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Mathematical Discourse Fluency and Numerical Competence: A Correlational Analysis of Senior High School Students' Mathematical Language and Skill Profiles

Jenielve T. Bisnar*[1], Janet F. Rabut, PhD[2]
[1, 2] Sultan Kudarat State University, ACCESS Campus, EJC Montilla, Tacurong City, Philippines
*Corresponding Author e-mail: *jenielve.bisnar@deped.gov.ph*

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Abstract
Aim: This study examined the relationship between mathematical language proficiency and mathematical skills among senior high school students at Lamian National High School in Surallah, South Cotabato.
Methodology: Using a descriptive-correlational research design, the study assessed 297 Grade 11 students across six academic strands. Data were collected using PISA-based assessment tools and researcher-developed instruments to measure proficiency in mathematical language (words, symbols, diagrams) and skills (number fact, arithmetic, information, language, visual-spatial).
Results: Results revealed that students exhibited beginning-level proficiency in both mathematical language (M=64.72, SD=10.21) and mathematical skills (M=69.93, SD=13.19), with a significant but slight correlation between these variables ($r=0.256$, $p<0.001$). Students performed best in visual-spatial skills and struggled most with information skills. Common challenges included difficulty with mathematical concepts, precise mathematical meanings, and problem-solving processes.
Conclusion: These findings suggest the need for enhanced instructional approaches that strengthen mathematical language comprehension to improve mathematical skills proficiency.
Keywords: *mathematical language, mathematical skills, proficiency, senior high school students*

INTRODUCTION

Mathematics is widely recognized as a challenging academic subject for many students, yet mathematical skills and knowledge are essential for daily life, career advancement, and higher education (Powell et al., 2020). The ability to understand and communicate using mathematical language—including specialized vocabulary, symbols, and visual representations—is fundamental to developing mathematical proficiency (Moschkovich, 2015; Zhang & Wang, 2023).

Language barriers significantly impact mathematical achievement, as students may struggle with verbal communication, reading, and writing in mathematical contexts. The complexity of mathematical vocabulary alone creates linguistic challenges for learners (Schleppegrell, 2021; Curran et al., 2024). Students often encounter difficulties comprehending written or verbal instructions and interpreting word problems (Prediger & Zindel, 2017; Roberts & Chen, 2023). Recent literacy assessment results in the Philippines indicated that while 93.1% of Filipinos aged 10-64 possess basic literacy, only 70.8% demonstrate functional literacy, suggesting that approximately two out of nine individuals struggle with comprehension (Mapa & Philippine Statistics Authority, 2025).

Contemporary mathematics education emphasizes "knowing how" rather than merely "knowing what." As noted by mathematician Georg Polya, practical expertise in mathematics—the ability to solve problems requiring independence, judgment, originality, and creativity—is more valuable than accumulated knowledge (Jones & Jones, 2023). This perspective aligns with modern educational standards that prioritize advanced cognitive abilities, adaptable problem-solving skills, and collaborative communication competencies over basic skills and memorization (Amihan, et al., 2023; Dizon & Sanchez, 2020; Kortesi & Georgieva, 2016; Hernandez-Martinez & Vos, 2023).

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Students face numerous obstacles in understanding mathematical language. While seemingly minor, comprehension difficulties with mathematical terminology require attention due to their connection to persistent underperformance in mathematics (Riccomini et al., 2015; Bergqvist & Österholm, 2022). Understanding mathematical language is essential for developing numeracy skills, yet previous research has typically focused on the correlation between mathematical language and broadly assessed numeracy skills rather than examining specific components of mathematical language and their relationship to discrete mathematical skills (Hornburg et al., 2018; Purpura et al., 2023).

Recent meta-analyses have demonstrated that interventions targeting mathematical language proficiency can improve overall mathematical performance by 0.47 standard deviations, highlighting the critical role of language comprehension in mathematical achievement (Thompson et al., 2024). Furthermore, longitudinal studies suggest that early mathematical language deficits can have compounding effects throughout a student's academic career, with implications extending into tertiary education and beyond (Vukovic & Lesaux, 2023). The integration of digital tools specifically designed to address mathematical language comprehension has shown promising results in diverse educational settings, suggesting potential pathways for pedagogical innovation (Calder & Murphy, 2024).

Objectives

This study aimed to examine the correlation between students' mathematical language and skills proficiency as a foundation for developing intervention tools. Specifically, it addressed the following questions:

1. What is the students' mathematical language proficiency in terms of:
   a. mathematical words;
   b. symbols; and
   c. diagrams?
2. What is the mathematical skills proficiency of students in terms of:
   a. number fact skill;
   b. arithmetic skill;
   c. information skill;
   d. language skill; and
   e. visual spatial skill?
3. Is there a significant relationship between the mathematical language and mathematical skills proficiency of students?
4. What problems beset students in understanding:
   a. mathematical language; and
   b. mathematical skills?

Hypothesis

Given the stated research problems, the following hypotheses were tested at 0.05 level of significance:

H_0: There is no significant relationship between mathematical language and mathematical skills proficiency of students.

H_a: There is a significant relationship between mathematical language and mathematical skills proficiency of students.

METHODS

Research Design

This study employed a descriptive-correlational research design to describe and determine the relationship between students' mathematical language and skills proficiency. According to Devi et al. (2022), a descriptive correlational design aims to delineate relationships between variables without attempting to infer causality. This approach allowed for describing both mathematical language and skills proficiency while assessing their relationships.

Population and Sampling

The research utilized a census or complete enumeration survey method of all Grade 11 Senior High School students at Lamian National High School, comprising 297 students across six academic strands: Humanities and

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Social Sciences (HUMSS, n=109), Science, Technology, Engineering, and Mathematics (STEM, n=32), Agri-Fishery Arts (AFA, n=22), Home Economics (HE, n=17), Industrial Arts (IA, n=97), and Information and Communication Technology (ICT, n=20).

Instruments

Three research instruments were utilized in this study:

1. **Mathematical Language Proficiency Test**: A 30-item multiple-choice test developed by the researchers evaluated students' understanding of mathematical language (words, symbols, diagrams) based on PISA's four content categories: quantity, uncertainty and data, change and relationships, and space and shapes.
2. **Mathematical Skills Proficiency Test**: Adapted from PISA Released Items – Mathematics (2006), this instrument assessed five categories of mathematics skills: number fact skill, arithmetic skill, information skill, language skill, and visual spatial skill.
3. **Problems Survey Questionnaire**: A 20-item survey developed by the researchers, using a 5-point Likert scale (5=Always, 4=Often, 3=Sometimes, 2=Seldom, 1=Never) identified problems students face in understanding mathematical language and learning mathematical skills.

Instrument validity was established through expert validation by six specialists using Content Validity Index with an acceptable CVI of 0.83 (Yosuff, 2019). The researchers-made test questionnaire has a computed S-CVI/UA of 0.93, and the survey questionnaire has a computed S-CVI/UA of 1.00. All items have CVIs above the critical acceptable index. Therefore, the S-CVI/UA meet the satisfactory level, and thus the scale of test and survey questionnaires has achieved satisfactory level of content validity. While reliability was confirmed through pilot testing at Lamsugod National High School, yielding a Kuder-Richardson 20 value of 0.77 (average reliability) for the test and a Cronbach's Alpha of 0.88 (highly acceptable) for the survey.

Data Collection

Prior to conducting the study, the researchers prioritized the validation and reliability testing of all research instruments. This process began with securing formal communication letters from the Graduate School, which were then submitted to obtain permission from the Schools Division Superintendent of SDO South Cotabato and the school head of Lamsugod National High School for the validation phase. Following successful validation, the researchers formally requested authorization from the administration of Lamian National High School to administer the instruments to the target population. Upon receiving approval, the researchers coordinated closely with the school principal to establish an appropriate schedule and venue for data collection. During the administration process, the researchers provided comprehensive instructions to participants regarding each section of the instruments and allocated sufficient time for thoughtful completion. The researchers remained present throughout the session to address any clarifications needed by respondents. After participants completed the instruments, all test materials and questionnaires were systematically collected, organized, and secured to maintain data integrity.

Treatment of Data

Raw scores were converted to percentages using a transmutation table. Mean scores and standard deviations determined proficiency levels according to DepEd Order No. 31, s. 2012: Beginning (74% and below), Developing (75-79%), Approaching Proficiency (80-84%), Proficient (85-89%), and Advanced (90% and above).

Pearson's product-moment correlation coefficient assessed relationships between mathematical language and skills at a 0.05 significance level. Weighted means determined the frequency of problems students encountered, interpreted using a five-point scale: Always (4.21-5.00), Often (3.41-4.20), Sometimes (2.61-3.40), Seldom (1.81-2.60), and Never (1.00-1.80).

Ethical Considerations

The researchers ensured that all ethical guidelines were followed, including obtaining informed consent from participants and ensuring the confidentiality and privacy of their responses throughout the study.

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RESULTS and DISCUSSION

Mathematical Language Proficiency

Table 1 shows students' mathematical language proficiency across three domains.

Table 1. **Students' Mathematical Language Proficiency**

Domain	*Mean Percentage*	*SD*	*Proficiency Level*
1. Diagrams	*65.52*	*11.61*	*Beginning*
2. Mathematical Words	*64.63*	*9.40*	*Beginning*
3. Symbols	*64.00*	*9.63*	*Beginning*
Overall Mean	***64.72***	***10.21***	***Beginning***

Students demonstrated a beginning level of proficiency across all mathematical language domains: diagrams (M=65.52, SD=11.61), mathematical words (M=64.63, SD=9.40), and symbols (M=64.00, SD=9.63). Overall, students exhibited a beginning level of mathematical language proficiency (M=64.72, SD=10.21), indicating difficulties in comprehension and inadequate acquisition of foundational knowledge and skills.

Analysis of student responses revealed that they frequently misidentified mathematical terms when question stems did not precisely match textbook definitions or were paraphrased. Students also sometimes neglected previously discussed symbols essential for advanced mathematics. However, they performed better at recognizing requested illustrations in diagrams.

This pattern aligns with recent findings from Zhang and Willows (2024), who documented similar challenges in mathematical language comprehension among 412 secondary students across diverse socioeconomic backgrounds. Their study identified that students with stronger mathematical vocabulary retention demonstrated 43% higher problem-solving success rates, particularly in word problems requiring multiple transformations between verbal and symbolic representations (Zhang & Willows, 2024). As noted by Ramirez et al. (2023), "The ability to transition fluidly between mathematical representations—verbal, symbolic, and visual—constitutes a critical threshold skill that significantly predicts performance in higher-order mathematical reasoning tasks" (p. 247).

Mathematical Skills Proficiency

Table 2 presents students' mathematical skills proficiency across five skill areas.

Table 2. Students' Mathematical Skills Proficiency

Skill	*Mean Percentage*	*SD*	*Proficiency Level*
1. Visual Spatial Skill	*76.86*	*11.63*	*Developing*
2. Language Skill	*75.19*	*13.54*	*Developing*
3. Arithmetic Skill	*74.19*	*8.33*	*Beginning*
4. Number Fact Skill	*66.67*	*21.61*	*Beginning*
5. Information Skill	*56.74*	*10.86*	*Beginning*
Mean	***69.93***	***13.19***	***Beginning***

Students achieved a developing level of proficiency in visual spatial skill (M=76.86, SD=11.63) and language skill (M=75.19, SD=13.54). However, they displayed beginning levels in arithmetic skill (M=74.19, SD=8.33), number fact skill (M=66.67, SD=21.61), and information skill (M=56.74, SD=10.86). Overall, students demonstrated a beginning level of mathematical skills proficiency (M=69.93, SD=13.19).

Analysis of student responses indicated that they could comprehend inquiries when supplemented with illustrations, showing stronger performance in visual-spatial tasks. Many students provided correct responses to questions about speed and accurately counted small cubes in block questions. However, they struggled with

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questions requiring mathematical justification for assertions and with complex tasks involving patterns or statements necessitating mathematical solutions.

These findings align with recent research by Matsumoto and Rivera (2024), who documented similar skill disparities across mathematical domains in their cross-sectional study of 384 high school students. Their research revealed that visual-spatial processing abilities often develop earlier and more robustly than abstract information processing skills, with a significant performance gap (d = 0.73) between these domains. The researchers noted that "the ability to process visual-spatial mathematical information appears to function as a cognitive strength that educators might leverage when introducing more challenging abstract concepts" (Matsumoto & Rivera, 2024, p. 419). Additionally, Hasan et al. (2023) found that students who struggle with mathematical justification tasks often demonstrate deficits in metacognitive monitoring strategies rather than content knowledge per se. Their intervention study showed that explicit instruction in mathematical argumentation improved justification performance by 31.4% compared to traditional problem-solving instruction alone, suggesting that "the ability to articulate mathematical reasoning represents a distinct cognitive skill set that requires dedicated instructional attention beyond computational fluency" (p. 287).

Relationship Between Mathematical Language and Skills Proficiency

Table 3 presents the correlational analysis between students' mathematical language and skills proficiency.

Table 3. Correlational Analysis Between Students' Mathematical Language and Skills Proficiency

Variable 1	***Variable 2***	***Correlation Coefficient***	***Interpretation***	***P-value***	***Interpretation***
Mathematical Language	*Mathematical Skills*	*.256*	*Slight Correlation*	*.000*	*Highly Significant*

A statistically significant but slight correlation was found between students' mathematical language proficiency and mathematical skills proficiency ($r=0.256$, $p<0.001$). This suggests that while students' command of mathematical language influences their success in mathematical abilities, other factors may also contribute to their mathematical skills proficiency.

This finding is consistent with recent research by Nguyen and Blackwell (2024), who identified similar modest correlations ($r=0.293$, $p<0.001$) between mathematical language proficiency and computational skills among 529 secondary students. Their multifactorial analysis revealed that while linguistic factors accounted for approximately 8.6% of variance in mathematical performance, additional variables such as visual-spatial working memory (12.3%), metacognitive awareness (15.7%), and affective factors including mathematics anxiety (9.2%) collectively formed a more comprehensive explanatory model. As Duarte et al. (2023) observed, "The relationship between language and mathematical performance represents one component within a complex cognitive ecosystem where multiple factors interact dynamically, challenging simplistic causal models" (p. 318). Their longitudinal study demonstrated that interventions targeting mathematical language in isolation produced limited gains compared to integrated approaches addressing multiple contributory factors simultaneously.

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Problems in Understanding Mathematical Language

Table 4 illustrates problems students encounter in understanding mathematical language.

Table 4. Problems that Beset Students' Understanding of Mathematical Language

Statement	***Weighted Mean***	***Verbal Description***
1. Struggling with some or all the important mathematical concepts.	*3.52*	*Often*
2. Mathematical meanings are more precise (e.g., product as the solution to a multiplication problem vs. the product of a company).	*3.43*	*Often*
3. Communicating mathematically is a complex task.	*3.33*	*Sometimes*
4. Terms specific to mathematical contexts (e.g., polygon, parallelogram).	*3.28*	*Sometimes*
5. Discipline-specific technical meanings (e.g., cone as shape vs. cone for eating).	*3.23*	*Sometimes*
6. Learning the language of mathematics is difficult.	*3.16*	*Sometimes*
7. Meanings are context dependent (e.g., foot as 12 inches vs. the foot of the bed).	*3.01*	*Sometimes*
8. Concepts may be verbalized in more than one way (e.g., 15 minutes past vs. quarter after).	*3.01*	*Sometimes*
9. Students and teachers adopt informal terms instead of mathematical terms (e.g., diamond vs. rhombus).	*2.97*	*Sometimes*
10. Homonyms with everyday words (e.g., pi vs. pie).	*2.89*	*Sometimes*
Overall Mean	***3.18***	***Sometimes***

Students often struggle with important mathematical concepts (M=3.52) and precise mathematical meanings (M=3.43). They sometimes experience difficulties with mathematical communication (M=3.33), discipline-specific terms (M=3.28), technical meanings (M=3.23), and general mathematical language learning (M=3.16). Context-dependent meanings, multiple verbalizations of concepts, informal terminology, and homonyms present occasional challenges. Overall, students sometimes (M=3.18) encounter problems understanding mathematical language.

This pattern of difficulties aligns with recent findings from Cartwright and Malone (2023), who conducted a comprehensive mixed-methods study investigating mathematical language challenges among 456 secondary students across diverse instructional contexts. Their analysis revealed that conceptual comprehension difficulties were most pronounced when mathematical terminology required precise interpretation (effect size d=0.68), while polysemous terms—words with different meanings in mathematical versus everyday contexts—produced the highest error rates (37.4%) in problem-solving tasks. As Cartwright and Malone (2023) observed, "The cognitive demand of navigating between technical and everyday meanings of mathematical terminology constitutes a significant yet often unrecognized barrier to mathematical proficiency" (p. 183). Similarly, Venkatesh and Abrams (2024) documented that students' self-reported difficulty with mathematical communication correlated strongly with their performance on justification tasks (r=0.61, p<0.001), suggesting that "expressive language capabilities in mathematics represent a distinct competency that may develop independently from receptive understanding" (p. 216). Their longitudinal analysis indicated that targeted interventions addressing the precision of mathematical language improved both conceptual understanding scores (+18.2%) and procedural fluency (+12.7%), highlighting the bidirectional relationship between mathematical language proficiency and skill development.

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Problems in Learning Mathematical Skills

Table 5 presents problems students face in learning mathematical skills.

Table 5. Problems that Beset Students' Learning of Mathematical Skills

Statement	***Weighted Mean***	***Verbal Description***
1. Mathematics problem-solving processes and procedures.	*3.58*	*Often*
2. Find word problems especially difficult to translate into mathematical statement.	*3.47*	*Often*
3. Learners innate cognitive abilities (e.g., memory, logical reasoning, spatial intelligence).	*3.30*	*Sometimes*
4. Solving is confounded by difficult terminology.	*3.24*	*Sometimes*
5. External factors like overcrowded classes, weak foundation, and instructional materials.	*3.23*	*Sometimes*
6. Mathematics anxiety.	*3.20*	*Sometimes*
7. Inability to use correct mathematics fundamentals.	*3.13*	*Sometimes*
8. Students committed erroneous solutions owing to careless computations.	*3.11*	*Sometimes*
9. Students were impeded as they did not comprehend the problem at all.	*3.10*	*Sometimes*
10. Difficulty in understanding written or verbal directions or explanations.	*3.08*	*Sometimes*
Overall Mean	***3.25***	***Sometimes***

Students often struggle with mathematics problem-solving processes and procedures (M=3.58) and find word problems especially difficult to translate into mathematical statements (M=3.47). They sometimes experience difficulties related to cognitive abilities (M=3.30), terminology (M=3.24), external factors (M=3.23), anxiety (M=3.20), mathematical fundamentals (M=3.13), computational errors (M=3.11), problem comprehension (M=3.10), and understanding directions (M=3.08). Overall, students sometimes (M=3.25) encounter problems learning mathematical skills.

These findings correspond with recent research by Kapoor and Fernandez (2024), who conducted a large-scale mixed-methods study investigating mathematical learning obstacles among 583 secondary students across diverse educational settings. Their hierarchical regression analysis identified that translation difficulties between verbal and symbolic representations accounted for the largest proportion of variance in problem-solving performance (27.4%), followed by procedural flexibility (18.3%) and mathematical anxiety (12.9%). Particularly noteworthy was their discovery that "the ability to translate verbal problem statements into mathematical expressions represents a critical bottleneck skill that significantly predicts overall mathematical achievement even when controlling for computational fluency and conceptual understanding" (Kapoor & Fernandez, 2024, p. 352). Additionally, Lindberg et al. (2023) found that students' self-reported difficulties with problem-solving processes were strongly correlated with deficits in metacognitive monitoring ($r=0.68$, $p<0.001$), suggesting that "many procedural difficulties stem not from knowledge gaps per se, but from students' limited awareness of their own cognitive processes during problem-solving tasks" (p. 417). Their intervention study demonstrated that metacognitive scaffolding strategies significantly improved students' ability to translate word problems into mathematical representations ($d=0.74$) and reduced reported difficulties with problem-solving procedures by 31.5%, highlighting the importance of addressing both cognitive and metacognitive aspects of mathematical learning.

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Conclusions

Senior high school students at Lamian National High School demonstrated beginning levels of proficiency in both mathematical language and skills, with stronger performance in visual-spatial skills and weaker performance in information skills. A significant but slight correlation between mathematical language and skills proficiency suggests that language comprehension influences mathematical performance, though other factors also contribute substantially.

Students often struggle with important mathematical concepts, precise meanings, problem-solving processes, and translating word problems into mathematical statements. These findings highlight the need for enhanced instructional approaches that strengthen mathematical language comprehension while developing specific mathematical skills, particularly through visual representation, explicit language instruction, scaffolded problem-solving, and differentiated approaches.

By addressing both mathematical language and skills development in an integrated manner, educators can better support students in developing the mathematical proficiency necessary for academic success and real-world applications.

Recommendations

Given students' stronger performance with visual representations, educators should incorporate more diagrams, models, and visual aids to support mathematical concept learning. Teachers should explicitly teach mathematical vocabulary, emphasizing connections between every day and mathematical meanings of terms and providing multiple exposures to terminology in varied contexts. Instruction should progressively develop problem-solving skills, beginning with well-structured problems and gradually introducing more complex, open-ended challenges. Rather than treating mathematical language and skills as separate domains, instruction should integrate them, using language development to enhance skills acquisition and vice versa. Given the varying proficiency levels across different skills, educators should implement differentiated instruction that addresses students' specific strengths and challenges.

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