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Article

Metacognitive Awareness and Numerical Proficiency of Bachelor of Secondary Education Major in Mathematics

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Abstract: This study investigates the relationship between metacognitive awareness and numerical proficiency among Bachelor of Secondary Education (BSED) students majoring in Mathematics at the University of Cabuyao during the academic year 2024–2025. Employing a descriptive-correlational research design, the study assessed metacognitive awareness in terms of knowledge (declarative, procedural, and conditional) and regulation (planning, monitoring, and evaluating), alongside numerical proficiency, which encompassed numerical literacy, skills, and aptitude. Data were collected from 103 respondents using validated researcher-made instruments and analyzed using statistical methods, including Spearman's Rho. Findings revealed that respondents demonstrated high levels of metacognitive awareness across all dimensions, with notable variability in individual performance. Similarly, numerical proficiency was predominantly rated as high, with numerical aptitude achieving the highest scores. A significant positive correlation was identified between metacognitive awareness and numerical proficiency, underscoring the critical role of metacognitive skills in enhancing mathematical competencies. The study highlights the importance of fostering metacognitive practices to improve problem-solving, critical thinking, and adaptability in mathematics education. These findings provide valuable insights for educators, curriculum developers, and policymakers in designing targeted interventions to enhance metacognitive and numerical skills among pre-service mathematics teachers. By addressing individual differences and promoting reflective learning strategies, this research contributes to the development of competent and adaptive mathematics educators capable of meeting the demands of 21st-century education.

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1. Introduction

Mathematics involves critical thinking, problem-solving, and creativity, rather than solely memorizing formulas. The Education Endowment Foundation (2024) emphasizes that metacognition is essential for effective student learning. Metacognition, defined as the awareness of one's own thought processes, is essential for structuring ideas and facilitating informed decision-making in mathematics, encompassing self-monitoring and the adaptation of learning strategies.

Metacognition is acknowledged as a crucial element in effective learning, especially within mathematics education. It encompasses an individual's capacity to oversee, regulate, and assess cognitive processes, essential for critical thinking and problem-solving. Students with metacognitive awareness can evaluate their comprehension, modify their strategies, and improve their mathematical performance. This study examines the link between metacognitive awareness and numerical proficiency in Bachelor of Secondary Education (BSED) Mathematics majors at the University of Cabuyao for the 2024–2025 academic year.

The Philippine Commission on Higher Education (CHED) emphasizes the necessity of cultivating critical thinking and problem-solving abilities in student teachers, particularly in mathematics. CHED Memorandum Order (CMO) No. 75, series of 2017, requires teacher education programs to develop skilled and competent educators to address the needs of 21st-century education (Commission on Higher Education, 2017). This directive, though established prior to the current study, remains pertinent, as recent research underscores the importance of metacognitive skills in mathematics instruction. The objectives established by CHED, which encompass promoting reflective and adaptive teaching practices, closely align with the enhancement of metacognitive skills.

Students exhibiting high metacognitive awareness often show enhanced problem-solving strategies and better learning outcomes. Mevarech and Fridkin (2006) demonstrated that the use of metacognitive strategies enhanced students' performance in mathematics tasks and problem-solving. Eggen and Kauchak (2001) observed that successful learners are aware of their use of strategic approaches, resulting in enhanced learning outcomes. Acquiring a broader range of metacognitive skills enables students to differentiate between relevant and irrelevant information, thus improving their numerical proficiency.

BSED Mathematics students must demonstrate proficiency in numerical reasoning, arithmetic, and problem-solving as future educators. Achieving high metacognitive awareness is essential for a comprehensive understanding of mathematical concepts, beyond numerical proficiency. This study examines the link between metacognitive awareness and numerical proficiency in BSED Mathematics students, highlighting the significance of both factors.

The main objectives are to evaluate students' numerical proficiency, assess their metacognitive awareness—particularly regarding mathematical metacognitive knowledge and regulation—and investigate the relationship between metacognitive awareness and numerical proficiency. Comprehending these factors facilitates a deliberate and self-regulated approach to mathematics learning and enhances teaching practices. Numerical proficiency, encompassing literacy, aptitude, and skills, is essential in mathematics education. Effective problem-solving, decision-making, and academic achievement are essential.

Research findings show that students who excel in numerical skills demonstrate better practical application of mathematical concepts. According to Aydin and Ubuz (2023) numerical proficiency demonstrates both mathematical aptitude and reveals students' metacognitive problem-solving approaches. The research demonstrates why it is essential to study the relationship between metacognitive awareness and numerical ability. BSED Mathematics students need to develop both superior mathematical competencies and teaching effectiveness because of the essential link between metacognitive awareness and numerical proficiency.

Students who develop metacognitive awareness learn to evaluate their learning process while identifying weak points and selecting appropriate strategies to overcome obstacles which leads to better numerical skills essential for future mathematics educators. Research conducted during the last few years demonstrates that metacognitive strategies play a vital role in mathematics education. Students who practiced metacognitive strategies through self-monitoring and self-regulation according to Efklides (2023) achieved better mathematical competence. The research shows that BSED Mathematics students who receive metacognitive awareness development will achieve better numerical skills and academic results. Kizilcec et al. (2023) demonstrated that metacognitive awareness plays a crucial role in developing problem-solving abilities particularly in mathematics because students need to handle abstract and complex mathematical concepts.

Metacognitive Awareness and Numerical Proficiency

The research shows that metacognitive awareness stands as a fundamental factor for students to learn mathematics and achieve numerical proficiency. Metacognitive awareness consists of two components: cognition management and cognition knowledge according to Chan et al. (2021). Research evidence shows that students who master metacognitive skills including planning and monitoring and evaluation tend to achieve better results in mathematics (Jose A., 2024; Sumilah & Sari, 2020; Tak & Eu et al., 2022). R.A. Baguin and Fe R. (2024) and Ferrer and Caballes (2025) demonstrate through their research that systematic strategies together with reflective thinking help students develop metacognitive awareness which leads to better mathematical problem-solving abilities. The research indicates that metacognitive awareness functions as an essential element of mathematical success because it provides students with better methods to handle mathematical problems.

The three components of metacognitive knowledge which include declarative knowledge and procedural knowledge and conditional knowledge serve as essential elements for achieving mathematical success (Tak & Zulnaidi et al., 2022). The knowledge domain of declarative knowledge includes facts and self-knowledge while procedural and conditional knowledge describe strategy application methods (Jose, C., 2024; Caparas & Ferrer, 2025). According to Melanie G. (2021) and Pathuddin and Bakri (2023) high-achieving students maintain metacognitive skills throughout their problem-solving activities but lower-achieving students apply these skills irregularly. Students' mathematics success and engagement depend heavily on their motivation and learning environment as well as their early educational experiences (Mary & Yvonne, 2025; Ozlem & Mesut, 2024). The complex nature of metacognitive knowledge demonstrates that students need both internal abilities and external elements such as motivation and environment to succeed in mathematics.

Students who possess procedural knowledge demonstrate better control over their learning methods while selecting appropriate strategies based on their individual requirements (Fe Janiola et al., 2023). Remote learning has made metacognitive strategies more essential for students to handle mathematical difficulties (Adaiah & Eugene, 2023). The development of these skills depends on teachers' teaching methods and their decision to add metacognitive components to educational resources (Susanna & Lasse E. et al., 2024; Edi, S. Yakin, & T., 2024; Torang & Almira et al., 2024). The solution of non-routine problems requires students to use decomposition and reflective thinking as systematic strategies (Norberto et al., 2025). The research shows that procedural knowledge together with metacognitive strategies play a crucial role in new learning environments and teachers must integrate these strategies into their teaching practices.

The ability to recognize appropriate strategy application leads to better problem-solving results (Beverly R., 2020; Mohamad & Norulhuda, 2020; Joseph, 2024). Research indicates that metacognitive instruction produces substantial improvements in students' conditional knowledge and their mathematical achievement (Yiming & Xia et al., 2022; Despina et al., 2023). Students need to learn when to apply particular strategies for effective problem-solving and instruction that focuses on conditional knowledge leads to major improvements in mathematical performance.

The essential components of self-regulated learning according to Tak et al. (2022) include planning and monitoring and evaluation which together form metacognitive regulation. Research conducted by Kms. & Agus P. et al. (2024) and Dwiani & Nuraini (2023) and Mohamad & Norulhuda (2020) shows that teaching metacognitive regulation strategies with formative assessment leads to better student understanding of mathematics and self-regulation. Metacognition affects performance through the mediation of hope and self-efficacy and social interactions according to Georgia & Foteini (2024) and Eetu (2022). Research demonstrates that metacognitive regulation requires both individual skill development and classroom support for self-efficacy and collaboration to achieve sustained learning.

The development of metacognitive and mathematical connection skills depends heavily on monitoring and evaluation practices according to Sultan & Arzu (2024) and Cosar et al. (2021) and Musarrat & Sarfraz et al. (2024) and Joachim & Corinna et al. (2025). The combination of collaborative learning with group regulation techniques produces the most significant benefits for these skills when dealing with complex mathematical problems (Eetu, H., 2022). The implementation of formative assessment and reflective practices through evaluative strategies leads to better academic results and improved problem-solving abilities according to Sudriman & Yustinus et al. (2025) and Zenaida R. (2024) and Ni Made & Ida Bagus et al. (2023) and Paul & Roxanne et al. (2023). The research demonstrates that continuous monitoring and evaluation practices both as individuals and groups lead to better mathematical understanding and adaptability through the essential tools of formative assessment and reflection.

Numerical proficiency which includes numerical literacy and skills together with aptitude maintains a direct relationship with metacognitive awareness according to Tak et al. (2022a) and Ferrer & Caballes (2025) and Jay A. (2024) and Bermudez (2024) and N. Dorji & P. Bdr. (2023) and Maria Luisa P. (2021). The development of numeracy depends on literacy and motivation while blended learning approaches improve these skills (Adzka et al., 2024; Caparas & Ferrer, 2025; Rahmawati et al., 2023; Nahdi et al., 2020; Rif'at et al., 2021; Salsabilah et al., 2022). Numeracy skill maintenance needs both initial and ongoing intervention programs according to Shallinie & Richard et al. (2023) and Legaspino et al. (2024) and Notarte et al. (2024) and Lopez-Pedersen et al. (2022) and Parcon et al. (2024). The research shows that numerical proficiency needs multiple components which reach their maximum benefits through sustained support beginning early with motivation and literacy as fundamental building blocks.

The ability to work with numbers which defines mathematical success depends on natural number skills (Rais & Samsul et al., 2023; Ridwan et al., 2023; Niepes, 2020; Santos et al., 2020; Subekti et al., 2022). Teachers play a vital role in developing these abilities through particular teaching methods and intervention programs. The teacher plays an essential role because they deliver effective instruction and individualized support which helps all students improve their math abilities and develop confidence regardless of their natural number aptitude.

There are many studies have proven that metacognitive awareness directly affects numerical proficiency. Research conducted by Jikamshi (2020), Tian (2023), Özsoy (2020), and Chytrý (2020) demonstrates that metacognitive awareness leads to better deep learning and increased motivation and self-efficacy which results in enhanced numerical skills. Academic success depends on metacognitive regulation which should become a fundamental part of curriculum reforms and instructional practices according to Bakar (2020), Ghosh (2021), Amin (2020), Schnaubert (2020) and Habók (2022). The combination of metacognitive awareness and regulation in mathematics education serves dual purposes because these skills support academic success and lifelong learning thus becoming fundamental elements for effective mathematics instruction.

Research Questions

This study determines the correlation between metacognitive awareness and numerical proficiency in BSED- mathematics at the University of Cabuyao 2024-2025.

Specifically, it seeks to answer the following;

1. What is the level of metacognitive awareness in knowledge of the respondents' in terms of:

Declarative Knowledge;

Procedural Knowledge; and

Conditional Knowledge?

2. What is the level of metacognitive awareness in regulation of the respondents' in terms of:

Planning;

Monitoring; and

Evaluating?

3. What is the level of numerical proficiency of the respondents in terms of:

Numerical Literacy;

Numerical Skills; and

Numerical Aptitude?

4. Is there a significant relationship between metacognitive awareness in knowledge and the numerical proficiency of the respondents?
5. Is there a significant relationship between metacognitive awareness in regulation and the numerical proficiency of the respondents?
6. Based on the result of the study, what intervention plan can be proposed?

2. Materials and Methods

Research Design

The study employed was descriptive-correlational. This design was commonly recognized for its ability to describe variables and the natural relationships that existed both between and within them. In this study, a descriptive-correlational design was used to illustrate the Metacognitive Awareness and Numerical Proficiency of BSED-Mathematics students. This approach proved to be appropriate for the study as it highlighted the relationship between the two variables. The research employed a researcher-made test as its methodological approach. The researchers selected BSED-Mathematics students from their first to third year to evaluate their Metacognitive Awareness and Numerical Proficiency levels. The researchers used an online survey as their data collection method because it provided both efficiency and convenience. The survey results from the online platform were automatically imported into Spreadsheet or SPSS for data analysis. The researchers applied stratified random sampling to distribute participants evenly across their year levels so they could identify all study participants.

Respondents of the Study

The researchers chose students from the 1st to 3rd year at the University of Cabuyao (Pamantasan ng Cabuyao) as their research subjects. The researchers used Stratified Random Sampling Technique to select all students from the 1st to 3rd year because 138 students were available. The table shows the distribution of respondents across each section. The researchers chose 47 students for the 1st year selection with 18 males and 29 females, 16 males and 24 females in the 40 2nd year students, and 51 22 males and 29 females in the 3rd year to participate in the study.

Table 1. Respondents of the Study.

Year Level	Population Size	Percent	Sample Size
1st Year	47	34.06%	35
2nd Year	40	28.99%	30
3rd Year	51	36.96%	38
Total	**138**	**100.00%**	**103**

The respondents of this study consisted of Bachelor of Secondary Education (BSED) students majoring in Mathematics at the University of Cabuyao, categorized by year level. The total population size was 138 students, distributed as follows: 47 first-year students (34.06%), 40 second-year students (28.99%), and 51 third-year students (36.96%). Using Roasoft Calculator with a 5% margin of error, the computed sample size was 103 respondents. The sample size had been proportionally allocated across the year levels, resulting in 35 first-year students, 30 second-year students, and 38 third-year students. This proportional distribution ensured that each year level was adequately represented in the study, maintaining the integrity and reliability of the data collected.

Sampling Design

The research used stratified random sampling to get balanced representation of student subgroups which enabled detailed examination of metacognitive awareness and numerical proficiency. The research selected this sampling method to ensure that participants represented the full spectrum of their metacognitive awareness and numerical proficiency. The research investigated the relationship between metacognitive awareness and numerical proficiency in these learners.

Instrumentation

The success of that study relied heavily on the use of appropriate abilities and methodologies. The instruments used in this study were researcher-made tests, which underwent a thorough validation process. The content of the instruments was first reviewed by the research adviser to ensure alignment with the study's objectives before proceeding to the validation phase. The test consisted of two sets: Set A, which measured the level of metacognitive awareness, and Set B, which assessed the level of numerical proficiency.

Set A utilized a 4-point Likert scale to measure the respondents' metacognitive awareness. The scale allowed respondents to indicate the degree to which they agreed or disagreed with each statement. The table below displayed the 4-point Likert scale that was used:

Table 2. Point Likert scale to measure the respondents' Metacognitive Awareness.

Scale	Range	Description	Interpretation
4	3.26 – 4.00	Strongly Agree	Very High Awareness
3	2.51 – 3.25	Agree	High Awareness
2	1.76 – 2.50	Disagree	Low Awareness
1	1.00 – 1.75	Strongly Disagree	Very Low Awareness

Set B, on the other hand, used a researcher-made test to measure the respondents' numerical proficiency. This test included items designed to evaluate numerical literacy, skills, and aptitude, ensuring that the assessment was objective and reliable.

Table 3. Interpretation of the rating scale score for Numerical Proficiency.

No.	Percentage (%)	Interpretation
1	0 – 29	Very Low
2	30 – 59	Low
3	60 – 89	High
4	90 – 100	Very High

(Adapted from Soeprapto et al., 2020, Interpretation of the rating scale score)

The research instruments underwent rigorous validation by three experts: a mathematics education expert, a statistician, and a language expert, ensuring content relevance, accuracy, and comprehensibility, and incorporating feedback for enhanced validity.

Table 4. Reliability Result.

Summary Variables	Cronbach's Alpha Result	Degree of Reliability
Declarative Knowledge	0.940	Excellent
Procedural Knowledge	0.927	Excellent
Conditional Knowledge	0.940	Excellent
Planning	0.947	Excellent
Monitoring	0.911	Excellent
Evaluating	0.954	Excellent

Legend for Cronbach Alpha value (Konting et al., 2009): 0.01 to 0.50 Unacceptable; 0.51 to 0.60 Poor; 0.61 to 0.70 Questionable; 0.71 to 0.80 Acceptable; 0.81 to 0.90 Good; and 0.91 to 1.00 Excellent.

Data Gathering Procedure

The researcher created two research instruments named Set A and Set B during the preparation phase. The researcher used Set A to measure metacognitive awareness through a 4-point Likert scale while Set B consisted of researcher-developed tests to evaluate numerical proficiency. The research adviser reviewed the instruments to verify their alignment with study goals and their suitability for the target population. Three experts consisting of a mathematics education specialist and a statistician and a language specialist provided complete validation of the instruments. The researcher applied feedback and suggestions to enhance validity and ensure the instruments were suitable for data collection. The researcher conducted the study at the University of Cabuyao among BSED students who majored in Mathematics by selecting participants proportionally according to sample size while providing detailed instructions and enough time for completion. The researcher obtained and documented responses from participants after they finished the instruments while maintaining their confidentiality and anonymity throughout the entire process.

Treatment of Data

Researchers created a test to measure students' metacognitive awareness and numerical skills, divided into two sets: Set A for metacognitive awareness and Set B for numerical proficiency. The respondents' metacognitive awareness levels were assessed using Weighted Mean and Standard Deviation, focusing on Mathematical Metacognitive Knowledge and Mathematical Metacognitive Regulation. The study utilized spearman rho test to assess numerical proficiency levels among respondents, examining the relationship between metacognitive awareness and numerical proficiency.

3. Results and Discussion

Table 5. Result in the level of metacognitive awareness in knowledge of the respondents in terms of Declarative Knowledge.

Declarative Knowledge	Mean	Stdev.	Interpretation
1. I am aware of what I need to learn before I start studying	3.30	0.733	Very High Awareness
2. I know the important concepts in a topic before diving deeper into details.	3.20	0.626	High Awareness
3. I can recognize when I have enough background knowledge to understand a new concept.	3.24	0.673	High Awareness

4. I understand the strengths and weaknesses of my own knowledge.	3.29	0.730	Very High Awareness
5. I possess knowledge of the most effective learning strategies for various subjects.	3.07	0.640	High Awareness
6. I am aware of how new knowledge connects with what I already know.	3.27	0.683	Very High Awareness
7. I understand the key principles underlying different topics I study	3.08	0.689	High Awareness
8. I have the ability to predict my success in learning new concepts based on my existing knowledge.	3.09	0.786	High Awareness
9. I recognize when I do not fully understand a concept	3.28	0.766	Very High Awareness
10. I understand how to evaluate whether I have correctly learned something.	3.25	0.690	High Awareness
Average Mean	**3.204**	**0.566**	**High Awareness**

Legend: 1.00 – 1.75 Very Low Awareness; 1.76 – 2.50 Low Awareness; 2.51 – 3.25 High Awareness; and 3.26 – 4.00 Very High Awareness

Table 6. Result in the level of metacognitive awareness in knowledge of the respondents in terms of Procedural Knowledge.

Procedural Knowledge	Mean	Stdev.	Interpretation
1. I know how to break complex problems into smaller steps.	3.02	0.693	High Awareness
2. I can effectively use different learning strategies for different tasks.	3.11	0.625	High Awareness
3. I am aware of how to organize my study materials efficiently.	3.15	0.690	High Awareness
4. I can accurately follow a set of steps to solve a problem	3.10	0.701	High Awareness
5. I know how to adjust my learning strategies if one method does not work.	3.17	0.627	High Awareness
6. I can apply what I have learned to solve real-world problems.	3.13	0.636	High Awareness
7. I understand how to use self-testing as a learning technique	3.14	0.627	High Awareness
8. I can successfully follow different problem-solving approaches.	3.06	0.648	High Awareness
9. I know when to slow down or speed up while studying based on task difficulty	3.14	0.685	High Awareness
10. I understand the steps required to complete different types of assignments	3.14	0.671	High Awareness
Average Mean	**3.117**	**0.513**	**High Awareness**

Legend: 1.00 – 1.75 Very Low Awareness; 1.76 – 2.50 Low Awareness; 2.51 – 3.25 High Awareness; and 3.26 – 4.00 Very High Awareness

Table 7. Result in the level of metacognitive awareness in knowledge of the respondents in terms of Conditional Knowledge.

Conditional Knowledge	Mean	Stdev.	Interpretation
1. I know when to apply different study strategies for different learning tasks.	3.10	0.587	High Awareness
2. I can determine which learning strategies are effective for specific situations.	3.10	0.643	High Awareness
3. I am aware of when to use memorization versus understanding for learning	3.27	0.724	Very High Awareness
4. I can recognize when a specific learning technique is not working and change it.	3.16	0.637	High Awareness
5. I know when to ask for help to improve my learning.	3.35	0.693	Very High Awareness
6. I understand when to use different problem-solving methods depending on the situation.	3.10	0.687	High Awareness
7. I can decide which learning resources (e.g., textbooks, videos, or discussions) will help me most.	3.32	0.672	Very High Awareness
8. I know how to choose between reviewing previous material and moving on to new topics.	3.28	0.672	Very High Awareness
9. I am aware of when I need to reflect on what I have learned.	3.23	0.711	High Awareness
10. I know how to evaluate the effectiveness of my learning methods.	3.11	0.655	High Awareness
Average Mean	**3.202**	**0.539**	**High Awareness**

Legend: 1.00 – 1.75 Very Low Awareness; 1.76 – 2.50 Low Awareness; 2.51 – 3.25 High Awareness; and 3.26 – 4.00 Very High Awareness

The results indicate that respondents exhibited high levels of metacognitive awareness across all three domains of knowledge. Specifically, the mean score for declarative knowledge was 3.204 with a standard deviation of 0.566, for procedural knowledge the mean was 3.117 with a standard deviation of 0.513, and for conditional knowledge the mean was 3.202 with a standard deviation of 0.539. These consistently high mean scores suggest that the respondents possess a strong ability to understand and articulate facts, implement specific methods, and discern when and why to apply particular strategies in mathematical contexts. Such high awareness across these domains implies that the respondents are well-equipped to identify, utilize, and adapt their cognitive resources, which is essential for effective problem-solving, reflective practice, and academic success in mathematics.

The fundamental aspect of metacognitive awareness known as declarative knowledge allows students to identify and use their existing knowledge across different situations. According to Tak and Zulnaidi (2022) declarative knowledge includes facts and ideas and self-knowledge which serve as essential foundations for learning and problem-solving. Ferrer and Caballes (2025) demonstrated that systematic strategies including reflective thinking and problem decomposition help students improve their declarative and procedural knowledge. The strategies help students develop organized methods to use their understanding which proves essential in mathematics because this subject requires defined frameworks for metacognitive development (Melanie, 2021).

The development of mathematical proficiency requires equal importance of procedural and conditional knowledge. Ferrer and Caballes (2025) explained that students need systematic strategies and reflective thinking to develop procedural knowledge which helps them solve tasks methodically and improve their processes. Pathuddin and Bakri (2023) discovered that students who perform well in mathematics use procedural knowledge together with planning and monitoring skills to succeed in problem-solving tasks particularly during the implementation and evaluation stages. Regarding conditional knowledge, Ferrer and Caballes (2025) stressed its significance in helping students assess problem contexts and select effective strategies, while Beverly (2020) linked conditional knowledge to the successful transfer of problem-solving skills across different situations, underscoring the importance of adaptability and flexibility in mathematics.

Table 8. Result in the level of metacognitive awareness in regulation of the respondents in terms of Planning.

Planning	Mean	Stdev.	Interpretation
1. I set specific goals before I begin studying.	3.15	0.690	High Awareness
2. I plan how to approach each learning task.	3.11	0.711	High Awareness
3. I set aside time to review what I have learned.	3.18	0.718	High Awareness
4. I think about the best way to study before I begin.	3.23	0.737	High Awareness
5. I organize my learning materials before starting a task.	3.26	0.707	High Awareness
6. I create a study schedule and follow it.	2.94	0.770	High Awareness
7. I set priorities when I have multiple tasks to complete.	3.28	0.766	Very High Awareness
8. I make sure I understand the requirements of a task before starting.	3.20	0.726	High Awareness
9. I plan ahead to ensure I have enough time to complete my work.	3.04	0.706	High Awareness
10. I break large assignments into smaller, manageable parts.	3.14	0.671	High Awareness
Average Mean	**3.153**	**0.593**	**High Awareness**

Legend: 1.00 – 1.75 Very Low Awareness; 1.76 – 2.50 Low Awareness; 2.51 – 3.25 High Awareness; and 3.26 – 4.00 Very High Awareness

Table 9. Result in the level of metacognitive awareness in regulation of the respondents in terms of Monitoring.

Monitoring	Mean	Stdev.	Interpretation
1. I regularly check my understanding while studying.	3.15	0.718	High Awareness
2. I notice when I am having difficulty understanding a concept.	3.33	0.645	Very High Awareness
3. I stop to review when I realize I do not understand something.	3.05	0.881	High Awareness
4. I ask myself questions to ensure I understand what I am studying.	3.24	0.658	High Awareness
5. I keep track of how well I am meeting my study goals.	3.12	0.661	High Awareness
6. I recognize when a learning strategy is not working for me.	3.25	0.632	High Awareness
7. I adjust my study techniques when I notice they are not effective.	3.23	0.654	High Awareness
8. I can tell when I need to take a break to improve my focus.	3.30	0.664	Very High Awareness
9. I compare my progress with my learning goals.	3.25	0.676	High Awareness

10. I stay aware of how much effort I am putting into my studies.	3.24	0.628	High Awareness
Average Mean	**3.215**	**0.510**	**High Awareness**

Legend: 1.00 – 1.75 Very Low Awareness; 1.76 – 2.50 Low Awareness; 2.51 – 3.25 High Awareness; and 3.26 – 4.00 Very High Awareness

Table 10. Result in the level of metacognitive awareness in regulation of the respondents in terms of Evaluating.

Evaluating	**Mean**	**Stdev.**	**Interpretation**
1. I reflect on what I have learned after completing a task.	3.19	0.666	High Awareness
2. I assess whether I have met my learning goals.	3.15	0.617	High Awareness
3. I think about what worked well and what did not after studying.	3.22	0.650	High Awareness
4. I evaluate how effective my learning strategies were.	3.19	0.652	High Awareness
5. I analyze my mistakes to improve in the future.	3.26	0.680	High Awareness
6. I determine if I need to change my approach to learning.	3.22	0.635	High Awareness
7. I consider whether I used my study time effectively.	3.17	0.657	High Awareness
8. I review my performance to find areas for improvement.	3.20	0.595	High Awareness
9. I use feedback to improve my future learning.	3.28	0.612	Very High Awareness
10. I think about how I can improve my learning process next time.	3.28	0.628	Very High Awareness
Average Mean	**3.215**	**0.538**	**High Awareness**

Legend: 1.00 – 1.75 Very Low Awareness; 1.76 – 2.50 Low Awareness; 2.51 – 3.25 High Awareness; and 3.26 – 4.00 Very High Awareness

The findings reveal that respondents demonstrated high levels of metacognitive awareness in the regulation domains of planning, monitoring, and evaluating. The mean score for planning was 3.153 with a standard deviation of 0.593, for monitoring the mean was 3.215 with a standard deviation of 0.510, and for evaluating the mean was 3.215 with a standard deviation of 0.538. The survey results demonstrate that participants demonstrate strong understanding of their goal-setting abilities and strategy selection and resource organization and progress evaluation and outcome assessment skills. The high level of awareness in these regulatory processes indicates that the respondents are proactive and reflective learners who can prepare for tasks, adapt their approaches, and make informed decisions to optimize their performance in mathematics. This level of metacognitive regulation is essential for enhancing problem-solving efficiency, accuracy, and overall academic success.

Metacognitive regulation requires planning to be its fundamental component according to research literature. Ruth (2020) found that students who employ formative assessment to establish learning intentions and success criteria will enhance their planning skills and academic achievements. Sultan and Arzu (2024) emphasize that planning serves as an essential element of mathematical modeling since it allows students to link concepts and representations between different subjects which improves their comprehension and problem-solving abilities. Research demonstrates that teaching planning skills allows students to manage their learning activities which produces enhanced academic outcomes.

Metacognitive regulation demands the same level of importance for monitoring and evaluation processes. Ferrer and Caballes (2025) explained that reflective thinking and systematic strategies help students develop monitoring skills which enable them to assess their progress and improve their mathematical methods for better success. Pathuddin and Bakri (2023) found that students who achieved high performance levels used monitoring to direct their thinking processes which led to enhanced proficiency. Ruth (2020) emphasized that formative assessment tools which include peer evaluation and feedback allow students to develop their evaluative competencies. Sultan and Arzu (2024) emphasized that evaluation stands as the fundamental element of mathematical modeling because it allows students to evaluate their methods and enhance their results. The research findings indicate that students need to acquire monitoring and evaluation skills through metacognitive regulation to achieve academic success and solve problems effectively.

Table 11. Result in the level of numerical proficiency of the respondents.

Level of Numerical Proficiency	Mean	Standard Deviation	At 95% Confidence Interval	Interpretation
Numerical Literacy	86.33	14.729	83.52 to 89.15	High
Numerical Skills	87.86	17.946	84.42 to 91.29	High
Numerical Aptitude	95.48	10.731	93.42 to 97.53	Very High
Total	**89.89**	**12.441**	**87.51 to 92.27**	**High**

Legend: 0 – 29 Very Low; 30 – 59 Low; 60 – 89 High; and 90 – 100 Very High

The survey results showed that participants achieved high numerical skills because their total mean percentage score reached 89.89 with a standard deviation of 12.441. The 95% confidence interval for the mean percentage score ranges from 87.51 to 92.27, suggesting that the true mean for the population is likely to fall within this range. The high mean score indicates that the respondents have solid foundational knowledge and advanced problem-solving skills which enable them to solve mathematical tasks accurately and with confidence. The reliability of the confidence interval confirms the consistency of their numerical proficiency which demonstrates their ability to effectively understand and apply mathematical concepts.

Numerous studies confirm that people with high numerical proficiency demonstrate strong logical reasoning abilities and advanced problem-solving capabilities and effective mathematical concept application in academic and real-world situations. The combination of reflective thinking with systematic problem decomposition strategies according to Ferrer and Caballes (2025) enables students to enhance their mathematical abilities. Pathuddin and Bakri (2023) demonstrated that students require metacognitive planning and monitoring and evaluation strategies to reach high numerical literacy levels. Ruth (2020) demonstrated that students can discover their strengths and weaknesses through self-assessment and peer review formative assessment methods. The research conducted by Sultan and Arzu (2024) demonstrates that mathematical modeling serves as an effective method to enhance numerical skills. Rais and Samsul (2023) together with Niepes (2020) demonstrated that students develop their numerical reasoning abilities and aptitude through focused teaching methods combined with interactive activities.

The research conducted by Ferrer and Caballes (2025) demonstrates that numerical proficiency directly results from systematic approaches which allow students to solve math problems accurately and with confidence. The research demonstrates that developing numerical proficiency stands essential for both mathematical success and future real-world problem-solving capabilities. Tak et al. (2022) discovered that students who develop metacognitive planning and monitoring abilities achieve better numerical proficiency because these skills allow them to direct their learning activities and improve their math results. Students need specific teaching methods along with supportive educational environments to develop their numerical competencies.

Table 12. Result in the test of significant relationship between metacognitive awareness in knowledge and the numerical proficiency of the respondents.

Numerical Proficiency	Metacognitive Awareness in Knowledge	Spearman Rho Correlation		p-value	Interpretation	Decision
Numerical Literacy	Declarative Knowledge	0.147	No or Negligible Correlation	0.134	Without Significant Relationship	Accept H0
	Procedural Knowledge	0.135	No or Negligible Correlation	0.170	Without Significant Relationship	Accept H0
	Conditional Knowledge	0.135	No or Negligible Correlation	0.171	Without Significant Relationship	Accept H0
Numerical Skills	Declarative Knowledge	0.097	No or Negligible Correlation	0.323	Without Significant Relationship	Accept H0
	Procedural Knowledge	0.049	No or Negligible Correlation	0.618	Without Significant Relationship	Accept H0
	Conditional Knowledge	0.079	No or Negligible Correlation	0.422	Without Significant Relationship	Accept H0
Numerical Aptitude	Declarative Knowledge	0.033	No or Negligible Correlation	0.323	Without Significant Relationship	Accept H0
	Procedural Knowledge	-0.018	No or Negligible Correlation	0.618	Without Significant Relationship	Accept H0
	Conditional Knowledge	-0.036	No or Negligible Correlation	0.422	Without Significant Relationship	Accept H0

Decision rule: *If p val < α, Reject Ho; and If p val > α, Accept Ho*

Legend: *0.00 – 0.19 No or Negligible Correlation; 0.20 – 0.29 Weak Correlation; 0.30 - 0.39 Moderate Correlation; 0.40 - 0.69 Strong Correlation; and 0.70 - 1.00 Very Strong Correlation*

Source: (Bawazir et al., 2023) adapted Dancey & Reidy Interpretation

The results indicate that there is no significant relationship between metacognitive awareness in knowledge and the respondents' numerical literacy, numerical skills, or numerical aptitude. This suggests that the ability of Bachelor of Secondary Education major in Mathematics students to understand and reflect on their cognitive processes does not directly influence their capacity to interpret, apply, or perform mathematical operations and solve numerical problems. While metacognitive awareness is essential for self-regulation and learning, these findings imply that other factors—such as instructional methods, prior knowledge, practice opportunities, and external support systems—may play a more critical role in shaping students' numerical proficiency. The acceptance of all null hypotheses highlights the complexity of the relationship between cognitive awareness and numerical performance, indicating that numerical proficiency may develop independently of metacognitive knowledge and requires a broader perspective to understand its determinants.

Numerous studies demonstrate that numerical proficiency depends on multiple elements which extend beyond metacognitive awareness. The research by Ridwan et al. (2023) demonstrates that numerical literacy develops through real-life examples and interactive teaching methods which enable students to relate mathematical concepts to practical situations. Lopez-Pedersen et al. (2022) stressed that early and continuous interventions remain essential because long-term support leads to enduring numerical literacy improvements. The research indicates that metacognitive awareness matters but it does not determine numerical proficiency alone so multiple strategies must be used to help students develop these skills.

The research conducted by Shallinie and Richard (2023) demonstrates that numerical skills form the basis of mathematics achievement while needing sustained support from teachers and parents. The research conducted by Legaspino et al. (2024) demonstrated that 21st-century core skills including numerical skills directly affect student learning results thus requiring extensive programs to improve these abilities for academic and career success. Subekti et al. (2022) stressed that pre-service teachers need to develop strong mathematical understanding and reasoning abilities to build their numerical skills. The research findings demonstrate that educators must implement a comprehensive approach which handles intellectual and environmental elements to develop numerical skills and achieve student mathematics success.

Table 13. Result in the test of significant relationship between metacognitive awareness in regulation and the numerical proficiency of the respondents.

Numerical Proficiency	Metacognitive Awareness in Regulation	Spearman Rho Correlation		p-value	Interpretation	Decision
Numerical Literacy	Planning	0.057	No or Negligible Correlation	0.562	Without Significant Relationship	Accept H0
	Monitoring	0.157	No or Negligible Correlation	0.109	Without Significant Relationship	Accept H0
	Evaluating	0.191	No or Negligible Correlation	0.051	Without Significant Relationship	Accept H0
Numerical Skills	Planning	0.018	No or Negligible Correlation	0.859	Without Significant Relationship	Accept H0
	Monitoring	0.041	No or Negligible Correlation	0.678	Without Significant Relationship	Accept H0
	Evaluating	0.106	No or Negligible Correlation	0.280	Without Significant Relationship	Accept H0
Numerical Aptitude	Planning	-0.030	No or Negligible Correlation	0.760	Without Significant Relationship	Accept H0
	Monitoring	0.039	No or Negligible Correlation	0.696	Without Significant Relationship	Accept H0
	Evaluating	-0.015	No or Negligible Correlation	0.878	Without Significant Relationship	Accept H0

Decision rule: *If p val < α, Reject Ho; and If p val > α, Accept Ho*

Legend: *0.00 – 0.19 No or Negligible Correlation; 0.20 – 0.29 Weak Correlation; 0.30 - 0.39 Moderate Correlation; 0.40 - 0.69 Strong Correlation; and 0.70 - 1.00 Very Strong Correlation*

Source: (Bawazir et al., 2023) adapted Dancey & Reidy Interpretation

The findings reveal that there is no significant relationship between metacognitive awareness in regulation and the respondents' numerical literacy, numerical skills, or numerical aptitude. This suggests that the ability of Bachelor of Secondary Education major in Mathematics students to plan, monitor, and evaluate their learning processes does not directly influence their capacity to interpret, apply, or perform mathematical operations and solve numerical problems. While metacognitive regulation is critical for self-directed learning and problem-solving, these results indicate that numerical proficiency may be shaped more by external factors such as teaching strategies, access to resources, prior knowledge, instructional quality, and innate abilities. The acceptance of all null hypotheses highlights the complexity of the relationship between metacognitive regulation and numerical proficiency, suggesting that these constructs may operate independently in certain contexts and that a broader set of variables must be considered to fully understand their development.

Numerical proficiency receives support from research which shows that multiple factors beyond metacognitive regulation play a role in its development. Lopez-Pedersen et al. (2022) stated that early numeracy abilities remain flexible yet students need extended and continuous intervention programs to show progress especially when they face difficulties with basic skills. The research by Ridwan et al. (2023) shows that interactive and cooperative learning strategies help students develop numerical literacy and aptitude through real-world application connections. The research by Bermudez (2024) revealed that pre-service teachers with strong metacognitive awareness showed excellent numerical literacy skills which indicates that teaching metacognitive regulation alongside effective methods can enhance numerical proficiency.

The development of numerical skills and aptitude requires a comprehensive method which multiple studies have demonstrated. Shallinie and Richard (2023) explained that numerical skills form the basis of mathematics performance thus students need ongoing teacher and parental support through specific interventions to achieve academic and professional success. Ferrer and Caballes (2025) demonstrated that systematic strategies which include reflective thinking and problem decomposition lead to better numerical skills and mathematics success. The research evidence indicates that educational programs should create complete intervention strategies which handle both mental and environmental elements to help students develop metacognitive regulation and numerical proficiency.

4. Conclusion

a. The respondents demonstrated robust metacognitive awareness across declarative procedural and conditional knowledge domains which shows their capability to understand and effectively apply knowledge in various situations. The results show that the respondents have the capacity to recognize their cognitive resources and solve mathematical problems systematically while adjusting their strategies based on specific situations. The varying levels of awareness between these domains show that teachers need to use particular teaching approaches and intervention methods to address individual differences and support equal metacognitive skill development.

b. The respondents showed robust metacognitive abilities because they set goals and monitored their progress and evaluated their performance. These skills are crucial for maximizing learning and problem-solving in mathematics. The high level of awareness among participants demonstrates the need for scaffolding and targeted support to help all learners develop these essential self-regulation skills.

c. The respondents demonstrated outstanding numerical literacy abilities together with strong numerical competencies and quantitative reasoning capabilities. Their solid mathematical understanding along with their computational skills and quantitative reasoning abilities make them ready to tackle advanced mathematical challenges in academic and professional environments. The performance differences show that students require continuous support and targeted interventions to address inequalities so they can achieve their highest numerical proficiency potential.

d. The research showed no meaningful connection between metacognitive awareness of knowledge and numerical proficiency. The study indicates that the capacity to recognize and analyze mental operations does not directly affect numerical literacy or numerical skills or aptitude. The development of numerical proficiency seems to be more influenced by instructional methods and prior knowledge and external support systems than by metacognitive awareness. The study results demonstrate the necessity for future research to identify additional factors that influence numerical proficiency and their relationships with metacognitive awareness.
e. The research findings show no substantial connection between metacognitive awareness in regulation and numerical proficiency which means that learning process planning and evaluation and monitoring do not directly affect numerical literacy or skills or aptitude. The results indicate that numerical proficiency develops primarily from external factors which include teaching methods and resource availability and past learning experiences. The study results demonstrate the need to investigate these factors for developing comprehensive interventions that enhance both metacognitive regulation and numerical proficiency.

Recommendations

The recommendations drawn from this study were based on the significance of the study along with the results of this study.

a. Teachers can integrate self-reflective activities to help students identify concepts and to let students connect these concepts into real world mathematical concepts. They could also apply chunking math problems to track their strategy skills.
b. Teachers can implement strategy which is executing a weekly step by step mathematics solving lessons or workshops that focuses on breaking complex problems into smaller chunks and lastly, creating flowchart or diagrams for easy visualization of procedures and logic. That way, students can have their idea on how to draft their plan or roadmap before solving chunky mathematical problems. Students can use peer review to assess their knowledge in the step by step process and also to compare their methods and learn from each other. Teachers can integrate activities that tackle procedures in solving mathematical problems to enhance their procedural knowledge skills.
c. Teachers can implement practice or drills that focus on identifying specific strategies and when is the optimal time to use them. They could also create a board or compilation of common mathematical topics, mapped to the strategies for better understanding of identifying the best strategy. They can also integrate reflective scenarios, such as “what if’s” into their lessons that way it could be engaging to the students since real world problems are being applied.
d. Incorporate checklists into mathematical problem solving to ensure that students are following a plan. Teachers can set goals to give their lesson an end goal per topic. Give ample time allocation for each mathematical problem for them to solve those problems effectively. Students can also collaborate with their peers in order to foster their proactive learning habits.
e. Teachers can facilitate feedback sessions that include the peers to enhance mathematical development, students can monitor their work and progress better when it is being reviewed by their peers. Students can use self-assessments in order to improve their ability to assess their skills and achievements when it comes to problem solving tasks. They can use their individualized, self-made checklists in order to assess themselves in how efficiently they solved a mathematical problem.
f. Teachers can facilitate reflection sessions at the end of the class or lesson to ensure lesson retention as well as to evaluate their own learnings. Teachers can also use

rubrics to evaluate mathematical solutions for every mathematical problem. Teachers can also conduct workshops to help their students to identify their strengths and weaknesses when it comes to solving mathematical problems. It can benefit their students to improve their skills.

g. Future research should investigate how additional cognitive and affective elements including motivation and self-efficacy and anxiety affect numerical proficiency beyond metacognitive awareness to achieve a complete understanding of mathematical performance drivers. Research following students over time would reveal how metacognitive abilities and numerical competencies evolve together with teaching approaches. The combination of quantitative data with qualitative student interview and classroom observation findings through mixed-methods approaches would reveal detailed aspects of student metacognitive strategy implementation in actual mathematical problem-solving. Research should evaluate the impact of particular instructional methods such as self-reflective activities and peer review processes on metacognitive regulation and numerical skills development in different student groups across various educational settings.

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REFERENCES

Adaiah, P., & Eugene, M., 2023. *Students' metacognitive strategies in solving mathematics problems in distance learning: A phenomenological study.* https://ejournals.ph/article.php?id=19490

Adegoke, B., 2022. *The association between mathematical attitudes, academic procrastination, and mathematical achievement among primary school students: The moderating effect of mathematical metacognition.* https://www.researchgate.net/publication/353451496

Adzka, et al., 2024. *The relationship between literacy and numeracy skills of prospective primary education teachers.* https://www.researchgate.net/publication/383669785

Albina., 2020. *Metacognitive awareness of mathematics teachers in Sivaganga District.* https://www.researchgate.net/publication/342317603

American Psychological Association (APA)., 2017. *Ethical principles of psychologists and code of conduct.* https://www.apa.org/ethics/code/

Amini, D., & Anhari, M. H., 2020. *Modeling the relationship between metacognitive strategy awareness, self-regulation, and reading proficiency of Iranian EFL learners. Problems of Education in the 21st Century, 78(3), 314–327.* https://www.tandfonline.com/doi/full/10.1080/2331186X.2020.1787018

Aydin, U., & Ubuz, B., 2023. *Metacognition in mathematics education: From academic chronicle to future research scenario. European Journal of Mathematics, Science and Technology Education, 19(1), 1–15.* https://doi.org/10.47750/pegegog.14.04.45

Baguin, R. A., & Janiola, F. R., 2024. *Students' level of metacognitive awareness as correlates of their mathematics achievement.* https://www.researchgate.net/publication/377570529

Bakar, M. A. A., & Ismail, N. H., 2020. *Exploring students' metacognitive regulation skills and mathematics achievement in implementation of 21st-century learning in Malaysia. Problems of Education in the 21st Century, 78(3), 314–327.* https://eric.ed.gov/?id=EJ1265851&need_sec_link=1&sec_link_scene=im

Belmont Report (U.S. Department of Health and Human Services, 1979). https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/index.html

Bermudez, F. V. A., 2024. *Metacognitive awareness as a predictor of mathematical modeling competency among preservice elementary teachers. International Journal of Educational Management and Development Studies, 5(3), 279–292.* https://www.ijem.com/metacognitive-awareness-as-a-predictor-of-mathematical-modeling-competency-among-preservice-elementary-teachers

Beverly, R., 2020. *Metacognitive knowledge predicts success in problem-solving transfer.* https://ejournals.ph/article.php?id=12386

Caparas, Ericson & Ferrer, Norberto Jr., 2025. *PERSONAL AND ENVIRONMENTAL RELATED FACTORS AFFECTING FRESHMEN STUDENTS IN ONLINE DISTANCE LEARNING. EPRA International Journal of Multidisciplinary Research (IJMR). 11. 529-540. 10.36713/epra20668.*

Chytrý, V., Říčan, J., Eisenmann, P., & Medová, J., 2020. *Metacognitive knowledge and mathematical intelligence—two significant factors influencing school performance. Mathematics, 8(6), 969.* https://www.mdpi.com/22277390/8/6/969?need_sec_link=1&sec_link_scene=im

Commission on Higher Education (CHED)., 2017. *CHED Memorandum Order No. 75, series of 2017: Policies, standards, and guidelines for Bachelor of Secondary Education.* https://ched.gov.ph

Cosar, & Kesan. et al., 2021. *Self-regulation behaviours of a gifted student in the mathematical* abstraction process. https://eric.ed.gov

Cruz, J., & Alves, D., 2024. *Measuring mathematical skills in early childhood: A systematic review of the psychometric properties of early maths assessments and screeners.* https://osf.io/hk37b/download/?format=pdf

Despina, D., et al., 2023. *The role of metacognitive instruction on children's conditional knowledge during mathematics problem solving.* https://www.researchgate.net/publication/376721516

Divinagracia, R., 2022. *An assessment of the numerical and analytical skills of Grade 11* students. https://ejournals.ph/article.php?id=20681

Dorji, N., & Bdr, P., 2023. *Unveiling the link between metacognitive skills and mathematics performance: A correlational study in Grade X.* https://www.researchgate.net/publication/371970641

Dwiani, K., & Nuraini, M., 2023. *Profile of student metacognition in solving elementary linear algebra problems viewed from tempo conceptual cognitive style*. https://www.researchgate.net/publication/379171500

Edi, S., & Yakin, T., 2024. *Students' metacognitive awareness in mathematics learning.* https://www.researchgate.net/publication/381243676

Eetu, H., 2022. *The role of metacognitive monitoring in regulation at multiple levels of collaborative learning.* https://www.researchgate.net/publication/365275070

Efklides, A., 2023. *Metacognitive awareness of pre-service teachers.* https://www.researchgate.net/publication/324209692

Fe Janiola, et al., 2023. *Students' level of metacognitive awareness as correlates of their mathematics achievement.* https://www.ejournals.ph/article.php?id=23417

Ferrer, Norberto Jr & Caballes, Dennis., 2025. *NON-ROUTINE PROBLEM-SOLVING SKILLS IN TRIGONOMETRIC IDENTITIES AMONG THIRD YEAR BACHELOR OF SECONDARY EDUCATION MAJOR IN MATHEMATICS STUDENTS: BASIS FOR A FRAMEWORK ON ALTERNATIVE THINKING. 37. 103-111*

General Data Protection Regulation (GDPR) European Union., 2018. https://gdpr-info.eu/

Georgia, S., & Foteini, T., 2024. *Effects of metacognition on performance in mathematics and language: Multiple mediation of hope and general self-efficacy.* https://www.researchgate.net/publication/336257354

Ghosh, S., & Jega, P. S., 2021. *Does metacognitive awareness improve self-regulated learning and ensure academic achievement in the COVID-19 crisis? Canadian Medical Education Journal, 12(5), 73–74.* https://pmc.ncbi.nlm.nih.gov/articles/PMC8603887

Global Metacognition., 2023. *Metacognition & self-regulated learning for mathematics education.* https://www.globalmetacognition.com/post/metacognition-self-regulated-learning-for-mathematics-education

Habók, A., Magyar, A., & Molnár, G. V., 2022. *English as a foreign language learners' strategy awareness across proficiency levels from the perspective of self-regulated learning meta-factors. Frontiers in Psychology, 13, 1019561.* https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.1019561/full

Hurst, Hurst, C., et al., 2022. *Early numeracy assessment: The development of the preschool early numeracy scales.* https://www.researchgate.net/publication/272843085

Indeed Editorial Team., 2024. *Numeracy skills: Definition and examples.* https://www.indeed.com/career-advice/finding-a-job/numeracy-skills

Jay, A., 2024. *Impact of paraphrasing strategy on mathematical problem-solving skills and performance: Exploring their interrelationship.* https://www.ejournals.ph/article.php?id=24257

Jikamshi, A., & Dahiru, A., 2020. *Metacognitive awareness and knowledge acquisition approaches among colleges of education students in Nigeria. Journal of Educational Psychology, 14(1), 12–25.* https://www.semanticscholar.org/paper/Metacognitive-Awareness-and-Knowledge-AcquisitionJikamshiDahiru

Joachim, W., & Corinna, S., et al., 2025. *Far transfer of metacognitive regulation: From cognitive learning strategy use to mental effort regulation.* https://www.researchgate.net/publication/388143693

Jose, A., 2024. *Examining the correlation and predictive power of metacognitive domains on mathematics performance among senior high school students.* https://www.ejournals.ph/article.php?id=23949

Joseph, R., 2024. *Metacognitive learning in solving mathematical word problems.* https://www.researchgate.net/publication/382304675

Karlen, Y., et al., 2023. *Metacognition and mathematical modeling skills: The mediating role of self-regulation.* https://www.ejmste.com/download/metacognition-in-mathematics-education-from-academic-chronicle-to-future-research-scenario-a-14381.pdf

Kizilcec, R. F., & Efklides, A., 2023. *Metacognition in mathematics education: From academic chronicle to future research scenario. European Journal of Mathematics, Science and Technology Education, 19(1), 1–15.* https://doi.org/10.29333/ejmste/14381

Kms, F., & Agus, P., et al., 2024. *Building learning path of mathematical creative thinking of junior students on geometry topics by implementing metacognitive approach.* https://www.researchgate.net/publication/330742670

Legaspino, & Casocot., 2024. *Influence of 21st-century core skills on the learning outcomes of students in mathematics.* https://eprajournals.com/IJMR/article/12390

Kms, Lopez-Pedersen, et al., 2022. *Improving numeracy skills in first graders with low performance in early numeracy: A randomized controlled trial.* https://journals.sagepub.com/doi/10.1177/07419325221102537

Maria Luisa, P., 2021. *Use of metacognitive knowledge and regulation and level of academic completion in asynchronous modular learning.* https://www.ejournals.ph/article.php?id=23508

Mary, M., & Yvonne, C., 2025. *Investigating the correlation between influencing factors affecting students' interest in learning and academic performance in mathematics.* https://ejournals.ph/article.php?id=25359

Melanie, G., 2021. *Metacognitive strategy knowledge use through mathematical problem solving amongst pre-service teachers.* https://www.researchgate.net/publication/349548887

Melvin, & Jing, et al., 2021. *Learning of mathematics: A metacognitive experiences perspective.* https://www.researchgate.net/publication/371685108

Mevarech, & Fridkin., 2006 Eggen, & Kauchak., 2001. *Metacognitive skills and problem-solving.* https://files.eric.ed.gov/fulltext/EJ1308166.pdf

Michaela, P., & Alexandra, P., 2021. *Metacognitive awareness.* https://www.sciencedirect.com/topics/medicine-and-dentistry/metacognitive-awareness

Mishra, S., & Panwar, R., 2024. *Influence of metacognitive awareness on students' academic performance.* https://tianjindaxuexuebao.com/dashboard/uploads/30.11032210.pdf

Mohamad, B., & Norulhuda, I., 2020. *Express students' problem-solving skills from metacognitive skills perspective on effective mathematics learning.* https://core.ac.uk/download/pdf/489549235.pdf

Mohamad, B., & Norulhuda, I., 2020. *Exploring students' metacognitive regulation skills and mathematics achievement in implementation of 21st-century learning in Malaysia.* https://www.researchgate.net/publication/342359161

Mohamad, B., & Norulhuda, I., 2020. *Technology integrated with metacognitive regulation approach to enhance students' mastery and creating effective learning in mathematics.* https://www.researchgate.net/publication/340900967

Musarrat, H., & Sarfraz, A., et al., 2024. *Navigating math minds: Unveiling the impact of metacognitive strategies on 8th-grade problem-solvers' abilities.* https://www.researchgate.net/publication/387521759

Nahdi, et al., 2020. *Pre-service teacher's ability in solving mathematics problems viewed from numeracy literacy skills.* https://ilkogretimonline.org/index.php/pub/article/view/6902

National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. 1979. *The Belmont Report: Ethical principles and guidelines for the protection of human subjects of research.*

National Numeracy. (n.d.). *What is numeracy?* https://www.nationalnumeracy.org.uk/what-numeracy

Ni Made, M., & Ida Bagus, P., et al., 2023. *Performance assessment: Improving metacognitive ability in mathematics learning.* https://www.researchgate.net/publication/376842201

Niepes., 2020. *Numeracy and mathematics performance of Grade 7 students of Santiago National High School, City of General Trias, Cavite: Basis for intervention program – Project MEMO (Materializing, Experiencing, Mathematical Operations).* https://www.instabrightgazette.com/blog/numeracy-and-mathematics-performance-of-grade-7-students-of-santiago-national

Notarte, et al., 2024. *Beyond memorization: Building problem-solving skills in sequences for future math teachers.* https://journal.formosapublisher.org

Ohtani, K., & Hisasaka, T., 2021. *Metacognition and self-efficacy in action: How first-year students solve challenging problems.* https://www.lifescied.org/doi/10.1187/cbe.23-08-0158

Ozlem, O., & Mesut, O., 2024. *Metacognitive training for algebra teaching to high school students: An action research study.* https://www.researchgate.net/publication/385492491

Özsoy, G., 2011. *An investigation of the relationship between metacognition and mathematics achievement. Asia Pacific Education Review, 12(2), 227–235.* https://link.springer.com/article/10.1007/s12564-010-9129-6

Özsoy, G., 2020. *The relationship between metacognitive knowledge and mathematics achievement: A study of fifth-grade students. Asia Pacific Education Review, 12(2), 227–235.* https://www.researchgate.net/publication/226174478

Parcon, & Bearneza., 2024. *Mathematical skills and general mathematics performance of Grade 11 students in a public national high school in Southern Negros Occidental, Philippines.* https://www.philssj.org/index.php/main/article/view/995

Pathuddin, P., & Bakri, B., 2023. *Profile of students' metacognitive skills in solving math problems in terms of mathematical ability.* https://www.researchgate.net/publication/377514120

Pathuddin, P., & Bakri, M., 2023. *Metacognition knowledge of high school students in solving limit of functions problems viewed from mathematical ability.* https://www.researchgate.net/publication/377309957

Paul, P., & Roxanne, C., et al., 2023. *Assessment practices of senior high school mathematics teachers in relation to students' test performance.* https://ejournals.ph/article.php?id=22134

Rahmawati, et al., 2023. *Numerical literacy in mathematical problem solving: A brief literature review.* https://pubs.aip.org/aip/acp/article-abstract/2614/1/040103/2897254/Numerical-literacy-in-mathematical-problem-solving?redirectedFrom=fulltext

Ridwan, et al., 2023. *A meta-analysis of numerical aptitude's effect on learning outcomes and mathematical ability.* https://www.ceeol.com/search/article-detail?id=1103644

Rif'at, & Sugiatno., 2022. *Unfolding the practical of numerical literacy for specialists in teaching mathematics.* https://www.researchgate.net/publication/357791767

Rosalyn, S., 2021. *Metacognition in the classroom: Benefits & strategies.* https://www.highspeedtraining.co.uk/hub/metacognition-in-the-classroom/

Ruth, W., 2020. *Formative assessment as a predictor of mathematics teachers' levels of metacognitive regulation.* https://www.researchgate.net/publication/347926177

Salsabilah, & Kurniasih., 2022. *Analysis of numerical literacy ability by self-efficacy of junior high school students.* https://www.online-journal.unja.ac.id/edumatica/article/view/18429

Santos, & Bouillon., 2020. *Numerical and verbal reasoning aptitudes as predictors of STEM students' performance on limits and continuity.* https://www.researchgate.net/publication/344729856

Schnaubert, L., 2020. *Providing cognitive and metacognitive awareness information to support regulation in individual and collaborative learning settings. Semantic Scholar.* https://www.semanticscholar.org/paper/Providing-cognitive-and-metacognitive-awareness-toSchnaubert/

Schneider, M., & Stern, E., 2024. *Item descriptions, core competencies assessed and topic.* https://www.researchgate.net/figure/tem-descriptions-core-competencies-assessed-and-topic_tbl3_254248602

Shallinie, & Richard, et al., 2023. *Pupils' numeracy skills and mathematics performance.* https://www.academia.edu/109025177

Soeprapto, A., Nurjayadi, M., Suluya, R., & Ichsan, I., 2020. *EM-SETS: An integrated e-module of environmental education and technology in natural science learning. International Journal of Advanced Science and Technology, 29, 7014–7025.*

Song, J. H. H., Loyal, S., & Lond, B., 2021. *Metacognitive knowledge and self-regulated learning: Implications for mathematics achievement. Frontiers in Psychology, 11, 607577.* https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2020.607577

Subekti, et al., 2022. *Mathematics pre-service teachers' numerical thinking profiles.* https://www.eu-jer.com/mathematics-pre-service-teachers-numerical-thinking-profiles

Sudriman, S., & Yustinus, W., et al., 2025. *Students' metacognitive activities in contextual mathematical problem solving.* https://www.researchgate.net/publication/388598632

Sue, D. W., & Sue, D., 2012. *Counseling the culturally diverse: Theory and practice (6th ed.). Hoboken, NJ: John Wiley & Sons.*

Sultan, D., & Arzu, Y., 2024. *An investigation of students' mathematical connection and metacognitive skills in the mathematical modelling process.* https://www.researchgate.net/publication/384659575

Sumilah, S., & Sari, E., 2020. *Relationship of metacognitive awareness and self-efficacy to mathematics learning outcomes*. https://www.researchgate.net/publication/349148377

Susanna, T., & Lasse, E., et al., 2024. *Combined conceptualisations of metacognitive knowledge to understand students' mathematical problem-solving.* https://eric.ed.gov/?q=Mathematical+Metacognitive+Knowledge&id=EJ1454032

Tak, et al. 2021, 2022a, & 2022b. *Undergraduate students' attitudes and mathematical reasoning during the pandemic: The mediating role of metacognitive awareness.* https://www.researchgate.net/publication/373995990

Tak, & Zulnaidi, et al. 2021 & 2022. *Measurement model testing: Adaption of self-efficacy and metacognitive awareness among university students.* https://files.eric.ed.gov/fulltext/EJ1359504.pdf

Tian, Y., Fang, Y., & Li, J., 2023. *The effect of metacognitive knowledge on mathematics performance in self-regulated learning framework—multiple mediation of self-efficacy and motivation. Frontiers in Psychology, 9, 2518.* https://pmc.ncbi.nlm.nih.gov/articles/PMC6315178/?need_sec_link=1&sec_link_scene=im

Torang, S., & Almira, A., et al., 2024. *Level of metacognitive awareness of prospective mathematics teachers in solving absolute value problems.* https://www.researchgate.net/publication/382914196

Vidhya., 2024. *What is numerical aptitude? Definition, skills & examples.* https://www.iscalepro.com/post/what-numerical-aptitude/

Wahba, & Tabieh, et al., 2022. *Students' metacognitive awareness in mathematics learning.* https://www.researchgate.net/publication/381243676

World Medical Association Declaration of Helsinki., 2013. https://www.wma.net/policies-post/wma-declaration-of-helsinki/

Yiming, Z., & Xia, C., et al., 2022. *Mathematical metacognitive characteristics of Chinese middle school students in efficient mathematics learning.* https://www.researchgate.net/publication/360553459