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Linguistic and Mathematical Complexity in Word Problems

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This study examines how linguistic and mathematical complexity jointly influence primary school students' performance on word problems. A total of 117 Croatian students completed a test containing four tasks that systematically varied in linguistic and mathematical complexity (simple vs. complex). The students also rated the perceived linguistic complexity of each task. Quantitative analyses were conducted to examine performance differences, interactions between complexity levels and correlations with students' complexity ratings. The findings show a pattern of interaction between linguistic and mathematical complexity. The students performed best on tasks with simple mathematical structure, indicating that low mathematical demand reduces the impact of linguistic complexity. When mathematical structure was complex, simple language became crucial: students achieved significantly higher scores on complex problems written in simple language. The lowest performance occurred when both linguistic and mathematical demands were high. The students' perceived linguistic complexity negatively correlated with performance, suggesting that student assessment of linguistic complexity can hinder problem solving. Fourth-grade students outperformed third graders, reflecting developmental progress in reading comprehension and mathematical reasoning. The results underscore the pedagogical importance of aligning word problems with students' linguistic readiness and the need for explicit instruction in academic language structures that support mathematical comprehension and problem solving.

Keywords: complex language, mathematical complexity, plain language, word problems

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Jezikovna in matematična kompleksnost v besedilnih nalogah

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Ta študija preučuje, kako jezikovna in matematična kompleksnost skupaj vplivata na uspešnost osnovnošolcev pri reševanju besedilnih nalog. 117 hrvaških učencev je opravilo preizkus, ki je vseboval štiri naloge, ki so se sistematično razlikovale po jezikovni in matematični kompleksnosti (preproste v nasprotju z zapletenimi). Učenci so ocenili tudi zaznano jezikovno kompleksnost vsake naloge. Opravili smo kvantitativne analize za preučitev razlik v uspešnosti, medsebojnih vplivov med stopnjami kompleksnosti in korelacij z ocenami učencev, kar se tiče kompleksnosti. Ugotovitve kažejo vzorec medsebojnega vpliva med jezikovno in matematično kompleksnostjo. Učenci so najbolje opravili naloge s preprosto matematično strukturo, kar kaže na to, da nizke matematične zahteve zmanjšujejo vpliv jezikovne kompleksnosti. Kadar je bila matematična struktura kompleksna, je preprost jezik postal ključen: učenci so dosegli znatno višje rezultate pri kompleksnih nalogah, napisanih v preprostem jeziku. Najnižja uspešnost je bila zaznana takrat, ko so bile visoke jezikovne in matematične zahteve. Pri učencih zaznana jezikovna kompleksnost je negativno korelirala z uspešnostjo, kar kaže, da lahko ocena jezikovne kompleksnosti pri učencih ovira reševanje nalog. Učenci četrtega razreda so dosegli boljše rezultate kot učenci tretjega razreda, kar odraža razvojni napredek na področju bralnega razumevanja in matematičnega razmišljanja. Izsledki poudarjajo pedagoški pomen usklajevanja besedilnih nalog z jezikovno pripravljenostjo učencev ter potrebo po izrecnem poučevanju akademskih jezikovnih struktur, ki podpirajo matematično razumevanje in reševanje nalog.

Ključne besede: kompleksen jezik, matematična kompleksnost, preprost jezik, besedilne naloge

Introduction

Language as a Foundation for Learning: Plain and Complex Language

Language functions as both the medium and the tool of learning, shaping how students access, understand and express knowledge, including in mathematics instruction. Comprehension is an active cognitive process in which new knowledge is organised through linguistic concepts, with words serving as tools for abstraction, integration and memory (Vygotsky, 1986). Without adequate vocabulary and syntactic skills, students may struggle to structure or express their understanding, even when conceptual knowledge is present.

In educational contexts, particularly in teaching, speech therapy and educational linguistics, two key categories of language are distinguished: *plain* or *simple* and *complex*. Each serves distinct functions and has implications for learning and instruction (Ćužić, 2019). Plain language comprises forms adapted for broad comprehension, including learners with language difficulties, early learners or non-native speakers. It features short sentences, simple syntax, familiar vocabulary and concrete meanings, often with visual or contextual support. Complex language involves advanced grammatical structures, broader and academic vocabulary, abstract concepts and multi-layered sentences, enabling expression of abstract thought, argumentation and academic development (Cummins, 2000; Nagy & Townsend, 2012). It is used to teach higher-level content and promote deep understanding. In this sense, early education requires adapted content, use of clear structures, concrete concepts and visual support, followed by gradual introduction of complex language by extending the vocabulary and presenting abstract concepts. Once acquired, complex language fosters abstract thinking, critical analysis and academic growth (Nagy & Townsend, 2012; Halliday & Martin, 1993).

The use of plain language in mathematics instruction plays a crucial role in supporting student comprehension and problem-solving abilities. Mathematical language, which includes specific terms, symbols and structures, can be a barrier for learners, especially those with limited exposure to formal mathematics or with language difficulties (Lenček et al., 2025). Research shows that tasks formulated in clear, concise and familiar language reduce cognitive load, allowing students to focus on the underlying mathematical concepts rather than decoding complex wording (Moschkovich, 2013). In this sense, teachers have to be aware of the issues in acquiring mathematical language and must be creative in supporting student learning. Kuzle (2013) emphasises the need to develop writing competencies among mathematics teachers as an essential component of effective mathematical communication, highlighting the importance of integrating mathematical notation and visual representations with verbal explanations. As stated by Jourdain and Sharma (2016), language is both a barrier and a solution to participating in mathematics instruction. In order to achieve success in mathematics, students must master the specific terms and ways of expressing ideas that set mathematical language apart from everyday English. Mathematical concepts should therefore be elaborated in language that gradually transitions from ordinary language understood by the students to more complex language (Schleppegrell, 2007). By simplifying language at early levels of education, without altering the mathematical meaning, educators can enhance accessibility and foster deeper understanding among diverse learners. Furthermore, they can impact students' attitudes and self-confidence, as these decrease if students perceive maths as challenging. For the purpose of the present paper, and in order to ensure clarity, the term *simple language* (i.e., low linguistic complexity) will be used as a synonym for plain language.

Word Problem Tasks in Teaching Mathematics

Mathematical word problems are problem situations in which mathematical relations appear within a short, logically structured unit of text, with the goal of reaching the unknown quantity from the known conditions (Markovac, 2001). They allow students to connect mathematical knowledge with everyday situations and develop the ability to translate language descriptions into mathematical models. In their investigation of the quality of mathematical reasoning tasks designed by student teachers, Masriyah et al. (2024) highlight the pedagogical importance of incorporating such tasks into mathematics instruction. They argue that the successful formulation of reasoning problems requires not only adherence to established criteria for mathematical reasoning but also the use of clear, precise and linguistically accessible instructional language. Solving school word problems often poses difficulties precisely because they contain two parallel demands: understanding the linguistic representation and transforming that representation into a mathematical expression (Kurnik, 2010). Mathematical word problems connect mathematical concepts with real-life situations and require deep comprehension of the problem. Unlike pure computational tasks, word problems involve interpreting a description of a situation, identifying relevant information and recognising relationships among quantities, which requires students to integrate linguistic, cognitive, and mathematical processes (Cooper & Dunne, 1999; Verschaffel et al., 2002). Such tasks promote the development of mathematical literacy and the ability to model real situations, with text comprehension emerging as a crucial prerequisite for successful problem solving (Adu-Gyamfi et al., 2010; Hickendorff, 2013).

Correct comprehension of a word problem is essential, as students must identify relevant information, determine unknowns and conditions, and restate the task before applying mathematical procedures (Polya, 2003). Solving word problems requires shifting between everyday language and mathematical language, involving interpretation, formalisation and reformulation of results (Posokhova, 2001). Success therefore depends on text comprehension, mathematical literacy, persistence and the quality of the task, which should be realistic, clearly formulated and linguistically appropriate to support motivation and understanding (Markovac, 2001; Ovčar, 1987).

The role of language in mathematical word problems is multifaceted and well documented. Mathematical texts often differ from everyday language because they are dense with information and include specific discourse and structures (Österholm, 2006; Österholm & Bergqvist, 2013). This specificity means that students with strong general reading skills are not necessarily successful in reading mathematical problems. The linguistic complexity of the text – such as sentence length, vocabulary complexity, implicit links and information density – increases cognitive load and may hinder the recognition of the mathematical structure of the problem (Bergqvist et al., 2018; Leiss et al., 2019).

Research shows that success in mathematics, particularly in word problems, is closely linked to students' reading comprehension abilities (Caponera et al., 2016; Vilenius-Tuohima et al., 2008). Students with weaker text comprehension often misinterpret problems before applying mathematical procedures, and studies using reading time and eye-tracking confirm that greater linguistic complexity increases processing difficulty and errors (Leiss et al., 2019; Sanz et al., 2020; Strohmaier et al., 2019). Consequently, the complexity of mathematical word problems arises from the interaction of linguistic and mathematical factors, both of which must be considered when analysing or designing tasks (Daroczy et al., 2015).

Linguistic complexity particularly affects certain groups of students, such as those with reading difficulties and those learning in a language that is not their mother tongue. These students often exhibit differential item functioning: the mathematical task becomes harder not because it is mathematically more demanding, but because it is linguistically more complex (Martiniello, 2009). In the Croatian context, the correlation between reading and mathematical word problems was demonstrated by Lakuš and Erdeljac (2012), who studied children with dyslexia and found that their reading difficulties impact their understanding, and consequently their success, in solving word problems. Lenček et al. (2025) provided an overview of mathematical language in Croatian and its challenges for students with dyscalculia. They highlighted that teaching mathematical language should be a structured and integral part of the curriculum for all students. Studies show that simplifying linguistic structure, removing ambiguities and reducing syntactic complexity can significantly improve problem-solving success without compromising mathematical content (Johnson & Monroe, 2004), confirming that failure in solving word problems sometimes reflects not a lack of mathematical competence but difficulties in linguistic processing (Shorrocks-Taylor & Hargreaves, 1999).

At the level of problem-solving processes, research indicates that students often rely on superficial strategies of imitation or pattern recognition instead of analysing relationships between quantities (Sidenvall et al., 2015). When the text of the task is complex, students drift further away from analytic strategies and shift toward heuristic or incorrect approaches. Likewise, many contextual problems in textbooks actually require more reading than mathematical skills, leading to information overload and hindering mathematical modelling (Wijaya et al., 2015).

Finally, results from genetic and cognitive studies suggest that the connection between success in language and mathematics is deeply rooted. Large twin studies reveal that the same cognitive and genetic factors influence reading, mathematical comprehension and general academic abilities, further emphasising the need for integrated approaches to teaching and assessment (Haworth et al., 2009).

Lexical and Semantic Complexity in Mathematics

Mathematical language is thought to be inherently precise. In mathematics instruction, however, students often encounter linguistic barriers arising from the lexicon itself: words that are polysemous, have everyday meanings as well as specialised mathematical meanings or are linguistically ambiguous, hindering content comprehension. Words such as "product", "sum", or "square" carry everyday meanings that differ from their mathematical definitions, making linguistic simplification essential (Núñez et al., 2020:45). The word "square" in everyday English means "plaza/town square" whereas in mathematics/algebra, it is used in the context "to square a number" (e.g., 2 x 2 = 4) (Prediger et al., 2019).

Having studied ambiguity in the mathematics classroom and compared formal and discursive models of teaching mathematical concepts, Barwell

(2005) highlights the limitations of a formal model that views ambiguity as a problem to be resolved. He suggests embracing ambiguity, as it can foster a dynamic learning environment where students actively construct meaning. Educators should therefore enable and encourage discussions that allow exploration and negotiation of mathematical language. Hickendorff (2021) shows that linguistic complexity, including both lexicon and syntax, is a significant factor in mathematics learning. When students are not familiar with the distinctions in meaning, "mathematicising" errors may occur, i.e., students apply everyday meanings despite the requirement for specialised mathematical meanings.

In the Croatian context, a study by Lenček et al. (2025) shows that mathematical language in Croatian is marked by significant lexical and semantic complexity as early as in the first grade, where students are confronted with vocabulary and expressions that differ in meaning from everyday language. Mathematical terms in Croatian have multiple meanings, and the meaning in a mathematical context may not correspond to the everyday meaning; for example, a collection of exercises for the third grade of primary school includes the following task: "Will the difference change if we add the same number to both the minuend and the subtrahend? YES – NO" (Markovac, 2019a). As well as including complex syntax, such tasks require knowledge of words such as "*razlika*/difference", "*umanjenik*/minuend" and "*umanjitelj*/subtrahend", which children do not know unless they are explicitly taught. A similar situation can be found in a textbook for the fourth grade of primary school (Cindrić et al., 2025): "An equilateral triangle and an isosceles triangle share a common side of 45 dm. What is the length of the triangle equal side if the perimeter of the equilateral triangle is 5 m smaller than the perimeter of the isosceles triangle?". The task abounds in mathematical concepts that require explicit teaching, such as "*jednakostranični*/equilateral", "*jednakokračan*/isosceles", or "*opseg*/perimeter". Benjamin (2013) argues that many teachers deny the conversational meaning of mathematical terms, suggesting it would be better to acknowledge and draw from the original meaning and background knowledge about mathematical concepts and then narrow the word from the familiar to the mathematical meaning.

The same study indicated semantic complexity. The concept of semantic transparency refers to the degree to which the meaning of a complex word can be inferred from the meanings of its components (morphemes) or familiar vocabulary (Sun, 2024). In mathematics, high transparency helps students relate new words to known concepts, e.g., triangle (tri + angle) is relatively transparent. Conversely, terms like "irrational" (Croatian: *iracionalan*) have low transparency for many students, as they are unable to easily decompose the word into familiar parts. Low transparency increases the linguistic barrier and the risk that the student will not fully understand the term; words like "*suma*" (sum) or "*proizvod*" (product) are not immediately interpretable without explanation and context.

Relying on Sharma's six stages of acquiring mathematical skills and concepts, Posokhova (2001) emphasises that teachers often start introducing new mathematical concepts from the abstract level, skipping one or several stages and causing difficulties in understanding among students. Erath et al. (2018) suggest that the discursive practice of explaining should be an explicit learning goal in mathematics instruction in order to compensate for differences in students' background knowledge. A lexically informed approach is recommended to support mathematics learning, involving explicit introduction of mathematical terminology, use of visual and linguistic supports, semantically transparent terms and avoidance of unexplained polysemous vocabulary.

Syntactic Complexity in Mathematics

Syntactic complexity refers to sentence structure, length, subordinate clauses and logical connections (Ćužić, 2019). Word problems often contain long, multi-clausal sentences with embedded conditions, complicating the extraction of relevant information (Lenček et al., 2025). The same authors emphasise that syntactic rules in mathematical language do not necessarily comply to the native language rules, which is why some sentences might be challenging. In the context of mathematics, syntax has proven to be a challenge in many languages, especially for children struggling with mathematics in general (Chow et al., 2021).

In practice, the collection of exercises for the third grade of primary school includes tasks such as: "What is the sum if the first addend is 47 and the second addend is: 26, 18, 37, and 29?" (Markovac, 2019a). In addition to including abstract mathematical language (*pribrojnik*/addend), which needs to be explicitly taught to children as they cannot relate it to anything in their everyday lives, such a sentence requires parsing multiple clauses and conditional relationships. As there are multiple conditions embedded in a single sentence, children have to simultaneously interpret the meaning of the words and the implicit logical links between the provided data and task requirements. The same complexity of lexis and syntax can be found in the collection of exercises for the fourth grade of primary school: "The sum does not change if we add the same number to one addend and subtract it from the other. Check it!" (Markovac, 2019b). The combination of lexical and syntactic complexity increases the difficulty of the task.

Even when there is no lexical complexity, complex syntax might cause difficulties in understanding mathematical word problems. Students often fail to parse complex sentences correctly, skipping or misinterpreting clauses, which leads to errors (Lenček et al., 2025). It is therefore suggested that multi-clausal sentences be broken down into single-clause sentences. Furthermore, combining simple syntax with simple vocabulary results in better understanding of mathematical tasks and enhanced accessibility. Research implemented with English language learners by Barbu and Beal (2010) supports this claim, finding that cognitive and linguistic demands, both in terms of vocabulary and syntax, faced by English learners when solving math problems negatively impact their success. Separating clauses and clearly stating conditions in a mathematical task reduces cognitive load, allowing students to focus on calculations rather than parsing (Lenček et al., 2025). Such strategies enable the language in mathematics instruction to become a facilitator of learning, supporting both comprehension and cognitive development.

Research Aim and Hypotheses

The present study aimed to examine how linguistic and mathematical complexity jointly affect primary school students' performance on mathematical word problems, with particular emphasis on cognitive load and the role of syntactic and lexical features in task comprehension. Based on the theoretical framework and the research aim, the following hypotheses were formulated:

- *There is a statistically significant difference in student performance between word problems with simple and complex language.*
- *There is a statistically significant interaction between linguistic complexity and mathematical complexity of word problems in the context of explaining student performance.*
- *There is a statistically significant correlation between the estimated linguistic complexity of the text and student success in solving tasks.*
- *There is a statistically significant difference in performance between third- and fourth-grade students on tasks with complex language.*

Method

Participants

A total of 117 students from two primary schools in Croatia participated in the study: 62 third-grade students and 55 fourth-grade students (six different classes), aged 8–10. All of the students attended regular classes and had no documented specific difficulties in reading, writing or learning mathematics (such as dyslexia, dysgraphia, dyscalculia or language comprehension difficulties). This criterion ensured that differences in performance stemmed from the manipulated word problem features (language and mathematics) rather than from individual difficulties.

Instrument

The research instrument consisted of a test with four mathematical word problems set in everyday contexts and designed to combine linguistic and mathematical complexity in four variants. The tasks were created by the authors, who are experts in mathematics and language. Two versions of the instrument were used: one for the third grade and one for the fourth grade. The versions differed in linguistic and mathematical demands appropriate to the students' age. In order to ensure the clarity and appropriateness of the word problems, the authors consulted primary school teachers, and certain formulations were adapted based on their suggestions.

The mathematical complexity of the complex word problems used arises from the need to coordinate multiple operations and translate real-life situations into mathematical relationships, which increases cognitive load. Mathematical complexity therefore refers to the cognitive demands imposed by the mathematical structure of the task, such as the number of operations and the relationships between quantities (Hickendorff, 2021). It includes several subcomponents: number of operations, type of operation, position of the unknown, numerical properties and problem structure. Mathematically complex tasks require procedural planning and integration of successive operations, making them cognitively more challenging than simpler problems. The difference between the third- and fourth-grade word problems corresponds to the outcomes defined by the mathematics curriculum.

Linguistic complexity refers to the properties of the problem text that affect its comprehensibility, including high lexical density, semantic embedding and syntactic complexity, requiring students to integrate multiple levels of linguistic processing before constructing a mathematical model (Daroczy et al., 2015). Extended sentence structures and distributed information in these tasks significantly increase linguistic processing load. Previous research identifies linguistic complexity in word problems as a multidimensional construct encompassing lexical and syntactic complexity, semantic relations, discourse structure and overall information density (Daroczy et al., 2015; Jaffe & Bolger, 2023).

In the present study, the terms linguistic complexity and mathematical complexity are used consistently throughout. Where relevant, linguistic complexity is operationalised through lexical, syntactic and semantic features, while mathematical complexity denotes the cognitive demands of the task structure.

The tasks and their main characteristics in terms of complexity are presented in Table 1.

Table 1
Task Descriptions and Features

Tasks and their complexity	Task	Mathematical complexity features	Linguistic complexity features
Task 1: Simple language, simple mathematics	Grandma bought 84 plums at the market to make jam. The plums are packed in containers with 7 plums in each. How many containers did Grandma buy? (numbers 27 and 9 were used for third-graders)	Single mathematical operation	Familiar everyday vocabulary, simple sentences, explicit semantics
Task 2: Complex language, simple mathematics	In a school supplies store, Marija found packs of markers, each containing 16 markers. She decided to purchase four such packs, as she does not want to run out of colours during the school year. Determine the total number of markers that Marija bought in the store. (12 and 4 were used for third-graders)	Simple mathematical operation	Density of informational nouns, extended long sentences with embedded clauses, implicit semantics
Task 3: Simple language, complex mathematics	The students sold 84 tickets on Monday. On Tuesday, they sold 7 times more tickets. How many tickets did they sell in total? (instead of 7 times more, 16 more tickets was used for third-graders)	Multiple interconnected mathematical operations, implicit mathematical operations	Familiar everyday vocabulary, simple sentences, explicit semantics

Tasks and their complexity	Task	Mathematical complexity features	Linguistic complexity features
Task 4: Complex language, complex mathematics	For a school trip to the Biokovo Nature Park, a total of 102 students have registered. The organisers have buses available, each with 8 seats. Calculate how many buses are needed to accommodate all of the students and determine whether one additional bus will be required if 4 more students register. (buses with 36 seats are used for third-graders)	Multiple interconnected mathematical operations, implicit mathematical operations, estimating (division)	Density of informational nouns, extended long sentences with embedded clauses, implicit semantics

After completing each task, the students were asked to rate the complexity of the text and the mathematical component on a scale from 1 to 5. For linguistically complex tasks, the students additionally indicated whether the complexity referred to words, sentences or a combination of both. The instrument therefore recorded both actual performance and the students' perception of task complexity. The study was conducted during regular class time. Teachers instructed the students to carefully read each task, write their solution and then rate the complexity of the language and mathematics. It was emphasised that the task was not graded and that the answers should be completed independently. The process for one class lasted approximately 15–20 minutes, depending on the students' pace.

Research Design

The study was conducted within a quantitative comparative design, structured to systematically examine the students' performance across different levels of linguistic and mathematical complexity in word problems. The scales used in the instrument demonstrated acceptable reliability: ratings of linguistic complexity yielded a Cronbach's alpha of 0.66, which is satisfactory given the small number of items, while ratings of mathematical complexity were reliable with an alpha of 0.75. These results confirm that the tasks consistently measured what they were intended to measure: linguistic and mathematical complexity, as well as students' assessments. The tasks were scored with one point for a correct answer and zero points for an incorrect answer. The responses were collected, coded and entered into SPSS for subsequent statistical analysis. The data were analysed using descriptive statistics and the following inferential procedures were applied: a paired-samples *t*-test, a two-way repeated-measures

ANOVA, Spearman's rank correlation coefficient and Levene's test of homogeneity of variances. Differences between the groups (third- and fourth-grade students) were additionally examined using an independent-samples *t*-test.

Results and Discussion

First, a descriptive overview of performance for each task (Table 2) will be provided. It should be noted that Task 1 is simple both linguistically and mathematically, Task 2 is mathematically simple but linguistically complex, Task 3 is linguistically simple but mathematically complex and Task 4 is complex in both aspects.

Table 2
Performance by Tasks

	N	*Mean (0-1)*	*Std. Deviation*	Accurately solved
Task 1	117	.73	.448	72.6%
Task 2	117	.74	.563	68.4%
Task 3	117	.25	.434	24.8%
Task 4	117	.10	.305	10.3%

The frequency distribution of correct answers shows a clear pattern: the students achieved high performance on word problems with simple mathematics (72.6% and 68.4% correct answers) and considerably lower performance on word problems with complex mathematics (24.8% and 10.3%). The combination of complex language and complex mathematics resulted in the lowest scores.

The data were also analysed in the context of the hypothesis stating that *there is a statistically significant difference in student performance between word problems with simple and complex language*. Paired-sample t-tests revealed different effects of linguistic complexity depending on the level of mathematical complexity.

Table 3
T-test Results

		T	*Df*	Sig. (2-tailed)
Pair 1	Task 1 – Task 2	-.159	116	.874
Pair 2	Task 3 – Task 4	3.418	116	.001

In word problems with simple mathematics (Tasks 1 and 2), no statistically significant difference in performance was found between simple and complex language, $t(116) = -0.16$, $p = .874$. However, in word problems with complex mathematics (Tasks 3 and 4), a statistically significant difference was observed, $t(116) = 3.42$, $p = .001$, with the students achieving higher scores on the task with simple language. These results indicate that linguistic complexity is particularly important when the mathematical content is also cognitively demanding. Such results comply with those of Barbu and Beal (2010), who found that English learners were significantly worse in solving word problems when they were written in more complex language, and the worst when problems were both linguistically and mathematically challenging. This supports the idea that linguistic load adds to cognitive load in mathematics tasks. A study by Hickendorf (2021) also argues that linguistic complexity – not just arithmetic operations – is a critical factor in complex word problems. When language is complex, cognitive load is greater and it is therefore more difficult to retain numbers, conditions and operations in mind, resulting in worse performance.

In order to examine the extent to which linguistic and mathematical complexity affects student performance in solving mathematical word problems, a two-way repeated measures analysis of variance was conducted. Since all of the students completed all four tasks, this approach allowed for precise examination of the main effects of each factor separately as well as their interaction.

The analysis revealed a statistically significant main effect of language, $F(1, 116) = 22.65$, $p < .001$, $\eta^2 = .163$, indicating that the students achieved significantly higher scores on tasks with simple language ($M = .731$) than on tasks with complex language ($M = .175$). A statistically significant main effect of mathematical complexity was also observed, $F(1,116) = 13.16$, $p < .001$, $\eta^2 = .102$, indicating that the students performed significantly better on tasks with simple mathematical structures compared to those with complex mathematical demands. However, the interaction between linguistic and mathematical complexity was not statistically significant, $F(1,116) = 2.90$, $p = .091$, $\eta^2 = .024$, suggesting that the effects of linguistic and mathematical complexity operate independently.

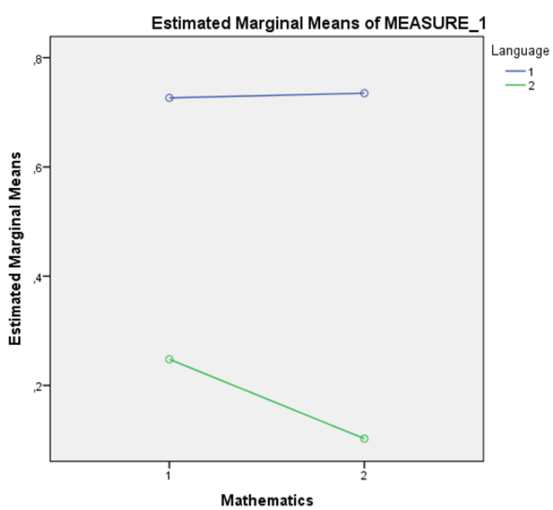
Estimated marginal means (Table 4) show that performance decreases as both linguistic and mathematical complexity increase. However, these effects operate independently, as indicated by the non-significant interaction.

Table 4
Estimated Marginal Means for Linguistic and Mathematical Complexity
(1-simple,2-complex)

LANGUAGE * MAT					
LANG	*MAT*	*Mean*	*Std. Error*	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	.726	.041	.645	.808
	2	.735	.052	.632	.838
2	1	.248	.040	.168	.327
	2	.103	.028	.047	.158

A graphical representation of the estimated marginal means further illustrates the effects of linguistic and mathematical complexity on student performance (Figure 1). It is evident that performance is higher for tasks with simple language compared to complex language, regardless of mathematical complexity. Additionally, performance decreases as mathematical complexity increases, indicating that both linguistic and mathematical factors negatively affect performance. Although the descriptive pattern suggests a potential interaction between linguistic and mathematical complexity, this effect was not statistically significant in the present study.

Figure 1
Estimated Marginal Means of Measure



The results suggest that both linguistic and mathematical complexity independently contribute to student performance in solving word problems. While linguistic complexity affects reading comprehension and interpretation of the problem, mathematical complexity influences the cognitive demands related to numerical reasoning and problem-solving processes.

These findings are consistent with previous research indicating that both language and mathematical complexity can pose challenges for students, particularly in multi-step and context-rich problems (Barbu & Beal, 2010; Hickendorff, 2021). When mathematical operations are simple, students may rely more on basic computational skills, whereas more complex tasks require deeper understanding and integration of both linguistic and mathematical information.

In order to examine the relationship between the students' ratings of linguistic complexity and actual task performance, a Spearman correlation was calculated. The results revealed a statistically significant negative correlation between the perceived linguistic complexity of the text and student performance, $\rho = -.37$, $p < .001$. This confirms the hypothesis that *there is a statistically significant correlation between estimated linguistic complexity and student success in solving tasks*. The students who rated the word problems as more complex achieved lower scores, which supports the notion that perceived linguistic complexity constitutes a barrier to mathematical problem-solving and aligns with theories of cognitive load and language processing.

Previous studies have shown that mathematics performance is negatively related to math anxiety and perceived complexity, and positively related to enjoyment, self-confidence and positive self-assessment (Ruijia et al., 2022; Živković et al., 2021). These findings align with the present study, which also identified a negative association between the students' perceived complexity and their performance on word problems. Overall, the results suggest that mathematical success is shaped by both cognitive and affective factors, as negative perceptions and emotions can reduce motivation and engagement, leading to poorer outcomes.

Beyond the established link between perceived linguistic complexity and performance, the students' responses revealed a clear pattern in how linguistic demands were experienced. Only 1.7% of the students identified vocabulary as the sole source of complexity, while 46.2% pointed to long and syntactically complex sentences, and 52.1% reported challenges with both vocabulary and sentence structure. These findings confirm that linguistic complexity extends beyond individual words to broader features such as sentence length, syntactic complexity and information density, which can hinder comprehension and reduce performance.

Syntactic comprehension – understanding sentence structure and complex sentences, as well as identifying relevant and irrelevant clauses – can be a stronger predictor of success in solving word problems than simple vocabulary knowledge (Chow & Ekhlom, 2019). When students describe a word problem as complex, they often refer to confusing sentence structure rather than challenging vocabulary, particularly in mathematically complex, multi-step tasks, where syntactic and discourse complexity increases cognitive load. Careful design of syntactically clear word problems and explicit instruction in identifying key information, discarding irrelevant details and rephrasing problems in simpler syntax can therefore support student comprehension and performance.

An analysis of differences between grades showed that the level of schooling plays a significant role in student performance in linguistically complex word problems. A Levene's test indicated that the variances of the two groups were not equal. The resulting t-test showed that the fourth-grade students were statistically significantly more successful in solving linguistically complex tasks compared to the third-grade students.

Table 5
T-test Results

	t-test for Equality of Means		
	Std. Error Difference	95% Confidence Interval	
		Lower	Upper
Harder_linguistic_mean	.05898	-.28727	-.05349

This confirms the hypothesis that *there is a statistically significant difference in performance between third- and fourth-grade students on tasks with complex language*. The average overall performance of the fourth-grade students (M = .51, SD = .26) was notably higher than that of the third-grade students (M = .34, SD = .37), representing a difference of approximately 17% points. This result indicates that older students possess more developed linguistic skills, such as a richer vocabulary, better ability to comprehend longer and syntactically more complex sentences, and more efficient extraction of key information from the text. These competencies develop naturally during primary education and enable fourth-grade students to process and interpret demanding mathematical word problems more effectively. The observed difference is therefore both expected and theoretically justified. Accordingly, Hickendorff (2021) emphasises that student experience plays a crucial role in solving linguistically complex word problems, as older students more easily translate situational language into mathematical models. Gradually introducing word problems of increasing linguistic and mathematical complexity may help manage cognitive load and support the progressive development of students' linguistic and problem-solving capacities (Hickendorff, 2021).

Conclusion

The present study examined the interaction between linguistic and mathematical complexity in primary school students' performance on mathematical word problems. The results showed that low mathematical complexity mitigated the negative effects of linguistic complexity, whereas low linguistic complexity significantly improved performance on mathematically complex tasks, with the poorest outcomes occurring when both demands were high. A significant negative correlation was also found between perceived linguistic complexity and performance, with the participating students attributing complexity mainly to syntactic complexity and informational density, while the fourth-grade students outperformed the third graders, indicating developmental gains in language-related mathematical competence.

In terms of limitations, the sample was restricted to two grades within a single educational context, thereby limiting the generalisability of the findings. The linguistic manipulations may not capture all dimensions of real-world language variation in textbooks. Additionally, the students' ratings of linguistic complexity reflect individual perceptions that can be influenced by factors such as self-confidence or prior experience with similar tasks.

Future research could expand the age range, include diverse educational settings and investigate additional linguistic features in order to deepen understanding of how language shapes mathematical reasoning. Future studies should also include older primary and secondary school students in order to examine how sensitivity to linguistic and mathematical complexity develops with age and increasing curricular demands.

The findings highlight the need to align word problems with students' linguistic readiness, especially when mathematical demands are high. Explicit instruction in mathematical syntax and scaffolded support can reduce unnecessary linguistic load and strengthen students' academic language skills essential for problem solving. Overall, the study provides evidence that addressing the language dimension of mathematics can improve comprehension, reduce cognitive load and promote more equitable mathematical achievement.

Ethical Statement

The research was conducted in accordance with ethical standards for educational research. Participation was voluntary, informed parental consent was obtained prior to data collection, and all of the data were collected and analysed anonymously to ensure confidentiality. The study was conducted in partner primary schools affiliated with the Faculty of Humanities and Social Sciences, University of Split, which are authorised training schools approved by the Ministry of Science and Education. The research was approved by the Ethics Committee of the Faculty of Humanities and Social Sciences in Split, Croatia.

Data Availability Statement

The datasets generated and analysed during the current study are not publicly available due to data protection and confidentiality requirements, particularly given the involvement of minors as participants, but are available from the corresponding author on reasonable request.

Disclosure Statement

The authors have no conflict of interest to declare.

When preparing this article, the authors used ChatGPT on 5 December 2025 with the following prompt for the purpose of proofreading and language editing: "Please proofread and linguistically refine the following text. Do not alter the original meaning or add new information. Focus only on grammar, style, clarity, and academic tone." The authors subsequently reviewed and edited the output as necessary and accept full responsibility for the content and integrity of the publication.

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