry-based learning methods in science and math [4]. Understanding their ability towards problem-solving contributes to the quality of education young learners will receive in these foundational subjects. Further, teachers' problem-solving skills should be given attention in mathematics teaching as they directly influence the problem-solving abilities of the students [5].

However, preservice teachers' problem-solving skills are inadequate. In the Philippines, for instance, a study found that preservice elementary teachers exhibited low performance on a problem-solving test [5] and that many preservice teachers believe that they cannot do mathematics, which can highly impact their problem-solving abilities [6]. The same problem occurs even in other countries. In Indonesia, a study reported that most students failed to reach adequate proficiency in problem-solving [7]. In the USA, it was found that only a few preservice teachers could correctly answer a multistep fraction word problem, showing a lack in their ability to solve problems better than other subjects [8]. Further, in Spain, it was observed that preservice teachers faced difficulties with mathematical content, particularly when solving multistep problems [9]. These findings underscore preservice teachers' challenges in effectively solving mathematical problems.

Aligned with this, several factors, such as disposition, could influence an individual's problem-solving performance. Disposition refers to individuals' attitudes, perceptions, and qualities, which play a crucial role in various contexts, such as teaching, learning, and professional practice [10]–[12]. In other words, individuals' inherent tendencies or qualities shape their approach to tasks and relationships. In education, teacher dispositions are the moral virtues or qualities that shape how teachers engage with students and colleagues [13]. Likewise, in mathematics education, dispositions are recognized as essential to being a critical thinker and are crucial for developing critical thinking skills [14].

In the present study, disposition was specified as problem-solving disposition. The problem-solving disposition refers to an individual's inclination, beliefs, attitude, confidence, and willingness to engage in and persist with problem-solving activities [15]–[19]. Problem-solving involves actively seeking solutions for challenging situations that are difficult to resolve [20]. When students encounter an unfamiliar or complex problem, they should possess a strong drive and motivation to find a resolution. Additionally, they should believe in their ability to succeed in that mathematical task and other related tasks. Further, these dispositions are often related to performance [21]–[23], implying that having a high disposition toward problem-solving helps individuals solve mathematical problems. The development of a variety of cognitive and emotional mathematical abilities, including problem-solving techniques, mathematical communication, and conceptual understanding, is positively influenced by a mathematical disposition [24]. This implies they are likelier to foster and enhance mathematical abilities by establishing a mathematical disposition as a foundational aspect.

To date, there are immense studies on problem-solving performance. In particular, Cansoy and Türkoğlu [25] found that preservice teachers' ability to think critically and solve problems predicts how effective they are in engaging students, using teaching methods, and managing classrooms; Pentang *et al.* [26] examined the creative thinking and problem-solving abilities of preservice teachers in statistics, and Mariano-Dolesh *et al.* [6] emphasized the significance of the mindset and conceptual understanding levels of preservice teachers in the context of problem-solving. Likewise, extensive studies have also been conducted on the mathematical disposition in general and linked to learning outcomes [27], [28]; mathematical literacy [29]; learning environment [30]; and instructional methods [31], [32]. However, the problem-solving disposition and its ability to predict problem-solving performance in the context of preservice elementary teachers remains unexplored. Hence, the present study examined the relationship between the independent variable (mathematical problem-solving disposition) and the dependent variable (mathematical problem-solving performance). Guided by the previous studies, the researcher aimed to answer the primary research inquiry: Do preservice elementary teachers' mathematical problem-solving dispositions predict their problem-solving performance?

2. METHOD

This study used descriptive-correlational design to address the research inquiry to determine the relationship between mathematical problem-solving dispositions and preservice elementary teachers' performance. Descriptive design was used to describe the mathematical problem-solving dispositions and level of problem-solving performance of the preservice elementary teachers. Additionally, correlational design was used in determining the relationship between the variables, specifically between the problem-solving disposition and problem-solving performance. Before data gathering, informed consent was obtained from all individuals involved, outlining the purpose of the research, the voluntary nature of participation, and the confidentiality measures. The ethical considerations were also applied as the conduct of the study was subjected to ethical review from Central Luzon State University - Ethics Review Committee in Science City of Muñoz, Nueva Ecija, Philippines [ERC Code: 2023-500]. Moreover, random sampling was used in selecting participants. The targeted preservice elementary teachers are students taking Bachelor of Elementary Education at a particular higher education institution in Nueva Ecija, Philippines, from the first to fourth year, for 134 participants. The central focus of this study was directed towards preservice elementary teachers, as they assume a crucial role in becoming practitioners responsible for establishing the foundations of mathematical knowledge among learners.

The instrument utilized in this study is divided into two parts. The first part is the mathematical problem-solving dispositions and beliefs scale, an adopted scale [33]. It is composed of a 40-item scale, which the preservice elementary teachers rated from one to six (1 for strongly disagree, 2 for somewhat disagree, 3 for slightly disagree, 4 for slightly agree, 5 for somewhat agree, and 6 for strongly agree). It is subdivided into six constructs: i) mathematical mindset (Cronbach's alpha = 0.878); ii) mathematical problem-solving perseverance (Cronbach's alpha = 0.907); iii) mathematical revision and refinement (Cronbach's alpha = 0.879); iv) mathematical communities of practice (Cronbach's alpha = 0.783); v) problem-solving processes (Cronbach's alpha = 0.738); and vi) problem-solving utility (Cronbach's alpha = 0.874). The constructs were developed by reviewing previous problem-solving studies [34]–[37].

The second part is the mathematical problem-solving test, a researcher-made five test items from mathematics in the modern world (MMW), all non-routine problems. In the test, most preservice elementary teachers used the following strategies taught in MMW: making a tree diagram, looking for a pattern, working backward, and using tabular methods. The identify, define, explore, act, and look (IDEAL) problem-solving model, developed by Bransford and Stein [38], was used as a guide to answer the problems. It consists of five steps: identifying problems, defining goals, exploring strategies, anticipating outcomes before acting, and looking back and learning as shown in Figure 1. Moreover, an adopted scoring guide using IDEAL problem-solver indicators was applied to measure preservice elementary teachers' problem-solving performance [39]. There are five indicators with two points each. Therefore, preservice elementary teachers can receive a maximum of ten points per item, adding up to a total of 50 points.

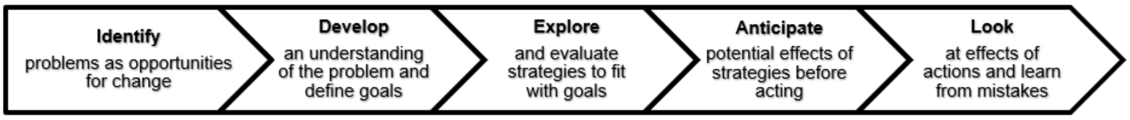

Figure 1. IDEAL model

This research employed various data analysis techniques according to the study's objectives. Descriptive statistics, including weighted mean and standard deviation, were used to assess the mathematical problem-solving disposition of preservice elementary teachers. The computed means for mathematical problem-solving dispositions were transmuted to qualitative description: below average (1.00 to 2.67), average (2.68 to 4.34), and above average (4.35 to 6.00). Moreover, problem-solving test scores, using the IDEAL model, were also transmuted into qualitative descriptions to evaluate aspiring elementary teachers' problem-solving abilities, ranging from below average (0.00 to 1.67), average (1.68 to 3.34) to above average (3.35 to 5.00). Additionally, a linear regression analysis assessed if overall problem-solving disposition predicts performance. Finally, a stepwise multiple regression analysis determined which parameters of mathematical problem-solving disposition best predict the respondents' problem-solving performance.

3. RESULTS AND DISCUSSION

This study investigated the predictive role of problem-solving disposition in the problem-solving performance of preservice elementary teachers. Despite the extensive studies linking mathematical disposition to performance, problem-solving disposition still needs to be explored. Hence, utilizing the scale developed by Barrett [33], the study tested the influence of problem-solving disposition through the six parameters: mathematical mindset, problem-solving perseverance, revision and refinement, communities of practice, problem-solving utility, and valuing problem-solving processes.

3.1. Preservice elementary teachers' levels of mathematical problem-solving disposition

Table 1 illustrates the mathematical problem-solving disposition levels among preservice elementary teachers, assessed across various parameters. Mean scores reveal insights into their overall attitudes and approaches to mathematical problem-solving. High mean scores in mathematical mindset (4.58), mathematical revision and refinement (4.43), and problem-solving utility (4.39) suggest a strong positive disposition in these areas. Preservice elementary teachers embrace a positive mindset, refining their mathematical understanding and recognizing the utility of problem-solving strategies, which are crucial for effective teaching and student engagement in mathematics. However, parameters like mathematical problem-solving perseverance (4.12), mathematical communities of practice (4.03), and valuing problem-solving processes (4.19) show slightly lower mean scores, indicating room for improvement in terms of perseverance, fostering communities of practice, and emphasizing the value of problem-solving processes.

The result also shows that preservice elementary teachers exhibit an average overall problem-solving disposition, consistent with the previous studies showing that preservice elementary school teachers' beliefs about mathematical problem-solving were average [40], [41]. This result might be attributed to several factors, including preservice elementary teachers' academic and experiential backgrounds, which may vary widely. While some may enter teacher education programs with a strong foundation in mathematics and problem-solving skills, others may have limited exposure or confidence in these areas [42]. This can be rooted in their tracks during senior high school, including general academic strands, humanities, and social sciences.

Table 1. Levels of mathematical problem-solving disposition of the preservice elementary teachers

Parameters of disposition	Mean	Verbal description
Mathematical mindset	4.58	Above average
Mathematical problem-solving perseverance	4.12	Average
Mathematical Revision and Refinement	4.43	Above average
Mathematical Communities of Practice	4.03	Average
Problem-solving utility	4.39	Above average
Valuing problem-solving processes	4.19	Average
Overall disposition	4.29	Average

Legend: below average (1.00 to 2.67), average (2.68 to 4.34), and above average (4.35 to 6.00)

Moreover, the levels of problem-solving dispositions of preservice teachers can be influenced by their opportunities to learn mathematical courses. A study found that by providing learners with more opportunities to learn related to mathematical procedural tasks, they tend to believe they have complete control of their success [43]. This implies that dispositions can be developed after engaging with more learning opportunities. Interestingly, back in 2011, Tatto and Senk [44] reported that Filipino future primary teachers have the highest opportunities to learn compared to other countries such as Chinese Taipei, Singapore, Spain, Switzerland, and the United States. However, in the updated curriculum, the only available elementary-level mathematics courses are MMW and two other courses about teaching mathematics. This reduced exposure to mathematics courses implies a lack of exposure to real-world problem-solving scenarios, which may have led to an overall average disposition of preservice elementary teachers.

3.2. Preservice elementary teachers' levels of problem-solving performance

Regarding problem-solving performance, the study found that most respondents performed well using the IDEAL model as shown in Table 2. Out of 134, 96 respondents have above-average performance, while few showcased average (32) and below-average (6) problem-solving abilities. This result aligns with the findings that the preservice elementary teachers achieved satisfactory problem-solving performance [45]. Still, it contradicts several studies that reported poor performance among preservice teachers [5]‒[9]. This intriguing outcome could arise from the types of problem-solving tests administered to the participants and the methodologies employed. In the present study, the participants have already taken a preparatory course for non-routine problems MMW before the study, resulting in a high level of performance. This is because non-routine problems allow individuals to explore and not solely rely on memorizing formulas. This result can be linked to the findings of Barham [46], who also gave non-routine problems after the participants' exposure to different strategies such as pattern making, tabular method, and logical reasoning and found that most of the preservice elementary teachers solved the given problems. Maulana and Yuniwati [47] also argued that learners should be trained to solve non-routine problems, allowing them to undergo unique mathematical processes.

Two ideas can be generated from this result: exposure to strategies in solving non-routine problems will help improve performance, and using a problem-solving model in solving problems, such as the IDEAL model, has resulted in better performance. Bransford and Stein [38] argued that the IDEAL model promotes awareness of the problem-solving processes, which is valuable when solving non-routine problems. However, this study did not explicitly tackle the comparison of other models, such as Polya's. Hence, further study is recommended. Additionally, the study would like to suggest giving more problem-solving items, which can be divided into easy, average, and difficult, to properly assess the overall skills of preservice teachers, as a previous study reported that preservice teachers had satisfactory performance in different areas in the easy and average level of problems but performed unsatisfactorily on the difficult items [5]

Table 2. Levels of problem-solving performance of the preservice elementary teachers

Level	*f*	%
Above average	96	71.6
Average	32	23.9
Below average	6	4.5

3.3. Predictors of problem-solving performance

To test the link between disposition and the respondents' performance, linear regression analysis was utilized as shown in Table 3, and found that the overall problem-solving disposition is a significant predictor of problem-solving performance ($\beta = 4.978$, $p < 0.01$). It implies that an increase of one unit in problem-solving disposition is associated with an average increase of 4.978 units in problem-solving performance ($y = 18.667 + 4.978x$). It shows that despite the study's focus on problem-solving unlike previous research about general math disposition, the result is still consistent that disposition affects mathematics achievement [22]. Recognizing the significance of problem-solving disposition as a predictor of problem-solving performance allows for targeted interventions for students who may struggle in this area.

Table 3. Linear regression analysis result

Predictor	β	p	R^2
Constant	18.667	0.001	0.361
Problem-Solving Disposition	4.978	0.001	

Note: β: regression coefficient, p: significance of the regression model, and R^2: regression model accuracy.

Further, a stepwise regression analysis was conducted to test which, specifically among the six problem-solving disposition parameters, significantly influence performance as shown in Table 4. Results show that parameters such as "mathematical problem-solving perseverance", "mathematical revision and refinement", "problem-solving utility", and "valuing problem-solving processes" failed to meet the criteria for being included in the model based on their p-values. Meanwhile, the two predictors that emerged as significant contributors were "mathematical mindset" and "mathematical communities of practice". Thus, the equation of regression will be in this form: $y = 21.223 + 2.413x_1 + 1.866x_2$ with a coefficient of determination (R^2) for the regression model of 0.451, indicating that the combination of "mathematical mindset" and "mathematical communities of practice (CoP)" accounted for 45.1% of the variance in problem-solving performance. This implies that those students with a high mathematical mindset tend to have high performance, and those with a strong disposition towards CoP also tend to excel in problem-solving performance.

"Mathematical mindset" is a positive predictor of problem-solving performance ($\beta = 2.413$, $p < 0.001$), indicating that individuals with a more positive and growth-oriented mindset toward mathematics were more likely to exhibit better problem-solving performance. This result aligns with the previous studies showing that mindset is positively associated with performance [6], [48]. It suggests that by fostering a belief in the malleability of intelligence and the capacity for growth, students can approach problem-solving tasks with resilience, persistence, and a willingness to embrace challenges. It also supports that an individual with a growth mindset achieves significant accomplishments [49]. Conversely, a negative mindset, such as lacking confidence in solving problems, may result in a lack of interest, fear, and avoidance of activities that may improve problem-solving skills [38]. In line with this, institutions may consider role modeling for the students. Social cognitive theory proposes that individuals learn not only from direct experiences but also from observing and emulating others [50]; in the educational context, a positive disposition towards problem-solving and other academic tasks can be acquired by observing role models, receiving positive feedback, and developing a sense of self-efficacy. Higher education institution teaches education students to include motivation in their lesson plans. Still, they must consider that these students must also be motivated before their teaching internships, as this may develop a positive mindset among them. Individuals with confidence in their abilities and a positive attitude towards mathematics and problem-solving are more inclined to solve problems effectively.

Likewise, "CoP" is also a positive predictor of problem-solving performance ($\beta = 1.866$, $p < 0.001$), suggesting that individuals who actively engage in mathematical communities and collaborative learning environments tend to demonstrate higher problem-solving performance. It aligns with the previous research findings that collaborative problem-solving in classroom instruction can substantially improve mathematical understanding and performance [51]. Further, CoP refers to individuals who share a common interest and engage in collective learning to achieve common goals. Research has indicated that such communities can lead to practical meaningful effects, as learning, meaning, and identity within a community may lead to sustained practice, supporting that CoP can enhance performance [52]. Hence, a positive disposition towards participating in CoP allows individuals to learn from others, gain insights, stay updated on best practices, and engage in discussions, workshops, and other learning activities to help develop their performance. If teacher education programs do not provide sufficient opportunities for hands-on, collaborative problem-solving experiences, preservice teachers may not have the chance to develop and apply their skills fully. Thus, by providing a CoP where members collectively practice solving problems, the overall disposition of the participants will improve alongside their abilities to solve problems.

This study supports the idea that individuals lack an inherent inclination for a preference in mathematics [53]. Since preservice elementary teachers are generalists, not all have a high disposition and background in mathematics. Research shows that preservice elementary teachers may have negative beliefs and anxiety about teaching mathematics [54]–[56], which may influence their classroom performance as future educators. Since problem-solving disposition can predict problem-solving performance, interventions can be made towards improving overall disposition to improve performance, contributing to mathematics education’s success.

Table 4. Predictors using stepwise regression analysis

Predictors	β	p	R^2
Constant	21.223	0.000	0.451
Mathematical mindset	2.413	0.000	
Mathematical Communities of Practice	1.866	0.000	
Excluded variables			
Mathematical problem-solving perseverance	0.047	0.532	
Mathematical Revision and Refinement	0.191	0.075	
Problem-solving utility	0.113	0.970	
Valuing problem-solving processes	0.150	0.062	

This improvement can be done through several methods. Firstly, by providing more opportunities for them to learn the concepts and procedures of mathematics and exposing them to lots of problem-solving practices. Also, by encouraging them to reflect, revise, and refine their solutions by emphasizing the problem-solving process instead of the outcomes and creating social learning environments that collaboratively work on problems because engaging in such an environment will boost an individual’s motivation to complete tasks. Another is promoting cross-disciplinary problems that can tap into and align with students’ interests. Incorporating topics and challenges related to their passions makes students more likely to be engaged and motivated to tackle problems. Aside from these, literature offers some ways to improve problem-solving disposition, such as the use of learning tools from model eliciting activities [57], application of relating, experiencing, applying, cooperating, and transferring (REACT) strategy [17], participation in open-ended learning based on ethnomathematics [58], and engagement in metacognitive activities [59].

4. CONCLUSION

Disposition significantly shapes the problem-solving skills of preservice elementary teachers. These positive dispositions impact the teachers’ problem-solving skills and create a conducive learning environment for students, fostering critical thinking and resilience. Their attitudes, beliefs, and personal attributes, particularly a positive mindset, adaptability, and perseverance, play a crucial role in how they handle challenges in the classroom. Prioritizing the cultivation of positive problem-solving dispositions among preservice elementary teachers, especially regarding mindset and community of practice, is essential for improving their problem-solving performance and, in turn, contributing to the development of effective and well-rounded educators who can positively influence their students’ future. Thus, it is recommended for the teacher education community, specifically, the instructors and policymakers, to design interventions and programs targeting mindset development and encourage peer-to-peer interaction and collaboration among preservice teachers. In this way, educational institutions can effectively prepare preservice elementary teachers regarding their problem-solving disposition and performance, equipping them with the necessary skills and mindset before engaging in practice teaching. The findings of this study are the product of the explored relationship between disposition and performance. However, it needed to thoroughly explore the varied educational backgrounds, including experiences, chosen tracks, and teaching methods during senior high school, which may influence their disposition and performance. Therefore, it is recommended for future research to investigate other factors about the respondents. Since this study is purely quantitative, it needed to provide deeper contexts for the numerical data. Hence, it is suggested to employ mixed methods in the future by adding interviews or observations to enhance the understanding of the factors and the quantitative data.

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