What Makes Word Problem-Solving Difficult? Factors Influencing Word Problem-Solving Ability

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An essential aspect of mathematics education is represented by word problem-solving. Word problems pose challenges for many students worldwide, underscoring the need to comprehend the factors influencing this maths ability. Drawing upon the theoretical framework proposed by Daroczy et al. (2015), this contribution examines three primary factors contributing to students' difficulties in solving word problems. Firstly, it investigates how the inherent characteristics of the problems themselves (i.e. linguistic features, numerical features, and their interaction) influence the problems' complexity and increase cognitive load. Secondly, it discusses the cognitive abilities, both domain-specific and domain-general, that are involved in word problem-solving. Lastly, it considers the role of environmental factors such as textbooks, technology integration, and quality of teaching. By examining the impact of each factor, we advocate for pedagogical approaches that prioritize deep understanding of the situation described in the problems.

Keywords: word problem-solving, linguistic features, numerical features, cognitive abilities, environmental factors

Introduction

A central aspect of mathematics educational curricula across all school levels is represented by word problem-solving (Swanson, Lussier, and Orosco 2015). Word problems are defined as a particular type of maths problem presented in a verbal rather than numerical formulation (Verschaffel, Greer, and Corte 2000). Throughout history, they have played a significant role within mathematics education, tracing their origins back to nearly 4,000 years ago, appearing in Egyptian papyri, ancient Chinese, and Indian manuscripts (Swetz 2009). Their enduring presence in educational contexts stems from their multifaceted utility, such as preparing students to connect and apply mathemat-

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ical concepts to real-world situations (Depaepe, De Corte, and Verschaffel 2010; Pongsakdi et al. 2020), deepening the understanding of mathematical knowledge, fostering creative thinking and flexible problem-solving skills, and serving as a motivational tool to spark interest in mathematics (Verschaffel et al. 2020).

However, despite their educational value, word problems pose considerable challenges for many students worldwide (Cotič and Valenčič Zuljan 2009; Fuchs et al. 2020). For instance, OECD (2013) reported that one third of students in all participating countries were not able to solve simple word problems involving whole numbers. These findings underscore the need to investigate the factors influencing students' proficiency in word problem-solving, in order to develop more effective instructional strategies. In the present contribution, we aim to give a comprehensive overview of the factors that influence students' word problem-solving performance and discuss some implications for educational practice.

Difficulties in Word Problems: A Comprehensive Theoretical Model

Numerous empirical studies have sought to elucidate the challenges encountered by individuals, both children and adults, in word problem-solving (e.g. Hegarty, Mayer, and Monk 1995; Jaffe and Bolger 2023; Pongsakdi et al. 2020). A theoretical model that attempts to comprehensively explain the difficulties in word problem-solving is the model proposed by Daroczy et al. (2015), illustrated in figure 1. The model identifies three main aspects that contribute to word problem-solving difficulties: task characteristics (linguistic and numerical features of the problem and their interaction that determine the problem's complexity), individual differences (domain-specific and domain-general cognitive abilities), and environmental factors (the teaching-learning environment).

Central to this model is the assertion that task characteristics and individual differences influence students' performance both directly and indirectly over two mediator variables: cognitive load and problem-solving strategies. Task characteristics influence cognitive load; as the complexity of problems increases, cognitive load also rises. Moreover, cognitive load is also subject to individual differences, where individuals with higher cognitive abilities may exhibit lower cognitive load compared to those with poorer abilities. The second mediator refers to the application of specific problem-solving strategies, which is influenced by both the features of the problem, and students' abilities and knowledge. Finally, environmental factors impact individual cognitive abilities, solution strategies, and word problem performance. In the fol-

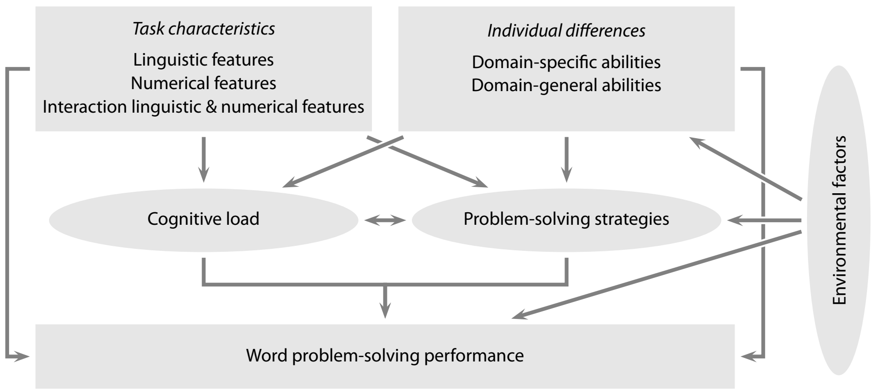

Figure 1 Theoretical Model of Word Problem-Solving Difficulties (adaptation from Daroczy et al. 2015)

lowing sections, we briefly describe the research on the role of task characteristics, individual differences, and environmental factors on students' word problem-solving performance.

Task Characteristics

Consider the following word problems:

1. Linda has 16 red apples and 10 green apples. How many apples does she have altogether?
2. Linda has 16 apples. She has 10 apples less than Jessica. How many apples does Jessica have?

Although both problems require the same arithmetic operation (16 + 10 = 26), the second problem typically poses more challenges due to its characteristics (see, for example, Boonen and Jolles 2015; Schumacher and Fuchs 2012). Thus, the first aspect to consider when addressing students' difficulties in solving word problems concerns the complexity of the problem itself, i.e. the problem's linguistic and numerical features, as well as their interaction.

Linguistic Features

Difficulties encountered in solving word problems are intricately linked to the linguistic complexity of the word problem. Literature has found that general descriptive characteristics (e.g. word count, average sentence length), grammatical features (e.g. using passive instead of active form), and most lexical properties (e.g. use of ambiguous words, presence of implicit linguistic information) influence both the time and the accuracy of performance (Barbu and Beal 2010; Haag et al. 2013), despite the fact that these factors do not alter the mathematical complexity of the problem.

An example of a linguistic feature that significantly increases language complexity is nominalization, which involves turning verbs, typically denoting actions, into nouns (Francis 1989). For instance, consider the following problem with nominalization: 'Pablo worked diligently and saved 245 dollars. The next day, he was happy about *the earning* of 92 euros. How much money does Pablo have now?,' whereas the counterpart without nominalization reads: 'Pablo worked diligently and saved 245 dollars. The next day, he *earned* 92 euros. How much money does Pablo have now?' Both problems present the same mathematical structure and can be solved using the same arithmetic operation (245 + 92 = 337); however, they differ in terms of their linguistic complexity. The problem with nominalization is more complex to solve (Daroczy et al. 2020) since nominalization increases the difficulty of comprehension (Halliday, Matthiessen, and Matthiessen 2014; To, Lê, and Lê 2013) and necessitates more cognitive resources for integrating the verbal information.

Numerical Features

Naturally, difficulties in word problem-solving also depend on the numerical features of the problem, as some errors stem from arithmetic computation errors themselves. Numerical aspects, such as the magnitude of numbers (e.g. single-digit numbers vs. multi-digit numbers), the type of numbers (e.g. whole numbers vs. rational numbers), the type of arithmetic operation (e.g. addition vs. subtraction), and the presence of irrelevant numerical information can influence the time and accuracy of calculations (Haghverdi, Semnani, and Seifi 2012; Raduan 2010).

An interesting numerical aspect that significantly influences the accuracy of word problems is the presence of addition with carrying and subtraction with borrowing (Daroczy, Meurers et al. 2020; Dresen, Pixner, and Moeller 2020). In addition with carrying, adding the units leads to a change in the number of tens. An example of addition with carrying is 14 + 19 = 33, and addition without carrying is 14 + 11 = 25. Similarly, subtractions with borrowing occur when the unit of the minuend is smaller than the unit of the subtrahend, necessitating the 'borrowing' of a ten from the minuend. An example of subtraction with borrowing is 33 – 14 = 19, and a subtraction without borrowing is 33 – 11 = 22. Both children and adults take more time and commit more errors when computing carry/borrow problems compared to non-carry/nonborrow problems (Daroczy, Meurers et al. 2020; Dresen, Pixner, and Moeller 2020).

Interaction Between Numerical and Linguistic Features

Linguistic complexity and arithmetic complexity in word problems are often seen as subsequent additive processes which do not interact with each other. This means, first, linguistic complexity is experienced through text comprehension then arithmetic complexity through calculation. However, studies have highlighted an interaction between linguistic and numerical factors (e.g. Pape 2003). The most prominent example of such interaction is *lexical consistency* (Lewis and Mayer 1987), which refers to the presence of specific keywords in the text, called cue words, that are semantically linked to an arithmetic operation. A word problem is considered lexically consistent if the semantics of the cue words signal an operation that is congruent with the operation required for the correct solution. For example, in the problem 'Mary ate 7 cookies. Kate ate 2 more than Mary. How many cookies did Kate eat?,' the cue word 'more,' which is typically associated with addition, coincides with the arithmetic operation required to correctly solve the problem (addition, 7 + 2 = 9). In contrast, in inconsistent word problems, the cue word hints at an incorrect operation. For instance, in the problem 'Mary ate 7 cookies. She ate 2 more than Kate. How many cookies did Kate eat?,' the relational term 'more' evokes an addition which is inconsistent with the operation needed for the correct solution (subtraction, 7 – 2 = 5).

Inconsistent problems are more difficult compared to consistent ones, and the most frequent error is to apply the arithmetic operation semantically linked to the cue word (Hegarty, Mayer, and Green 1992; Hegarty, Mayer, and Monk 1995; Pape 2003). This is because cue words automatically trigger a superficial solution strategy based on keywords (e.g. 'if *more,* then addition; if *less,* then subtraction'), which must be inhibited to correctly understand the problem's situation (Passolunghi et al. 2022).

Individual Differences

While the examination of problem characteristics has yielded valuable insights into comprehending students' challenges in word problem-solving, it must be noted that some children solve the same word problem with ease while others struggle. This indicates that difficulties in solving word problems are also influenced by individuals' cognitive profiles. Here, we illustrate research concerning both domain-specific cognitive components (that is, cognitive components that are specific to the word problem-solving process) and domain-general factors (that is, cognitive factors fundamental in a variety of different tasks).

Domain-Specific Cognitive Components

A model of the cognitive processes involved in problem-solving has been proposed by Passolunghi, Lonciari, and Cornoldi (1996) and later by Lucangeli, Tressoldi, and Cendron (1998). The model is presented in figure 2 and posits that the problem-solving process comprises five cognitive components: text comprehension, representation, categorization, planning, and metacognition. According to this model, the problem-solving process begins with text comprehension, where the solver tries to understand the problem's scenario. Text comprehension encompasses linguistic knowledge for understanding words and sentences, semantic knowledge for inferring implications, and knowledge of mathematical terminology (e.g. 'more'). It assumes a supraordinate role, as an inaccurate comprehension of the problem's text can detrimentally impact all other components of the problem-solving process. The representation involves connecting the solution-relevant information into a coherent mental representation of the problem situation. During categorization, the solver recognizes the problem's deep or mathematical structure. In the planning process, the solver creates a solution plan according to the solution method and strategies and executes the operations. Finally, metacognition refers to the individual's awareness and understanding of their own thought processes, including the ability to monitor, control, and regulate cognitive activities (Brown 1978). Metacognitive abilities play a crucial role throughout the problem-solving process, enabling solvers to analyse the task's structure more effectively, flexibly choose appropriate strategies,

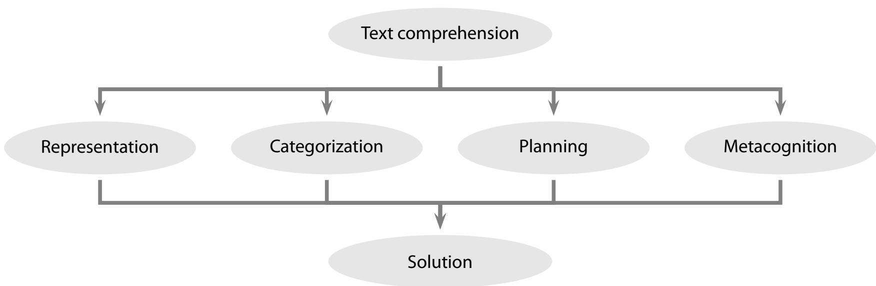

Figure 2 Cognitive Components of Word Problem-Solving According to the Model by Passolunghi, Lonciari, and Cornoldi (1996) and Lucangeli, Tressoldi, and Cendron (1998)

make more productive use of cognitive resources, and assesses the reasonableness of the mathematical outcome.

Empirical evidence suggests that the construction of a mental representation of the problem and the recognition of the mathematical structure are critical steps in word problem-solving (see Doz, Cotič, and Passolunghi 2023), since unsuccessful solvers appear to lack engagement in these steps (Hegarty, Mayer, and Monk 1995).

Domain-General Cognitive Factors

Alongside the influence of domain-specific cognitive factors (i.e. text comprehension, representation, categorization, planning, arithmetic skills, metacognition), there is also an important role for general cognitive abilities. Among these, research highlights the importance of working memory and executive functions (Passolunghi et al. 2022; Peng and Fuchs 2016).

Working memory is defined as a limited capacity cognitive system that allows individuals to hold and simultaneously manipulate information over brief periods of time (Baddeley and Hitch 1974). Extensive research has shown a strong connection between students' working memory and their ability to solve word problems effectively (see Peng and Fuchs 2016). Indeed, working memory is essential during text comprehension, where the solver integrates incoming information with previous information, and during the creation of a comprehensive representation of the problem, where the solver manages the visualizations implied by the problem. Moreover, working memory is needed for devising the solution plan and keeping the solution pathway and goals in mind while performing them, as well as for executing the necessary computations.

Regarding executive functions, research has highlighted the importance of inhibition, defined as the ability to suppress irrelevant information, and inhibit dominant or prepotent responses (Miyake and Friedman 2012). Word problem-solving requires processing a great number of linguistic and numerical information and necessitates inhibiting all irrelevant information in order to retain in the memory only the solution-relevant elements (Passolunghi and Siegel 2001). Passolunghi, Cornoldi, and De Liberto (1999) found that unsuccessful solvers, compared to successful ones, struggled to recall relevant information from a problem and made more intrusion errors (that is, remembering irrelevant information). These results indicate that students with poor problem-solving ability tend to have difficulty in effectively suppressing irrelevant information, which may potentially result in memory overload and an inadequate mental model of the problem.

Another executive function associated with word problem-solving is updating. Updating is a complex ability that requires replacing outdated and irrelevant information with new and relevant information (Miyake and Friedman 2012). The ability to update information is fundamental in word problem-solving, as during the comprehension and representation phase the solver must integrate all data, replacing existing irrelevant information with new incoming information (Passolunghi and Pazzaglia 2005). Passolunghi et al. (2022) explored the role of both inhibition and updating in a sample of fourth and fifth graders. Children were asked to solve several word problems with different difficulty: one- and two-step word problems with consistent and inconsistent language. Findings revealed that inhibition was a significant predictor of performance in one-step consistent and inconsistent problems, even after controlling for students' reading comprehension and intelligence. Interestingly, however, in more complex problems (two-step inconsistent problems) inhibition lost its relevance in favour of updating abilities. These results suggest that updating skills would be particularly important in complex inconsistent problems where the mathematical operation evoked by the relational term must be firstly processed, but then inhibited and replaced with the opposite operation. It could thus be speculated that lexical inconsistency and the problem's complexity may increase the demand on the solver's ability to update and integrate information in order to create a coherent mental representation of the problem.

Environmental Factors

Environmental factors, such as the teaching-learning environment, also deserve consideration as they influence the development of students' cognitive abilities underlying word problem-solving, as well as the problem-solving strategies. In this section, we briefly discuss research on three important factors in the teaching-learning environment: mathematics textbooks, technology, and teachers.

Mathematics Textbooks

Mathematics textbooks are recognized as essential instructional resources widely employed by educators globally (Verschaffel et al. 2020). Data indicate that, on average, 96% of teachers make use of textbooks and for the great majority of teachers textbooks serve as the main basis for their educational practice (Mullis et al. 2011).

Mathematics textbooks are believed to influence the development of word problem-solving skills in two main ways: (1) the diversity of problems they offer, and (2) the word problem-solving approaches they advocate (Vicente, Sánchez, and Verschaffel 2020). Regarding the diversity of problem types, research found that textbooks typically present a stereotypical set of word problems, which are often solvable though the straightforward application of an arithmetic operation with the given numerical data (Powell, Namkung, and Lin 2022). Notably, there is a significant absence of word problems that require applying real-life knowledge and reasoning (Orrantia, González, and Vicente 2005; Pongsakdi et al. 2016; Verschaffel et al. 2020). An example of a word problem that necessitates real-world knowledge and reasoning is as follows: 'Robert wants to tie together two poles that are 12 metres apart using pieces of rope that are 1.5 metres long. How many pieces of rope does he need?' In this problem, the solver must recognize that when tying the pieces of rope together, part of their length will be consumed in tying the knots. Consequently, the straightforward answer 12/1.5 = 8 is not correct, as more than 8 pieces will be needed. Engaging with these types of problems, which Verschaffel et al. (2020) refer to as situationally difficult problems, allows children to practice not only domain-specific knowledge and skills, but also promotes critical thinking and creative reasoning. Creativity is a crucial element of maths problems-solving (Cotič and Felda 2011), and it should be encouraged in order to foster adequate maths reasoning skills. It follows that the continuing experience with stereotypical word problems and the absence of situationally difficult problems in textbooks may hinder the development of problem-solving abilities.

Textbooks also provide different word problem-solving approaches. For instance, Vicente, Sánchez, and Verschaffel (2020) compared primary school textbooks from Singapore and Spain. They found that textbooks in Singapore, a nation where students exhibit high word problem-solving performance (Mullis et al. 2011), prioritize a meaningful problem-solving approach, emphasizing the representation of the problem situation and comprehension of its mathematical structure. As previously discussed, building a coherent mental representation of the problem is crucial for successful word problem-solving (Doz, Cotič, and Passolunghi 2023; Hegarty, Mayer, and Monk 1995). In contrast, textbooks in Spain, a country where students exhibit lower achievement (Mullis et al. 2011), tend to promote an approach that lacks reasoning. These textbooks mainly focus on steps related to problem solution, such as providing specific strategies without promoting generalized application.

A second major difference observed was related to the use of illustrations (Vicente, Sánchez, and Verschaffel 2020; Vicente et al. 2022), that is, any pic-

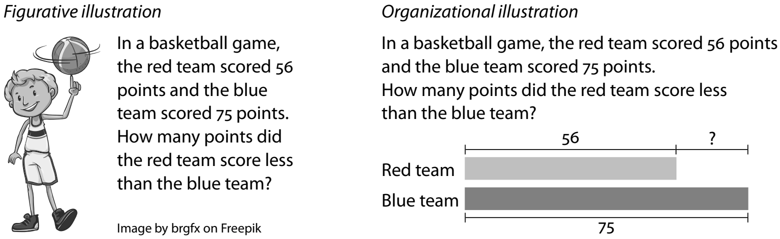

Figure 3 An Example of Figurative and Organizational Illustrations in Textbooks

torially or schematically depicted information accompanying a word problem (e.g. drawings, photographs, diagrams). In this respect, Vicente et al. (2022) found that Singaporean textbooks prioritize organizational illustrations, which elucidate the mathematical relations between the quantities, guiding the solver in constructing a coherent mental model of the problem. On the other hand, Spanish textbooks contain a higher percentage of figurative illustrations depicting the problem in a decorative manner (figure 3).

Overall, textbooks that prioritize diverse problem types and meaningful problem-solving approaches, supplemented by organizational illustrations, seem to offer valuable support in fostering students' problem-solving ability. Therefore, educators must critically evaluate and select textbooks that align with pedagogical principles aimed at promoting deep understanding of word problems.

Technology

Technology is an essential tool in teaching mathematics as 'it influences the mathematics that is taught and enhances student learning' (National Council of Teachers of Mathematics 2000, 24). Several studies highlighted that technology can be used to promote critical, analytic, and higher order thinking skills, provide drill and practice, and engage students in real-world problem solving (e.g. Wiske, Franz, and Breit 2005). Moreover, incorporating technology into mathematics instruction provides variation in modes of delivery formats, which may promote engagement and improve learning experiences, student motivation and attitudes toward maths (Higgins, Huscroft-D'Angelo, and Crawford 2019).

To date, different technology-based approaches have been proposed for word problem-solving: (1) drill-and-practice programmes, where students engage in repetitive exercises on specific types of word problems with basic computer-generated feedback (e.g. correct/incorrect) and assistance (e.g.

hints or scaffolding provided in the case of mistakes), (2) adaptive tutoring systems that offer tailored support, (3) environments aimed at personalizing or enhancing the realism of the word problem-solving experience, and (4) software designed to foster students' systematic use of metacognitive strategies (see Verschaffel et al. 2020). Although most studies that used technology-based approaches demonstrated an improvement in the learning outcomes (see the meta-analysis by Higgins, Huscroft-D'Angelo, and Crawford 2019), suggesting the potential of technology interventions to positively impact problem-solving abilities, more research is necessary to draw definitive conclusions about the unique contribution of technology. Furthermore, research is warranted to ascertain the applicability and effectiveness of such interventions in real-world educational settings.

The Role of Teachers

A final consideration should be made in respect to teachers, as their proficiency in word problems and the quality of their teaching significantly impact students' problem-solving skills (Verschaffel et al. 2020). Studies that examined the content knowledge of future teachers revealed that many encounter difficulties when solving word problems themselves (Verschaffel, Corte, and Borghart 1997). For instance, in a study by Cramer, Post, and Currier (1993), pre-service elementary education teachers in the United States were presented with the problem: 'Sue and Julie were running equally fast around a track. Sue started first. When she had run 9 laps, Julie had run 3 laps. When Julie completed 15 laps, how many laps had Sue run?' Despite the problem's simplicity, most participants attempted to solve it proportionally: $9/3 = x/15$; $3x = 135$; $x = 45$, rather than using additive reasoning. Hence, it is imperative for teachers to acknowledge and confront their own limitations to improve the quality of instructional practices.

A work by Daroczy et al. (2020) has investigated teaching styles and highlighted two teaching styles that promote better problem-solving skills, especially in the case of particularly complex problems: (1) developing a supportive climate characterized by a good teacher-student relationship, constructive feedback exchange, and a positive approach towards errors, and (2) a teaching method based on cognitive activation, where the teacher aims to cognitively stimulate students by proposing challenging exercises (not too easy to avoid boring students, not too difficult to avoid demotivating them). A supportive climate and the presence of constructive feedback would enhance word problem performance by increasing motivation and reducing student anxiety, while teaching based on cognitive activation would promote reflection and reasoning, as well as encourage the application of different solution strategies (Daroczy et al. 2020).

Educational Implications

In light of the literature discussed in the previous sections, several implications can be drawn to enhance students' proficiency in word problem-solving. In this section, two educational implications will be presented.

Firstly, we highlight the importance of teaching a problem-solving strategy based on mental representation of the problem. As observed, difficulties arise when the solver constructs a poorer mental model of the problem (e.g. excluding relevant information or keeping irrelevant information) or does not engage in this process at all (e.g. using a superficial solution strategy based on keywords). In this regard, teachers should avoid proposing strategies solely based on identifying keywords and linking those words to operations (Doz, Cotič, and Passolunghi 2023; Powell and Fuchs 2018). This instructional strategy is superficial in nature since it bypasses the deeper understanding of the problem and the construction of the mental model (Mayer et al. 1995). In a similar vein, teachers should refrain from explaining the meaning of a keyword by connecting it to an arithmetic operation, like, 'The word *more* tells us to add.' Telling students to add whenever they see the word 'more' is a teaching error (see the case of inconsistent problems). Practitioners should rather focus on teaching children to integrate a problem's textual information into an adequate mental representation. To support students in building effective problem representations, educators are advised to utilize graphical representations, such as diagrams (Jitendra 2002). Diagrams also provide children with strategies that reduce the cognitive demands involved in problem-solving (Fuchs et al. 2021), thus making them effective for students with difficulties in working memory.

Another consideration pertains to the textbooks utilized and the diversity of word problems proposed to children. Practitioners must be aware that an educational approach that chooses to 'train' students to tackle only standard problems generates interpretative stereotypes that reinforce over time, such as 'The problem text contains all and only the data necessary for the solution,' 'Every problem always has a solution,' or 'There are keywords in the problem suggesting the operations to be performed.' These beliefs will lead students to develop a superficial problem-solving strategy that does not aim at a deep understanding of the problem.

If the aim is to develop meaningful word problem-solving skills, then it is imperative to alternate routine and non-routine problems. Routine problems enable students to automate the solving process, whereas non-routine problems encourage them to reason and find a solution by trying to understand the problem situation (e.g. problems with irrelevant information, with missing data, or with multiple solutions). For instance, practitioners could consider presenting problems such as the following: 'The teacher asks Paul to count the students in the first class and Rolando to count the students in second class. Paul takes 3 minutes to complete his task while Rolando takes 5 minutes. Are there more students in the first or second class?' Children, referring to the numbers in the text, may think that there are more students in the second class because Rolando took longer to count them. However, real-life knowledge suggests that it is not possible to reach a solution based on the information provided in the task: Rolando may have taken longer because he is slower at counting. Similarly, it is useful to present students with problems that may have more than one solution or even infinite solutions. An example of this type is: 'Max and Fiona are siblings, and there is a 5-year age difference between them. How old are Max and Fiona?' This word problem admits infinite solutions given by the ordered pairs (n, $n + 5$), where n is the number of years of one of the two siblings.

Conclusion

The ability to solve word problems is one of the most complex and challenging mathematical skills to acquire. Difficulties in this maths domain are multifaceted and influenced by various factors including task characteristics, individual differences, and environmental factors. In moving forward, educators should critically evaluate instructional practices and embrace pedagogical approaches that prioritize deep understanding, critical thinking, and creative reasoning in word problem-solving. Furthermore, integrating real-life contexts and interdisciplinary connections into problem-solving activities can deepen students' engagement and promote the transfer of mathematical skills to practical situations.

References

Baddeley, A. D., and G. Hitch. 1974. 'Working Memory.' In *Psychology of Learning and Motivation: Advances in Research and Theory,* edited by G. A. Bower, 47–89. Vol. 8. New York: Academic Press.

Barbu, O. C., and C. R. Beal. 2010. 'Effects of Linguistic Complexity and Math Difficulty on Word Problem Solving by English Learners.' *International Journal of Education* 2 (2). https://doi.org/10.5296/ije.v2i2.508.

Boonen, A. J., and J. Jolles. 2015. 'Second Grade Elementary School Students' Differing Performance on Combine, Change and Compare Word Problems.' *International Journal of School and Cognitive Psychology* 2 (122). http://dx.doi.org/10.4172/1234-3425.1000122.

Brown, A. 1978. 'Knowing When, Where, and How to Remember: A Problem of Metacognition.' In *Advances in Instructional Psychology,* edited by R. Glaser, 77–165. Vol. 1. Hillsdale, MI: Erlbaum.

Cotič, M., and D. Felda. 2011. 'Solving Realistic Problems in the Initial Instruction of Mathematics.' *Metodički obzori: časopis za odgojno-obrazovnu teoriju i praksu* 6 (11): 49–61.

Cotič, M., and M. Valenčič Zuljan. 2009. 'Problem-Based Instruction in Mathematics and Its Impact on the Cognitive Results of the Students and on Affective-Motivational Aspects.' *Educational Studies* 35 (3): 297–310.

Cramer, K., T. Post, and S. Currier. 1993. 'Learning and Teaching Ratio and Proportion: Research Implications.' In *Research Ideas for the Classroom: Middle Grades Mathematics,* edited by D. T. Owens, 159–178. New York: Macmillan.

Daroczy, G., B. Fauth, K. Cipora, D. Meurers, and H. C. Nuerk. 2020. 'The Relation of Teaching Quality to the Task Difficulty in Word Problems.' *PsyArXiv.* https://doi.org/10.31234/osf.io/dz9he.

Daroczy, G., D. Meurers, J. Heller, M. Wolska, and H. C. Nürk. 2020. 'The Interaction of Linguistic and Arithmetic Factors Affects Adult Performance on Arithmetic Word Problems.' *Cognitive Processing* 21 (3): 105–125.

Daroczy, G., M. Wolska, W. D. Meurers, and H. C. Nuerk. 2015. 'Word Problems: A Review of Linguistic and Numerical Factors Contributing to Their Difficulty.' *Frontiers in Psychology* 6. https://doi.org/10.3389/fpsyg.2015.00348.

Depaepe, F., E. De Corte, and L. Verschaffel. 2010. 'Teachers' Approaches towards Word Problem Solving: Elaborating or Restricting the Problem Context.' *Teaching and Teacher Education* 26 (2): 152–160.

Doz, E., M. Cotič, and M. C. Passolunghi. 2023. 'The Development of Strategies for Solving Arithmetic Word Problems: Using Keywords or Diagrams?' In *Vzgoja in izobraževanje med preteklostjo in prihodnostjo,* edited by A. Istenič, M. Gačnik, B. Horvat, M. Kukanja Gabrijelčič, V. R. Kiswarday, M. Lebeničnik, M. Mezgec, and M. Volk, 411–426. Koper: Založba Univerze na Primorskem.

Dresen, V., S. Pixner, and K. Moeller. 2020. 'Effects of Place-Value and Magnitude Processing on Word Problem Solving.' *Cognitive Development* 54 (4): 100876.

Francis, G. 1989. 'Thematic Selection and Distribution in Written Discourse.' *Word* 40 (1–2): 201–221.

Fuchs, L. S., D. Fuchs, P. M. Seethaler, and C. Craddock. 2020. 'Improving Language Comprehension to Enhance Word-Problem Solving.' *Reading and Writing Quarterly* 36 (2): 142–156.

Fuchs, L. S., P. M. Seethaler, S. K. Sterba, C. Craddock, D. Fuchs, D. L. Compton, D. C. Geary et al. 2021. 'Closing the Word-Problem Achievement Gap in First

Grade: Schema-Based Word-Problem Intervention with Embedded Language Comprehension Instruction.' *Journal of Educational Psychology* 113 (1): 86–103.

Haag, N., B. Heppt, P. Stanat, P. Kuhl, and H. A. Pant. 2013. 'Second Language Learners' Performance in Mathematics: Disentangling the Effects of Academic Language Features.' *Learning and Instruction* 28:24–34.

Haghverdi, M., A. S. Semnani, and M. Seifi. 2012. 'The Relationship between Different Kinds of Students' Errors and the Knowledge Required to Solve Mathematics Word Problems.' *Bolema: Boletim de Educação Matemática* 26 (42B): 649–666.

Halliday, M., C. M. Matthiessen, and C. Matthiessen. 2014. *An Introduction to Functional Grammar.* New York: Routledge.

Hegarty, M., R. E. Mayer, and C. E. Green. 1992. 'Comprehension of Arithmetic Word Problems: Evidence from Students' Eye Fixations.' *Journal of Educational Psychology* 84 (1): 76–84.

Hegarty, M., R. E. Mayer, and C. A. Monk. 1995. 'Comprehension of Arithmetic Word Problems: A Comparison of Successful and Unsuccessful Problem Solvers.' *Journal of Educational Psychology* 87 (1): 18–32.

Higgins, K., J. Huscroft-D'Angelo, and L. Crawford. 2019. 'Effects of Technology in Mathematics on Achievement, Motivation, and Attitude: A Meta-Analysis.' *Journal of Educational Computing Research* 57 (2): 283–319.

Jaffe, J. B., and D. J. Bolger. 2023. 'Cognitive Processes, Linguistic Factors, and Arithmetic Word Problem Success: A Review of Behavioral Studies.' *Educational Psychology Review* 35 (4): 105.

Jitendra, A. K. 2002. 'Teaching Students Math Problem-Solving through Graphic Representations.' *Teaching Exceptional Children* 34 (4): 34–38.

Lewis, A. B., and R. E. Mayer. 1987. 'Students' Miscomprehension of Relational Statements in Arithmetic Word Problems.' *Journal of Educational Psychology* 79 (4): 363–371.

Lucangeli, D., P. Tressoldi, and M. Cendron. 1998. 'Cognitive and Metacognitive Abilities Involved in the Solution of Mathematical Word Problems: Validation of a Comprehensive Model.' *Contemporary Educational Psychology* 23 (3): 257–275.

Miyake, A., and N. P. Friedman. 2012. 'The Nature and Organization of Individual Differences in Executive Functions: Four General Conclusions.' *Current Directions in Psychological Science* 21 (1): 8–14.

Mullis, I. V. S., M. O. Martin, P. Foy, and A. Arora. 2012. *TIMSS 2011 International Results in Mathematics.* Chestnut Hill, MA: TIMSS and PIRLS International Study Center.

National Council of Teachers of Mathematics. 2000. *Principles and Standards for School Mathematics.* Reston, VA: National Council of Teachers of Mathematics.

OECD. 2013. *PISA 2012 Results in Focus: What 15-Year-Olds Know and What They Can Do With What They Know.* Paris: OECD.

Orrantia, J., L. B. González, and S. Vicente. 2005. 'Analysing Arithmetic Word Problems in Primary Education Text Books.' *Infancia y Aprendizaje* 28:429–451.

Pape, S. J. 2003. 'Compare Word Problems: Consistency Hypothesis Revisited.' *Contemporary Educational Psychology* 28 (3): 396–421.

Passolunghi, M. C., and F. Pazzaglia. 2005. 'A Comparison of Updating Processes in Children Good or Poor in Arithmetic Word Problem-Solving.' *Learning and Individual Differences* 15 (4): 257–269.

Passolunghi, M. C., and L. S. Siegel. 2001. 'Short-Term Memory, Working Memory, and Inhibitory Control in Children with Difficulties in Arithmetic Problem Solving.' *Journal of Experimental Child Psychology* 80 (1): 44–57.

Passolunghi, M. C., C. Cornoldi, and S. De Liberto. 1999. 'Working Memory and Intrusions of Irrelevant Information in a Group of Specific Poor Problem Solvers.' *Memory and Cognition* 27 (5): 779–790.

Passolunghi, M. C., I. Lonciari, and C. Cornoldi. 1996. 'Abilità di pianificazione, comprensione, metacognizione e risoluzione di problemi aritmetici di tipo verbale.' *Età Evolutiva* 54:36–48.

Passolunghi, M. C., G. D. De Blas, B. Carretti, I. Gomez-Veiga, E. Doz, and J. A. Garcia-Madruga. 2022. 'The Role of Working Memory Updating, Inhibition, Fluid Intelligence, and Reading Comprehension in Explaining Differences between Consistent and Inconsistent Arithmetic Word-Problem-Solving Performance.' *Journal of Experimental Child Psychology* 224 (4): 105512.

Peng, P., and D. Fuchs. 2016. 'A Meta-Analysis of Working Memory Deficits in Children with Learning Difficulties: Is There a Difference between Verbal Domain and Numerical Domain?' *Journal of Learning Disabilities* 49 (1): 3–20.

Pongsakdi, N., B. Brezovszky, K. Veermans, M. M. Hannula-Sormunen, and E. Lehtinen. 2016. 'A Comparative Analysis of Word Problems in Selected Thai and Finnish Textbooks.' In *Proceedings of the 40th Conference of the International Group for the Psychology of Mathematics Education,* edited by C. Csikos, A. Rausch, and J. Szitanyi, 75–82. Szeged: International Group for the Psychology of Mathematics Education.

Pongsakdi, N., A. Kajamies, K. Veermans, K. Lertola, M. Vauras, and E. Lehtinen. 2020. 'What Makes Mathematical Word Problem Solving Challenging? Exploring the Roles of Word Problem Characteristics, Text Comprehension, and Arithmetic Skills.' *ZDM: The International Journal on Mathematics Education* 52 (1): 33–44.

Powell, S. R., and L. S. Fuchs. 2018. 'Effective Word-Problem Instruction: Using Schemas to Facilitate Mathematical Reasoning.' *Teaching Exceptional Children* 51 (1): 31–42.

Powell, S. R., J. M. Namkung, and X. Lin. 2022. 'An Investigation of using Keywords to Solve Word Problems.' *The Elementary School Journal* 122 (3): 452–473.

Raduan, I. H. 2010. 'Error Analysis and the Corresponding Cognitive Activities Committed by Year Five Primary Students in Solving Mathematical Word Problems.' *Procedia - Social and Behavioral Sciences* 2 (2): 3836–3838.

Schumacher, R. F., and L. S. Fuchs. 2012. 'Does Understanding Relational Terminology Mediate Effects of Intervention on Compare Word Problems?' *Journal of Experimental Child Psychology* 111 (4): 607–628.

Swanson, H. L., C. M. Lussier, and M. J. Orosco. 2015. 'Cognitive Strategies, Working Memory, and Growth in Word Problem Solving in Children with Math Difficulties.' *Journal of Learning Disabilities* 48 (4): 339–358.

Swetz, F. J. 2009. 'Culture and the Development of Mathematics.' In *Culturally Responsive Mathematics Education,* edited by B. Greer, S. Mukhupadhyay, A. B. Powell, and N. Nelson-Barber, 11–42. New York: Routledge.

To, V., T. Lê, and Q. Lê. 2013. 'A Comparative Study of Nominalisation in IELTS Writing Test Papers.' *International Journal of Innovative Interdisciplinary Research* 1 (4): 15–21.

Verschaffel, L., E. de Corte, and I. Borghart. 1997. 'Pre-Service Teachers' Conceptions and Beliefs about the Role of Real-World Knowledge in Mathematical Modelling of School Word Problems.' *Learning and Instruction* 7 (4): 339–359.

Verschaffel, L., B. Greer, and E. de Corte. 2000. *Making Sense of Word Problems.* Lisse: Swets and Zeitlinger.

Verschaffel, L., S., Schukajlow, J. Star, and W. Van Dooren. 2020. 'Word Problems in Mathematics Education: A Survey.' *ZDM Mathematics Education* 52 (1). https://doi.org/10.1007/s11858-020-01130-4.

Vicente, S., R. Sánchez, and L. Verschaffel. 2020. 'Word Problem Solving Approaches in Mathematics Textbooks: A Comparison between Singapore and Spain.' *European Journal of Psychololgy of Education* 35 (7): 567–587.

Vicente, S., L. Verschaffel, R. Sánchez, and D. Múñez. 2022. 'Arithmetic Word Problem Solving: Analysis of Singaporean and Spanish Textbooks.' *Educational Studies in Mathematics* 111:375–397.

Wiske, M. S., K. R. Franz, and L. Breit. 2005. *Teaching for Understanding with Technology.* Hoboken, NJ: Jossey-Bass.

Kateri dejavniki vplivajo na težavnost reševanja besedilnih nalog?

Reševanje matematičnih besedilnih nalog je ključen element pri pouku matematike. Kljub temu se veliko učencev po vsem svetu sooča s težavami pri reševanju besedilnih nalog, kar poudarja potrebo po razumevanju dejavnikov, ki vplivajo na to matematično spretnost. Prispevek predstavi model, ki ga oblikujejo Gabriella Daroczy idr. (2015), in si prizadeva preučiti tri glavne dejavnike, ki prispevajo k težavam pri reševanju besedilnih nalog. Najprej predstavimo, kako lastnosti besedila (tj. jezikovne lastnosti, številske lastnosti in njihova medsebojna povezanost) vplivajo na kompleksnost naloge in kognitivni napor. Nato obravnavamo kognitivne sposobnosti, tako specifične kot splošne, ki so vpletene v reševanje besedilnih nalog. Nazadnje pa analiziramo vlogo okoljskih dejavnikov, kot so učbeniki, uporaba tehnologije in kakovost poučevanja. Zagovarjamo pedagoške pristope, ki temeljijo na razumevanju problemske situacije in na ustvarjanju notranje predstave problema, saj sta ti dve osnovi za uspešno reševanje.

Ključne besede: matematične besedilne naloge, jezikovne lastnosti, številske lastnosti, kognitivne spretnosti, učno okolje