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Lost in Translation: Unraveling the Linguistic Codes behind Students' Struggles with Mathematics Word Problems

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Abstract **Review Article**

Mathematical word problems require students to interpret linguistic information before applying mathematical procedures, making language an important factor in problem-solving performance. This study examined the syntactic and semantic challenges experienced by first-year Bachelor of Science in Agricultural and Biosystems Engineering (BSABE) students at Quirino State University when solving College Algebra word problems. Guided by Schema Theory and the Linguistic Relativity Hypothesis, the study employed a qualitative design involving analysis of students' written examination responses and in-depth interviews with students and mathematics instructors. Findings revealed notable semantic difficulties, particularly with unfamiliar non-mathematical vocabulary (e.g., "liquidated damages") and relational expressions with multiple interpretations (e.g., "twice as old"), which hindered students' ability to construct accurate mental representations of problem scenarios. Syntactic barriers were also evident, as long sentences, compounded clauses, and embedded conditions increased cognitive load and disrupted comprehension. These results indicate that linguistic complexity can significantly affect students' success in solving mathematical word problems. The study underscores the importance of integrating language support into mathematics instruction to enhance comprehension and problem-solving.

Keywords: language proficiency, mathematical reasoning, semantic ambiguity, syntactic complexity, and word problems.

Introduction

Mathematical word problems are widely recognized as one of the most challenging aspects of mathematics learning because they require students not only to perform calculations but also to interpret written language accurately. Solving such problems involves translating verbal statements into mathematical representations while navigating complex sentence structures and specialized vocabulary. Studies indicate that linguistic features, particularly syntactic complexity and semantic ambiguity, can significantly influence students' comprehension and problem-solving performance (Hickendorff, 2021; Larivière et al., 2024; Wang, Lopez-Reyna, & Kim, 2023).

In the Philippine context, national and international assessments continue to report persistent difficulties in both reading comprehension and mathematics literacy (DepEd, 2019; OECD, 2019). These challenges may be more pronounced in rural and multilingual settings where exposure to academic English is limited. Consequently, students may struggle to understand the language of mathematical word problems even when they possess the necessary mathematical knowledge.

Although previous studies have examined the relationship between language and mathematical performance (Aforklenu & Bukari, 2023; Garcia & Chuang, 2023; Luna, Alviar, et al., 2024), limited research has investigated how specific syntactic and semantic features of word problems affect comprehension in Philippine engineering education. Addressing this gap, the present study explores the linguistic factors influencing first-year Bachelor of Science in Agricultural and Biosystems Engineering (BSABE) students' understanding and problem-solving of mathematical word problems in College Algebra. The findings aim to inform the design of clearer word problems and support instructional strategies that improve students' comprehension and problem-solving performance.

Methodology

This study employed a qualitative descriptive research design to examine the syntactic and semantic challenges encountered by first-year Bachelor of Science in Agricultural and Biosystems Engineering (BSABE) students in solving mathematical word problems in College Algebra at Quirino State University. A total of 62 first-year BSABE students participated in the initial phase of the study by completing a 15-item mathematical word-problem test covering topics such as motion, work, mixture, age, and clock problems. Extreme-case purposive sampling was used to select 12 students for in-depth analysis, consisting of the top 10% highest scorers and the bottom 10% lowest scorers. Mathematics instructors handling College Algebra were also interviewed to provide contextual insights into students' linguistic and comprehension-related difficulties.

Data were collected through document analysis of students' written responses and semi-structured interviews with selected students and instructors. Students' responses were analyzed using Newman's Error Analysis (NEA) to identify breakdowns in the stages of problem solving. In addition, a linguistic coding scheme was applied to examine syntactic features (e.g., sentence length and clause structures) and semantic features (e.g., vocabulary complexity and relational expressions) embedded in the word problems. Interview data were analyzed using thematic analysis following the procedures of Braun and Clarke (2006), while triangulation was employed to compare patterns across written responses, linguistic features, and interview findings. Ethical considerations, including informed consent, confidentiality, and voluntary participation, were observed throughout the research process.

Results and Discussions

Table 1. Participants' difficulties with mathematical word problems

Generic Theme	Subtheme	Description
Semantic Barrier	1. Technical & Unfamiliar Vocabulary	Influence of lexical unfamiliarity and non-mathematical jargon on student engagement and comprehension.
	2. Relational & Comparative Phrasing	Ambiguity involving the directionality of mathematical operators and comparative statements.

	3. Temporal & Technical Terms	Challenges arising from specialized non-mathematical nouns (jargon) and specific time-related markers that dictate the timeline of the problem.
Syntactic Complexity	4. Sentence Length & Overload	Dense sentence structures, length, and lack of explicit segmentation impose cognitive load.
	5. Lack of Explicit Segmentation	Difficulty in parsing sentences due to insufficient punctuation (commas/pauses), leading to an inability to separate distinct mathematical conditions.
	6. Embedded Conditions	Cognitive overload caused by nested clauses containing multiple numerical constraints within a single sentence.

Based on the findings presented in Table 1, students experienced significant difficulties in interpreting mathematical word problems due to both semantic and syntactic barriers. Semantic challenges were primarily associated with unfamiliar vocabulary, relational phrases, and technical or temporal expressions embedded in the problem statements. These linguistic elements often hindered students' ability to construct accurate mental representations of the scenarios, even when the required mathematical operations were relatively simple.

These findings are consistent with previous studies indicating that unfamiliar terminology and ambiguous relational language can disrupt the translation of verbal information into mathematical expressions (Bicer et al., 2021; Toxtle-Colotl et al., 2024). In addition, syntactic complexity, such as long sentences, lack of segmentation, and embedded conditions, further increased cognitive load and reduced comprehension. Research suggests that such linguistic complexity can overwhelm students' working memory and negatively affect their problem-solving performance (Lapasau et al., 2022; Octavia et al., 2023).

Table 2. Linguistic factors that affect the participants' comprehension of solving mathematical word problems

Generic Theme	Subtheme	Description
Cognitive Strategy	1. "Number-Grabbing" (The Formula-First Approach)	A dominant strategy where students bypass the text to scan for numerical values immediately, attempting to fit them into a memorized formula without understanding the context.
	2. Keyword Matching (The "Algorithm" Approach)	Reliance on specific keywords or memorized procedural steps ("algorithms") to trigger mathematical operations, often bypassing deep semantic processing.
Processing Breakdown	3. Visualization vs. Translation	While some students attempt to visualize the scenario, many fail to "translate" the English narrative into a mathematical equation, often guessing operations based on available keywords.

Based on the findings presented in Table 2, students demonstrated several cognitive strategies when solving mathematical word problems, many of which relied on procedural shortcuts rather than conceptual understanding. A common approach observed was the "number-first" strategy, in which students immediately searched for numerical values in the problem without fully interpreting the text. This tendency often led students to apply familiar formulas prematurely or guess operations when the numbers did not correspond to a known procedure. Similar findings have been reported in previous studies showing that learners frequently rely on fast, intuitive heuristics when faced with linguistically complex problems (Dayaganon et al., 2023; Wang, 2023).

Another prevalent strategy involved keyword matching, where specific words such as total, difference, or twice triggered automatic selection of mathematical operations. Although this approach sometimes produced correct answers, it often resulted in errors when problems contained unfamiliar vocabulary or required deeper contextual interpretation. Research indicates that reliance on keyword cues encourages shallow text processing and limits students' ability to interpret relational meaning within problem statements (Bednorz & Kleine, 2023; Boctot et al., 2022).

Additionally, students experienced processing breakdowns when translating problem scenarios into mathematical expressions. While some learners could visualize the situation described in the problem, they struggled to convert these mental representations into equations. This difficulty reflects the well-documented challenge of coordinating linguistic, visual, and symbolic representations during mathematical problem solving (Baumanns, 2022; Kurisappan & Pandiyan, 2024). Overall, the findings highlight how reliance on procedural strategies and translation difficulties contribute to students' challenges in interpreting and solving mathematical word problems.

Table 3. Recurring themes and patterns of misunderstanding or misinterpretation

Generic Theme	Subtheme	Description
Misinterpretation Pattern	1. Variable Assignment Reversal	A recurring error in "Age Problems" where students reverse the assignment of variables (e.g., confusing \$x\$ and \$2x\$ for "twice as old").
Contextual Confusion	2. Temporal & Conditional Shifts	Students misinterpret problems involving changing time frames (e.g., "after 5 days" vs. "on the 6th day") or complex mixture conditions.
	3. Cognitive Resignation	Attribution of mathematical difficulties to fundamental deficits in English language competence.

Analyzing the results presented in Table 3, several misinterpretation patterns were evident in students' responses to mathematical word problems. One common difficulty was contextual disconnect, where students focused primarily on numerical values while disregarding the narrative elements that explain the relationships in the problem. As a result, many learners treated the story context as unnecessary information rather than as a guide for mathematical reasoning. Research suggests that successful word-problem solving requires integrating narrative comprehension with mathematical abstraction, and failure to coordinate these processes often leads to reliance on superficial numerical cues (Yu & Li, 2022; Decristan et al., 2023).

Another notable issue involved errors in variable assignment, particularly in relational statements such as age comparisons. Students frequently misinterpreted expressions like "twice as old" or reversed variables when translating the relationships into equations. Studies indicate that such mistakes occur when learners struggle to align linguistic structures with algebraic representations, a challenge commonly associated with relational reasoning in mathematics (Lutalo-Kiingi et al., 2022; Firdausi et al., 2023).

Additionally, the findings revealed instances of cognitive resignation, where students skipped problems containing unfamiliar vocabulary or lengthy narratives. This behavior suggests that perceived linguistic complexity can discourage engagement even when the underlying mathematics is manageable. Previous research confirms that unfamiliar terminology and dense text may increase cognitive load and trigger avoidance behaviors during problem solving (Cruz Neri & Retelsdorf, 2022; Zhang & Xin, 2022). Overall, the results highlight that students' difficulties in solving word problems are strongly influenced by challenges in interpreting contextual language and translating relationships into mathematical expressions.

Table 4. Mathematics instructors' perceptions regarding the syntactic, semantic, and comprehension-related difficulties of students

Generic Theme	Subtheme	Description
Perceived Root Cause	1. Language Proficiency Gap	Instructors perceive the primary difficulty as linguistic rather than mathematical. They note that students lack the English comprehension skills necessary to parse the problems.
	2. Retention & Transfer Issues	Instructors observe that students struggle to retain logic when problem contexts are slightly altered (e.g., changing numbers or timeframes) during exams.
	3. Dependency on Translation	The pedagogical reliance on translating English problems into the native tongue (Tagalog/Ilocano) to bypass linguistic barriers and access mathematical reasoning.

The findings presented in Table 4 highlight instructors' perspectives on the factors influencing students' difficulties in solving mathematical word problems. A dominant issue identified was the language proficiency gap, where students demonstrated adequate computational skills but struggled to interpret problems written in English. Instructors observed that many learners became confused when mathematical tasks were embedded in narrative form, suggesting that comprehension of linguistic cues and relational phrases served as a primary barrier. This observation supports studies indicating that language proficiency significantly influences word-problem performance because students must first understand the textual context before identifying the mathematical relationships involved (Boonen et al., 2016; Stephany, 2021).

In addition, instructors reported retention difficulties, noting that students often understood concepts during guided instruction but struggled to apply them independently when problem contexts changed. Even minor modifications in wording or numerical values disrupted students' reasoning, indicating reliance on memorized procedures rather than flexible conceptual understanding. Previous research explains that procedural learning often limits knowledge transfer, making it difficult for learners to adapt concepts to unfamiliar situations (Ho, 2020; Sonnenschein et al., 2025).

Furthermore, instructors acknowledged students' dependency on translation, frequently converting English word problems into Filipino to facilitate comprehension. While this practice helps clarify meaning during instruction, it may also reinforce reliance on translation and hinder the development of academic English needed for independent problem solving. Studies suggest that excessive dependence on translation can restrict students' ability to interpret disciplinary language, emphasizing the importance of integrating language development with mathematical reasoning in instruction (Taner, 2022; Wawire & Barnes, 2022). Overall, these findings underscore that linguistic competence, conceptual retention, and instructional language practices play significant roles in students' ability to interpret and solve mathematical word problems.

Table 5. Proposed instructional strategies based on identified student difficulties

Area	Proposed Strategy	Description of Strategy	Basis in Transcript / Findings
Problem Construction	**Simplify Non-Math Vocabulary**	Replace unfamiliar or technical nouns (e.g., *antifreeze*, *liquidated damages*) with familiar, culturally relevant terms (e.g., *dues*, *savings*, *allowance*) during initial practice. Gradually reintroduce complex vocabulary once comprehension improves.	Students cited unfamiliar nouns as primary blockers that caused them to "freeze" or skip problems entirely.
Problem Construction	**Structural Segmentation**	Break long paragraphs into bullet points, shorter clauses, or numbered steps. Use commas, periods, and transition signals (e.g., "first," "next") to separate conditions clearly.	Students noted difficulty understanding "long, continuous text" and struggled to identify where one condition ended and another began.
Instructional Strategy	**Explicit Translation Training**	Dedicate class time to converting English phrases into mathematical symbols (e.g., *is* → "=", *of* → multiply, *less than* → subtraction reversal). Conduct guided translation drills before problem solving.	Instructors observed that students struggle in *constructing* equations—not in performing operations.
Instructional Strategy	**Scaffolding Through Culturally Relevant Contexts**	Introduce word problems using familiar cultural scenarios (e.g., *sari-sari store*, *jeepney fare*, *allowance budgeting*) before moving to foreign terms. Encourage visualization of familiar contexts.	Instructors reported success when *"Tagalog-izing or Tagalizing"* examples or relating them to students' everyday realities.
Student Strategy Development	**Context-First Reading**	Train students to read the entire problem once without focusing on numbers. First, identify the narrative, relationships, and what is being	This counters the "Number-Grabbing" habit, where students immediately look for numbers and plug them

		asked before extracting numerical information.	into a formula without understanding.

The findings in Table 5 indicate that the proposed instructional strategies directly address students' comprehension difficulties in mathematical word problems. By targeting language, sentence structure, and contextual interpretation, the strategies aim to reduce reliance on shortcuts such as number-first approaches or translation into Filipino. These strategies are designed to improve students' ability to read for meaning, translate English phrases into mathematical expressions, and engage with problems in familiar contexts.

This outcome aligns with research emphasizing that interventions focused on linguistic decoding and relational understanding enhance mathematical problem-solving (Chow, 2023; Krause, 2022; Wawire & Barnes, 2022). Thus, the data suggest that implementing these strategies can effectively strengthen students' comprehension and support more accurate and confident problem-solving in mathematics classrooms.

NEA Results and Linguistic Coding

The document analysis of students' responses using Newman's Error Analysis (NEA) indicated that most errors occurred during the reading, comprehension, and transformation stages. These breakdown points were further clarified through the linguistic coding of Problems 3, 8, 10, and 15, which revealed that each problem contained long sentences, embedded clauses, temporal shifts, and technical vocabulary that imposed a high cognitive load.

For example, students struggled with the comparative structure in Problem 3 ("slower than"), the multiple temporal references in Problem 8 ("eight years from today," "fifteen years ago"), the chronological sequencing in Problem 10 ("at the start," "after"), and the multi-step quantitative transformation in Problem 15. These linguistic features corresponded directly to NEA findings where students misread, misunderstood, or incorrectly translated these problems into algebraic equations.

Thus, the NEA results and linguistic coding jointly confirm that students' difficulties arise when they cannot parse the sentence structure or interpret the meaning of key relational and technical terms embedded in the problems.

Based on the findings of this study, it can be concluded that students' difficulties in solving mathematical word problems are primarily rooted in linguistic and conceptual comprehension rather than computational ability. While students possess the necessary calculation skills, semantic and syntactic barriers, along with reliance on shortcuts like "number-grabbing" and keyword matching, impede accurate problem-solving. Limited English proficiency further contributes to cognitive resignation, causing learners to disengage from linguistically complex problems. These results highlight the need for instructional strategies that strengthen language comprehension, relational reasoning, and conceptual understanding to support more effective and confident mathematical problem-solving.

Integrating the findings of this study, several recommendations are proposed to enhance students' performance in solving mathematical word problems. Teachers are encouraged to integrate language-focused strategies, such as Context-First approaches, structured reading drills, visualization, and text-chunking techniques, to help students decode problem statements and translate narratives into mathematical representations. A specialized English module tailored for AB Engineering students may also be developed to strengthen comprehension of technical vocabulary, relational phrases, and domain-specific contexts.

To support effective implementation, professional development and training should be provided to equip instructors with strategies that bridge English proficiency and mathematical reasoning. Differentiated instruction and targeted support should be offered to students who struggle with language comprehension to ensure equitable access to learning. Administrators are advised to foster collaborative networks among instructors for sharing best practices and refining instructional approaches. Future research should explore how integrated language-and-mathematics interventions affect problem-solving skills across different engineering courses and contexts, potentially developing a conceptual model of students' linguistic processing of word problems to inform curriculum design and teaching practices.

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