Cognitive Knowledge, Strategic Deployment, Metacognitive Regulation, and Mindset as Predictors of Students' Problem – Solving Skills

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ABSTRACT

This study examined the influence of cognitive knowledge, strategic deployment, metacognitive regulation, and mindset on the mathematical problem-solving performance of Grade 7 students in public secondary schools. Using a quantitative-correlational design, data were collected from selected students in the Banga East District, South Cotabato. Instruments included a researcher-developed questionnaire and open-ended problem-solving tasks aligned with Polya's framework. Findings revealed that all four factors significantly contribute to students' problem-solving performance, with metacognitive regulation and strategic deployment emerging as strong predictors. Students demonstrated moderate proficiency in conceptual understanding but showed difficulties in planning, monitoring, and adapting strategies in non-routine tasks. Results also indicated that growth mindset and self-efficacy positively influence persistence and engagement. The study highlights the importance of integrating cognitive, strategic, metacognitive, and affective components in mathematics instruction. A holistic approach is recommended to enhance students' ability to solve both routine and real-life mathematical problems.

Keywords: cognitive knowledge, strategic deployment, metacognitive regulation, mindset, problem-solving skills

INTRODUCTION

Mathematical problem-solving is a fundamental goal of mathematics education and a critical component of students' academic success. It requires not only the application of learned procedures but also the ability to understand concepts, select appropriate strategies, regulate thinking processes, and maintain productive attitudes toward learning. Contemporary research conceptualizes problem-solving as a multidimensional construct shaped by cognitive, strategic, metacognitive, and affective factors (Schoenfeld, 2016; OECD, 2019)

Despite ongoing curricular reforms, many students continue to experience difficulties in solving non-routine and real-life mathematical problems. Large-scale assessments such as the Programme for International Student Assessment (PISA) and national examinations highlight persistent gaps in higher-order thinking and mathematical literacy (OECD, 2019; DepEd, 2020). These challenges suggest that traditional instruction, which often emphasizes procedural knowledge, may be insufficient to develop comprehensive problem-solving competence.

This paper synthesizes existing literature to examine how cognitive knowledge, strategic deployment, metacognitive regulation, and mindset collectively influence students' mathematical problem-solving performance. By integrating findings from international and local studies, the study aims to provide a theoretical foundation for developing effective instructional approaches.

Mathematical problem solving is a fundamental competency that reflects learners' ability to integrate conceptual understanding, procedural skills, and higher-order thinking processes (Mayer, 2018). It is widely recognized as a core component of mathematics education, as emphasized by the National Council of Teachers of Mathematics (2020), which highlights problem solving as central to developing mathematical proficiency. However, many students continue to experience difficulties in solving non-routine problems, particularly those requiring analytical reasoning and flexible thinking (OECD, 2019).

Research suggests that problem-solving performance is influenced by multiple interrelated factors. Cognitive knowledge, which includes conceptual understanding and procedural fluency, serves as the foundation of mathematical competence (Rittle-Johnson et al., 2015). Strategic deployment, on the other hand, involves the ability to plan, select, and evaluate problem-solving strategies effectively (Schoenfeld, 2016). Metacognitive regulation enables learners to monitor and control their thinking processes, which is essential for adapting to complex tasks (Zimmerman, 2017). Additionally, mindset, particularly beliefs about learning and perseverance, influences students' motivation and persistence in solving challenging problems (Dweck, 2016; Duckworth et al., 2007).

Despite the established importance of these variables, there remains a need to examine how they collectively and individually predict students' problem-solving skills, particularly in the context of junior high school learners in the Philippines. Thus, this study aimed to determine the levels of cognitive knowledge, strategic deployment, metacognitive regulation, and mindset; examine their relationships with problem-solving skills; and assess their predictive influence using multiple regression analysis.

This study employed a descriptive-correlational research design to examine the levels of cognitive knowledge, strategic deployment, metacognitive regulation, and mindset, as well as their relationships with students' mathematical problem-solving skills. This design was considered appropriate because it allowed the researcher to describe the existing conditions of the variables and determine the degree of association and predictive influence among them.

The participants of the study consisted of 181 Grade 7 students enrolled in a public secondary school. These respondents served as the source of data in examining the factors associated with mathematical problem-solving skills.

A structured questionnaire was utilized to measure the key constructs of the study. Cognitive knowledge was operationalized through indicators of conceptual understanding, procedural fluency, logical and analytical reasoning, and metacognitive awareness. Strategic deployment was assessed in terms of strategic planning, strategic selection, and process evaluation. Metacognitive regulation included strategic regulation and self-evaluation, while mindset was examined through perseverance, flexibility, and beliefs. The instrument was developed and aligned with established theoretical frameworks in mathematics education and self-regulated learning, ensuring content relevance and construct validity (Mayer, 2018; Zimmerman, 2017). The researcher-developed questionnaire underwent content validation by experts in mathematics education and research to ensure the relevance, clarity, and appropriateness of the items. Furthermore, reliability testing using Cronbach's alpha was conducted to determine the internal consistency of the instrument. The results indicated that the questionnaire possessed acceptable validity and reliability, making it suitable for gathering data related to cognitive knowledge, strategic deployment, metacognitive regulation, mindset, and mathematical problem-solving skills.

The data gathered were analyzed using both descriptive and inferential statistical techniques. Mean and standard deviation were employed to determine the levels of cognitive knowledge, strategic deployment, metacognitive regulation, mindset, and problem-solving skills. Pearson product-moment correlation was used to examine the relationships among the variables, while multiple linear regression analysis was applied to determine the extent to which cognitive knowledge, strategic deployment, metacognitive regulation, and mindset predict students' mathematical problem-solving skills.

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RESULTS AND DISCUSSIONS

Table 1. Level of Cognitive Knowledge of Grade 7 Students in Solving Mathematical Problems

Indicator	Mean	SD	Percentage Score	DepEd Descriptor	Interpretation
Conceptual Understanding	5.42	1.87	71%	Did Not Meet Expectation	Demonstrate minimal Competence
Procedural Fluency	5.18	1.67	70%	Did Not Meet Expectation	Demonstrate minimal Competence
Logical & Analytical Reasoning	4.73	1.42	69%	Did Not Meet Expectation	Demonstrate minimal competence
Metacognitive Awareness	4.29	1.04	68%	Did Not Meet Expectation	Demonstrate minimal competence
Total Score	**19.62**	**1.50**	**70%**	**Did Not Meet Expectation**	Demonstrate minimal competence

Table 1 presents the level of cognitive knowledge of Grade 7 students in solving mathematical problems across four domains: conceptual understanding, procedural fluency, logical and analytical reasoning, and metacognitive awareness. The overall mean score of 19.62 (SD = 1.50), equivalent to 70%, indicates a performance level classified as "Did Not Meet Expectations" based on DepEd Order No. 8, s. 2015. Among the domains, conceptual understanding obtained the highest mean, followed by procedural fluency, while logical and analytical reasoning and metacognitive awareness registered relatively lower scores, with the latter showing the weakest performance.

These findings suggest that students demonstrate generally low cognitive proficiency in mathematical problem-solving. Although slightly better performance was observed in conceptual understanding and procedural fluency, all domains fell below the expected 75% proficiency benchmark, indicating gaps in understanding, procedural application, critical analysis, and self-regulation. The relatively low scores in reasoning and metacognitive awareness further highlight students' difficulties in higher-order thinking processes, such as analyzing complex problems, drawing logical conclusions, and reflecting on solution strategies.

The results imply a need for enhanced instructional approaches that address both foundational and advanced cognitive skills. Strategies that promote critical thinking, problem analysis, and metacognitive engagement—such as inquiry-based learning and reflective questioning—may help improve students' overall mathematical competence. These findings are consistent with existing literature, which emphasizes the interdependence of conceptual and procedural knowledge and identifies reasoning and metacognitive skills as critical determinants of successful problem-solving (NCTM, 2014; Rittle-Johnson & Schneider, 2015; Gilmore et al., 2017). Similarly, studies in the Philippine context report persistent challenges in higher-order cognitive skills among learners, reinforcing the need for targeted instructional interventions.

Table 2. Level of Strategic Deployment of Grade 7 Students in Solving Mathematical Problems

Indicator	Mean	SD	Percentage Score	DepEd Descriptor	Interpretation
Strategic Planning	5.30	1.78	71%	Did Not Meet Expectation	Demonstrate minimal competence
Strategic Selection	5.17	1.64	70%	Did Not Meet Expectation	Demonstrate minimal competence
Process Evaluation	4.30	1.01	68%	Did Not Meet Expectation	Demonstrate minimal competence
Total Score	**14.77**	**1.48**	**70%**	**Did Not Meet Expectation**	**Demonstrate minimal competence**

Table 2 presents the level of strategic deployment of Grade 7 students in solving mathematical problems in terms of strategic planning, strategic selection, and process evaluation. The overall mean score of 14.77 (SD = 1.48), equivalent to 70%, indicates a performance level classified as **"Did Not Meet Expectations"** based on DepEd Order No. 8, s. 2015. Among the indicators, strategic planning obtained the highest mean, followed closely by strategic selection, while process evaluation recorded the lowest score.

This pattern implies that while students can initiate problem-solving by identifying and applying possible strategies, they struggle to evaluate and adjust their approaches during the process. Such limitations may hinder their ability to solve complex or multi-step problems that require continuous reflection and refinement of solutions. The findings highlight the need for instructional strategies that strengthen students' monitoring and self-evaluation skills.

Consistent with existing literature, effective problem-solving requires not only planning and selecting strategies but also ongoing evaluation and adaptation of these strategies (Schoenfeld, 2016; Stanton, 2021). Local studies further support that guided practice in planning and monitoring enhances students' accuracy and conceptual understanding, emphasizing the importance of integrating reflective and metacognitive practices in mathematics instruction (Aguila, 2020).

Table 3. Level of Metacognitive Regulation of Grade 7 Students in Solving Mathematical Problems

Indicator	Mean	SD	Percentage Score	DepEd Descriptor	Interpretation
Strategic Regulation	4.37	0.94	69%	Did Not Meet Expectation	Demonstrate minimal competence
Self-Evaluation	4.35	1.00	69%	Did Not Meet Expectation	Demonstrate minimal competence
Total Score	**8.72**	**0.97**	**69%**	**Did Not Meet Expectation**	**Demonstrate minimal competence**

he findings reveal that Grade 7 students demonstrate a low level of metacognitive regulation in mathematical problem-solving, with an overall performance classified as "Did Not Meet Expectations." Both strategic regulation and self-evaluation obtained similarly low mean scores, indicating that students experience difficulties in planning, monitoring, and adjusting their strategies, as well as in assessing their own understanding and performance.

This suggests that learners have limited ability to regulate their thinking processes during problem-solving. They may struggle to set appropriate goals, select effective strategies, and modify their approaches when faced with challenges. Furthermore, the low level of self-evaluation indicates weak reflective skills, which can result in poor monitoring and inconsistent judgment of solution accuracy, especially in complex or unfamiliar tasks.

These findings highlight the need for instructional interventions that strengthen students' metacognitive skills, particularly in strategic regulation and self-evaluation. Approaches such as guided reflection, think-aloud strategies, and self-assessment activities may enhance students' awareness and control of their learning processes. This is consistent with existing literature, which emphasizes that effective problem-solving is strongly linked to the ability to plan, monitor, and evaluate one's thinking (Zimmerman, 2002; Schraw & Dennison, 1994; Dignath & Büttner, 2008; Panadero & Alonso-Tapia, 2014).

Table 4. Level of Mindset of Grade 7 students in Solving Mathematical Problems

Indicator	Mean	SD	Percentage Score	DepEd Descriptor	Interpretation
Perseverance	5.45	1.82	71%	Did Not Meet Expectation	Demonstrate minimal competence
Flexibility	4.31	0.91	68%	Did Not Meet Expectation	Demonstrate minimal competence

Beliefs	4.60	1.21	69%	Did Not Meet Expectation	Demonstrate minimal competence
Total Score	**14.36**	**1.31**	**69%**	**Did Not Meet Expectation**	**Demonstrate minimal competence**

Table 4 shows that Grade 7 students obtained a total mindset score of 14.36 (SD = 1.31), with a percentage equivalent of 69%, interpreted as “Did Not Meet Expectations” based on DepEd Order No. 8, s. 2015. Among the indicators, perseverance had the highest mean score, followed by beliefs, while flexibility obtained the lowest mean score.

Overall, the findings indicate that students have a limited mindset in mathematical problem-solving. Although they show some perseverance and moderately positive beliefs about learning mathematics, these are not enough to reach the expected level. Their low flexibility suggests difficulty in adapting strategies and shifting thinking when faced with unfamiliar or complex problems.

These results imply the need for instructional strategies that promote a growth-oriented and flexible mindset. Activities that encourage multiple solution strategies, reflective thinking, and engagement with non-routine problems may help improve students’ adaptability and problem-solving performance.

Table 5. Level of Problem-Solving Skills of Grade 7 Students in Mathematics.

Indicator	**Mean**	**SD**	**Percentage Score**	**DepEd Descriptor**	**Interpretation**
Cognitive Knowledge	19.62	1.50	70%	Did Not Meet Expectation	Demonstrate minimal competence
Strategic Deployment	14.77	1.48	70%	Did Not Meet Expectation	Demonstrate minimal competence
Metacognitive Regulation	8.72	0.97	69%	Did Not Meet Expectation	Demonstrate minimal competence
Mindset	14.36	1.31	69%	Did Not Meet Expectation	Demonstrate minimal competence
Total Score	**57.47**	**1.32**	**70%**	**Did Not Meet Expectation**	**Demonstrate minimal competence**

Table 5 presents the level of problem-solving skills of Grade 7 students in mathematics in terms of cognitive knowledge, strategic deployment, metacognitive regulation, and mindset. The results show a total score of 57.47 (SD = 1.32), with a percentage equivalent of 70%, interpreted as “Did Not Meet Expectations” based on DepEd Order No. 8, s. 2015. Overall, the findings indicate that students demonstrate a generally low level of problem-solving skills across all domains.

Among the indicators, cognitive knowledge and strategic deployment obtained relatively higher scores, suggesting that students have basic understanding of mathematical concepts and can apply simple problem-solving strategies. However, these competencies are still insufficient to meet the expected proficiency level. In contrast, metacognitive regulation obtained a low score, indicating difficulty in monitoring, evaluating, and adjusting their thinking processes while solving problems.

The mindset indicator shows a slightly better result compared to metacognitive regulation, implying that students have some willingness to persist and exert effort, but this is still not strong enough to significantly enhance their performance. Overall, the results suggest that students struggle to integrate cognitive, strategic, metacognitive, and affective components, which limits their ability to solve complex and non-routine mathematical problems effectively. These findings emphasize the need for instructional approaches that develop conceptual understanding, strategic flexibility, self-regulation, and positive mindset to improve students’ overall problem-solving performance

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Table 6. Degree of Relationship between cognitive knowledge, strategic deployment, metacognitive regulation, and mindset, and the mathematical problem-solving skills of Grade 7 students

Pair of Variables	**r**	**Probability**	**Interpretation**
Cognitive vs Problem Solving	0.812	< 0.001	Very High Positive Correlation
Strategic Deployment vs Problem Solving	0.768	< 0.001	Very High Positive Correlation
Metacognitive Regulation vs Problem Solving	0.702	< 0.001	Very High Positive Correlation
Mindset vs Problem Solving	0.745	< 0.001	Very High Positive Correlation

Table 6 presents the relationship between cognitive knowledge, strategic deployment, metacognitive regulation, and mindset with students' problem-solving skills in mathematics. The results show that all variables obtained very high positive and significant correlations with problem-solving skills ($p < 0.001$), indicating strong and meaningful relationships among the variables.

Among the indicators, cognitive knowledge showed the highest correlation ($r = 0.812$), followed by strategic deployment ($r = 0.768$), mindset ($r = 0.745$), and metacognitive regulation ($r = 0.702$). These results suggest that students with stronger conceptual understanding, better use of strategies, positive mindset, and improved self-regulation tend to perform better in mathematical problem-solving.

Overall, the findings imply that all variables are strongly interconnected and contribute significantly to students' problem-solving skills. This means that improvement in cognitive knowledge, strategic deployment, metacognitive regulation, and mindset can lead to better mathematical performance, as these factors work together in supporting effective problem-solving.

Table 7. Regression Analysis of Cognitive Knowledge, Strategic Deployment, Metacognitive Regulation, and Mindset as Predictors of Students' Problem-Solving Skills in Mathematics

Predictor	Estimate	SE	β	t	p
Intercept	0.00167	0.00176	—	0.949	.344
Cognitive Knowledge	0.99970	0.00030	.377	3320.14	< .001
Strategic Deployment	1.00038	0.00040	.280	2509.67	< .001
Metacognitive Regulation	0.99939	0.00048	.122	2062.75	< .001
Mindset	1.00030	0.00030	.244	3305.35	< .001

Note: $R = 1.000$, $R^2 = 1.000$, Adjusted $R^2 = 1.000$

Table 7 presents the influence of cognitive knowledge, strategic deployment, metacognitive regulation, and mindset on the problem-solving skills of Grade 7 students in mathematics. The results show that the overall regression model is statistically significant, $F(4, 176) = 5.05 \times 10^8$, $p < .001$, indicating that the predictor variables significantly explain variations in students' problem-solving skills. The model yielded R and R^2 values of 1.000, suggesting that 100% of the variance in problem-solving skills is explained by the combined predictors.

Among the variables, cognitive knowledge emerged as the strongest predictor, followed by strategic deployment and mindset, while metacognitive regulation showed the least contribution, though still significant. This implies that students' conceptual understanding and ability to apply strategies play the most important role in their problem-solving performance, while mindset also contributes positively, and metacognitive regulation has a comparatively smaller effect.

However, the perfect model fit ($R^2 = 1.000$) suggests possible methodological issues such as multicollinearity or overlapping constructs among the variables, which may inflate the results. Despite this, the findings still indicate that all four variables significantly influence problem-solving skills. This highlights the importance of integrating cognitive, strategic, metacognitive, and affective factors in mathematics instruction to improve students' problem-solving performance.

CONCLUSION

The study concludes that mathematical problem-solving is influenced by multiple interconnected factors. Cognitive knowledge provides the foundation, while strategic and metacognitive skills guide the process. Mindset plays a supporting role by enhancing persistence and motivation. An integrated instructional approach is essential to improve students' problem-solving performance**.**

RECOMMENDATIONS

The findings of this study suggest several important recommendations for improving students' mathematical problem-solving skills. Teachers are encouraged to integrate metacognitive strategies into their instruction to help students develop the ability to plan, monitor, and evaluate their own thinking processes. At the school level, initiatives that promote growth mindset should be implemented to foster students' resilience, motivation, and positive attitudes toward learning mathematics. Furthermore, curriculum developers are advised to design contextualized problem-solving tasks that connect mathematical concepts to real-life situations, thereby enhancing students' engagement and understanding. Finally, future research should consider employing experimental designs to test the effectiveness of specific instructional interventions aimed at improving cognitive, strategic, metacognitive, and affective factors in mathematical problem-solving. Future studies may also incorporate qualitative methods, such as interviews, focus group discussions, or classroom observations, to gain deeper insights into students' metacognitive processes, strategic behaviors, and learning experiences during mathematical problem-solving. The inclusion of qualitative approaches may provide a more comprehensive understanding of how students plan, monitor, evaluate, and apply strategies when solving mathematical tasks.

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