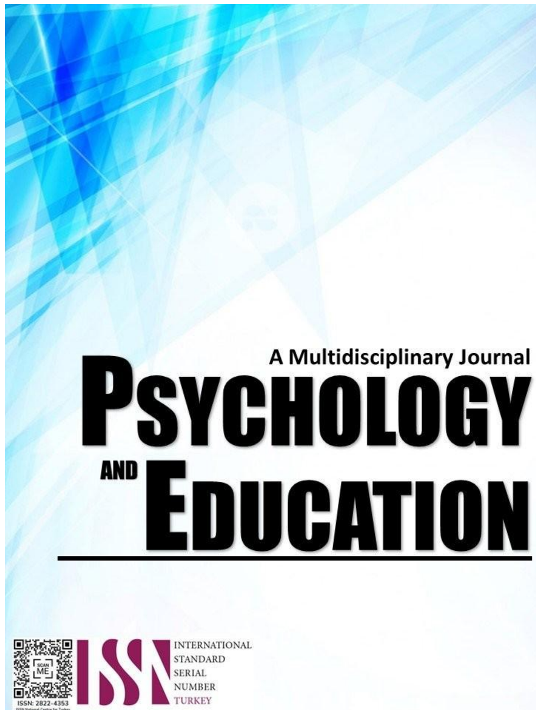
METACOGNITION AND PROBLEM-SOLVING SKILLS OF GRADE 9 STUDENTS



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Research Article

Metacognition and Problem-Solving Skills of Grade 9 Students

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Abstract

The study examined the relationship between metacognitive knowledge, metacognitive regulation, and problem-solving performance among Grade 9 students at Balele Integrated High School. Anchored on the principles of metacognition and problem-solving theory, the study aimed to determine the levels of students' metacognitive abilities and their association with specific components of problem-solving skills. A descriptive-correlational design was utilized, involving 123 Grade 9 students selected through stratified random sampling. Data were gathered using a validated, researcher-made metacognitive questionnaire and a problem-solving test, both of which were evaluated through a structured rubric. Results revealed that students demonstrated a high level of metacognitive regulation, with composite mean scores of 3.70 in planning, 3.50 in monitoring, and 3.52 in evaluation—each interpreted as "Highly Manifested." Similarly, 52% of students were rated Excellent in declarative knowledge, 49% in procedural knowledge, and 43% in conditional knowledge. Problem-solving skills were also high, with 98% of students rated Excellent in "Read and Think," 97% in "Explore," and 93% in "Select a Strategy." However, Pearson correlation analysis showed a weak negative relationship between metacognitive regulation and the problem-solving component "Select a Strategy" ($r = -0.238$), and a weak positive relationship between metacognitive regulation and "Find and Answer" ($r = 0.300$). No significant relationship was found between metacognitive knowledge and problem-solving skills, suggesting the independence of the two variables. These findings imply that while students exhibit strong metacognitive awareness, its influence on specific problem-solving processes varies, highlighting the need for targeted instructional interventions.

Keywords: *metacognitive regulation, metacognitive knowledge, problem-solving*

Introduction

The K to 12 curriculum of the Department of Education (DepEd) emphasizes spiral progression in core subject areas across elementary and junior high school levels, as mandated by Republic Act No. 10533, Section 5g. In Mathematics, this progression enables learners to build foundational knowledge, progressing from number sense to algebra, geometry, trigonometry, and statistics across successive grade levels (Mathematics Curriculum Guide, 2016). Each concept is introduced gradually and deepened annually, aligning with learners' cognitive development.

Beyond content delivery, the curriculum promotes meaningful learning by integrating lessons with real-life contexts and interdisciplinary approaches—DepEd Order No. 8, s. In 2015, educators were encouraged to design instruction that allows learners to apply academic concepts to practical scenarios, thereby fostering both cognitive and experiential understanding. This paradigm shift aims to equip learners with critical thinking skills necessary for their future professions.

One crucial element in enhancing students' learning capacity is metacognition, defined as the ability to reflect on one's thinking. According to Winne and Azevedo (2019), metacognition has a significant influence on various cognitive tasks, including learning, reasoning, and problem-solving. Jacobson (2015) further emphasizes that metacognition allows individuals to reflect on their thoughts and actions, enabling emotional regulation, goal setting, and adaptive learning.

In Mathematics, metacognition is vital as learners must not only grasp precise concepts but also connect prior knowledge to more advanced topics. This self-awareness allows students to plan, monitor, and evaluate their learning strategies, thereby improving their academic performance. As they progress through each grade level, the ability to apply previous mathematical knowledge becomes foundational to mastering new content.

Problem-solving is a core aspect of Mathematics education and personal development. Karatas and Baki (2013) describe it as the cognitive effort to find solutions to challenging tasks. Bostic et al. (2016) and Guerra and Lim (2014) argue that engaging in problem-solving allows students to deepen their understanding by translating problems into mathematical representations. This process often requires iterative thinking and analysis, highlighting the importance of metacognitive engagement during problem-solving activities.

Santoso et al. (2022) assert that metacognitive processes are key to developing mathematical problem-solving skills. Since students approach problems differently based on their mathematical aptitude, understanding their metacognitive strategies provides insight into how they learn and perform. These insights are especially relevant given DepEd's learner-centered approach (DO 36, s. 2013), which positions students as active participants in the learning process while teachers facilitate real-world, performance-based tasks.

Assessment practices under DO 8, s. 2015 reflects this focus, with Mathematics grades comprising 40% written work, 40% performance tasks, and 20% quarterly assessments. As performance-based evaluation becomes more prevalent, learners' metacognitive skills become increasingly critical for academic success.

Metacognition has garnered attention in Mathematics education for its role in enhancing learning outcomes (Safitri & Arnawa, 2019). However, recent trends suggest a decline in learners' metacognitive skills, partly due to the two-year disruption caused by the COVID-19 pandemic. The influence of social media and readily available information has also contributed to a decline in analytical engagement among students (Pew Research Center, 2020).

At Balele Integrated High School, approximately 24% of students were identified as emergent learners in numeracy, based on the School's Monitoring, Evaluation, and Adjustment (SMEA) report. This highlights a pressing need to examine how metacognitive knowledge and regulation affect the problem-solving abilities of Grade 9 Mathematics students.

This study aims to analyze the relationship between students' metacognitive abilities and their problem-solving performance. By doing so, Balele Integrated High School hopes to gain actionable insights that can inform instructional strategies and improve learners' mathematical proficiency in the post-pandemic educational landscape.

Research Questions

This study aimed to determine the relationship between metacognition and the problem-solving skills of Grade 9 students of Balele Integrated High School in Mathematics. Specifically, this is targeted to answer the following questions:

1. To what extent of manifestation of metacognitive regulation of Grade 9 students in terms of:
    1.1. planning;
    1.2. monitoring; and
    1.3. evaluating?
2. What is the level of metacognitive knowledge of Grade 9 students in terms of:
    2.1. declarative;
    2.2. procedural; and
    2.3. conditional?
3. What is the level of problem-solving skills of Grade 9 students in terms of:
    3.1. read and think;
    3.2. explore;
    3.3. select a strategy;
    3.4. find and answer; and
    3.5. review and discuss?
4. Is there a significant relationship between the metacognitive regulation and problem-solving skills of Grade 9 students?
5. Is there a significant relationship between the metacognitive knowledge and the problem-solving skills of Grade 9 students?

Methodology

Research Design

This study employed a descriptive-correlational research design to investigate the relationship between metacognitive knowledge, metacognitive regulation, and problem-solving skills in Grade 9 learners. This design was appropriate for identifying associations between variables without manipulating the study environment. According to Almazan et al. (2019), descriptive-correlational research is commonly employed to describe variables and examine the strength and direction of relationships between them. The data were gathered using a researcher-designed questionnaire and a performance test, both of which were designed to measure the targeted variables.

Respondents

The respondents consisted of 123 Grade 9 students from Balele Integrated High School. A stratified random sampling technique was utilized to ensure equal representation across the four Grade 9 sections. Out of a total population of 180 students, 123 were randomly selected proportionally from each section. As noted by Akinyemi et al. (2018), stratified random sampling increases the representativeness of the sample and minimizes sampling error, thereby enhancing the validity of the results.

Instrument

To assess the students' metacognitive awareness and problem-solving performance, two primary instruments were utilized in the study. The first was a Metacognition Survey Questionnaire, which measured both metacognitive knowledge and metacognitive regulation. Metacognitive knowledge was evaluated through 24 items covering three core components: declarative knowledge, procedural knowledge, and conditional knowledge, with each component represented by eight questions. Meanwhile, metacognitive regulation was assessed using a parallel set of items aligned with the same three components, rated on a 4-point Likert scale, allowing for an analysis of students' ability to plan, monitor, and evaluate their cognitive processes during problem-solving tasks.

The second instrument was a Problem-Solving Skills Test, which the researcher developed to measure students' practical application of mathematical knowledge. The test consisted of four sets of mathematical problems, each accompanied by guiding questions that directed students through the problem-solving process in a structured, chronological manner. A scoring rubric was used to evaluate students across five cognitive stages: Read and Think, Explore, Select a Strategy, Find and Answer, and Review and Discuss. This rubric-based assessment provided a comprehensive picture of the learners' ability to engage with mathematical problems using metacognitive strategies.

To ensure the validity of the research instruments, a panel of internal experts, including the research adviser, subject specialist, statistician, and technical editor, conducted a thorough review and provided feedback for refinement. Additionally, external validation was sought from education professionals, such as DepEd supervisors and master teachers. A pilot test was also conducted with a group of Grade 10 students, and the reliability of the survey questionnaire was assessed using Cronbach's alpha, where values between 0.6 and 0.8 were considered acceptable indicators of internal consistency (Shi et al., 2012).

Procedure

Upon securing the necessary approval from the Schools Division Superintendent and the School Head of Balele Integrated High School, the researcher implemented the study during the third grading period. Prior to data collection, students participated in a two-week instructional period focused on the topic of parallelograms, where they were intentionally exposed to metacognitive strategies within problem-solving tasks. Following this instructional phase, the researcher distributed the metacognition questionnaire and the problem-solving performance test to the respondents. Students completed both instruments under guided conditions to ensure consistency and reliability in responses. Afterward, the responses were collected, scores were tabulated, and the data were submitted to the school's statistics center for analysis. All instruments were carefully validated before administration, and written informed consent was obtained from the student respondents to ensure ethical compliance and voluntary participation.

Data Analysis

The data collected from the instruments were analyzed using appropriate statistical tools. To describe the levels of metacognitive knowledge and metacognitive regulation among students, the mean and standard deviation were computed. The frequency and percentage were used to present the distribution of respondents according to their levels of problem-solving skills. To determine the presence and strength of a significant relationship between the metacognitive variables and students' problem-solving performance, the Pearson Product-Moment Correlation Coefficient (Pearson r) was employed. All results were organized in tabular form, analyzed, and interpreted to address the research questions and test the hypotheses.

Ethical Considerations

Ethical standards were strictly adhered to throughout the study's conduct. Prior to implementation, formal permission was obtained from the Schools Division Office and the School Principal. Informed consent was also secured from all participating students, ensuring they fully understood the nature, purpose, and voluntary nature of the study. The confidentiality and anonymity of the respondents were maintained throughout, with data coded and used solely for academic research purposes. The study adhered to the ethical guidelines established by the Department of Education (DepEd) and institutional research protocols, ensuring that no participant experienced harm, risk, or academic disadvantage at any stage of the research process.

Results and Discussion

This section presents the analysis and interpretation of data collected during the study on metacognition and problem-solving skills.

Students' Manifestation of Metacognitive Regulation

This part presents the manifestation of metacognitive regulation in Grade 9 students. The variable has three (3) components: planning, monitoring, and evaluating.

Table 1. *Students' Manifestation of Metacognitive Regulation in terms of Planning*

I can…	*Mean*	*Std. Deviation*	*Verbal Interpretation*
1. Recall a strategy or method I have used that might be useful for the task.	3.68	0.53	Highly Manifested
2. Consider what I truly need to learn before I start a task	3.75	0.45	Highly Manifested
3. Think deeply about a strategy to use in a certain task.	3.59	0.60	Highly Manifested
4. Be used to get into some ideas about the material or performance task before I start.	3.63	0.59	Highly Manifested
5. Read guidelines precisely before I start a specific task.	3.85	0.40	Highly Manifested
Mean	3.70	0.33	Highly Manifested

Legend: 3.5-4.0 Highly Manifested (HM); 2.5-3.49 Manifested (M); 1.5-2.49 Less Manifested (LM); 1.0-1.49 Not Manifested (NM)

In this table, the indicator "I can read guidelines precisely before I start a specific task" has the highest mean of 3.85, with a standard deviation of 0.40, and is interpreted as Highly Manifested. The table also has an overall mean of 3.70 and SD of 0.33 and interpreted as Highly Manifested.

This indicates that the student-respondents have shown a high level of metacognitive regulation in terms of planning. This also means that the skill of planning a strategy for a specific task is highly salient among the respondents. This manifestation is evident in the classroom. In the properties of parallelograms, it was evident that most learners were planning the strategy they would use to analyze and solve the specific task given to them. Students used the tangent line method in order to find the relationship between opposite angles of a parallelogram.

This suggests that the student-respondents are not only aware of the importance of planning but also actively engage in thorough preparation when faced with new tasks. This strong inclination towards planning may positively impact their overall learning process and problem-solving abilities, as it allows them to approach tasks with a clear understanding of the requirements and a well-defined strategy.

The study by Liu et al. (2018) provides a comprehensive review of the effects of planning on mathematics. The results showed that planning improved problem-solving performance and that this effect was mediated by increased metacognitive awareness and regulation. The researchers concluded that planning can be an effective strategy for improving problem-solving skills in mathematics.

Table 2. *Students' Manifestation of Metacognitive Regulation in terms of Monitoring*

I am…	*Mean*	*Std. Deviation*	*Verbal Interpretation*
1. Periodically asking myself whether I am achieving my goals	3.45	0.62	Highly Manifested
2. Thinking about different alternatives to a problem while answering	3.46	0.68	Highly Manifested
3. Asking myself many times whether I considered all options while problem-solving.	3.37	0.73	Highly Manifested
4. Reviewing periodically to know the important relationships.	3.63	0.58	Highly Manifested
5. Analyzing the effectiveness of strategies during studies.	3.59	0.58	Highly Manifested
Mean	3.50	0.39	Highly Manifested

Legend: 3.5-4.0 Highly Manifested (HM); 2.5-3.49 Manifested (M); 1.5-2.49 Less Manifested (LM); 1.0-1.49 Not Manifested (NM)

Table 2 shows that the indicator "I am reviewing periodically to know the important relationships" has the highest mean of 3.63 and SD of 0.58, with a verbal interpretation of Highly Manifested. Also, the overall mean is 3.50 and the SD of 0.39, which means in words, Highly Manifested.

This finding suggests that the learners possess a high level of self-awareness and metacognitive regulation when it comes to tracking their learning progress. They actively engage in reviewing and reflecting on their learning experiences, which allows them to identify areas of improvement and adjust their strategies accordingly. This proactive approach to monitoring their learning acquisition not only enhances their understanding of the subject matter but also contributes to their overall academic success and personal growth.

This manifestation is apparent to Grade 9 students while they are immersed in lessons on parallelograms, particularly in activities where they are tasked with discovering theorems about rhombuses, rectangles, and squares. Since the activities are process-based, meaning there are specific instructions to follow, learners monitor their progress and ensure that their work aligns with the expected output. When learners notice something not in line with the progress, they stop and look for a concept that may have been missed in the process.

Fuchs et al.'s study on progress monitoring in mathematics (2012) found that progress monitoring had a positive effect on mathematics achievement, and that this effect was greater for students who received more frequent progress monitoring.

Table 3. *Students' Manifestation of Metacognitive Regulation in terms of Evaluating*

I can…	*Mean*	*Std. Deviation*	*Verbal Interpretation*
1. Determine how well I did once I give a test.	3.52	0.59	Highly Manifested
2. Analyze what did not go well with my strategy	3.43	0.64	Highly Manifested
3. Summarize my learning using the strategy I use.	3.59	0.59	Highly Manifested
4. Think of another problem that the strategy I used might be useful.	3.42	0.76	Highly Manifested
5. Rethink after solving a problem whether I considered all alternatives.	3.63	0.66	Highly Manifested
Mean	3.70	0.33	Highly Manifested

Legend: 3.5-4.0 Highly Manifested (HM); 2.5-3.49 Manifested (M); 1.5-2.49 Less Manifested (LM); 1.0-1.49 Not Manifested (NM)

Table 3 displays the manifestation of student-respondents in their metacognitive regulation, specifically in evaluating the indicator "I can rethink after solving a problem whether I considered all alternatives," which has the highest mean value of 3.63, with a standard deviation of 0.66, indicating "Highly Manifested." Overall, the mean value of the table is 3.52, and the SD is 0.44, which is verbally interpreted as Highly Manifested.

These findings suggest that they have high metacognitive regulation in evaluating. The learner-respondents believe that they assess their thinking and rethink their decision in their tasks. This observation also suggests that the students are highly conscious of their ability to evaluate their performance after solving problems. They actively engage in reflecting upon their problem-solving strategies, considering whether they have explored all available alternatives. This self-assessment practice is indicative of a strong metacognitive regulation in the evaluation phase, which can positively impact their learning and problem-solving skills by fostering continuous improvement, adaptability, and the ability to learn from their experiences.

This evaluative ability of the learners was evident in their two-column proofs, which involved finding properties and theorems for different kinds of parallelograms. This evaluative ability typically occurs immediately after reviewing the quizzes and activities. Students usually asked the teacher the specific reason why it was used in the given statement, and when the teacher explained, they realized their mistakes and remembered the concept for their use in the following activities.

According to Hendrickson et al. (2018), evaluation can enhance students' mathematics learning by providing information on their progress, identifying errors, and promoting metacognitive awareness. Additionally, the study by Platas et al. (2015) discussed the potential benefits of evaluating mathematical thinking in the context of learning progress.

Level of Metacognitive Knowledge of Students

This section presents the level of metacognitive knowledge among Grade 9 students in three components: declarative knowledge, procedural knowledge, and conditional knowledge.

Table 4. *Frequency Distribution and Percentage in Finding the Level of Declarative Knowledge of Grade 9 Students*

Scores	*F*	*%*	*Interpretation*
7 - 8	64	52	Excellent
5 - 6	56	46	Good
3 - 4	3	2	Fair
0 - 2	--	--	Poor
Total	123	100	

The frequency distribution table above shows that 64 out of 123 students (52%) fall into the Excellent level, 56 out of 123 students (46%) fall into the Good level, and 3 out of 123 students (2%) fall into the Fair level. This indicates that almost half of the students have a high level of declarative knowledge. This also suggests that most students have a clear understanding of the strategies they will use in the given task.

This observation highlights that most students have a strong foundation in understanding the strategies they need to employ when approaching a given task. They possess the necessary knowledge of facts, concepts, and ideas that enable them to tackle various challenges effectively. This strong base of declarative knowledge is likely to contribute positively to their overall learning experience, problem-solving abilities, and academic performance, as it allows them to make informed decisions and select the most appropriate strategies for the tasks at hand.

In the classroom setting of Grade 9 students discussing parallelograms, it is essential for the student-respondents to understand the specific methodology involving parallelograms, including the concepts of alternate interior angles in general parallelograms, finding the measurements of angles bisected, and how to formulate reasoning for the statement using prerequisite concepts. Learners demonstrate a high level of knowledge about the strategy to be applied in the specific topic.

In a study by Ozsoy et al. (2015), it was found that metacognitive strategies are an effective way to enhance students' problem-solving skills in mathematics. Additionally, Van Dooren's (2017) study examines the role of declarative knowledge in mathematical problem-solving, with a particular focus on the use of examples. The authors found that the use of examples can improve students' declarative knowledge and their ability to apply that knowledge to new problems. The study suggests that the use of examples may be an effective way to enhance students' declarative knowledge in mathematics.

Table 5. *Frequency Distribution and Percentage in Finding the Level of Procedural Knowledge of Grade 9 Students*

Scores	*F*	*%*	*Interpretation*
7 - 8	60	49	Excellent
5 - 6	49	40	Good
3 - 4	13	11	Fair
0 - 2	1	1	Poor
Total	123	100	

The paragraph presents an analysis of student-respondents' procedural knowledge based on the data provided in Table 5. The results reveal that the majority of students (49%, or 60 out of 123) possess an excellent level of procedural knowledge. A significant portion of the students (40% or 49 out of 123) also demonstrate good procedural knowledge. However, a smaller percentage of students (11% or 13 out of 123) fall into the fair category, and only 1% (or 1 out of 123) of the respondents exhibit poor procedural knowledge. Overall, the majority of students have a strong understanding of procedural knowledge, with a few students requiring improvement in this area.

Overall, the insight highlights the importance of focusing on both the majority of students who already possess strong procedural knowledge and the minority who require further support and development in this area. By addressing the needs of all students, educators can ensure that every individual has the opportunity to excel in their problem-solving abilities.

The procedural knowledge of Grade 9 students is highly evident in the class of parallelograms, where learners engage in both board work and seat work to solve for the value of the diagonals of the parallelogram by analyzing the relationship between the diagonals. Moreover, there are activities in the rhombus where students are asked to find the measure of the angle cut by the diagonals that intersect.

In the literature, Rittle-Johnson et al. (2015) examined the connection between procedural and conceptual knowledge in the field of mathematics. Their research discovered that students possessing solid procedural knowledge excelled in problem-solving activities. Additionally, the study emphasized the significance of combining procedural and conceptual knowledge to ensure students' comprehensive success in mathematics. This research corroborates the idea that most students possess a robust comprehension of procedural knowledge, which probably plays a crucial role in their problem-solving achievements.

Table 6. *Frequency Distribution and Percentage in Finding the Level of Conditional Knowledge of Grade 9 Students*

Scores	*F*	*%*	*Interpretation*
7 - 8	53	43	Excellent
5 - 6	64	52	Good
3 - 4	6	5	Fair
0 - 2	-	-	Poor
Total	123	100	

Table 6 demonstrates the level of conditional knowledge of Grade 9 students. Based on the results, it is evident that 53 out of 123 students (43%) achieved an Excellent rating, 64 out of 123 students (52%) achieved a Good rating, and 6 out of 123 students (5%) achieved a Fair rating.

This suggests that almost half of the student-respondents are proficient in reasoning about when or why to use the strategy in a specific task. The insight emphasizes the importance of cultivating conditional knowledge in students, as it enables them to adapt their approaches to the specific context and requirements of a task. By continuing to develop and strengthen their conditional knowledge, students can enhance their overall academic performance and problem-solving abilities, ultimately leading to more successful learning outcomes.

The said component is manifesting in solving problems involving parallelograms in the Grade 9 class. In this specific situation, learners are tasked with finding the values of the angles divided by intersecting diagonals in a rhombus, given only the value of one of the whole angles. Through a thorough analysis, learners applied the concept of the theorem to a rhombus, where the diagonals serve as angle bisectors of the angles in the given parallelogram. In this matter, learners understand that they need to divide the value of the angle in half to find the measure of the smaller angle.

The study by Kalyuga et al. (2017) investigates the role of conditional knowledge in mathematical problem-solving, with a focus on the acquisition, representation, and transfer of knowledge about conditional relationships between propositions. The authors argue that conditional knowledge is crucial for effective problem-solving and that interventions designed to improve students' conditional knowledge may be beneficial in enhancing their problem-solving skills.

Level of Students' Problem-Solving Skills

This part of the study provides the level of problem-solving skills in 5 different categories: Read and Think, Explore, Select a Strategy, Find and Answer, and Review and Discuss.

Table 7. *Frequency Distribution and Percentage of the Level of Problem-solving skills of Grade 9 students*

Score	*Read and Think*			*Explore*			*Select a Strategy*			*Find and Answer*			*Review and Discuss*		
	F	*%*	*Int*	*F*	*%*	*Int*	*F*	*%*	*Int*	*F*	*%*	*Int*	*F*	*%*	*Int*
7 - 8	121	98	E	119	97	E	114	93	E	118	96	E	117	95	E
5 - 6	2	2	G	4	3	G	9	7	G	5	4	G	6	5	G
3 - 4	-	-	F	-	-	F	-	-	F	-	-	F	-	-	F
0 - 2	-	-	P	-	-	P	-	-	P	-	-	P	-	-	P
Total	123	100		123	100		123	100		123	100		123	100	

Table 7 shows the level of problem-solving skills of Grade 9 students. The results show that most of the learners are in the Excellent category in terms of Read and Think (98%).

This observation suggests that the students are not only capable of identifying the given information in a problem but also adept at determining the subsequent tasks and steps required to solve it. Their ability to effectively analyze and break down problems is an essential skill for successful problem-solving and learning. This insight highlights the importance of developing students' analytical skills, as it empowers them to approach complex tasks with confidence and effectiveness.

Learners demonstrated the Read and Think skill in the competencies related to the topic involving parallelograms. Students are tasked with proving the existence of congruence or a relationship between parts using a two-column proof. Students demonstrated their ability to find facts and apply the given information effectively in the problem. In line with this, they were also able to decipher the next steps in solving the problem.

It is also evident in the classroom activities that correctly identifying the information in the problem serves as the key to determining the next steps in solving it. Learners can formulate procedures for the given task.

In the study by Krawec et al. (2014), the aim was to investigate how the presence or absence of specific information and problem structure affects students' problem-solving performance. The results showed that students who identified the given information in the problem were more likely to solve the problem correctly. The researchers concluded that identifying the given information is a critical step in mathematical problem-solving and should be explicitly taught to students. Another study provides an overview of research on problem-solving in mathematics education, highlighting the importance of identifying the given information in a problem. The researchers argued that finding the given information is crucial in problem-solving as it helps students to determine what they need to do to solve the problem (Verschafell, 2012).

Moreover, in terms of Explore, it shows that 119 out of 123 students fall into the Excellent category, while 4 out of 123 students fall into the Good category.

This indicates that learners are applying their previous concepts and strategies to solve the problem presented to them. Additionally, they have applied the necessary concepts to address the problem. This implies that learners are adept at applying previous knowledge to integrate it into the present situation.

The results were evident in the classroom setting on the topic of parallelograms. Since learners were taught about reasoning and the use of triangle congruence postulates in their previous school year, they had utilized those concepts and integrated them into formulating strategies and solutions to problems. They also applied some concepts learned in their elementary school days to the methods for solving the problem.

This insight highlights the importance of developing students' ability to explore and draw upon their existing knowledge base when faced with new problems. By encouraging learners to build upon and connect their previous learnings continuously, educators can help them develop more effective problem-solving skills and enhance their overall academic performance. This ability to explore and apply prior knowledge is a critical component of lifelong learning and adaptability, which will serve students well beyond their academic careers.

The study by Hsu et al. (2018) aimed to investigate the effectiveness of prior knowledge activation strategies in mathematical problem-solving. The results showed that the strategies were effective in enhancing students' problem-solving performance by activating their prior knowledge. The researchers concluded that these strategies should be explicitly taught to students to help them effectively utilize their prior knowledge in mathematical problem-solving. The study by Krawec et al. (2018) investigated the role of prior knowledge and strategic processing in mathematical problem-solving among elementary students. The results showed that students who used strategic processing and drew on their prior knowledge were more likely to solve the problem correctly. The researchers concluded that teaching students how to utilize their prior knowledge and employ strategic processing effectively is crucial in enhancing their mathematical problem-solving skills.

In terms of Select a Strategy, it implies that 114 of 123 students (93%) belong to the Excellent category, and 9 of 123 students (7%) belong to the Good category.

This observation suggests that the majority of learners are highly skilled at selecting effective strategies for solving problems based on their understanding of relevant concepts. They can critically assess the given problem and select the most effective approach, drawing upon their conceptual knowledge.

The Select a Strategy component was salient in the learning scenario of Grade 9 students when investigating problems in parallelograms, particularly those involving rectangles. Students demonstrated a high level of skill in choosing the appropriate strategies to solve the problem. While there are numerous strategies for solving the problem, learners most often choose the easiest and most effective one to solve it in a shorter period.

This features the importance of developing students' ability to select suitable strategies when faced with various challenges. By nurturing this skill, educators can help learners become more efficient problem solvers and improve their overall academic performance. The ability to choose the right strategy based on a strong conceptual foundation is a valuable skill that will benefit students not only in their academic pursuits but also in their future careers and personal lives.

The study by Anggraini et al. (2018) identified the problem-solving strategies employed by high-ability students in solving non-routine mathematical problems. The results showed that high-ability students employed various strategies, including drawing diagrams, working backward, and using a combination of guessing and checking. The researchers concluded that teaching students different strategies can help them solve non-routine problems effectively.

In terms of Find and Answer, it shows that 118 out of 123 students (96%) are in the Excellent category. Meanwhile, 5 out of 123 students (4%) are in the Good category. This implies that most of the students can solve and answer the problem according to the planned strategy ahead.

Their results were distinct in the classroom setup during the discussion on the properties of parallelograms. It was evident in their activity that they had successfully executed the planned strategy, and they were able to identify which property of a parallelogram was utilized in the problem. They planned to use the SSA Triangle Congruence Postulate to prove the existence of congruence of the diagonals of the parallelogram. The case is also evident in solving problems involving rectangles and squares.

Kılıç et al. (2015) investigated the effect of problem-solving plans on students' problem-solving performance and self-efficacy beliefs in mathematics. The results showed that students who used problem-solving plans performed better on mathematical problem-solving tasks and had higher self-efficacy beliefs than those who did not use problem-solving plans. The researchers concluded that teaching students how to use problem-solving plans can help them solve mathematical problems more effectively.

In terms of Review and Discuss, it depicts that 117 out of 123 students (95%) are in the Excellent category, while 6 out of 123 students are in the Good category. This means that students are demonstrating exemplary skills in reviewing their answers, and when they are incorrect, they can analyze where or why they are wrong and identify possible alternatives to solve the problem.

This observation indicates that the majority of students possess exemplary skills in reviewing their answers and engaging in self-assessment. They can identify any errors in their problem-solving process, analyze the reasons behind these errors, and find possible alternatives to reach a correct solution. This ability to reflect on their work, learn from mistakes, and adapt their approaches is a critical component of effective problem-solving and lifelong learning.

These results were evident in Grade 9 students after they discovered the special properties of rhombuses, rectangles, and squares. After a thorough investigation of the results in proving the theorems of the parallelograms, they found out in their reflection that the square is the most special kind of parallelogram because all of the properties of parallelograms and the theorems of rhombus and rectangles exist in a square.

The study by Lee et al. (2017) demonstrated the importance of self-reflection in enhancing problem-solving performance. The results showed that self-reflection improved problem-solving performance and that this effect was mediated by increased self-efficacy. The researchers concluded that self-reflection can be an effective strategy for improving problem-solving skills.

The importance of fostering students' ability to review and discuss their problem-solving process is very essential to students' learning. By encouraging learners to engage in self-assessment and reflection, educators can help them develop a deeper understanding of their strengths and weaknesses, leading to continuous improvement and growth. Developing these skills not only enhances students' academic performance but also prepares them for future challenges in their careers and personal lives, as they become more adaptable and resilient problem solvers.

Table 8. *Relationship Between Metacognitive Regulation and Problem-solving skills of Grade 9 students.*

Metacognitive Regulation	*Problem Solving Skills*				
	Read and Think	*Explore*	*Select a strategy*	*Find and answer*	*Review and Discuss*
Planning	-.079	.017	-.187*	.178*	-.030
Monitoring	-.156	.113	-.195*	.300**	.018
Evaluating	-.194*	.130	-.238**	.259**	-.037

***. Correlation is significant at the 0.01 level (2-tailed).*
**. Correlation is significant at the 0.05 level (2-tailed).*

Table 8 indicates that the indicator "Select a strategy" shows a low negative correlation with metacognitive regulation indicators (Planning-Select a Strategy, r = -.187; Monitoring-Select a Strategy, r = -.195; Evaluating-Select a Strategy, r = -.238).

This indicates a weak negative relationship between metacognitive regulation and learners' problem-solving skills in terms of Read and Think. This indicates that when learners focused on planning, monitoring, or evaluating their strategies, they sometimes overlooked important information to include in solving a specific problem. This usually occurred in the Grade 9 class while discussing the properties of parallelograms. As the teacher presented the problem to solve, a group of learners focused on finding the essential information in the problem, which led to a lack of planning, monitoring progress, and evaluation of the task completed. On the other hand, some learners focused on their metacognitive regulation abilities, solving the same problem. At the end of the activity, their answers were insufficient due to a lack of awareness in collecting the necessary information for the problem.

The study by Zainuddin et al. (2016) supports the evidence observed in the classroom regarding the relationship between metacognitive regulation and the Read and Think component in problem-solving. This suggests that learners need to balance their metacognitive regulation with cognitive skills to solve problems effectively.

Meanwhile, the indicator "Find and Answer" exhibits a low positive correlation with metacognitive regulation, specifically in the areas of Planning-Find and Answer (r = .178), Monitoring-Find and Answer (r = .300), and Evaluating-Find and Answer (r = .259).

This suggests that when learners focus on their metacognitive regulation abilities, there is a slight relationship between their execution of the planned strategy and its success, indicating an increase in the strategy's effectiveness. This was evident in the classroom environment during the Grade 9 Mathematics class on squares. As they seek to measure the angle formed by the intersecting diagonals within the square, they conduct an investigation using the available facts, recalling and integrating previous concepts. It turned out that as they focused on how to solve the problem and monitor and evaluate their progress, they seemed to have answers with more convincing reasons and evidence. (This does not conclude that the answer is already correct.)

These focus on the complex relationship between problem-solving skills and metacognitive regulation. While 'Select a Strategy' appears to have a weak negative association with metacognitive regulation, 'Find and Answer' shows a weak positive relationship. This information can help educators better understand the interplay between these skills and develop more targeted strategies to support students' growth in both problem-solving and metacognitive regulation.

In the study by Güner et al. (2021), it was found that metacognitive skills have a significant effect on students' problem-solving success. The study found that students with high metacognitive skills tend to solve problems more effectively than those with low metacognitive skills. These findings suggest that metacognitive regulation plays a crucial role in problem-solving and that educators should prioritize developing students' metacognitive skills to enhance their problem-solving abilities.

Table 9. *Relationship Between Metacognitive Knowledge and Problem-solving skills of Grade 9 students.*

Metacognitive Regulation	*Problem Solving Skills*				
	Read and Think	*Explore*	*Select a strategy*	*Find and answer*	*Review and Discuss*
Declarative	-.083	.075	-.015	.008	-.109
Procedural	-.088	-.156	.075	-.117	-.001
Conditional	-.143	.119	-.027	-.036	.064

The data presented in this table reveal that the correlation values are not statistically significant, indicating that there is no significant relationship between metacognitive knowledge and problem-solving skills. This suggests that the students' ability to solve problems may not be directly influenced by their metacognitive knowledge, as the correlation between the two variables is very low.

As demonstrated during the discussion on the conditions of a parallelogram, learners' ability to use the strategy for the task, as well as when and why to use it, is independent of their problem-solving ability. There are cases where learners can apply the strategy to determine the condition of a parallelogram presented in the problem. At the same time, they cannot solve the problem in terms of assigning values.

The results in this table contradict the studies of Garcia et al. (2019) and Schoenfeld et al. (2013), which suggest that metacognitive knowledge exhibits a strong positive relationship with problem-solving skills in mathematics. This might be affected by the prerequisite competencies in parallelograms and the triangle congruence postulate, a Grade 8 competency, which learners in modular distance learning have not had the opportunity to focus on, as it is essential for the Grade 9 competencies in parallelograms.

Conclusions

Based on the summary of findings, several conclusions were drawn from the study. First, a weak negative relationship exists between metacognitive regulation and problem-solving skills, specifically in the component of Selecting a Strategy. This indicates that as students' metacognitive regulation increases, their ability to choose appropriate strategies when solving problems does not necessarily improve. As a result, the null hypothesis for this component is rejected. Second, a weak positive relationship was found between metacognitive regulation and problem-solving skills in the component Find and Answer, suggesting that students who demonstrate better regulation skills may show slight improvements in executing solutions. Therefore, the null hypothesis is also rejected in this area. Third, the study found no significant relationship between metacognitive knowledge and students' problem-solving performance. This suggests that metacognitive knowledge may function independently of how students currently approach and solve mathematical problems. In this case, the null hypothesis is accepted.

In light of these findings, the study offers several recommendations. Teachers and future researchers are encouraged to explore additional factors that may influence students' learning outcomes and problem-solving abilities. A broader investigation into these factors could yield valuable insights to inform classroom strategies and educational policies. Educators are also advised to implement targeted interventions aimed at enhancing students' capacity to select appropriate problem-solving strategies. This can involve teaching multiple problem-solving techniques, offering scaffolded practice, and encouraging reflection on the effectiveness of strategies. Moreover, it is essential to continually promote the development of metacognitive regulation through activities that foster self-reflection, goal setting, and self-monitoring. Finally, future research may further investigate the role of metacognitive knowledge with other mathematics-related competencies. Although no significant correlation was found in this study, the consistently high levels of metacognitive knowledge among students suggest it may play a meaningful role in other aspects of mathematical learning and thus remains a promising area for continued research.

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