



Cognitive Domain Predictors of Mathematics Achievement in Junior High School Learners: A Rapid Mathematics Assessment Study

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Abstract

Background and Aim: Mathematics achievement is a key focus in education, especially in relation to cognitive performance. The frameworks emphasize knowing, applying, and reasoning, but there is little empirical research on interpreting as a predictor. This study aimed to determine the cognitive domain predictors of mathematics achievement of learners in the junior high school through rapid mathematics assessment.

Materials and Methods: The study employed quantitative-correlational research using a total of 233 Grade 7-10 Junior High School learners of a public secondary school in Kapatagan, Lanao del Norte, Philippines. Stratified random sampling was used to obtain a sample that represented all grade levels. The Regional Unified Quarterly Assessment (RUQA) was used to measure mathematics achievement, and the Rapid Mathematics Assessment was used to measure cognitive-domain performance. Descriptive statistics were used to determine proficiency levels. The Shapiro–Wilk test showed that the distribution of the data was not normal, so Spearman's rho correlation was used to explore the statistical relationships between variables. Multiple linear regression analyses were also performed to determine significant cognitive predictors of mathematics achievement.

Results: The findings revealed that students' mathematics achievement was at an average mastery level ($M = 52.1$, $SD = 11.78$). Learners were approaching proficiency in knowing ($M = 55.10$, $SD = 20.40$), interpreting ($M = 56.40$, $SD = 23.40$), and reasoning ($M = 52.80$, $SD = 26.30$), while applying showed low proficiency ($M = 45.60$, $SD = 22.70$). Spearman's rho indicated statistically significant positive correlations between mathematics achievement and knowing ($\rho = .257$, $p < .001$); interpreting ($\rho = .347$, $p < .001$); applying ($\rho = .204$, $p = .002$); and reasoning ($\rho = .171$, $p = .009$). The results for multiple regression yielded a model that was statistically significant, $F(4, 227) = 8.16$, $p < .001$, with a variance accounted for of 13% for mathematics achievement ($R^2 = .130$). Of the cognitive domains, only 'interpreting' was a significant predictor of mathematics achievement ($B = 0.2198$, $p < .001$), whereas knowing, applying, and reasoning were not significant in the analyses that accounted for shared variance.

Conclusion: The findings indicate that mathematics achievement is influenced by interconnected cognitive processes, with interpreting emerging as the unique predictor of learners' mathematical performance. This suggests that learners' ability to construct meaning from mathematical representations and contextual information plays a central role in mathematical understanding and achievement. Strengthening interpretation-centered instruction through conceptual, contextual, and inquiry-based learning approaches may improve mathematical literacy, higher-order thinking skills, and overall mathematics proficiency among junior high school learners.

Keywords: Mathematics Achievement, Cognitive Domains, Interpretive Competence, Mathematical Literacy, Rapid Mathematics Assessment

Introduction

Mathematics performance remains a significant concern for education systems globally, with implications for students' academic achievement, employment preparation, and participation in a global knowledge-based economy. Large-scale international assessments, including Trends in International Mathematics and Science Study (TIMSS) and Programmes for International Student Assessment (PISA), consistently reveal that many learners struggle not only with procedural computation but also with understanding, interpreting, and applying mathematical concepts in unfamiliar contexts (Mullis &





Martin, 2021; OECD, 2023; von Davier et al., 2024). These ongoing difficulties have amplified worries about the effectiveness of current teaching methods, especially in regions with learning disparities.

In the Philippines, this is particularly evident in areas like Kapatagan, Lanao del Norte, where geographical and socio-economic differences are evident. Kapatagan is a rural municipality in Northern Mindanao, Philippines, where public secondary schools face challenges such as inadequate instructional resources, uneven learner readiness, and a lack of consistent, readily available mathematics intervention programs. Many students in such settings struggle to apply the procedures to conceptual understanding and mathematical meaning-making. Clearly, these challenges emerged after the COVID-19 pandemic, which led to nationwide school closures and exacerbated inequities in access to quality mathematics teaching and learning in rural areas. While this study takes place in a particular school context, the challenges faced by learners in Kapatagan have national and global implications for mathematics underachievement, educational inequality, and the need for a responsive diagnostic assessment system. Therefore, the investigation of cognitive predictors of mathematics achievement in this context not only has implications for local educational improvement but also for broader issues of equitable mathematics education in low-resource countries worldwide.

Recent studies clearly show that cognitive skills are the most consistent predictors of performance. Cognitive constructs have been found to explain a significant portion of the variance in mathematics achievement across contexts (Arastaman et al., 2024). Similarly, longitudinal studies show that domain-specific cognitive abilities, such as numerical processing and reasoning, significantly influence mathematical development (Mononen et al., 2024). Existing cognitive frameworks, particularly those associated with TIMSS, commonly emphasize three major domains: knowing, applying, and reasoning (Mullis & Martin, 2021). These domains have long served as the primary structure for evaluating mathematical cognition, as they align with educational assessment of measurable domains of procedural knowledge, analytical thought, and problem-solving abilities.

In mathematics education, Rapid Mathematics Assessment is a standardized assessment tool developed by the Department of Education that is directly linked to SDG 4 and provides immediate diagnostic information about learners' strengths and weaknesses, enabling teachers to provide targeted instructional interventions before learning gaps become cumulative and irreversible. Timely feedback and data-driven remediation improve equitable access to quality learning opportunities, instructional responsiveness, and learners' foundational competencies in mathematics. In particular, in under-resourced schools, learning difficulties may not be identified until later in the school year, and such mechanisms are especially crucial in contributing to achievement gaps. In this sense, rapid mathematics assessment is not only used to evaluate but also as a strategy to facilitate inclusive, responsive, and equitable quality education.

However, these frameworks have dominated the understanding of how mathematics is constructed in learners' minds, potentially limiting the scope of understanding of mathematics learning. In traditional cognitive models, interpretation has been implicitly included in application, reasoning, conceptual understanding, or mathematical literacy, and has not been considered a cognitive process in its own right. For example, TIMSS frameworks primarily operationalize mathematics cognition through observable problem-solving behaviors, while PISA situates interpretation within broader constructs of mathematical literacy and real-world application (OECD, 2023). As a result, interpretation is frequently seen as secondary to procedural execution or analytical thinking rather than as an autonomous cognitive process. This theoretical stance might account for the limited research on interpreting as a predictor in empirical models of mathematics achievement.

Emerging views in mathematics education indicate that there is a unique role for interpreting in mathematical cognition. Interpretation involves making sense of a mathematical representation (graph, symbol, table, equation, and/or math problem situation) rather than procedural application (perform mathematical operations) or reasoning (justify and infer). Interpretation helps learners to translate abstract mathematical information into meaningful relationships that facilitate higher-order thinking and application—so, interpreting functions is not only a subskill but also a mediating cognitive process between conceptual understanding, procedural knowledge, and problem-solving performance. This view is echoed by theories of mathematical cognition and representation, such as those by Gilmore





(2023) and Sun et al. (2023), which highlight the role of meaning-making and representational comprehension in mathematical success.

The exclusion of interpreting as an independent construct in previous models may have limited instructional effectiveness and curriculum design. Instructional approaches based on procedures and performance-based criteria tend to focus on the process of calculation and algorithmic skills while neglecting students' capacity to read and understand mathematical representations and contextual information. Consequently, students can gain procedural fluency without gaining deep conceptual understanding or transferable problem-solving skills. This imbalance may account for the success of many students in routine exercises and problems, and their failure to complete the non-routine, contextualized, and application-based mathematics tasks that are part of many international assessments. Despite numerous curriculum changes over the years, poor performance in mathematics suggests that current cognitive models are inadequate for explaining the interpretive processes that underpin meaningful mathematical learning. This recognition of interpreting as a limited predictor may have restricted both assessment practices and instructional interventions designed to enhance mathematics achievement.

Meanwhile, the 21st-century competencies such as critical thinking, data literacy, and contextual problem-solving are increasingly being prioritized in educational systems. The competencies are closely linked to the United Nations Sustainable Development Goal 4 (Quality Education), which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Rapid assessment is a practical tool in Mathematics education that helps teachers and schools meet SDG 4 by detecting learning gaps early, tracking learners' progress throughout the year, and intervening, based on evidence, when necessary to close learning gaps and prevent further learning losses. Immediate diagnostic feedback enables differentiated instruction, targeted remediation, and supports data-driven teaching that increases responsiveness to learning and mitigates inequities in learner achievement. Assessment systems are especially useful in low-resource schools, as they allow teachers to make informed decisions about next steps in the moment by using current learner-performance data to create inclusive and equitable learning opportunities (United Nations, 2015).

Despite the growing body of literature on cognitive predictors of mathematics achievement, several important gaps remain. First, much of the existing research is concerned with cognitive domains without adequately investigating the specific meaning-making processes of mathematical learning. (Cirino et al., 2024). Secondly, while TIMSS and PISA, among others, have included topics of interpretation indirectly, there has been little empirical research on interpreting as an independent cognitive predictor in localized formative assessments like rapid mathematics assessment. Third, few studies examine the influence of knowing, interpreting, applying, and reasoning together on the mathematics achievement of junior high school students in a developing country. In the current literature, these domains are often discussed independently of their interactions in affecting learner performance. Last, and certainly not least, there are a few empirical studies that examine the predictive value of cognitive domain measures for achievement using a fast mathematics assessment format in authentic classroom settings.

To address these gaps, this study examines the predictive value of cognitive domains on mathematics achievement among junior high school learners through rapid mathematics assessment. Specifically, the study examines the influence of knowledge, interpretation, application, and reasoning on mathematics achievement. By positioning interpreting as a potentially distinct cognitive predictor, this study contributes to ongoing theoretical discussions regarding mathematical cognition while also providing evidence relevant to curriculum development, assessment design, and instructional practice.

Using a predictive approach, this study contributes to the literature in several ways. First, it provides empirical evidence regarding the relationship between domain-specific cognitive processes and mathematics achievement at the secondary education level. Second, it expands traditional cognitive-domain models by theoretically and empirically examining interpreting as a distinct meaning-making process rather than merely a component of applying or reasoning. Third, it demonstrates how rapid mathematics assessment can generate timely diagnostic information to support responsive and equitable mathematics instruction. Ultimately, the findings may guide curriculum enhancement,





assessment reform, and targeted instructional interventions to improve mathematical cognition and support the achievement of SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities).

Objectives

The primary objective of this study is to examine the cognitive domain predictors of mathematics achievement among junior high school learners using rapid mathematics assessment. The study attempted to answer the research questions:

1. What is the level of mathematics achievement and cognitive-domain performance of junior high school learners?
2. Is there a significant relationship between mathematics achievement and the cognitive domains of knowing, interpreting, applying, and reasoning?
3. Which cognitive domains significantly predict mathematics achievement among junior high school learners?
4. What instructional framework may be proposed based on the significant cognitive predictors of mathematics proficiency?

Null Hypothesis

H₀₁: There is no significant relationship between mathematics achievement and the cognitive domains of knowing.

H₀₂: There is no significant relationship between mathematics achievement and the cognitive domains of interpreting.

H₀₃: There is no significant relationship between mathematics achievement and the cognitive domains of applying.

H₀₄: There is no significant relationship between mathematics achievement and the cognitive domains of reasoning.

Literature review

Mathematics Achievement is a Multidimensional Construct

A recurring theme across recent literature suggests that mathematics achievement is a multidimensional construct shaped by the interaction of cognitive, affective, and contextual factors. Contemporary studies emphasize that mathematical proficiency extends beyond procedural competence toward conceptual understanding, reasoning, interpretation, and flexible problem-solving (Ngu & Phan, 2024; Svraka et al., 2024). International large-scale assessments such as PISA further reinforce the view that mathematics performance emerges from the combined influence of learner characteristics, instructional conditions, and sociocultural contexts (Wang et al., 2023). Recent evidence likewise indicates that early cognitive abilities, including numeracy, working memory, and intelligence, significantly contribute to later mathematics achievement (Bütüner et al., 2025; Chang, 2023). Collectively, these studies position mathematics achievement as a complex and multidimensional educational outcome rather than a product of isolated procedural skills.

Cognitive Domains and Mathematics Achievement

Recent literature consistently identifies cognitive domains as significant predictors of mathematics achievement. Rather than functioning independently, cognitive processes such as knowing, interpreting, applying, and reasoning interact dynamically during mathematical problem-solving. Collectively, studies on executive functioning, cognitive flexibility, and conceptual understanding suggest that mathematics achievement arises from the interplay of cognitive processes rather than from isolated procedural abilities (Cirino et al., 2024; Gökçe & Güner, 2024). Similarly, inhibition control, working memory, and cognitive flexibility have been associated with both mathematics achievement and learning difficulties (Deaño et al., 2023).

Across the literature, a recurring pattern suggests that higher mathematics achievement is associated with learners' ability to connect foundational knowledge with deeper conceptual understanding. Systematic reviews further demonstrate that cognitive factors significantly predict mathematics performance, although their effects are moderated by contextual influences such as instructional quality, school climate, and socioeconomic conditions (Wang et al., 2023). These findings





collectively support the argument that mathematics learning involves interconnected cognitive processes that operate simultaneously rather than independently.

Interpreting and Conceptual Understanding as Core Predictors

An emerging body of literature highlights the roles of interpretation and conceptual understanding as central processes in mathematics learning. Recent studies suggest that learners' ability to interpret mathematical information plays a critical role in transforming procedural knowledge into meaningful and transferable understanding (Ngu & Phan, 2024; Svraga et al., 2024). Functional mathematical competence, particularly the interpretation of quantitative information in contextual situations, has likewise been associated with improved academic performance and real-world problem-solving (Guimaraes & Mervis, 2024).

A recurring theme across empirical studies indicates that conceptual comprehension is often a stronger predictor of achievement than rote procedural execution. Learners who meaningfully interpret mathematical representations such as graphs, equations, tables, and symbols demonstrate greater ability to apply procedures appropriately and engage in higher-order reasoning (Gökçe & Güner, 2024; Almeida et al., 2026). This perspective suggests that interpreting functions is not merely a supporting skill but a mechanism through which learners construct mathematical meaning and connect prior knowledge with unfamiliar situations.

Cognitive Theory of Multimedia Learning and the Interpreting Domain

The interpreting domain may be further explained through the Cognitive Theory of Multimedia Learning (CTML), which posits that learners construct knowledge by actively processing verbal and visual information through dual cognitive channels (Mayer, 2021). Within this framework, meaningful learning occurs when learners select relevant information, organize it into coherent mental structures, and integrate these structures with prior knowledge and experiences. Recent literature emphasizes that multimedia learning environments support deeper conceptual understanding when learners are guided to simultaneously connect symbolic, graphical, textual, and visual representations, particularly in cognitively demanding subjects such as mathematics (Cavanagh & Kiersch, 2023; Çeken & Taşkın, 2022; Zhuang & Liu, 2022).

In mathematics education, interpreting involves more than simply reading symbols or extracting information from diagrams. Rather, it requires learners to transform multiple representations into meaningful conceptual relationships that support understanding and problem-solving. Studies on multimedia and representational learning suggest that learners achieve stronger mathematical comprehension when visual and verbal representations are meaningfully integrated, since these processes reduce cognitive overload and promote generative processing. The ability to interpret graphs, equations, animations, and contextual models, therefore, becomes essential in bridging abstract concepts with real-world mathematical reasoning (Erlebach & Frank, 2022; Khatin-Zadeh et al., 2022; Zhuang & Liu, 2022).

From this perspective, CTML provides a strong theoretical foundation for explaining how interpreting supports the progression from foundational knowledge toward application and higher-order reasoning. Learners who effectively process and integrate multiple representations are more likely to engage in analytical thinking, conceptual transfer, and contextual problem-solving. Contemporary studies further indicate that multimedia-supported interpretation enhances cognitive organization and facilitates meaningful learning by enabling learners to construct coherent mental models from complex information. Consequently, the interpreting domain may function as a translative cognitive mechanism that links conceptual understanding with mathematics achievement and performance (Kramer, 2022; Zumbach et al., 2022).

Predictive Mathematics Achievement Models

Contemporary predictive models consistently recognize cognitive ability as a significant determinant of mathematics achievement; however, recent findings also reveal the limitations of models that rely solely on cognitive predictors. Evidence suggests that mathematics performance is simultaneously influenced by socio-economic conditions, instructional quality, school climate, learner motivation, and mathematics anxiety (Passiatore et al., 2024; Wang et al., 2023). These findings indicate that predictive models become more robust when cognitive, affective, and contextual variables are examined collectively rather than independently.





At the same time, current literature continues to support the importance of cognitive domains in explaining classroom mathematics performance. The interaction among executive functioning, processing speed, reasoning ability, and conceptual understanding has been shown to significantly influence learners' achievement across educational levels (Deaño et al., 2023). This reinforces the need to examine how interconnected cognitive processes contribute to mathematics achievement.

Rapid Mathematics Assessment (RMA)

The Department of Education (DepEd) introduced the Rapid Mathematics Assessment (RMA) as part of national initiatives to enhance numeracy and mathematics achievement among Filipino students. The assessment was a diagnostic measure intended to assess learners' mathematics abilities across grade levels and learning shortcomings. RMA materials comprised teacher guides, learner booklets, and scoring sheets, which helped teachers efficiently and accurately evaluate students' performance (Department of Education, 2025).

Previous studies examining the implementation of Rapid Mathematics Assessment indicated that the instrument was effective in identifying learners' numeracy gaps and helped formulate specific instructional interventions. As an illustration, a study of elementary students found that an RMA-based instructional intervention led to significant improvements in numeracy, demonstrating that diagnostic assessment is effective in enhancing mathematics learning outcomes (Dulay, 2025). Moreover, the Department of Education focused on educational activities and training workshops to enhance teachers' capacity to administer RMA and use assessment results to plan instruction (Department of Education, 2025). These activities were part of the emerging trend of using data for decision-making in education, in which assessment results informed teaching and learning strategies, thereby improving student learning outcomes.

However, current literature also points to several limitations of rapid diagnostic assessments. Because RMAs are generally time-constrained and performance-oriented, they may insufficiently capture deeper conceptual understanding, metacognitive processes, and affective influences related to mathematics learning. Some studies also suggest that standardized diagnostic tools may emphasize procedural accuracy over learners' interpretive and contextual reasoning skills. Consequently, while RMAs remain useful for identifying patterns in cognitive performance, their findings should be interpreted alongside broader instructional, contextual, and affective considerations (Tolibas, 2025; Quiozon & Marmol-Dado, 2026; Valledor et al., 2025).

Conceptual Framework

This study was anchored on the premise that mathematics achievement is influenced by domain-specific cognitive processes, as explained in the TIMSS Mathematics Cognitive Domain Framework, Bloom's Revised Taxonomy, and Cognitive Load Theory. These viewpoints provide ways in which students learn, think, understand, and apply mathematical content as it becomes increasingly complex. Accordingly, the framework views mathematical learning as an interaction of cognitive processes that collectively shape learners' performance.

In this model, four cognitive domains (knowing, interpreting, applying, and reasoning) were identified as independent variables, and mathematics achievement was the dependent variable. Knowing is the ability to recall mathematical facts, concepts, and procedures. Interpretation of mathematics refers to the meaning of the mathematical symbols, graphs, equations, tables, and contexts. Using knowledge in routine and non-routine problem-solving tasks is application, and using knowledge at higher levels of problem-solving, such as analysis, justification, and inference, is reasoning. The Rapid Mathematics Assessment (RMA) was used to assess these domains, and mathematics achievement was measured through mathematics scores from the Regional Unified Quarterly Assessment (RUQA), which are based on the Most Essential Learning Competencies (MELCs).

Although treated as distinct constructs, the framework recognizes the overlap and interdependence among the cognitive domains. To solve a mathematical problem, students will be required to work through these processes continuously, not just one at a time. Knowing is the foundation of knowledge, and interpretation is a way of putting this knowledge into context and understanding its meaning. This translative function helps students relate prior knowledge to the mathematical situation,



choose relevant procedures, create relationships, and validate their solution, thereby supporting application and reasoning. Procedural knowledge can be mechanical and difficult to transfer to new contexts if it is not interpreted.

In the framework, the concept of interpreting functions is defined as a translative cognitive activity connecting basic mathematical knowledge with more complex reasoning. Students must be able to interpret symbols, relationships, representations, and contextual information to apply procedures or construct a mathematical justification.

The framework also recognizes the affective, contextual, and environmental factors that can affect mathematics achievement. The present study, however, is primarily concerned with cognitive domains and their role in the classroom assessment of mathematics. Thus, knowing, interpreting, applying, and reasoning have been shown to have a significant influence on mathematics achievement in the framework, and those influences are compounding and interacting.

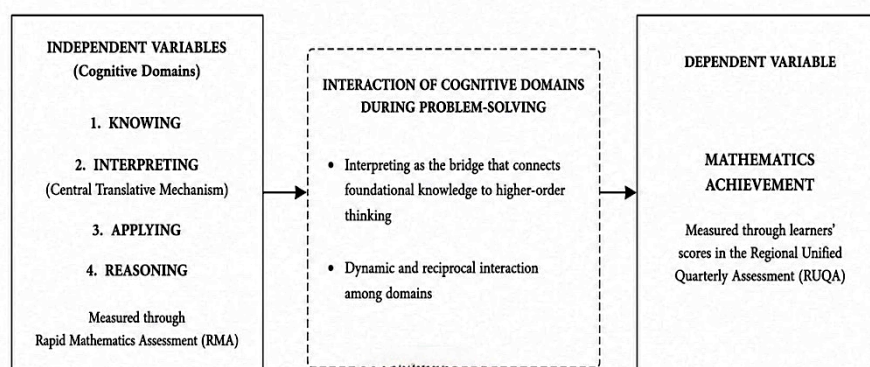


Figure 1: Schematic Diagram of the Study

Methodology

1. Research Design

A quantitative descriptive-correlational research design was used to explore the correlation between performance on cognitive domains and junior high school students' achievement in mathematics. This design was suitable because it allowed the description of the learners' proficiency levels and the analysis of statistical associations between variables without manipulation. Descriptive statistics were used to describe the levels of mathematics achievement and cognitive ability, and correlational and regression analyses were used to examine statistical and predicted relationships among the variables.

2. Research Locale and Participants

The study was carried out in one public secondary school in Kapatagan, Lanao del Norte, Philippines, under the supervision of the Department of Education (DepEd). The total number of junior high school learners (Grades 7-10) involved in the study was 233, of whom were selected using stratified random sampling to ensure proportional representation across grades. This method was used to reduce sampling bias, maximize sample representativeness, and account for differences in mathematics content, mathematics competencies, and cognitive load across junior high schools (Creswell & Creswell, 2023). Learners were stratified by grade level and class sections to ensure equal representation across the junior high school population. This procedure reduced sampling bias and increased the representation of students in various academic categories in the school.

3. Research Instrument

The researchers used two standardized tests developed and administered by the Department of Education: The Rapid Mathematics Assessment (RMA) and the Regional Unified Quarterly Assessment (RUQA). To evaluate students' mathematics performance, the RMA was applied to four cognitive levels: knowing, interpreting, applying, and reasoning. Developed in accordance with the K-12 curriculum, the assessment was designed to evaluate foundational numeracy competencies and mathematical cognition. Meanwhile, the RUQA was employed to measure mathematics achievement



and learners' proficiency in the Most Essential Learning Competencies (MELCs). As standardized assessment instruments officially developed by the Department of Education, both tools underwent expert validation, pilot testing, and quality-assurance procedures before nationwide implementation. These procedures support the content validity and institutional reliability of the instruments for educational assessment purposes.

To establish the internal consistency reliability of the instruments used in this study, Cronbach's alpha coefficients were computed. The internal consistency reliability of the Rapid Mathematics Assessment was good ($\alpha = .87$), and for the Regional Unified Quarterly Assessment, it was also good ($\alpha = .84$); both were suitable for measuring mathematics-related cognitive performance and achievement.

To ensure procedural transparency and replicability, the RMA used a standardized scoring rubric to align with the identified cognitive-domain indicators. The conditions for assessing responses in the knowing domain were accurate recall of mathematical facts and procedures; interpreting assessed the ability to derive meaning from mathematical representations; applying assessed the appropriate use of mathematical concepts in problem-solving situations; and reasoning assessed logical justification and analytical explanation. All items were evaluated for correctness, comprehensiveness, and suitability of the answers in accordance with the official RMA scoring guidelines issued by the Department of Education. The raw scores were scaled to percentage scores for determining levels of proficiency. The standardized rubrics helped to enhance the objective, consistent, and replicable nature of the assessment process.

4. Data Gathering Procedure

Before data collection, permission was obtained from the school administration. Students were informed about the nature of the study, and confidentiality and voluntariness were maintained. The RMA was given under the supervision of the researchers and subject teachers. After test administration, the answer sheets were collected, marked as per the rubrics, and entered into the computer for analysis. The mathematics achievement measure was obtained from official school records (RUQA scores).

5. Data Analysis

Descriptive statistics (mean and standard deviation) were used to establish learners' mathematics achievement and cognitive domain scores. To assess normality, the Shapiro–Wilk test was used, and the results indicated that the distribution was not normal. Statistical association between variables was then assessed using Spearman's rho correlation. In addition, multiple regression analysis was performed to identify which cognitive domains significantly predicted mathematics achievement. Assumptions of multicollinearity, independence of errors, and homoscedasticity were checked before the regression analysis was done. Data were analyzed using Jamovi statistical software with a significance level of $\alpha = .05$.

6. Limitations of the Study

The sample was obtained from a single public secondary school, which may limit its representativeness. Furthermore, the study focused only on a limited set of cognitive variables and did not include other factors that might have predicted them. Future studies are recommended to use larger samples and more variables to support their findings.

7. Ethical Considerations

This study adhered to ethical guidelines in educational research. Permission was obtained from the educational authorities, and consent from the participants and their parents or guardians, where applicable. They were assured of confidentiality and anonymity, and that their responses would not affect their academic performance. Data were collected and kept secure for research purposes only, in accordance with appropriate ethical principles for research integrity and respect for human subjects.





Results and Discussion

Table 1: Level of Mathematics Achievement of Junior High School Learners Across Grade Levels

Grade level	N	M	SD	Interpretation
Grade 7	63	44.1	9.59	Average Mastery
Grade 8	69	53.6	13.07	Average Mastery
Grade 9	57	50.8	11.80	Average Mastery
Grade 10	44	59.9	12.65	Average Mastery
Overall	233	52.1	11.78	Average Mastery

Note. M = mean; SD = standard deviation

The results indicated that the mathematics achievement of junior high school learners was at an average mastery level ($M = 52.1$, $SD = 11.78$). Mean scores varied across grade groups and generally improved from Grade 7 through Grade 10. Grade 10 learners obtained the highest mean scores, and the lowest mean scores were achieved by learners in Grade 7, suggesting a positive development from lower to higher grades in mathematics achievement. Although this constitutes an improvement, learners from all grades remained in the same performance category of average mastery, suggesting that learning achievement had not reached proficiency. This trend highlights that while learners' mathematical knowledge and skills develop gradually with age, higher-level processing skills, such as conceptual understanding and reasoning, remain lacking. These results are consistent with previous research showing that although mathematics achievement increases as learners progress through grades, this is constrained by a lack of development of advanced cognitive skills (Wang et al., 2023; Bütüner et al., 2025).

Mathematics teaching and learning implications of these findings include the need for interventions, especially at early grades, where achievement is comparatively low. Increasing attention to both basic and higher-level skills, and ensuring that mathematics skills are developed through instruction that encourages reasoning, application, and understanding, for instance, may positively impact mathematics achievement. The literature suggests that a holistic approach, encompassing cognitive development, teaching strategies, and an appropriate learning environment, is important for enhancing mathematics performance (Yang et al., 2024; Bütüner et al., 2025).

Table 2: Level of Cognitive Domain Performance of Junior High School Learners

Cognitive Domain	M	SD	Interpretation
Knowing	55.1	20.4	Approaching Proficiency
Interpreting	56.4	23.4	Approaching Proficiency
Applying	45.6	22.7	Low Proficiency
Reasoning	52.8	26.3	Approaching Proficiency

Note. M = mean; SD = standard deviation

Findings revealed learners were approaching proficiency in the cognitive domains of knowing ($M = 55.10$), interpreting ($M = 56.40$), and reasoning ($M = 52.80$), but were still low in proficiency in applying ($M = 45.60$). This appears to imply that learners were quite proficient in understanding (know) and interpreting (interpret) mathematical knowledge, and moderately proficient in reasoning (reason). However, they faced challenges in applying their understanding to problem-solving tasks.

The relatively high standard deviations ($SD = 20.40$ - 26.30) also indicated significant variability in learners' cognitive performance. This suggests that some students performed well while others did not, particularly in cognitively complex domains, like applying and reasoning. Applying refers to the application of knowledge in different situations; reasoning refers to higher-order thinking skills, such as analyzing, inferring, and justifying (Choi et al., 2026).

These results align with earlier studies reporting that mathematics education tends to focus on lower-order skills, which may negatively impact the development of higher-order skills (Kong & Rosli,





2024; Bulut & Taşpınar-Şener, 2023). This can lead learners to have adequate knowledge about a topic, but they are not necessarily able to apply it effectively in new or real-world situations.

Generally, these results support the need to improve higher-order thinking abilities, including reasoning and application. These skills are encouraged through teaching strategies, such as problem-based learning, contextualized tasks, and mathematical modeling, which enable better applications of mathematical knowledge.

Table 3: Relationship Between Mathematics Achievement and Cognitive Domain Performance

Mathematics Achievement & Cognitive Domains	Correlation Coefficient (Spearman's rho)	P-value	Interpretation
Knowing	.257	< .001	Significant
Interpreting	.347	< .001	Significant
Applying	.204	.002	Significant
Reasoning	.171	.009	Significant

Before the correlation analysis, the Shapiro–Wilk test indicated that the variables significantly deviated from normality ($p < .001$). Consequently, Spearman's rho was employed to examine the relationship between mathematics achievement and performance across the cognitive domains, as it is appropriate for non-normally distributed data (Field, 2022; Kim, 2023).

Table 3 shows that mathematics achievement had statistically significant positive relationships with all cognitive domains. Specifically, interpreting demonstrated the strongest correlation with mathematics achievement ($r_s = .347$, $p < .001$), followed by knowing ($r_s = .257$, $p < .001$), applying ($r_s = .204$, $p = .002$), and reasoning ($r_s = .171$, $p = .009$). Because all p-values are below .05, the null hypotheses were rejected, indicating that there was a significant relationship between each cognitive domain and mathematics achievement.

Findings indicate that students who performed better in the cognitive domains also tended to achieve higher mathematics performance. The strongest relationship was found for interpreting, indicating that the understanding, explanation, and linkage of mathematical representations are important to mathematics achievement. This finding implies that learners who can interpret the meaning of mathematical concepts are better able to apply procedures and think at a higher-order level when solving mathematical problems.

The strong association between knowing the domain and mathematics achievement also indicates that mathematical facts, concepts, and procedures still play a critical role in mathematics achievement. Likewise, the positive correlations for applying and reasoning indicate that students' ability to use mathematical procedures in contextual situations and to justify mathematical solutions contribute to achievement, although at relatively lower levels than interpreting. The results aligned with the multidimensional conception of mathematical cognition and the dynamic nature of the support provided by cognitive domains for achievement, with none operating independently of the others (Gilmore, 2023).

The findings are in line with recent literature that highlights the role of conceptual understanding, interpretation, and reasoning in mathematics learning. George (2023) reported significant positive relationships between cognitive domains and overall mathematics achievement, highlighting that knowledge and comprehension underpin higher-order reasoning. Similarly, Spiller et al. (2023) found that domain-specific mathematical skills and higher-order cognitive processes significantly predict mathematics achievement. Furthermore, Ingram et al. (2023) highlighted the importance of conceptual understanding and meaningful interpretation in fostering mathematical growth and achievement.

Findings are relevant to mathematics teaching and evaluation. Because interpreting was the most highly correlated with mathematics achievement, mathematics instruction should emphasize meaning-making, understanding of mathematical representations, and conceptual understanding, not just memorizing procedures. Teachers can integrate problem-solving activities into the curriculum in context, multiple mathematical representations, and reflective conversations to develop students'





interpretive and reasoning skills. Moreover, classroom assessments should focus on students' ability to interpret, use, and explain mathematical ideas, in addition to assessing procedural knowledge. Improving these areas of cognition could lead to improvement in mathematical learning and achievement for students.

Table 4: Multiple Regression Analysis Predicting Mathematics Achievement

Independent Variables	Coefficients			p-value
	B	SE	t	
(Constant)	40.4624	2.3965	16.851	<.001
Knowing	0.0530	0.0620	0.854	.394
Interpreting	0.2198	0.0560	3.922	<.001
Applying	-0.0639	0.0533	-1.197	.233
Reasoning	-0.0242	0.0381	-0.636	.525
R ²			0.130	
F			8.49	

Note. $R^2 = .131$, $F = 8.16$, $p < .001$.

Diagnostic tests were carried out to assess the assumptions of multiple linear regression before the regression analysis. Residual plots showed linearity and homoscedasticity, and a Durbin–Watson statistic of 2.04 confirmed the independence of errors. Furthermore, the Distance of Cook values were all less than 1.00, which showed no influential outliers. These findings supported the use of multiple regression analysis with this data set (Field, 2022; Hair et al., 2022).

Variance Inflation Factor (VIF) and tolerance statistics were examined to assess multicollinearity among predictors. Variance Inflation Factor (VIF) was between 1.57 and 2.68, and tolerance was between .37 and .64, indicating no severe multicollinearity and no violation of regression assumptions. However, there is a moderate intercorrelation among the cognitive domains, indicating conceptual relatedness and shared variance in the knowing, interpreting, applying, and reasoning processes. This overlap could explain the high bivariate relationships between some domains and mathematics achievement that were not observed in the regression model.

Table 4 presents the multiple regression analysis predicting mathematics achievement from the four cognitive domains. The regression model was statistically significant, $F(4, 227) = 8.49$, $p < .001$, accounting for 13% of the variance in mathematics achievement ($R^2 = .130$). While statistically significant, the regression model explained only a small amount of variance in mathematics achievement, suggesting that other cognitive, affective, instructional, and contextual factors not addressed in the present study also play a significant role in mathematics achievement. Among the predictors, only interpreting significantly contributed to the model ($B = 0.2198$, $t = 3.922$, $p < .001$). In the present model, interpreting proved to be the best unique predictor of mathematics achievement, but a significant portion of the variance in mathematics achievement remained unexplained. Results indicate that the skill of making meaning out of the mathematical representation, real-world context, and symbolic information presented to learners could be an important component in the relationship between conceptual understanding and mathematical performance.

In contrast, knowing ($B = 0.0530$, $p = .394$), applying ($B = -0.0639$, $p = .233$), and reasoning ($B = -0.0242$, $p = .525$) did not significantly predict mathematics achievement because their p-values exceeded the .05 significance level. While these domains may correlate with mathematics achievement, they did not independently predict achievement when other factors were included in the regression model. This indicates that there are common variances between the cognitive domains. This implies that there is common variance between the cognitive domains.

The results show that the interpreting domain is the unique predictor of learners' mathematics achievement among junior high school learners. This implies that the ability to analyze, make sense of mathematical representations, and connect concepts is more important to achievement than procedural knowledge or isolated higher-order skills. The findings are consistent with the idea that interpreting is a primary cognitive activity that connects conceptual understanding to math performance. The





correlational analysis indicated that knowing, applying, and reasoning were related to mathematics achievement but did not appear as unique predictors when controlling for the shared variance among the cognitive domains in the regression model.

Although applying and reasoning demonstrated significant correlations with mathematics achievement, these correlations were no longer significant in the regression model when analyzed simultaneously with the other cognitive domains. The finding indicates that these domains overlap in variance with interpreting, suggesting that higher-order mathematical processes may operate in close interaction rather than as independent predictors of achievement. The same results can be seen in research demonstrating that interrelated cognitive variables can be difficult to distinguish and may not uniquely explain variance in regression models, as they share variance explained among the predictors (Tabachnick & Fidell, 2023; Spiller et al., 2023).

This relatively low explained variance also suggests that many factors other than cognitive ability affect mathematics achievement. The remaining unexplained variance accounted for about 87% of the achievement variance; therefore, there is also a significant contribution due to affective, contextual, and instructional factors. Current studies reveal the following factors impacting mathematical performance: mathematics anxiety, motivation, self-efficacy, classroom climate, socioeconomic background, and teacher support (OECD, 2023; Villavicencio & Bernardo, 2024). Therefore, cognitive domains are just one aspect of the many factors that influence students' performance in mathematics.

While the regression model accounted for only 13% of the variance in mathematics achievement, this is not unusual in educational research studies involving complex human learning processes. Many other cognitive, affective, motivational, instructional, and socioeconomic factors not related to mathematics education exist and interact with mathematical achievement that cannot be elaborated here. Thus, the findings are seen as a single important cognitive contribution, rather than a complete explanation of mathematics achievement.

The results also reflect the current trends in mathematical literacy worldwide, with a focus on trends highlighted in international large-scale assessments like the Programme for International Student Assessment (PISA). From this perspective, the student's ability to interpret and understand mathematical concepts is a key element of mathematical problem-solving, not just the ability to remember a procedure. The findings presented are consistent with the global trend toward meaning-making and higher-order cognition in math education. (OECD, 2023).

Moreover, international research has consistently found that students have difficulties not in computation but in meaning-making and understanding mathematical information, interpreting relationships, and applying concepts in situations different from those they are used to. The findings from the present study validate these observations worldwide and reinforce the significance of interpretation in mathematics learning. A recent study by Svärd et al. (2024) showed that conceptual interpretation is a better predictor of mathematical success than procedural fluency, while Yang et al. (2024) showed that students who are more successful at conceptual interpretation have improved mathematical reasoning and problem-solving skills. Together, these results stress the importance of learners' capacity to make sense of representations of mathematics rather than to perform rote-learned procedures.

Table 5 Comparison of Present Findings with Previous Studies on Mathematical Interpretation and Achievement

Study	Key Findings	Relationship to the Present Study
Organisation for Economic Co-operation and Development (2023)	Mathematical literacy depends on learners' ability to interpret, formulate, and apply mathematics in real-world contexts rather than merely recall procedures.	Supports the present finding that interpreting is a critical cognitive process influencing mathematics achievement.





Study	Key Findings	Relationship to the Present Study
Svård et al. (2024)	Conceptual interpretation and meaning-making predicted mathematics achievement more strongly than procedural fluency.	Similar to the present study, in which interpreting was the most significant predictor for mathematics achievement.
Yang et al. (2024)	Better reasoning and problem-solving performance were exhibited by students with higher interpretive abilities.	Supports the observed conceptual overlap among interpreting, applying, and reasoning domains in the present study.
Present Study	Knowing, applying, and reasoning did not individually predict mathematics achievement in the regression model when shared variance was controlled for, but interpreting did predict mathematics achievement.	Extends previous literature by identifying interpreting as a central cognitive pathway linking mathematical understanding and performance among junior high school learners.

Table 5 compares the results obtained in the present study with some related international literature on mathematical interpretation, cognition, and achievement. This comparison shows good convergence between the findings of the present study and recent international studies, highlighting the importance of interpretive competence and conceptual understanding in mathematical literacy and achievement. The findings highlight the importance of teacher support in making classroom activities and assessment processes more international from an educational perspective. The teaching of mathematics needs to go beyond memorizing procedures to approaches that cultivate conceptual understanding, interpretation, and the application of mathematical ideas in real-life situations. Inquiry-based learning, contextualized problem-solving, mathematical discourse, and multiple representations could be ways to enhance students' interpretive competence and deepen mathematical understanding.

Classroom practices associated with the interpretation-centered instruction approach can include mathematical discourse, think-aloud problem-solving, graph interpretation activities, real-world data analysis activities, and multiple mathematical representations (tables, diagrams, symbolic expressions, contextual scenarios). The teacher could also employ error-analysis activities and reflective questioning to further support learners' meaning-making and representational understanding. Similarly, students' mathematical thinking should be assessed in terms of their ability to explain, interpret, and justify mathematical reasoning as well as their procedural accuracy. Enhancing the above skills could equip students with a greater capacity to face the future.

Proposed Instructional Framework

Based on the study's findings, an Interpretive Mathematical Learning Framework (IMLF) is proposed to strengthen mathematics proficiency among junior high school learners. The framework is anchored on the finding that interpreting was the only significant cognitive predictor of mathematics achievement, highlighting the importance of students' ability to construct meaning from mathematical concepts, representations, and relationships.

The framework consists of four interconnected instructional components: conceptual understanding, mathematical interpretation, contextual application, and reflective reasoning. Conceptual understanding serves as the foundation for developing learners' knowledge of mathematical concepts, symbols, and procedures through meaningful and learner-centered activities. Mathematical interpretation functions as the core process of the framework by engaging students in analyzing mathematical representations, explaining relationships, translating symbolic and verbal information, and connecting mathematical ideas to contextual situations. Contextual application enables learners to apply mathematical concepts and procedures to authentic, unfamiliar problem-solving tasks, while reflective reasoning develops students' ability to justify solutions, evaluate strategies, and communicate their mathematical thinking effectively.



The framework further recognizes that mathematical cognition is multidimensional and interactive. Although applying and reasoning were significantly correlated with mathematics achievement, their predictive influence diminished in the regression model because of multicollinearity and overlapping cognitive functions with interpreting. This suggests that interpretation serves as a central cognitive mechanism linking foundational knowledge with higher-order mathematical processes.

The proposed framework aligns with contemporary global trends in mathematical literacy, particularly the Programme for International Student Assessment (PISA), which emphasizes the capacity to formulate, interpret, and apply mathematics in real-world contexts rather than relying solely on procedural fluency (OECD, 2023). Recent studies likewise emphasize that conceptual interpretation and representational understanding significantly predict mathematics achievement and problem-solving performance (Svård et al., 2024; Yang et al., 2024). Consequently, the framework promotes instructional approaches that prioritize meaning-making, conceptual understanding, inquiry-based learning, mathematical discourse, contextualized problem-solving, and the use of multiple mathematical representations.

In terms of assessment, the framework recommends integrating formative and performance-based assessments to evaluate students' interpretive competence, conceptual understanding, reasoning, and ability to communicate mathematical ideas. Through these instructional and assessment practices, the framework aims to enhance students' mathematical literacy, conceptual depth, and overall proficiency in mathematics.

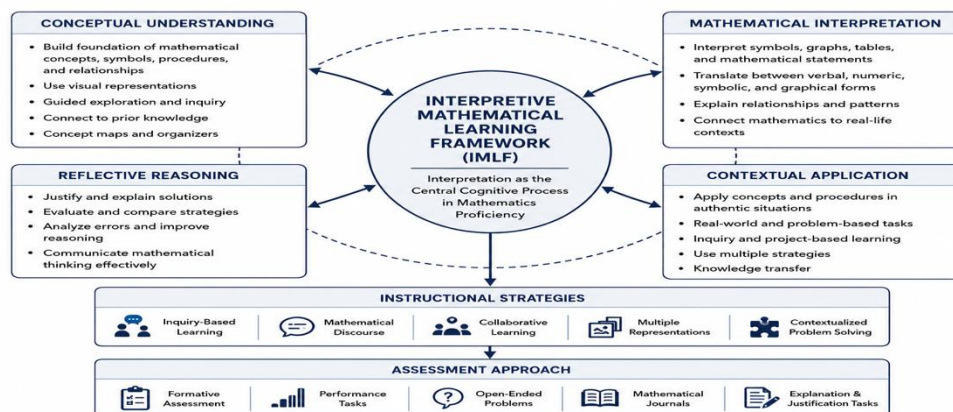


Figure 2: Interpretive Mathematical Learning Framework for Mathematics Proficiency

Knowledge Contribution

The present study contributes to mathematics education by identifying interpreting as the most significant cognitive predictor of mathematics proficiency among junior high school learners. Unlike knowing, applying, and reasoning, interpreting demonstrated the strongest unique influence on achievement when the cognitive domains were analyzed simultaneously. This finding advances prevailing views on mathematical cognition by highlighting interpretation as a fundamental process of meaning construction that links conceptual comprehension to proficient mathematical execution.

A major theoretical contribution of the study is the development of the Interpretive Mathematical Learning Framework (IMLF), which positions interpretation as the “pivot” cognitive process in mathematics learning. The framework proposes that mathematical cognition does not progress linearly from knowing to applying and reasoning; rather, interpretation functions as the integrative mechanism that enables learners to connect mathematical concepts, representations, and contextual information to higher-order thinking processes. Through interpretation, learners transform procedural and conceptual knowledge into meaningful application and reasoning.

The framework also extends Cognitive Load Theory (CLT) by proposing that interpretive processes help organize mathematical information into coherent cognitive structures, thereby reducing



extraneous cognitive load and strengthening schema construction during problem-solving (Sweller et al., 2019). In this sense, interpretation functions not only as a comprehension skill but also as a cognitive organizer that facilitates efficient processing, conceptual integration, and knowledge transfer in mathematics learning.

Furthermore, the study supports the multidimensional and interconnected nature of mathematical cognition. The loss of predictive significance of applying and reasoning in the regression model, despite their significant correlations with achievement, highlights the overlapping cognitive functions among the domains. This finding suggests that higher-order mathematical processes operate through interpretive competence rather than independently.

From an educational practice perspective, the IMLF is very similar to the Department of Education (DepEd) K to 12 Mathematics Curriculum, which focuses on conceptual understanding, critical thinking, problem-solving, and the application of mathematics in everyday life. The framework can be embedded in existing DepEd programs by incorporating interpretation-based teaching methods, contextualized learning activities, formative assessment, and differentiated remediation based on results from the Rapid Mathematics Assessment (RMA). In particular, the IMLF promotes the use of the Most Essential Learning Competencies (MELCs) by fostering learners' ability to interpret mathematical representations, explain relationships between concepts, and use mathematics in real-world contexts. The framework can also bolster the National Learning Recovery Program with a diagnostic and intervention-based approach to addressing learners' concept and interpretive deficits in mathematics.

Globally, the IMLF is aligned to the cognitive and mathematical orientations of Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), which focus on students' capacity to interpret, formulate, reason, and apply mathematics in diverse contexts (OECD, 2023; Mullis & Martin, 2021). The framework also aligns with key SDG 4 goals of inclusive, equitable, and meaningful mathematics learning, both in terms of evidence-based and learner-centered approaches to mathematics teaching. The IMLF fosters 21st-century mathematical literacy through contextualized problem-solving, mathematical discourse, multiple representations, and performance-based assessment. The IMLF's focus on interpretive proficiency provides an evidence-based basis for enhancing curricula, innovating instruction, developing teachers' professional knowledge, and reforming assessment practices across a range of educational settings to foster mathematical literacy and achievement outcomes.

This evidence-based framework can be used in any context to inform curriculum enhancement, instructional innovation, teacher professional development, and even assessment reform, helping improve mathematical literacy and achievement outcomes.



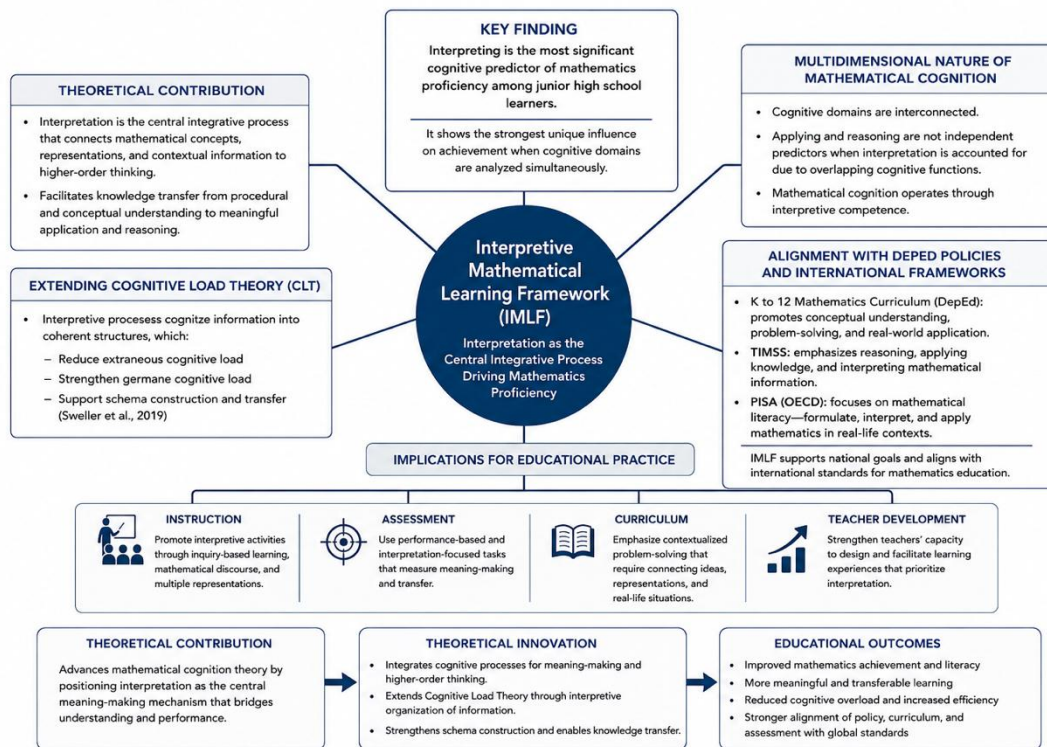


Figure 3: Interpretive Mathematical Learning Framework (IMLF): Theoretical contribution, cognitive integration, and educational implications

Conclusion

This study concludes that junior high school learners demonstrated only an average level of mastery in mathematics, indicating that while learners possess foundational mathematical knowledge, substantial gaps remain in achieving higher levels of proficiency. More specifically, learners showed relative strengths in knowing, interpreting, and reasoning, yet these competencies remained only at the “approaching proficiency” level, suggesting incomplete mastery of conceptual and analytical mathematical skills. The weakest performance was observed in the applying domain, indicating that many learners continue to struggle to transfer mathematical understanding to unfamiliar, contextualized, and real-world problem-solving situations. The findings indicate that students are not completely lacking in mathematical skills, but they have difficulty integrating procedural knowledge with meaningful, functional mathematical knowledge.

The study further revealed a significant association between all cognitive domains and mathematics achievement, indicating that mathematics learning is multidimensional and influenced by interactions among cognitive processes. But, all domains, interpreting was the strongest and only significant predictor of mathematics achievement. The finding underscores that the mechanism of learning mathematics is the learner's ability to derive meaning from mathematical representations, symbols, equations, graphs, and contexts. Interpreting is a vital link between application, reasoning, and procedural competence in mathematics, and is crucial for students to make connections between knowledge and understanding.

The findings indicate that mathematical competence in the 21st century is not limited to mere memorization and strict procedure. To effectively learn mathematics, students must be able to think critically about information, relate ideas meaningfully, and be flexible in applying mathematical knowledge across varying contexts, especially in an increasingly data-driven and problem-oriented world. Therefore, mathematics education must take an interpretive and meaning-based step toward



using conceptual understanding, contextual reasoning, and mathematical literacy beyond isolated procedural performance. This view of mathematics is not just a subject of computation, but also one of understanding, communication, and informed decision-making, fundamental to lifelong learning and functioning in modern society.

Ultimately, the findings reinforce the view that mathematics learning in the 21st century extends beyond procedural computation to the construction of meaning, the interpretation of relationships, and the application of knowledge in complex real-world contexts. The ability to interpret could then be a key stepping stone toward greater mathematical literacy and problem-solving skills in learners' future lives.

Recommendation

Short-Term Instructional Recommendations

Based on the results of the study, it is recommended that mathematics teachers improve learners' ability to interpret mathematics by applying learning-centered approaches that focus on conceptual understanding and the meaning of mathematics. Interpretation was the unique cognitive predictor of mathematics achievement, suggesting that instruction in the classroom should not focus solely on procedural computation but should provide opportunities for learners to interpret, explain, and link mathematical representations. Think-aloud protocols could be used by teachers to have students articulate their thinking and interpretation while solving problems. Multiple-representation tasks using graphs, tables, equations, diagrams, and verbal explanations could also help students translate mathematical ideas across representations.

In addition, word problems should be used frequently in realistic contexts to enhance students' capacity to make mathematical sense of real-world situations. The results of the Rapid Mathematics Assessment (RMA) can also be used to identify learners who need immediate remedial and targeted intervention in the interpretation-related competencies. The following classroom-based strategies can be used to enhance learners' conceptual knowledge and mathematics achievement.

Long-Term Curriculum and Policy Recommendations:

Interpretation skills could be more emphasized in the mathematics curricula and assessment processes. There should be greater focus in Mathematics curricula on conceptual explanation, mathematical representation, and the interpretation of quantitative information, as well as on skills in mathematical procedure and reasoning. The results of this study indicate that interpretation is an important cognitive process that links basic knowledge and higher-order mathematical thinking. The Department of Education and school principals or administrators also have the authority to establish professional development programs to train teachers in interpretation-based instructional strategies, the use of diagnostic assessments, and data-driven remediation planning. Furthermore, schools can implement systematic RMA-informed remediation programs to continuously monitor learners' performance in the cognitive domain and remediate learning gaps early on. These activities can help to enhance mathematics performance and increase equity in learning opportunities for junior high students.

Recommendations for Future Research

Other demographic and psychological factors, including affective and contextual factors such as mathematics anxiety, motivation, self-efficacy, socioeconomic status, and instructional quality, could be included in future studies to better explain mathematics achievement. The researchers can also use more sophisticated statistical analyses, such as mediation and structural equation modeling, to further explore potential indirect connections among cognitive domains. Furthermore, future research with larger and more varied samples of students in additional schools or regions could enhance the generalizability of the results and shed more light on interpretation-centered mathematics learning.





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