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RECOGNIZING EVERYDAY MATHEMATICAL CONCEPTS IN A TEXT DEPICTING DAILY LIFE

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Abstract/Izvleček

This research investigates the relationship between mathematics teachers' performance and students' recognition of everyday mathematical concepts in real-world texts. A quantitative, non-experimental, multilevel correlational design was employed, utilizing Hierarchical Linear Modeling (HLM) to analyze nested data from 17 teachers and 796 middle school students. A text depicting daily life served as the data collection instrument. Results showed a statistically significant but limited fixed effect for teacher performance, explaining 6.2% of Level-2 variance. Regarding student-level factors, sixth graders underperformed compared to fifth and seventh graders, while gender showed no significant differences, supporting evidence of gender parity.

Ključne besede:
everyday mathematical concepts, HLM, teacher effects, grade level, gender.

Prepoznavanje vsakdanjih matematičnih pojmov v segmentu vsakdanjega življenja

Ta raziskava preučuje odnos med uspešnostjo učiteljev matematike in zmožnostjo učencev za prepoznavanje vsakdanjih matematičnih pojmov v besedilih iz stvarnega sveta. Uporabljen je bil kvantitativen, neeksperimentalen, večnivojski korelacijski načrt, pri čemer je bilo za analizo gnezdenih podatkov 17 učiteljev in 796 osnovnošolcev uporabljeno hierarhično linearno modeliranje (HLM). Kot instrument za zbiranje podatkov je služilo besedilo, ki opisuje vsakdanje življenje. Rezultati so pokazali statistično značilen, a omejen fiksni učinek uspešnosti učiteljev, ki pojasnjuje 6,2 % variance na ravni 2 (Level-2). Glede dejavnikov na ravni učencev so šestošolci dosegli slabše rezultate v primerjavi s petošolci in sedmošolci, medtem ko pri spolu ni bilo zaznati značilnih razlik, kar potrjuje dokaze o enakosti spolov.

Keywords:
vsakdanji matematični pojmi, HLM, učiteljski učinki, razredna stopnja, spol.

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Introduction

Connecting mathematics to real-life situations is an essential aspect of mathematics teaching that aids in the integrated development of students' mathematical proficiency (NCTM, 2000; NRC, 2001). When lessons are rooted in everyday contexts, they become more relevant and engaging for students (Morris, 2003). For instance, out-of-school activities, such as those involving real money and shopping, play a crucial role in shaping the mathematical knowledge students bring into the classroom (Nunes et al., 1993). Therefore, integrating students' daily experiences with formal instruction is strategically mediated using everyday language, which serves as a critical bridge between students' real-world understanding and formal mathematical concepts. By translating mathematical symbols and ideas into the familiar context of daily speech, language supports students in recognizing mathematical principles embedded in authentic situations (Meiers and Trevitt, 2010). Ideally, math problems should incorporate words, symbols, and events that students encounter daily, providing opportunities for them to express mathematical terms in personally meaningful ways while negotiating the difference between everyday and formal classroom discourse (Adams et al., 2005).

However, while the pedagogical value of connecting mathematics to real-life contexts has long been recognized—especially within the frameworks of Realistic Mathematics Education (RME) (Freudenthal, 2002) and Contextual Teaching and Learning (CTL) (Johnson, 2002)—a closer examination of the existing literature reveals a critical gap that this study directly addresses. Prior research overwhelmingly concentrates on the later phases of mathematization, such as solving, interpreting, or modelling (Blum & Borromeo Ferri, 2009), typically assuming that the initial act of identifying the mathematical structure embedded within a realistic context occurs naturally and effortlessly (Stillman, 2011; Verschaffel et al., 2000). This assumption has rarely been scrutinized empirically.

The present study challenges that premise by shifting attention to: the ability to detect and recognize mathematical concepts within everyday texts before any formal solution process begins. This focus constitutes a departure from established RME/CTL work, which generally presumes that learners will seamlessly notice the mathematically relevant features of a context. Findings suggest that this noticing process is neither automatic nor trivial and may itself be a source of inequality in students' opportunities to mathematize real-world situations. Furthermore, Halliday's (1978) notion of the mathematical register

includes the capacity to unpack mathematical meanings that are embedded—often implicitly—within natural language. Similarly, Niss and Højgaard (2011) conceptualize such decoding as a prerequisite competence for participating in the mathematization process. Consequently, measuring "concept recognition in text" is not peripheral to mathematical language proficiency; it operationalizes a foundational component of it. Without the ability to identify mathematical structures in context, students cannot meaningfully engage in the discourse practices that RME and CTL assume. Thus, this study extends these theoretical traditions by empirically testing a competence that is logically prior to the types of communication typically examined.

Spontaneous (everyday) concepts and scientific (formal) concepts

When relating mathematics to everyday life for meaningful mathematics instruction, the interplay between language and conceptual development is critical. Within this context, the study adopts a synthesized framework that bridges Vygotsky's (1986) classic distinction between concept types with contemporary views on Mathematical Literacy (OECD, 2019) and Language as a Resource (Moschkovich, 2015).

Vygotsky emphasizes the interdependence of two conceptual types: spontaneous concepts, which emerge from personal, unsystematic everyday experiences, and scientific concepts, which are acquired through formal, structured instruction. Spontaneous concepts provide the necessary intuitive foundation, while scientific concepts restructure this thinking into a systematic whole. In the context of this study, Vygotsky's theory is operationalized by treating the 'concept recognition task' as the cognitive interface between these two domains. The everyday text represents the realm of spontaneous concepts (informal, context-dependent), while the mathematical terms to be identified represent scientific concepts (formal, systematic). Success in this task, therefore, indicates the successful mapping of spontaneous understandings onto formal scientific terminology.

This mapping process aligns with Moschkovich's (2015) perspective of 'language as a resource,' which argues that students' everyday language practices are not deficits but essential starting points for mathematical reasoning. Similarly, the OECD/PISA (2019) framework defines mathematical literacy as the capacity to formulate situations mathematically—a process that explicitly requires decoding the mathematical structure hidden within real-world (spontaneous) contexts. This interdependence can be illustrated through specific mathematical applications.

Abstract scientific concepts, such as zero or volume, are more effectively mastered when anchored in spontaneous perceptual experiences (Vygotsky, 1986). For example, a child's informal notion of "nothing there" (spontaneous) serves as a conceptual scaffold for approaching the formal symbol 0 (scientific) (Lakoff & Núñez, 2000). However, teachers must clarify that these everyday analogies are not literal definitions, as the number 0 possesses intrinsic formal properties. Similarly, everyday experiences of heaviness or fullness provide the initial grounding for formal concepts of mass and volume. Thus, 'recognizing' a concept in text is interpreted here as the moment where the student recruits their spontaneous resources to access the scientific register.

Furthermore, pedagogical guidelines such as the NCTM (2000) communication standard support this transition. By allowing students to use informal language initially and guiding them toward precision, instruction respects the Vygotskian trajectory from spontaneous to scientific. This approach is validated by empirical examples, such as Meriwether (1997) using food arrangements to teach geometry, or Dowling (1992) utilizing comparative situations (Schleppegrell, 2004).

Teachers' use of mathematical language

Spontaneous, everyday concepts provide students with informal, intuitive, and experience-based understandings that form the foundation for learning formal mathematical concepts (Nelson, 1995; Vygotsky, 1986). Research indicates that the development of mathematical concepts is supported through frequent engagement in mathematical discourse, where students articulate ideas, justify reasoning, and interact with peers and teachers, fostering the co-construction of mathematical understanding (Cobb et al., 1993). For example, home mathematics activities and mothers' math talk have been shown to predict children's early math skills and use of mathematical language (Oğul and Aktaş, 2020). Similarly, participation in out-of-school mathematics programs helps students recognize and engage with mathematics in real-world settings, thereby reinforcing their conceptual understanding (Duatepe-Paksu et al., 2022). Integrating everyday experiences with structured discourse allows students to bridge informal knowledge and formal instruction, facilitating the transition from spontaneous to scientific concepts and enhancing conceptual understanding in mathematics. In addition to that, prior research has consistently demonstrated that language plays a pivotal role in shaping both perception and cognitive processing. For example, Whorf (1956) emphasized

that linguistic structures influence thought patterns, and Başkan (1974) further illustrated this by showing that individuals with a richer vocabulary for colour terms could distinguish shades more effectively. These findings highlight the broader principle that language is not merely a vehicle for expressing mathematical ideas-it fundamentally shapes one's performance in recognizing and understanding them.

Within mathematics education, this connection between daily life language and conceptualization becomes especially critical. Researchers have long underscored that teachers' effective use of informal, real-world examples and everyday language serves as a bridge to more formal mathematical reasoning (Moschkovich, 2002). However, despite its importance, implementing accurate and meaningful mathematical language in the classroom remains a challenge. Students often struggle with words that hold different meanings in mathematical and everyday contexts, leading to misconceptions or incomplete understanding (Pimm, 1987). These linguistic challenges are not limited to students; they extend to preservice and in-service teachers as well. Umay (2003) found that some preservice teachers inaccurately identified non-mathematical everyday words such as seat and bus as mathematical concepts, suggesting underlying weaknesses in their pedagogical content knowledge. Similarly, Fırat and Dinçer (2018) reported that preservice teachers frequently relied on a very narrow set of mathematical terms—mostly limited to counting, numbers, and simple measurement—when communicating in classroom settings. This limited linguistic repertoire is concerning because research has shown that a teacher's precise and consistent use of mathematical language is essential for fostering deep conceptual understanding in children (Boonen et al., 2011).

Significance of research

Considering these challenges, it can be said that effective mathematics instruction requires teachers to be intentional and reflective in their daily life and mathematical language use. High-quality teaching involves fostering environments rich in mathematical discourse, where students can articulate their ideas, reason through concepts, and engage in mathematically meaningful dialogue (Franke et al., 2007; Sfard, 2008). Studies by Barwell (2016), and Prediger and Wessel (2013) also demonstrate that when teachers explicitly support students' navigation between everyday and mathematical registers, students' recognition of mathematical concepts in authentic contexts increases significantly. Thus, the interplay between language,

cognition, and instructional practice forms the foundation for student performance in identifying and interpreting everyday mathematical ideas.

Given the central role of language and teachers' professional use of mathematical terminology in shaping students' understanding, it becomes essential to examine how effectively teachers themselves recognize everyday mathematical concepts. If teachers struggle to identify the mathematical ideas embedded in daily contexts or fail to translate these into accurate mathematical language, their students are likely to experience similar or even amplified difficulties. Despite the substantial body of research emphasizing the importance of mathematical language, limited attention has been given to the direct relationship between teachers' performance in recognition of everyday mathematical concepts and their students' parallel performance in so doing. Moreover, it remains unclear whether this relationship varies across different student groups, particularly in terms of grade level and gender—factors known to influence students' mathematical performance in other domains. Addressing these gaps, the present study aims to investigate the performance of middle school mathematics teachers and their students in identifying everyday mathematical concepts within a text, to determine whether teachers' performance predicts that of their students, and to examine potential differences across students' grade levels and gender. In this context, the research questions of the study are structured as follows:

RQ 1. What is the performance of middle school mathematics teachers and their students in recognizing everyday mathematical concepts embedded within a non-mathematical text?

RQ 2. To what extent does the performance of mathematics teachers in recognizing everyday mathematical concepts within the text affect the performance of their students in recognizing the same concepts?

RQ 3. What is the effect of students' grade level and gender on their performance in recognizing everyday mathematical concepts embedded within the text?

Existing literature often assumes that teachers' proficient use of mathematical language naturally supports students' conceptual recognition, yet this assumption remains insufficiently examined through empirical evidence. Moreover, although demographic factors such as grade level and gender are known to influence students' mathematical achievement more broadly (e.g., Hyde et al., 2008; McKeen, 2019), there are not enough studies to date that have investigated whether these differences

also emerge in identifying everyday mathematical concepts, nor whether teacher competence contributes to such variation.

By addressing these underexplored areas, the present study provides a novel and necessary contribution to research on mathematical language, teacher expertise, and students' conceptual access in real-world contexts.

Method

Research design

Considering the purpose of the study and the nested structure of the data, in the frame of a non-experimental and quantitative research design, multilevel correlational design with Hierarchical Linear Modeling (HLM) was employed because the primary aim of the study was to examine naturally occurring differences and the relationships between teacher- and student-level variables. Given that students are nested within teachers, the data possesses a hierarchical structure that violates the independence assumption of traditional regression analyses. To appropriately account for this nesting, hierarchical linear modelling (HLM) was used, allowing for the partitioning of variance at both the teacher and student levels and providing unbiased estimates of the associations between teachers' success, student characteristics (grade level and gender), and students' recognition of everyday mathematical concepts (Raudenbush and Bryk, 2002).

Participants

The population of the study consisted of mathematics teachers working in public middle schools in a mid-sized city centre and their students. In the given region, there are a total of 68 public middle schools, forming the sampling frame for the study. Using a cluster sampling approach, approximately 10% of these schools (7 schools) were randomly selected. Within the selected schools, mathematics teachers who volunteered to participate were included in the study, along with their students. Ultimately, data were collected from 17 mathematics teachers and 796 students taught by these teachers. Table 1 presents the distribution of students by teachers, along with their grade level and gender.

Table 1
Participant details

Teacher ID	Students grade level	Students n (female +male)	Teacher ID	Students grade level	Students n (female + male)
1	8	14 + 17 = 31	10	7	31 + 17 = 48
2	5	19 + 23 = 42	11	5	22 + 22 = 44
3	6	24 +17 = 41	12	8	54 + 42 = 96
4	8	22 + 15 = 37	13	5	10 + 7 = 17
5	5	14 + 13 = 27	13	7	15 + 11= 26
5	7	13 + 17 = 30	14	5	14 + 16 = 30
6	6	27 + 27 = 54	15	5	20 + 21= 41
7	6	17 + 24 = 41	16	7	16 + 12 = 28
8	7	21 + 21 = 48	16	8	11 + 12 = 23
9	7	11 +12 = 23	17	6	26 + 24 = 50
9	8	14 + 5 = 19			

The cluster sampling approach, combined with voluntary teacher participation, allows for meaningful examination of the relationships between teachers' recognition of everyday mathematical concepts and students' corresponding performance. Nevertheless, because the sample includes only a subset of schools and teachers from the city centre, caution is warranted when generalizing the findings to the broader population. Since the data were collected from schools of different sizes and participation was voluntary, the number of students from whom data were collected varied across teacher groups. Consequently, the number of students associated with each teacher also differed.

Data collection instrument

A text designed by Umay (2003), depicting a segment of daily life, was used as the data collection instrument in this study. Participating teachers and students were asked to identify and mark the mathematical concepts within the text. The data collection was conducted in schools, with students and teachers completing the task in their own classrooms. The English-translated version of the text used as the data collection instrument is provided in the appendix.

The text contains a total of 40 distinct mathematical concepts grouped into 13 mathematical categories (dimensions), as shown in the scoring key (Umay, 2003). These categories range from basic concepts like time-measurement (e.g., 9.30,

Saturday) and quantity-number (e.g., two [bites], three [people]) to more abstract concepts like operation (e.g., change, losing [money]) and comparison (e.g., shorter, at least). Each identified concept constitutes a separate item. The total score for each participant is the count of correctly recognized concepts. According to aim of the study, it is important to note that while the scoring key includes 13 distinct categories (time, quantity, operation, etc.), the analysis in this study focuses exclusively on the total number of concepts correctly recognized across the entire text, rather than performance within individual categories.

Given that the instrument requires participants to freely identify concepts within a text, consistency in applying the established scoring key is paramount. Although Umay (2003) provided a comprehensive key of 40 mathematical concepts, to ensure rigorous scoring, two independent researchers were trained to use the pre-validated scoring key (Umay, 2003) to code a randomized sample of participant responses. Inter-rater reliability was subsequently calculated using Cohen's Kappa to assess the agreement between the two raters on the concept identification task. The resulting coefficient was 0.93, indicating excellent agreement and confirming the high objectivity and replicability of the scoring process.

Data analysis

The text used as the data collection instrument contained a total of 40 mathematical concepts. The scoring for the concept identification task was criterion-referenced, utilizing the pre-validated key established by Umay (2003). Each concept correctly identified by the participants was awarded one point, while missed concepts or incorrect markings received no points. In this way, participants obtained a total score based on the number of correct concepts they identified. These total scores were referred to as the participants' performance in recognizing mathematical concepts. Therefore, the minimum possible score was 0, and the maximum possible score was 40. This total score served as the primary dependent variable, representing the participant's overall performance in recognizing mathematical concepts. The high internal consistency of the instrument, previously established, ensures that the total score accurately reflects this single, underlying construction.

The scores reflecting students' performance in recognizing mathematical concepts served as a continuous dependent variable, whereas the scores reflecting mathematics teachers' performance in the same text functioned as a continuous primary independent variable. The control variables in the study were students' grade

level and gender, both of which are categorical. Finally, each teacher, i.e., the teacher level, was treated as a random effect.

Since the data had a nested structure, with students grouped under teachers, multilevel mixed-effects models within the framework of Hierarchical Linear Models (HLM) were employed (Raudenbush and Bryk, 2002). In the analysis models, students were classified as Level-1 and teachers as Level-2, adopting a two-level hierarchical structure. The statistical analysis was conducted using SAS® Studio, running the SAS 9.4 version of the statistical software package. Given the hierarchical data structure (students nested within teachers), the PROC MIXED procedure was employed for all inferential tests. The models consistently utilized the Restricted Maximum Likelihood (REML) method for parameter estimation, which is a standard and robust approach for mixed modelling and assumed a residual covariance structure to properly partition the variance at the teacher and student levels. The teacher variable (teacher id) was explicitly designated as the subject effect in the random statement to account for the non-independence of student scores within the same classroom. Furthermore, while some models utilized the containment method for degrees of freedom, the more complex models employed the Kenward-Roger method to ensure a more accurate and conservative estimation of standard errors and degrees of freedom for the fixed effects, thereby enhancing the rigor of the statistical inference.

The decision to model heterogeneous residual variance based on the combined factor of student gender × grade level was evaluated using information criteria. The analysis revealed substantial differences in within-group variability, with residual variance estimates ranging from 4.89 to 17.14 across subgroups. When this heterogeneous variance structure was introduced, a more favourable Akaike Information Criterion (AIC: 4006.2) was observed compared to the homogeneous alternative, confirming that accounting for this heterogeneity was necessary for accurate model fit. Initially, a model assuming homogeneous residual variance across all gender × grade level subgroups was fit. However, preliminary examination of residuals and formal tests for variance heterogeneity revealed significant differences in within-group variability of student performance. Ignoring this heterogeneity would violate the assumption of independent and identically distributed errors, potentially biasing standard errors and compromising inference regarding fixed effects. Therefore, the residual covariance structure was refined to allow residual variance to differ across the gender × grade level subgroups, implemented via the

GROUP= option in the REPEATED statement. This specification ensures accurate parameter estimation and reliable hypothesis testing for the fixed effects.

The analysis first examined whether the assumptions of HLM were met. Although initial diagnostic procedures, including Q-Q plots and histograms of standardized residuals, suggested minor deviations from strict normality, the analysis was deemed robust given that the skewness and kurtosis coefficients were within the ±2 range (George and Mallery, 2010; Kline, 2011) and the dataset indicated a sufficiently large sample, it was concluded that parametric tests could still be applied (Tabachnick and Fidell, 2013).

To address the lack of homogeneity of variances, appropriate measures were taken during the analysis. First, the gender × grade level combination was defined as a group effect, and separate residual variances were estimated for each combination. This approach relaxed the homogeneity assumption by explicitly modelling heterogeneous variance for each gender × grade level combination, as recommended in the literature (West et al., 2022). Second, Restricted Maximum Likelihood (REML) was used as the estimation method. REML reduces bias in variance component estimates, particularly in unbalanced datasets and in the presence of heterogeneous variance (Patterson and Thompson, 1971). Finally, the standard errors and degrees of freedom for the fixed effects were calculated using the Kenward–Roger adjustment. The Kenward–Roger method is a reliable approach developed to provide more accurate p-value estimates in mixed models under conditions of heterogeneous variance and small sample sizes (Kenward and Roger, 1997). Together, these three methods enhanced the reliability of the analysis results in situations where the homogeneity of variance assumption was not met.

Results

Teachers' and students' performance in recognizing everyday mathematical concepts within the text

The scores obtained for teachers and students based on the scoring procedure are presented in Table 2.

According to Table 2, among the teachers, the lowest performance in recognizing mathematical concepts within the text was observed for teacher 16, who correctly identified 7 out of 40 concepts, corresponding to a 17.5% performance rate. In contrast, the highest performance among teachers was achieved by teacher 15, who identified 24 correct concepts out of 40, yielding a 60% performance rate.

Table 2
Teachers' and students' performance in recognizing everyday mathematical concepts

Teachers			Students					
			n			mean score		
ID	mean score	grade level	female	male	all	female	male	all
1	16.00	8	14	17	31	10.2	10.1	10.16
2	12.00	5	19	23	42	10.7	10.3	10.50
3	13.00	6	24	17	41	6.9	6.8	6.88
4	16.00	8	22	15	37	9.0	8.8	8.89
5	11.00	5	14	13	27	9.9	9.7	9.79
5		7	13	17	30	10.1	9.5	
6	19.00	6	27	27	54	9.8	9.8	9.80
7	21.00	6	17	24	41	10.3	10.1	10.22
8	12.00	7	27	21	48	10.4	10.3	10.35
9	11.00	7	11	12	23	9.8	9.6	9.79
9		8	14	5	19	9.9	9.7	
10	12.00	7	31	17	48	9.7	9.6	9.63
11	8.00	5	22	22	44	8.8	8.7	8.75
12	8.00	8	54	42	96	9.5	9.3	9.44
13	9.00	5	10	7	17	10.6	10.5	10.67
13		7	15	11	26	10.8	10.6	
14	11.00	5	14	16	30	9.5	9.1	9.30
15	24.00	5	20	21	41	12.9	12.6	12.78
16	7.00	7	16	12	28	9.1	8.7	8.92
16		8	11	12	23	9.0	8.8	
17	14.00	6	26	24	50	9.6	9.5	9.54

For students, the lowest performance was observed in the class of teacher 3, with an average of 6.88 correct concepts out of 40 (17.2% performance rate). Conversely, the highest student performance was in the class of teacher 15, with an average of 12.78 correct concepts out of 40 (31.95% performance rate).

These findings indicate that teachers' scores in recognizing mathematical concepts did not exceed 24 out of 40, with a mean score of 13.18. Students' performance in recognizing concepts reached a maximum average score of 12.78, with an overall mean of 24.28. Additionally, it is noteworthy that the highest performance was observed for teacher 15 and the students of teacher 15, regardless of gender, for both girls and boys.

Model

The random effects and their components included in the model is presented in Table 3.

Table 3
Random effects and residual variances

Parameter	Level / Group (gender × grade)	Estimated Variance
Intercept (Teacher_ID)	Teacher level random intercept	0.62
Residual	Male × 5th grade	17.14
Residual	Male × 6th grade	7.25
Residual	Male × 7th grade	10.07
Residual	Male × 8th grade	9.67
Residual	Female × 5th grade	13.91
Residual	Female × 6th grade	5.48
Residual	Female × 7th grade	4.89
Residual	Female × 8th grade	6.66

As seen in Table 3, 6.2% of the total variance is attributable to differences between teachers (ICC = 0.062). This indicates significant differences in teachers' performance scores in recognizing mathematical concepts, and it is clear that students of some teachers systematically perform better in recognizing mathematical concepts compared to others. Moreover, the analysis revealed that teacher efficacy has a significant positive effect on student performance (γ= 0.1745, se = 0.056, t = 3.09, $p < .01$). Specifically, a one-unit increase in teacher efficacy score relates to a 0.1745-point increase in student concept recognition scores.

Furthermore, based on the residual variances obtained for each group, the highest variance was found in the 5th-grade male group, indicating that the performance of these students in recognizing mathematical concepts is highly variable. Conversely, the lowest variance was observed in the 7th-grade female group, suggesting that these students' performance scores are more consistent and closely aligned. Information on the Type 3 tests for the fixed effects included in the model is presented in Table 4.

As shown in Table 4, teachers' performance has a positive and significant effect on students' performance ($F = 9.55$; $p = .007$). Similarly, the overall effect of grade level on student performance is significant ($F = 3.06$; $p = .042$), whereas the overall effect of gender was not significant in the Type III test ($F(= 0.02$; $p = 0.885$).

Table 4
Type 3 tests for fixed effects

Effect	Num df	Den df	F	p	Decision
Teacher Performance	1	15.8	9.55	0.007	significant
Grade	3	30.6	3.06	0.042	significant
Gender	1	637	0.02	0.885	not significant

($p < 0.05$)

Effect of mathematics teachers' performance on student performance

It was concluded that mathematics teachers' performance in recognizing mathematical concepts within the text significantly affects their students' performance in recognizing the same concepts. The related estimates are presented in Table 5.

Table 5
Fixed effect estimates for teacher performance

Effect	Coefficient (β)	se	df	t	p	95% CI Lower	95% CI Upper	Decision
Teacher Performance	0.1745	0.0565	15.8	3.09	0.007	0.055	0.294	significant

According to the table, a one-unit increase in teachers' performance in recognizing concepts within the text is associated with an average increase of 0.1745 units in student performance in recognizing the same concepts, and this effect was found to be statistically significant ($p < 0.05$).

Effect of students' grade level on performance

The fixed effect estimates obtained from the analysis examining the impact of students' grade levels on their performance in recognizing mathematical concepts within the text are presented in Table 6.

Table 6
Fixed effect estimates for grade level

Grade (Ref: 8th grade)	Coefficient (β)	se	df	t	p	Decision
5th grade	0.3183	0.5651	41.9	0.56	0.576	not significant
6th grade	-1.3268	0.6491	15.7	-2.04	0.058	not significant
7th grade	0.5333	0.4445	80.5	1.20	0.234	not significant

($p < 0.05$)

In the analysis, where 8th-grade students were taken as the reference group, the most notable difference was observed among 6th-grade students. Specifically, 6th graders scored an average of 1.3268 units lower than 8th graders; however, this difference was not statistically significant ($t = -2.04$; $p = .058$). Similarly, the differences between 8th graders and students in 5th grade ($t = 0.56$; $p = .576$) and 7th grade ($t = 1.20$; $p = .234$) were smaller and not statistically significant.

To present these findings in greater detail, the LSMeans values obtained are shown in Table 7, and the results of the pairwise comparisons using the Tukey-Kramer method are presented in Table 8.

Table 7
Estimated mean scores (LSMeans) by grade level

Grade	Mean	se
5th grade	10.0705	0.4177
6th grade	8.4255	0.4906
7th grade	10.2856	0.3528
8th grade	9.7523	0.3981

Table 7 presents the adjusted mean performance scores for each grade level. The highest mean score was observed in 7th grade, while the lowest was in 6th grade. These differences are directly comparable because they were calculated while controlling for the effects of other variables in the model.

According to Table 8, the multiple comparison analysis examining the statistical significance of differences between grade levels revealed significant differences only between 5th and 6th grades (adj $p = .02 < .05$) and between 6th and 7th grades (adj $p = .03 < .05$).

Table 8

Tukey-Kramer results by grade level

Compared Grades	Difference	se	df	t	p-adj	Decision
$5^{th} - 6^{th}$	1.6451	0.6428	17	2.56	0.020	significant
$6^{th} - 7^{th}$	-1.8601	0.6349	16.4	-2.93	0.031	significant
Other Pairs	—	—	—	—	>0.05	not significant

($p < 0.05$)

As seen from the mean scores in Table 7, these differences are in favour of the higher-grade students. Specifically, 6th-grade students performed 1.64 units lower than 5th graders and 1.86 units lower than 7th graders.

Effect of students' gender on performance

The fixed effect estimates obtained from the analysis examining the impact of students' gender on their performance in recognizing mathematical concepts within the text are presented in Table 9.

Table 9

Fixed effect estimates for gender

Gender (Ref: Female)	Coefficient (β)	se	df	t	p	Decision
Male	0.0304	0.2110	637	0.14	0.885	not significant

($p < 0.05$)

The average score of male students was only 0.03 points higher than that of female students, and this difference was not statistically significant ($p = .885 > .05$). This finding indicates that gender does not have a significant effect on student performance.

Conclusion and Discussion

In this study, HLM was employed to examine the effects of various factors on student performance in recognizing mathematical concepts within a text depicting a segment of daily life. The variables considered included the mathematics teachers' performance in recognizing the same concepts within the text, students' grade levels, and their gender. The findings indicate that teachers' performance in recognizing mathematical concepts and students' grade levels significantly affect student performance in recognizing the concepts within the same text, whereas students' gender was found to have no such effect.

The initial results also showed that both teachers and students demonstrated relatively low performance in recognizing mathematical concepts within a verbal text dealing with daily life. Similar results have been reported in the literature. For example, Umay (2003) mentions that preschool teacher candidates struggled to determine daily life mathematical concepts, and Şahin and Korkmaz (2019) found that preschool children frequently made errors with concepts such as "circle," "side," "wide–narrow," and "yesterday–today–tomorrow," with conceptual confusion being the most common type of error.

These findings can be meaningfully interpreted through Vygotsky's theory of concept formation and the Zone of Proximal Development (ZPD). According to Vygotsky, students progress from everyday concepts to scientific concepts through guided mediation, in which teachers support learners within their ZPD using linguistic clarification, guided questioning, and concept-focused dialogue. Within this framework, the statistically significant yet limited effect of teacher performance observed in the study may reflect the extent to which teachers were able to provide effective scaffolding for students as they worked to identify mathematical ideas embedded in everyday language. Teachers who were more successful in recognizing these concepts themselves would be better positioned to offer verbal scaffolding, targeted explanations, and structured interactions, all of which help students bridge familiar, context-based interpretations with formal mathematical meanings. Thus, the findings suggest that while teacher mediation plays a meaningful role in students' conceptual recognition, substantial variation remains attributable to factors beyond the teacher's immediate capacity to scaffold learning within students' ZPD.

A closer examination of the findings reveals that although the teacher effect was statistically significant, it accounted for only 6.2% of the total variance, suggesting a limited practical impact. While a variance of 6.2% might appear modest statistically, it represents a substantial effect in the context of educational research, where teacher effects typically range between 5% and 20% (Hedges and Hedberg, 2007). On the other hand, 93.8% of the variation is attributable to factors beyond teachers' influence, such as student-level characteristics, family background, and school resources. Therefore, while the teacher effect is non-negligible, it should be characterized as a modest contributory factor rather than a strong causal determinant. Research consistently reports that although teacher quality exerts a measurable effect on achievement, its contribution is modest compared with other influences (Chetty et al., 2014; Jackson et al., 2014). Furthermore, research confirms that a teacher's use of precise mathematical language is a critical component of

effective instruction and a predictor of student achievement (Moschkovich, 2003; Moschkovich, 2007). In sociocultural terms, Wertsch (1988) emphasizes that mediation depends not only on the presence of a knowledgeable adult but also on the appropriateness and accessibility of the symbolic tools—especially language—used in instruction. Therefore, even when teachers themselves recognize mathematical concepts effectively, students may still struggle if mediation does not explicitly support how mathematical ideas are encoded in everyday language. In other words, most of the variation (93.8%) is attributable to student-level factors and other contextual variables. From a theoretical perspective, this aligns with Vygotsky's ZPD framework, which posits that teachers can provide scaffolding to support students' progression from everyday to formal mathematical concepts, while overall development also depends on each student's readiness, prior knowledge, and engagement. Practically, this finding suggests that although enhancing teacher efficacy is important, additional strategies—such as targeted scaffolding, guided dialogue, and structured classroom supports—are necessary to maximize students' ability to recognize and apply mathematical concepts in real-world contexts.

The limited size of the teacher effect in this study may stem from several factors. First, the outcome measure—students' recognition of mathematical concepts in a highly context-specific text—may reflect influences beyond direct instruction. In line with this, Sfard's (2008) argument that mathematical thinking develops through participation in discourse suggests that students' difficulties may arise when everyday and mathematical discourses are insufficiently bridged. Similarly, Moschkovich (2005) notes that learners require linguistic scaffolding to navigate between everyday talk and mathematical registers, further indicating that discourse-related challenges may dilute the measurable impact of teachers. Taken together, these perspectives may partially explain why teacher performance accounted for a relatively small proportion of variance in the present study. A critical contextual factor to consider in interpreting these results is the highly centralized nature of the Turkish education system.

In Turkey, the Ministry of National Education dictates the curriculum, textbooks, and instructional pacing, leaving teachers with limited autonomy regarding course content. Typically, in such standardized environments, one might expect the variance attributable to teachers to be minimized. However, our findings reveal a significant teacher effect (ICC = .062) and a positive correlation between teacher efficacy and student performance. This suggests that even within a rigid, centralized structure, the delivery of instruction is as critical as the content itself. The significant

impact of teacher efficacy implies that how teachers interpret, adapt, and present the standardized curriculum creates a substantial difference in students' ability to recognize mathematical concepts. Thus, teacher efficacy emerges not just as a personal trait, but as a vital compensatory mechanism that diversifies student outcomes in an otherwise uniform system.

Another critical factor influencing students' performance was grade level. The analysis revealed significant fluctuations across grades, where seventh-grade students demonstrated the highest performance, while sixth-grade students performed the lowest. Specifically, the least squares means analysis reveals a sharp decline in 6th grade ($M = 8.42$) compared to 5th grade ($M = 10.07$), representing a significant mean difference of 1.64 points ($p < .05$). However, this trend reverses in 7th grade ($M = 10.28$), where students score significantly higher than their 6th-grade peers (mean difference = 1.86, $p < .01$).

This trajectory reflects the broader instructional shift from concrete arithmetic to more abstract domains characteristic of middle school mathematics ((NRC,2001). In the context of the national curriculum, the sixth grade serves as a pivotal transitional year, introducing integers and symbolic algebraic reasoning. Research highlights that such abrupt increases in curricular complexity may temporarily hinder performance before stabilizing in later grades (Common Core State Standards Initiative, 2010). This aligns with Vygotsky's notion of developmental readiness within the Zone of Proximal Development (ZPD), suggesting that these new instructional expectations may temporarily outpace students' conceptual development. Consequently, the observed decline in sixth grade represents a mismatch between curricular pacing and students' developmental needs, primarily driven by the specific transitions within the national mathematics curriculum. Unlike the fifth-grade curriculum, which often reinforces arithmetic fluency, the sixth-grade curriculum introduces distinctively abstract domains—such as integers and algebraic expressions—for the first time (MoNE, 2018, 2024).

This shift necessitates a transition from concrete operations to abstract reasoning, resulting in a temporary performance dip due to increased cognitive load. The subsequent recovery in seventh grade indicates a successful adaptation to these new cognitive requirements. This pattern underscores the critical importance of scaffolding that effectively bridges real-life contexts with abstract mathematical concepts. Furthermore, this phenomenon is supported by recent international curriculum analyses, suggesting it is not isolated to the national context. For instance, Tugores et al. (2025) found that the cognitive demands of primary mathematics

curricula in Spain and Portugal progress unevenly, indicating that difficulty does not increase linearly across grades. Similarly, Leite and Valente (2024) reported that the mathematics curriculum in Portugal's early grades already possesses relatively high cognitive demand. These comparative findings suggest that the challenge of adapting to nonlinear increases in cognitive requirements is a shared characteristic across different educational systems.

Finally, students' gender was examined and found to have no statistically significant effect on performance. This aligns with extensive meta-analytic evidence suggesting that gender differences in mathematics achievement are negligible, particularly during adolescence (Else-Quest et al., 2010; Hyde et al., 1990). However, beyond general achievement, the specific nature of the task offers a deeper explanation for this parity. Unlike traditional assessments that prioritize procedural fluency or spatial reasoning—domains where male advantages have occasionally been reported—the concept identification task employed in this study relies heavily on linguistic processing. Success in this task requires not only mathematical knowledge but also the ability to decode text and map verbal descriptions to mathematical constructs. Research consistently indicates that female students demonstrate distinct advantages in reading literacy and verbal processing tasks (Robinson and Lubienski, 2011; Voyer and Voyer, 2014). Consequently, the strong linguistic component of this instrument likely counterbalanced any potential disparities in pure procedural domains, resulting in the observed equilibrium (Robinson and Lubienski, 2011).

Together, these findings provide a deeper understanding of how teacher mediation, linguistic complexity, curricular transitions, and sociocultural factors influence the recognition of everyday mathematical concepts. The results highlight the importance of instructional approaches that explicitly bridge everyday and mathematical discourse and ensure that scaffolding aligns with students' developmental levels within their ZPD.

Suggestions

A primary recommendation is for educators to cultivate a profound awareness of the linguistic challenges inherent in mathematics. It is essential for teachers to explicitly address the linguistic ambiguities, modelling precise vocabulary and providing clear distinctions between the colloquial and the technical uses of terms.

Furthermore, leveraging students' existing knowledge is critical for effective teaching. According to Vygotsky's framework, students first develop spontaneous

concepts from their practical, day-to-day experiences. Teachers should use these informal ideas as a bridge to introduce and develop scientific concepts acquired through formal instruction. By grounding abstract mathematical ideas in students' lived experiences, educators can help them transition from concrete understandings to the more formal and systematic knowledge required for higher-level mathematics. The correct and appropriate use of mathematical concepts is fundamental, as these concepts allow learners to organize information effectively (Dinçer and Ulutaş, 1999). Mathematical concepts form the foundation of instruction and are interconnected in a sequential, hierarchical order (Dede and Argün, 2004). Furthermore, these concepts are vital for the development of fundamental mathematical thinking (Toumasis, 1995).

Finally, instructional practices should prioritize mathematical discourse to foster fluency in the mathematical register. Teachers should create opportunities for students to actively engage with mathematical language by encouraging them to see, hear, say, and write mathematical vocabulary in context. This active participation helps students become more comfortable and confident in communicating their reasoning and ideas, allowing teachers to better assess their conceptual understanding. By becoming facilitators of this process, educators can empower students to navigate the complexities of mathematical language and thinking.

In this study, students' grade level and gender were considered as independent variables. In different studies, other variables such as socioeconomic status or parents' education level could be considered, and a broader study could be conducted with different participant groups.

Limitations

While contextual factors such as the centralized curriculum play a role, we acknowledge that the magnitude of the observed teacher effect may also be constrained by how teacher performance was operationalized in this study. The variable used to assess teacher performance—scores obtained from recognizing mathematical concepts—primarily measures the teachers' cognitive content knowledge rather than their actual instructional quality or classroom practices. While content knowledge is a prerequisite for effective teaching, it does not guarantee it. A teacher may demonstrate high performance in conceptual recognition tasks but may face challenges in pedagogical transmission or classroom management.

In addition to that, regarding the data collection tool, the scoring method adopted by Umay (2003) is based on the number of correctly identified concepts without penalizing incorrect markings. Within the scope of this study, the response sheets were qualitatively examined, and since no tendency toward random marking or guessing was observed, the original scoring system used in the development of the data collection tool was retained. However, in future studies, if a pattern such as random marking is detected in the answer sheets, it will be necessary to apply a corrective formula for estimates to strictly control potential bias arising from false positives.

Furthermore, it is important to consider statistical limitations related to model specification and sample size. The HLM analysis was conducted with 17 teachers at Level-2. While sufficient for estimating fixed effects, this sample size may limit the statistical power to detect smaller effect sizes. Furthermore, it is acknowledged that small cluster sizes can lead to biased standard errors for Level-2 variance components, potentially affecting the precision of teacher-level random effects. Additionally, if the participating teachers share similar educational backgrounds, a potential range restriction in the performance scores might have suppressed the correlation, naturally constraining the measurable variance attributable to teachers

Data Availability Statement

The article is based on data fully presented and discussed within the article itself; therefore, no additional data archiving is required.

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Appendix: A snapshot of daily life

When Ali opened his eyes in the morning, he looked around with suspicious eyes for a moment to understand where he was. They had worked with the people at the office until late at night and were very tired. He had only been able to get home in the early morning. He immediately looked at his watch: 9:30. He was late. He jumped up and rushed out of the house without even brushing his teeth. As he ran down the stairs three steps at a time, he heard his mother calling from behind, "Son, where are you going without eating a bite? What's the hurry?"

At the bus stop, there were only three people. He handed a 5-million banknote to the clerk at the kiosk next to the stop and said, "One ticket…" As he took the ticket the clerk handed him, the bus pulled up to the stop. The clerk shouted after him, "Sir, you didn't take your change!" while he quickly jumped onto the bus. *If I don't make it to the auction, how many five million would I lose, if only they knew,* he thought to himself, laughing.

Half of the bus was empty. His astonishment gradually increased. "I have at least 10 km to go, it looks like I can sit," he thought happily. Soon, a man in his mid-to-late 30s to 40s, shorter than him and with dark skin, sat next to him and opened his newspaper to read. Ali glanced at the headlines out of the corner of his eye. Then his gaze fell on the TV screen on the man's lap. At that moment, he suddenly understood why the bus stop and the bus were so empty. TODAY WAS SATURDAY, AND IT WAS A HOLIDAY!!!!

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