

Efficacy of the bar model method in solving algebraic word problems: An exploratory study with grade 8 Kosovo pupils

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Abstract

Using graphical representations such as strips, bars, or diagrams can help solve word problems. This study explores how Grade 8 pupils' use of bar models evolved after a brief instructional intervention in Kosovo, where visual representation strategies are not typically emphasised. The research focused on two questions: the types of bar models pupils create and the relationship between bar models and problem-solving success. The intervention involved 62 pupils who were initially unfamiliar with visual problem-solving strategies. After five lessons of practising the bar model method, pupils demonstrated improvements in both the frequency and quality of their bar models for complex two-step WPs. The findings revealed an association between the quality of the bar models and problem-solving success, with correct bar models leading to correct solutions. Even partially correct bar models with certain characteristics were associated with the right answers in more than 80% of cases. While some pupils quickly adopted the bar model method, others would require more tailored instruction to fully benefit from visual strategies. The study's significance lies in demonstrating that a brief teaching intervention can be effective in a cultural context where visual representation and problem-solving skills are not typically emphasised in the classroom. Moreover, it provides more insight into the characteristics of bar models drawn by pupils when solving word problems. Future research should explore the long-term effects of bar models and how incomplete representations facilitate understanding.

Keywords: bar model, intervention, mathematics, visual representations, word problems

INTRODUCTION

The ability to solve word problems (WPs) is a crucial skill that pupils need to develop, as it enables them, among other skills, to apply mathematical concepts to real-life situations. Visual representations such as tape diagrams in Japan (Murata, 2008) and bar models in Singapore (Kho, 1987) can be powerful strategies for solving WPs. Such visual representations mediate between verbal representations and symbolic representations, providing a bridge to transform WPs into abstract mathematical expressions (Baysal & Sevinc, 2022; Kaur, 2019; Kho, 1987; Murata, 2008) and, as Murata (2008) emphasises, giving pupils space to understand a problem before making an abstract representation.

However, drawing models is not an easy task and must be learned. Some pupils struggle to use visual

representations effectively for WP solving (e.g., Ng, 2003; Ng & Lee, 2009). Furthermore, Boonen et al. (2014) reported that when representations were inaccurate, pupils had a significantly lower chance of correctly completing a mathematical problem than did pupils with accurate representations. Similarly, de Koning et al. (2022) reported that the accuracy of the representation mattered, especially for more difficult WPs.

Pupils from Kosovo often fail to solve WPs. As Berisha et al. (2013) and Morina (2022) observed, problem-solving strategies are seldom promoted in mathematics lessons; teachers do not emphasise heuristic strategies, and pupils rarely use them. Pupils in Kosovo lack familiarity with the visual aspects of problem-solving. Thus, a teaching intervention to develop Kosovo lower secondary pupils' ability to solve WPs was designed. The intervention included learning bar model drawing (Kho, 1987). The present study

Contribution to the literature

- This study characterises the types of bar models used by pupils following a short instructional intervention.
- It examines the relationship between the quality of pupils' bar models and their problem-solving success.
- It provides new insights into how bar model representations develop in a context where this method has not been previously used.

focuses on part of the data from the intervention: the pupils' solutions to WPs. This study seeks to contribute to the literature by:

- (1) Characterising the types of bar models that pupils used after the intervention, and
- (2) Exploring the relationship between the quality of these models and problem-solving success.

By doing so, the aim was to characterise the types of bar models that pupils create and how they evolve over a short intervention period in a context where the bar model method has not been used before, an area not fully explored in previous studies.

LITERATURE REVIEW

Word problems are specific written mathematical tasks set in real-world contexts that require the application of mathematical concepts to answer the questions posed. They help pupils develop essential skills such as reading comprehension, problem-solving, and critical thinking while connecting mathematical concepts to real-world contexts (Blum & Niss, 1991; Englert et al., 1987; Pongsakdi et al., 2020; Verschaffel et al., 2020). WPs prepare pupils for situations that arise in daily life (Pongsakdi et al., 2020), and their solutions help pupils develop a deeper understanding of mathematical concepts and acquire skills that can be applied in various disciplines and contexts.

Word Problem Solving

Solving WPs requires both mathematical and situational comprehension. To solve a WP, Reusser (1985) distinguished the levels of text comprehension, situation comprehension (resulting in the creation of a situation model), mathematisation (in which the mathematical model arises from the abstraction of the situation model), calculation, and answer interpretation. The situation model is thus seen as an intermediate, less mathematical representation that is important for the mathematical model.

Many studies show that pupils struggle with WPs (Daroczy et al., 2015). One source of difficulty is inconsistent language. While consistent WPs use clear language without contradictions or misleading cues (de Koning et al., 2022), inconsistent WPs contain words or phrases that suggest the opposite operation needed for

the solution. Inconsistent WPs are generally more difficult than consistent ones (Hegarty et al., 1992; Verschaffel et al., 1992; Vondrová, 2020). Pupils often use the keyword strategy (e.g., Nesher & Teubal, 1975), bypassing the stage of the situation model, which is ineffective for this type of WPs. Visual representations can help reduce the reliance on such strategies.

Visual Representations in WP Solving

de Koning et al. (2022) describe the use of visual representations in solving WPs as a continuous process of coordinating the problem text with the construction of a visual structure. As pupils transfer information from the text to a drawing, they revisit the text iteratively, reshaping their understanding, identifying new relationships, and refining their interpretation. This process is externalised through the creation or revision of the visual representation.

The interaction between visual representation and problem comprehension influences cognitive processing and the selection of mathematical operations (de Koning et al., 2022). Visual representations thus serve as mediators between the situation model and the mathematical model. Encouraging visual representations can help deter learners from impulsive strategies, such as relying on keywords (Verschaffel et al., 2020). Bar models specifically help pupils bridge visual comprehension and mathematical relationships, aiding their transition from arithmetic to algebraic reasoning (Ng, 2022). For example, after a three-hour bar model instruction, pupils made fewer errors in solving algebraic WPs, and constructing bar models helped them correct their algebraic equations (Baysal & Sevinc, 2022).

Although visual representations are considered a heuristic strategy to ease task difficulty in the initial problem-solving stages (Verschaffel et al., 2020), they can add cognitive load. However, teaching pupils to use diagrams can reduce the cognitive demands of solving complex or multistep problems, as diagrams offload some of the intrinsic cognitive load of WPs (Jitendra & Woodward, 2019). When used effectively, visual representations support cognitive processes and improve problem-solving, particularly in more complex tasks.

Bar Models

This study focuses on a schematic rather than a pictorial representation (Hegarty & Kozhevnikov, 1999) for a WP, specifically representations that can be used consistently across grade levels. Examples include tape diagrams in Japan (Murata, 2008) and bar or block models in Singapore (Kho, 1987).

Bar models are rectangular-shaped representations that visually illustrate relationships among quantities. They were developed by the Singaporean Primary Mathematics Project team, led by Kho Tek Hong, in the 1980s and became a distinguishing feature of the curriculum and of mathematics textbooks. There are three basic types of bar models (Kho, 1987). The part-whole model illustrates the connection between a whole and its parts. In the comparative model, the rectangles are used to compare one quantity with another and indicate the difference in size. Finally, the before-and-after (change) model demonstrates the relationship between a quantity's original value and its new value after an increase or decrease (Ho & Lowrie, 2014).

There is evidence from countries like Japan, Singapore (Kaur, 2019; Murata, 2008; Ng, 2003), and the Netherlands (de Koning et al., 2022), where visual representations are consistently used, that the bar model method effectively enhances mathematics learning. Early on, this method aids in solving arithmetic problems, and later, it helps represent known and unknown quantities or variables. Successful attempts to introduce the bar model method at the primary level have been made globally (Bao, 2016; Baysal & Sevinc, 2022; Gani et al., 2019; Ho & Lowrie, 2014; Kaur, 2019), showing learning gains even for pupils with specific learning disabilities (Morin et al., 2017; Xin, 2019).

Quality of the Bar Models

Drawing bar models is challenging and requires practice. Some pupils struggle to use visual representations effectively to solve WPs (e.g., Ho & Lowrie, 2014; Ng & Lee, 2009). Accurate visual representations are crucial for success (Ho & Lowrie, 2014; de Koning et al., 2022). For instance, Boonen et al. (2014) found that pupils with inaccurate visual representations were almost six times less likely to solve the problem correctly than those with accurate ones. However, their study examined the spontaneous use of visual representations. In contrast, studies by de Koning et al. (2022) and Ng and Lee (2009) assessed the quality of visual representations among pupils who had been taught the bar model method.

Ng and Lee (2009) identified four types of errors when bar models were used:

- 1) Partly correct models with missing or misrepresented essential information,
- 2) Changing generators midway,

- 3) Correct model drawing and correct arithmetic equations, but failure to maintain the goal of the problem,
- 4) Insufficient conceptual knowledge required for problem-solving.

Ng and Lee (2009) emphasise that using the bar model method to solve WPs is not "an all-or-nothing process" (p. 310). For example, one-third of the pupils' solutions in their study were partly correct. They had a correct overall representation, but they made an error in the representation, which led to an incorrect solution. This error "could be the result of a misinterpretation of the information correctly captured in the model, a misrepresentation of a piece of information, or changing the generator midway through the solution" (Ng & Lee, 2009, p. 310).

de Koning et al. (2022) classified bar models in Grade 5 pupils' solutions as accurate, inaccurate, or absent. Accurate bar models include the correct representation of all values and relations expressed in the WP. They reflect a clear understanding of the problem structure and guide pupils towards a correct solution. Inaccurate bar models are those in which some value(s) and/or their relationships are incorrectly represented or missed. de Koning et al. (2022) reported that bar models provide adequate graphical support for both consistent and inconsistent WPs, with a more significant impact on inconsistent WPs. The accuracy of visual representation is important, especially for inconsistent WPs, which are more difficult for pupils than consistent WPs (Daroczy et al., 2015; Hegarty et al., 1992; Verschaffel et al., 1992; Vondrová, 2020). This may indicate that the quality of bar models matters primarily for WPs with complex parameters.

Local Context and Research Questions

The current Kosovo curriculum aims to develop higher-order thinking, practical skills, and real-world competencies, with a strong emphasis on problem-solving and WPs (MEST, 2020). However, lower-secondary mathematics textbooks in Kosovo offer limited opportunities for developing problem-solving strategies and higher-order thinking (Berisha et al., 2013), as most problems are routine and noncontextual (Berisha & Bytyqi, 2020). Additionally, textbooks lack visual representations for solving WPs, and teachers seldom use them (Morina & Vondrová, 2021). Therefore, exploring pupils' solutions in this setting can yield insights into how such models may support learning in resource-limited environments.

The literature shows that WP interventions focus on improving pupils' text comprehension (De Corte et al., 1985; Fuchs et al., 2019; Wong & Ho, 2017), cognitive awareness of solving steps using scaffolds (e.g., CRIME (Teong, 2003), SOLVE (Freeman-Green et al., 2015), STAR (Özkubat et al., 2021)), and visual representation

skills (Gani et al., 2019; Ho & Lowrie, 2014; Kaur, 2019; Kho, 1987; Verschaffel et al., 2020). In the teaching intervention, Kosovan pupils were taught to draw bar models. Therefore, the study addresses the following research questions.

RQ1 What bar models do pupils create when solving WPs, and how do they change after the teaching intervention, which allows pupils to practise the bar model method?

RQ2 How does pupils' problem-solving success vary according to the presence and quality of bar models?

METHODS

Procedure

While in Japan (Murata, 2008) and Singapore (Kho, 1987), visual representations are introduced in elementary textbooks, in Kosovo, a single grade level had to be selected, and a relatively short intervention had to be designed to align with the curriculum. It was decided to make use of the potential of the bar model method to facilitate the transition from arithmetic to algebra (Baysal & Sevinc, 2022; Ng, 2022), thereby enriching the repertoire of solving strategies for Grade 8 WPs.

The Kosovo Grade 8 curriculum includes more WPs than other grades because pupils are introduced to the system of linear equations at this level. Three Grade 8 teachers who agreed to implement the intervention were introduced to the bar model method. The first author answered the teachers' questions until they felt comfortable using the bar model method.

The study employed a one-group pretest-posttest design to examine pupils' use of bar models in a five-lesson intervention. The aim was primarily descriptive and exploratory to characterise the types of bar models produced by pupils and their relationship with problem-solving success. The pupils were given a pretest of six WPs and asked to solve them individually to examine their prior strategies for WPs. The teacher then used four WPs to introduce pupils to the bar model method, and the pupils practised drawing bar models on 16 other WPs spread over the intervention. They worked individually but could cooperate and seek assistance. The intervention lasted five lessons before the pupils were given a posttest with six WPs. They were instructed to work individually and to use the bar model method.

Finally, nine pupils who volunteered to participate immediately after the intervention were interviewed, with no selection based on performance. This data was secondary and served solely to provide illustrative insight into pupils' perceptions; it was not used as primary evidence to evaluate the intervention's effectiveness.

Participants

The study participants were 69 Grade 8 pupils from a public school in Kosovo. The school was purposely selected to provide a typical public educational setting in Kosovo. As the study aimed to develop a teaching approach intended for broad applicability within the national context, it was important to conduct the intervention in a school that does not implement alternative or specialised pedagogical models that would distinguish it from normal public education. The school follows the national curriculum and comprises pre-primary (ages 5–6), primary (ages 6–11), and lower secondary education (ages 11–15). With approximately 1,000 pupils, it is of medium size relative to other public schools in Kosovo. Pupils can enroll in the school under the standard public school area policy, with no specific admission or academic achievement criteria. The school has a mixed socioeconomic composition drawn from its surrounding urban area. Based on available school data, pupils' mathematics achievement levels are broadly consistent with municipal and national averages, with no indication of over- or underperformance. The school implements the curriculum and teaching practices in accordance with the national curriculum and curricular frameworks. These characteristics suggest that the school reflects common structural and demographic features of mainstream public schools in Kosovo. To ensure consistent implementation of the intervention and monitor instructional fidelity, the school was also chosen because it allowed the researcher to be present in all intervention lessons.

Three Grade 8 teachers from the school participated in the study. After informing them and the parents of pupils about the purpose and content of the research, their consent was obtained to implement the intervention and collect data, including pupils' written solutions. As seven pupils missed some lessons during the intervention, data from 62 pupils in this study were used. These pupils had an average age of 13 years, and prior to participating in the teaching intervention, they had no experience using visual representations when solving WPs.

Instruments

Visual representations are generally unnecessary for one-step consistent WPs as their situation models are relatively straightforward. In contrast, inconsistent WPs pose greater challenges for pupils, as they cannot be reliably solved using keyword strategies alone. To better demonstrate the added value of the bar model method, we therefore focused on two-step WPs, where the benefits of visual representation become more evident for both consistent and inconsistent problems.

The Kosovo curriculum also guided our selection. The WPs involved whole numbers and comparison terms like *more than*, *less than*, and *n times as many* to align

Table 1. Examples of the WPs with possible bar models (originally in Albanian)

Word Problems (with Bar Models)	Word Problems (with Bar Models)
<p>WP1. Of 450 books by an author, 124 were sold to a publishing house on the first day, which is 24 more books sold than on the second day. How many of the author's books are still unsold?</p> <p><u>Change bar model (Inconsistent - Pretest)</u></p>	<p>WP2. During the running competitions, on the first day, the pupils ran 0.7 km; on the second day, 0.4 km more than on the first day; and on the third day, 0.3 km less than on the second day. How many km did they run in total?</p> <p><u>Part whole bar model(Consistent - Pretest)</u></p>
<p>WP3. Brenda is an art teacher. She opens a box of 80 crayons to prepare for tomorrow's project. She removes 8 broken crayons. She then divides the rest of the crayons equally into 6 boxes. Find the number of crayons in each box.</p> <p><u>Change bar model (Inconsistent - Intervention)</u></p>	<p>WP4. Of the 2 100 kilogrammes of potatoes in the warehouse, 942 kilogrammes were sold on the first day, while on the second day, 118 kilogrammes less than on the first day. How many kilograms of potatoes are left in the warehouse?</p> <p><u>Change bar model (Consistent - Intervention)</u></p>
<p>WP5. 305 children went to a zoo on Saturday. The number of children who visited the Zoo on Saturday was 278 less than on the Sunday visit. How many children went to the zoo on Sunday?</p> <p><u>Change bar model (Inconsistent - Intervention)</u></p>	<p>WP6. Ron had three times as much money as Kiara. Greta had twice as much money as Kiara. If they have \$294 in total, how much money does each have?</p> <p><u>Comparative bar model (Consistent - Posttest)</u></p>
<p>WP7. Era, Hana, and Andy had to read 64 books this summer. Era read 16 books, which is 10 books more than Hanna and twice less than Andy. How many books were still left to read?</p> <p><u>Change bar model (Inconsistent - Posttest)</u></p>	<p>WP8. Era read 25 books this year, which is 5 books more than Hana and 12 books less than Andi. How many books did they read together?</p> <p><u>Part-whole bar model (Inconsistent - Posttest)</u></p>

with basic bar model types (Ng & Lee, 2009). All WPs could be solved algebraically. 28 WPs were used: Six in the pretest, 16 during the teaching intervention (six solved with teacher guidance, four as homework, and six solved individually), and six in the posttest.

Eight WPs are shown in **Table 1**. For example, WP2 is a consistent problem where phrases like “0.4 km more than on the first day” clearly indicate addition. In contrast, WP1, an inconsistent problem, uses “24 more books sold”, suggesting addition ($124 + 24$), but the correct solution requires subtraction ($124 - 24$). Here, the bar model helps visualise the subtraction by showing the initial number of books and removing a portion of that quantity (**Table 1**).

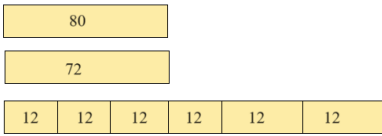

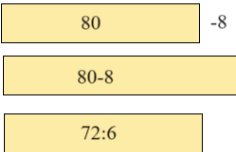
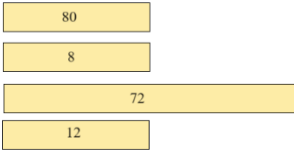
An *a priori* analysis of all the WPs was conducted to anticipate correct (**Table 1**) and incorrect bar models (examples provided for WP3 in **Table 2**).

Data and Analysis

The data for this study consisted of pupils' written solutions to six WPs in the pretest, six in the posttest, and the six assigned during the teaching intervention, which the pupils solved individually. Half of these WPs were consistent, and the other half were inconsistent. In total, 18 WPs' solutions for 62 pupils were analysed, $N = 1,116$.

The scans of the pupils' solutions were uploaded to Atlas.ti. Each written solution was number-coded: The

Table 2. Examples of possible incorrect bar models for WP3

The bar models do not have the correct dimensions.	Missing bars
	
<p>The shapes of the bar models do not have the correct dimensions, since the first bar (80) should be longer than the second bar (72), which should be the same size as the bars divided into six equal parts.</p>	<p>A bar model is missing for the second part of the task, indicating that eight crayons were taken out, while the bar models for the third part are only divided into five parts.</p>
The shape of the bar model does not fit the mathematical operation.	Unclear representations or shapes
	
<p>The second bar should be smaller than the first one to demonstrate subtraction (removing the crayons). The third bar should be divided into six parts to demonstrate the division by six.</p>	<p>The bars do not depict the relationship between the data in the problem and do not have the correct dimensions.</p>

first two digits denote the number assigned to each pupil (01–62), and the next digit depicts the number assigned to each WP. In the first stage of analysis, the basic characteristics of the solutions were determined and coded as ‘correct answer’, ‘incorrect answer’, ‘bar model present’, and ‘bar model not present’. Next, the solutions of the pupils who drew a ‘bar model were targeted. Given that no pupil attempted to draw the situation in the pretest, we proceeded with the solutions relevant to the teaching intervention and the posttest (N = 744).

Qualitative analysis

Coding was performed in an inductive-deductive way (Saldaña, 2016). Based on the results of others (de Koning et al., 2022; Ng & Lee, 2009) and the a priori analysis of the WPs, whether the structure of the bar models fitted the mathematical operation required by the WP was checked, whether all the bar models were drawn or some were missing, and whether they had correct dimensions. Five mutually exclusive codes emerged from this analysis:

All bars present and with the correct dimensions,

All bars present but not with the correct dimensions,

Some bars missing,

All bars present but not all fit the mathematical operations, and

Unclear representation.

The last code was used for (for us) ambiguous drawings.

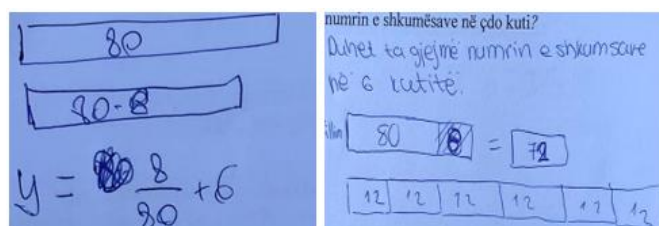


Figure 1. ‘Some bars missing’ (left) and ‘All bars present but not with the correct dimensions’ (right) for WP3 (Source: Field study)

These codes were merged into three categories:

- 1) ‘correct bars’,
- 2) ‘incorrect bars’, or
- 3) ‘partially correct bars’.

The bars in the ‘correct’ category align well with the information from the WP (similar to those presented in **Table 1**). The ‘partially correct’ category includes the bars that fit the required mathematical operation, but:

- (1) Their dimensions are not always precise, and/or
- (2) The bars for the second step are missing.

Examples are shown in **Figure 1**. The ‘incorrect’ category consists of solutions with bars not matching the correct mathematical operation or unclear bar models. Examples are shown in **Figure 2**.

Pupils’ bar models were hand-drawn, and proportional accuracy is a known challenge in such representations. In the analysis, emphasis was placed on the accurate representation of quantities and relationships between elements, and on overall



Figure 2. ‘All bars present but not all fit the mathematical operations’ (left) and ‘Unclear representation’ (right) for WP3 (Source: Field study)

structural accuracy, rather than on proportionality. A model was coded as structurally accurate if:

- (a) The quantities were represented in appropriate model relationships (e.g., part-whole, comparative, change model), and
- (b) The relative ordering of quantities reflected the mathematical relationships described in the problem.

Minor deviations in drawing proportions were considered acceptable, and such models were deemed correct as long as they reflected the mathematical relationships underlying the WP. This approach ensures that the assessment focuses on conceptual understanding rather than drawing precision. However, significant proportional distortions that deviated from the relational structure (e.g., representing a smaller quantity as visually larger in a comparison problem) were coded as inaccurate. This approach acknowledges the development of hand-drawn representations while maintaining consistency in evaluating conceptual understanding.

Next, the link between the accuracy of the bar models and the correctness of the answers was investigated. Some solutions, even those with incorrect bars, were correct. Five categories emerged:

- 1) ‘correct bars and correct answers’,
- 2) ‘incorrect bars and correct answers’,
- 3) ‘partially correct bars and correct answers’,
- 4) ‘incorrect bars and incorrect answers’, and
- 5) ‘partially correct bars and incorrect answers’.

The resulting framework is shown in Figure 3.

It was also sought to determine in the written work whether the bar model appeared to play a role in the solution process. In particular, we examined whether the drawing preceded the calculation steps, as this could indicate that the model informed the pupils’ reasoning.

For reliability, the data codes were examined by the second author, a mathematics education researcher familiar with the bar model method, who also checked 10% of the written solutions for coding consistency. To resolve any coding discrepancies, the two authors discussed the concerns until they reached an agreement.

A semi-structured interview was conducted with nine pupils to explore their overall experiences with the WPs, their feedback on the intervention, and their understanding of the learning experiences from their perspective. Due to the limited intervention time, pupils were interviewed immediately after the posttest and selected based on their willingness to participate.

Quantitative analysis

The data were also quantified. Summary tables were created that depict the number of solutions with a particular type of bar model, the number of solutions in each category, and the correctness of the answers.

The pretest and posttest were designed with different WPs to minimise potential learning effects from a short

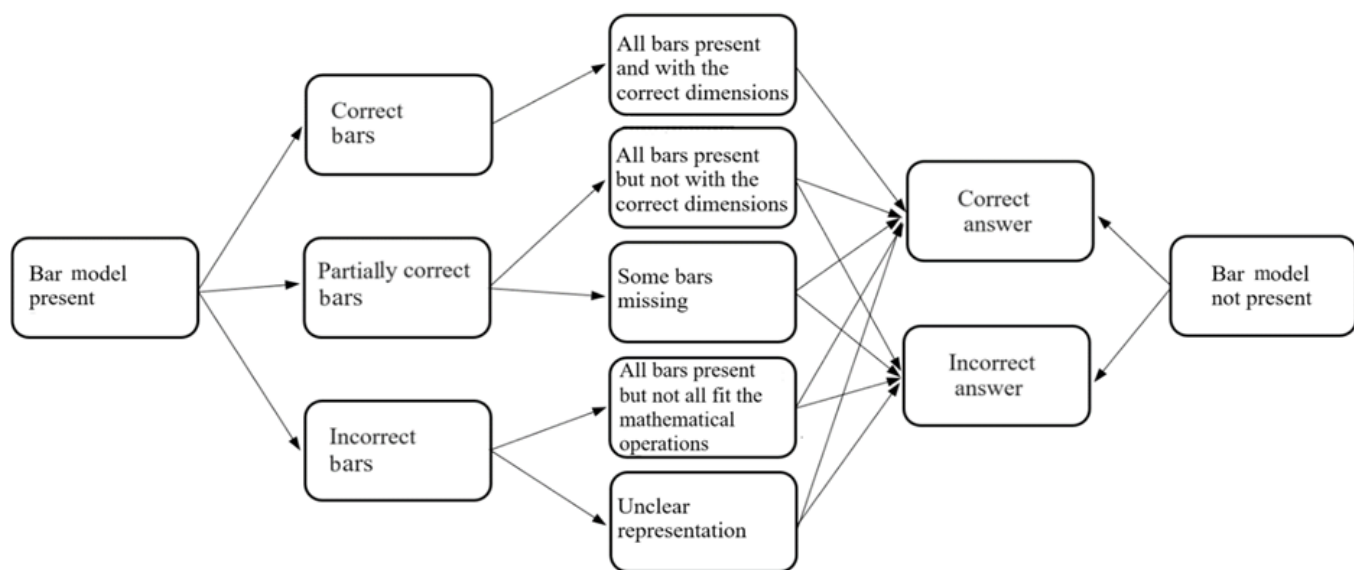


Figure 3. Categories of pupils’ solutions in terms of bar models and correctness of the answers (Source: Authors’ own elaboration)

Table 3. Average success rates (%)

Pretest			Intervention			Posttest		
Consistent	Inconsistent	Average	Consistent	Inconsistent	Average	Consistent	Inconsistent	Average
54	42	48	62	56	59	78	73	76

intervention. However, both tests were carefully elaborated to ensure equal difficulty levels. Each test contained the same number of consistent and inconsistent WPs, all two-step WPs set within familiar contexts and solvable using the three types of bar models and linear equations. Owing to differences in test content, only average success rates for consistent and inconsistent WPs were analysed, and substantive evaluation were performed.

The average success rates for each of the three bar model categories was then calculated:

- 1) 'incorrect',
- 2) 'partially correct', and
- 3) 'correct'.

Additionally, it was determined whether solution correctness varied according to the presence and quality of the applied bar models (coded as 0 – no bar model, 1 – incorrect bar model, 2 – partially correct bar model, 3 – correct bar model).

RESULTS

Before addressing the RQs, changes in average success rates for WPs after the intervention were first presented (Table 3). At all stages, the pupils solved inconsistent WPs less successfully than consistent WPs. The differences in success rates between the pretest and posttest indicate a marked improvement in performance for both types of WPs, with inconsistent WPs showing slightly greater gains. These findings suggest that the intervention positively impacted pupils' problem-solving ability.

The study's main focus is on the presence and quality of bar models. Figure 3 presents the framework that originated from the analysis of pupils' solutions and is the springboard for answering the RQs. The arrows show the relationships between three characteristics: correctness of the bar model (the second column), dimensions/completeness/operation fit (the middle column), and correctness of the answer (the fourth column). For example, if the pupil drew a correct bar model, the solution always included the correct answer. If the pupil drew an incorrect bar model whose shape did not fit the mathematical operation, the answer could be correct or incorrect.

What bar models do pupils create when solving WPs, and how do the bars change after the intervention? (RQ1)



Figure 4. Correct bar models for WP3 (Source: Field study)

Pupils' solutions to WP3 (see Table 1) will illustrate the types of bar models.

Figure 4 includes two *correct* bar models, visually clear, uncluttered, and with accurate proportional sizing. They do not necessarily adhere to exact dimensions (they might differ from the bars in Table 1) but provide a clear representation of the WP structure, quantities, and relationships between them.

For *partially correct bars*, the bars align with the mathematical operation required by the WP but:

- (1) The bar model for the second solving step is missing (e.g., division by 6 in WP3, see Figure 1, left) or
- (2) All the bars are present but do not have the correct dimensions (e.g., Figure 1, right – the last bar should be shorter than the bar above).

In solutions with *incorrect bars*, the bar model does not match the required mathematical operation or is unclear to us. Figure 2 (left) is an example of the former, as the last bar depicts the addition of 6 rather than the division by 6, as required by WP3. Figure 2 (right) is an example of an 'unclear representation', as there is no apparent relation of the bars to the WP3 structure. The bars are just frames around the numbers.

Table 4 presents the number of solutions in which the types of bars in the above categories are present in the solutions to WPs from the teaching intervention and the posttest (there were no drawings in the pretest). During the intervention, approximately the same number of solutions had correct (99), partially correct (97), and incorrect (96) bar models. In the posttest, the number of correct bar models increased considerably (170), and the number of incorrect bars decreased (65), whereas fewer solutions had no bar models.

Table 4. Number and per cent of solutions with each category of bar models

Category	Intervention		Posttest		Total	
	N	%	N	%	N	%
Correct bars	99	27	170	46	269	36
Partially correct bars	97	26	98	26	195	26
All bars present but not with the correct dimensions	68		84		152	
Some bars missing	29		14		43	
Incorrect bars	96	26	65	17	161	22
All bars present but not all fit the mathematical operations	50		35		85	
Unclear representation	46		30		76	
Bar model not present	80	22	39	10	119	16
Total	372	*	372	*	744	100

* The sum is not 100% due to rounding

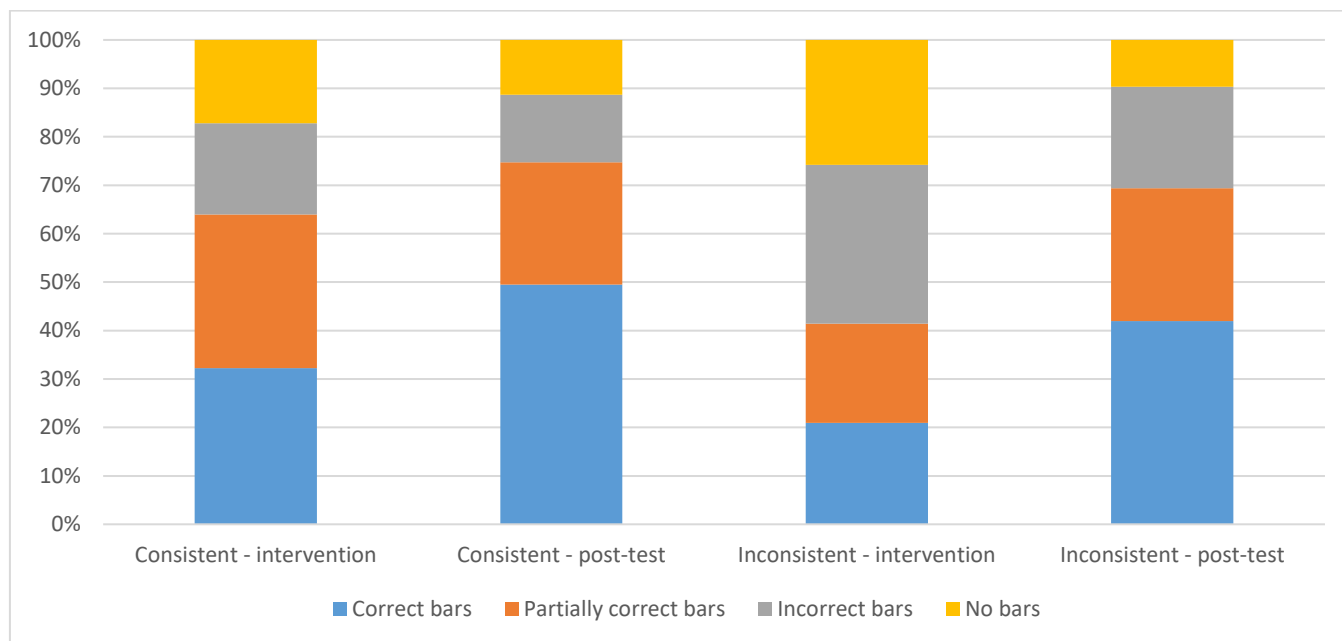


Figure 5. Types of bars in solutions to consistent/inconsistent WPs in the intervention/posttest (Source: Authors' own elaboration)

With respect to the same data regarding language consistency, in the posttest, the pupils drew more bar models for both consistent and inconsistent WPs, and their quality improved (Figure 5). There was a greater increase in the number of correct and partially correct bars for inconsistent WPs. The number of correct bar models doubled for inconsistent WPs in the posttest compared with the intervention.

How does pupils' problem-solving success vary according to the presence and quality of bar models? (RQ2)

To address RQ2, the solutions were first quantified into categories as shown in Figure 3. Figure 6 combines data from both the intervention and posttest, while Table 5 separates the information for each phase. Most pupils used bar models during the intervention and posttest when solving WPs.

Table 6 shows success rates in relation to bar model quality. The table illustrates a clear pattern: The higher the quality of the bar model, the higher the success rate in solving the WPs. All solutions with a correct bar

model included the correct answers. Additionally, partially correct bar models were accompanied by correct answers in 86% of cases during the intervention and 84% during the posttest. An example is shown in Figure 1, right. The representation of the relationship in the first step of the solution to WP3 is correct (the subtraction of 8 from 80). The bar for the second step corresponds to the required mathematical operation (division by 6), but the length of the bar does not correspond to that of bar 72. Another example of this category is shown in Figure 7. The first step is visualised correctly, whereas the second step (division into equal parts) is not depicted. The final answer is correct in both cases.

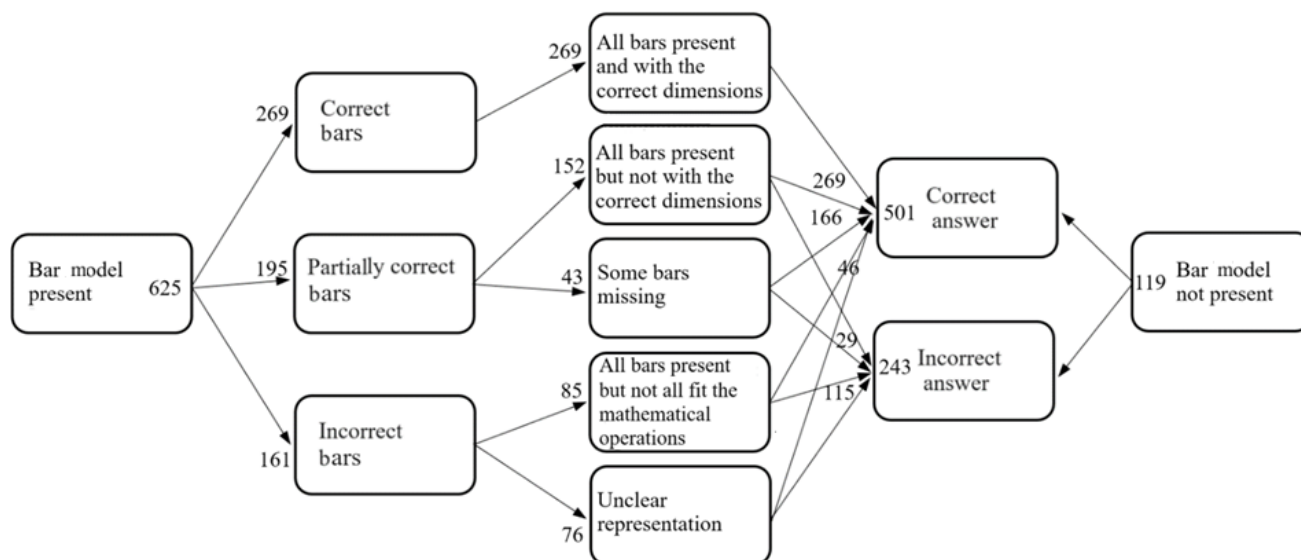


Figure 6. Number of solutions in each category in the intervention and posttest (Source: Authors' own elaboration)

Table 5. Number of correct/incorrect solutions in the teaching intervention/posttest and the quality of bar models

Answer	Bars	Intervention	Posttest	Total	%
Correct	Correct bars	99	170	269	36
	Partially correct bars	83	83	166	22
	All bars present but not with the correct dimensions	57	73	130	
	Some bars are missing	26	10	36	
	Incorrect bars	31	15	46	6
	All bars present but not all fit the mathematical operations	17	4	21	
	Unclear representation	14	11	25	
	Bar model not present	7	13	20	3
Incorrect	Partially correct bars	14	15	29	4
	All bars present but not with the correct dimensions	11	14	25	
	Incorrect bars	65	50	115	16
	All bars present but not all fit the mathematical operations	33	31	64	
	Unclear representation	32	19	51	
	Bar model not present	73	26	99	13
Total		372	372	744	*

* The sum is not 100% due to rounding

Table 6. Average success rates of solutions by bar model category during intervention and posttest (%)

Category	Intervention	Posttest
No bar model	9	33
Incorrect bar model	32	25
Partially correct bar model	86	84
Correct bar model	100	100

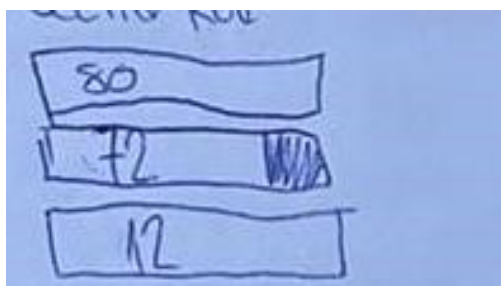


Figure 7. Correct answer and partially correct bars for WP3 (Source: Field study)

Approximately 32% and 25%, respectively, of the solutions with incorrectly drawn bar models were correct. Examples are shown in Figure 8. Such bars could hardly facilitate the creation of the mathematical model. The correct calculation was likely created without any visual representation, and the rectangles were included as an afterthought because the assignment required it. The bars are just frames around numbers; they do not depict any relationship between them.

For the sake of completeness, Figure 9 presents an example of an incorrect solution with a partially correct bar model, and Figure 10 is an example of an incorrect solution with incorrect bar models. The bar models did not facilitate the solution for the pupils.

Given the nature of our data, strong conclusions regarding causal influence between the presence and type of bar models in the written solutions can not be drawn. However, considering that in approximately

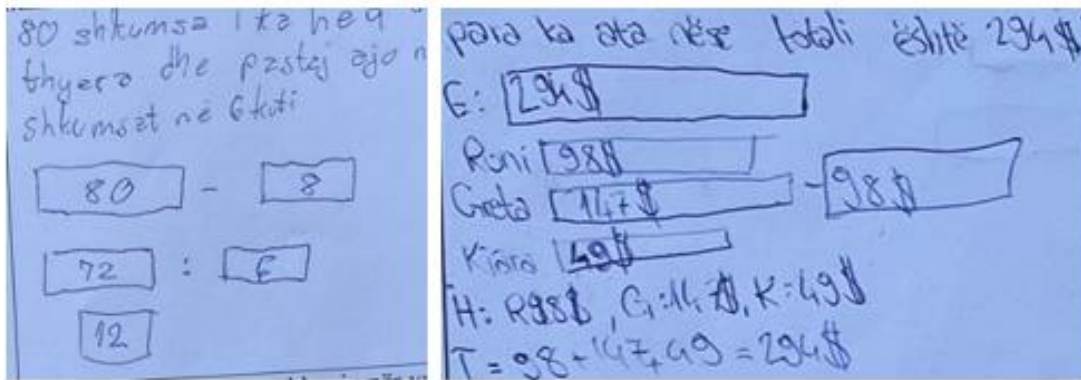


Figure 8. Incorrect bars and correct solutions (WP3, left; WP6, right) (Source: Field study)

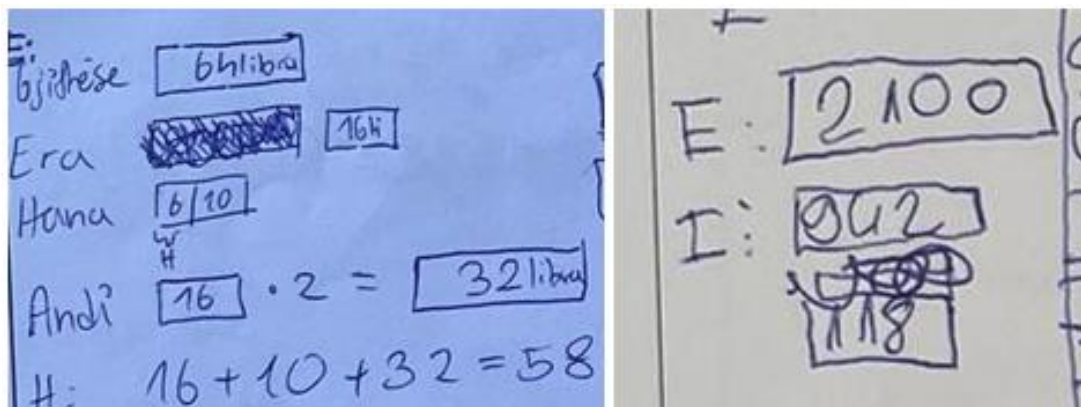


Figure 9. Partially correct bars with an incorrect answer (WP7 left, WP4 right) (Source: Field study)

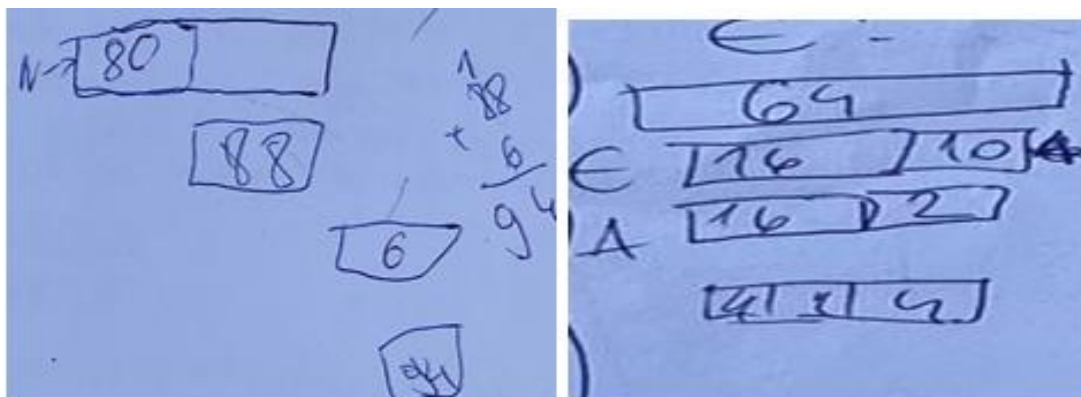


Figure 10. Incorrect bars with an incorrect answer (WP3, left; WP7, right) (Source: Field study)

87% of the solutions, the drawing preceded the calculations, it is cautiously suggested that there is a positive association between the quality of the bar model and problem-solving success.

Table 7 reports only the posttest results for the consistent and inconsistent WPs. Each percentage shows the proportion of pupils who, within that bar model category, correctly solved the corresponding WP type. For example, 100% of the pupils who drew a correct bar model successfully solved both consistent and inconsistent word problems. Closer inspection of the bolded data in Table 7 reveals that pupils tended to solve consistent WPs more successfully without employing bar models than inconsistent WPs.

Table 7. Average success rates of solutions by bar model category for consistent and inconsistent WPs in the posttest (%)

	Consistent WPs (% of correct solutions)	Inconsistent WPs (% of correct solutions)
No bar model	42	25
Incorrect bar model	19	29
Partially correct bar model	83	85
Correct bar model	100	100

Pupils' interview

A positive attitude toward the bar model method was observed in the pupils' interviews. Pupils reported that they rarely used WPs in their lessons and never used the bar model to solve such tasks. Initially, it was difficult for them to apply visualisation within the WP solutions. However, after some practice, they liked it and found solutions more easily through the bar model.

Pupil A At the beginning, it was very difficult to apply it to word problems. But after some time, we enjoyed it. Making some bars and linking them with mathematical operations is very good. But, hmm, sometimes it is tricky.

Pupil B We never did it like this when we solved word problems before. We only use equations in the solution. For me, it was good but difficult to understand. But if you understand, it helps you a lot.

Some of them found the approach to be very helpful and not tiring.

Pupil C It is very helpful. It helped me to solve the problems, and it was not tiring at all. The time passed very quickly while practising it.

Pupil D It helped me and guided me to arrive at the correct solution, and made me feel good.

Furthermore, they claimed that the intervention helped them as they were better in the posttest compared to the pretest.

Pupil E I would not have known how to solve the 3rd and 4th word problems [in the posttest] if I had not used the bar model method. I understood how much I should add and subtract when I drew them.

Pupil F In the first test [pretest], I was not that good. I remembered that I had only three or four WPS solved. But in the second test [posttest], after the intervention, I solved all.

The pupils were also asked if they would continue to use bar models in the future.

Pupils G The bar model method simplified the solution. However, as we had not learned any strategy for the solution before, I really liked this one and will use it again.

Pupil D I plan to participate in the mathematics competition Kangaroo next year. I will practise it until then, and I will definitely use it.

Pupil E It is a very good strategy. I will use the drawing of the bars in the future.

However, some pupils struggled to grasp the conceptual meaning of bar models.

Pupil H I was stressed sometimes, as I did not understand how to draw the bar model for each WP.

Pupil M I don't know why, in some tasks, I stopped, as I had difficulties drawing the bar models. An extra explanation would be good.

The reasons behind this need to be studied further.

DISCUSSION

The main objectives of this study were to characterise the types of bar models that pupils create and how they changed following the intervention, and to determine whether they were associated with the correctness of solutions.

Types of Bar Models Drawn by the Pupils and Their Changes after the Intervention

In the pretest, no pupils used visual representations to solve WPs, supporting findings by Berisha et al. (2013) and Morina (2022) that pupils in Kosovo are unfamiliar with this approach. This reflects broader research showing that pupils rarely use visual representations spontaneously in WPs (Uesaka & Manalo, 2012).

The analysis of 744 pupils' solutions involving bar models identified three key characteristics. The first concerns the presence of bars representing each step in a two-step WP. In some cases, the bars corresponding to the second step were missing. The second characteristic relates to the proportionality of the bars. It was assessed whether the bars were appropriately sized relative to one another; minor inaccuracies in drawing were tolerated, as the evaluation focused on proportional consistency rather than exact graphical precision. From a pedagogical perspective, some degree of proportional imprecision in hand-drawn bar models is expected, particularly at the lower secondary level. The focus of the intervention was to support pupils' conceptual understanding of quantitative relationships rather than to develop technical drawing precision. Minor inaccuracies do not necessarily indicate misconceptions. Instead, they may reflect motor execution constraints or the fact that, for the purpose of constructing a mathematical model of the situation, it is often sufficient for the solver to represent the qualitative relationship between quantities, such as which quantity is larger or smaller, without depicting their exact proportional difference. In this sense, bar models function primarily as schematic representations that support reasoning about relationships (Ng & Lee, 2008). However, substantial distortions that change the relationship between quantities can signal incomplete relational understanding. Differentiating between these is important both for research coding and classroom assessment. The third characteristic concerns the appropriateness of the bar models for the required mathematical operation. Five bar model types were

identified in the data, some aligning with Ng and Lee's (2009) classification of 'partly correct models with missing or misrepresented essential information' or 'correct model drawings.'

The comparison of bar models in the pupils' solutions in the intervention and in the posttest showed that in the posttest, bar models were more frequent (nearly 90% included some form of drawing) and of higher quality (46% of solutions included correct bar models, 26% partially correct bar models). The presence of correct or partially correct bar models in the solutions increased, especially for inconsistent WPs, similar to de Koning et al. (2022).

Pupils' Problem Solving Success and the Presence and Quality of Bar Models

As anticipated, posttest success rates improved following the teaching intervention. The increase in solution correctness was accompanied by a greater number of correct or partially correct bar models between the intervention and posttest phases. This finding is consistent with previous research by Gani et al. (2019), who reported similar outcomes in Grade 9 pupils introduced to the bar model method for solving percentage-based WPs, and it aligns with results from other studies (de Koning et al., 2022; Ng & Lee, 2009).

One of the most notable findings from the study is that pupils who drew correct bar models consistently arrived at the correct solution. This underscores the importance of accurate visual representations for achieving successful solutions (Bao, 2016; Boonen et al., 2014; de Koning et al., 2022; Ho & Lowrie, 2014). Although it is possible that pupils used an alternative strategy to solve the WP and added the bar model afterwards, this scenario is unlikely, as bar models generally preceded the calculations in the written solutions.

Another finding is that, in the study, more than 80% of the solutions with partially correct bar models were also correct, which resonates with Ng and Lee (2009), who identified cases in which errors in visual representation led to partially correct solutions. One possible explanation would be that a pupil attempted to draw bar models but found them unhelpful and resorted to another strategy. Another plausible explanation is that even partially correct models helped pupils build a situation model and, in turn, a mathematical model.

Partially correct bar models were of two types. In the more frequent one, bar models feature incorrect dimensions (e.g., the first and second steps are depicted correctly in isolation, but the relationship between them is flawed), a detail that does not seem to affect the final outcome. This observation echoes Ng and Lee (2008), who found that proportionality was less important than logical relationships depicted in bar models for Grade 5 pupils proficient in bar models. The data do not allow

for a more detailed investigation of how proportional imprecision may have influenced pupils' interpretation. Future studies could explore methods to support more precise representations, such as digital tools.

Other solutions with partially correct bar models included missing bars for the second step, yet the correct mathematical model was still applied. It is tentatively suggested that the initial drawing helped the pupils complete the first step, and they could proceed to the second step without accurately depicting it because they had already formed a suitable situation model.

Next, in terms of the types of WPs, a greater increase was observed in the number of correct and partially correct bar models for inconsistent WPs, with the number of fully correct bar models doubling in the posttest compared with the intervention phase. Moreover, a higher percentage of solutions to inconsistent WPs yielded correct answers, even when the accompanying bar models were incorrect. Taken together, these findings tentatively suggest that bar models played a more important role in solving inconsistent WPs (see also de Koning et al., 2022). This aligns with the view that prompting pupils to construct bar models may help them avoid superficial keyword-based strategies. Indeed, Verschaffel et al. (2020) emphasise the importance of inhibitory control in suppressing automatic but incorrect strategies, particularly in inconsistent WPs, where inhibiting the immediate association between keywords and operations is crucial. In the study, pupils were explicitly required to draw bar models during both the intervention and the posttest. This requirement necessitated repeated reference to the WP text, a process that likely supported a deeper understanding of the problem structure and improved pupils' ability to identify key actors and relationships within it (de Koning et al., 2022).

Finally, although the interviews served as secondary data, they provided additional insight into pupils' perceptions of the bar model method. During these interviews, several pupils reported that the method enhanced their understanding of how to solve WPs. Many also expressed a desire to continue using it in the future, recognising its value in facilitating problem-solving.

However, evidence from the written solutions revealed that some pupils struggled to grasp the conceptual meaning of bar models. Instead of using the bars to represent quantities and operations, they drew rectangles merely as frames around numbers, suggesting a limited understanding of bar models as visual representations of mathematical relationships. This pattern was consistent with statements made in the interviews, where some pupils acknowledged that they would require further practice to use the method.

Taken together, these findings indicate that additional instructional time or a more individualised approach may be necessary to foster a deeper conceptual understanding of bar models (Poch et al., 2015). Alternatively, introducing bar models more gradually in earlier grades (as it is done in some countries, de Koning et al., 2022; Kaur, 2019; Murata, 2008; Ng, 2003), initially through one-step WPs, may provide a stronger foundation for later, more complex applications.

Limitations

Several limitations should be acknowledged.

First, despite the effort to select a school that reflects common structural and institutional characteristics of public schools in Kosovo and is considered a 'typical' school in Kosovo, the relatively small sample drawn from a single grade level across three classes, each taught by a different teacher, limits the generalisability of the findings. Although statistical generalisation cannot be claimed, the findings may allow for cautious analytical generalisation to similar public school contexts within the country. Future research should replicate the intervention with larger and more diverse samples to examine the robustness of the observed effects across different educational contexts. In addition, cultural and curricular factors specific to Kosovo may have influenced the results, which restricts generalisation beyond this setting. Nevertheless, the documented effectiveness of the bar model method in diverse contexts (e.g., Baysal & Sevinc, 2022) suggests potential for broader applicability.

Second, the study did not examine the long-term maintenance or transfer of the bar model method. Although pupils indicated in the interviews that they intended to continue using the strategy, and teachers expressed similar expectations (Morina & Vondrová, 2025), it is not known whether pupils sustained its use over time or applied it across different mathematical topics. Longitudinal research is therefore needed to assess the durability and transferability of this strategy beyond the immediate intervention context.

Third, improvements observed between the pretest and posttest cannot be attributed exclusively to the bar model intervention. Factors such as increased WP familiarity, additional practice, or general instructional effects may also have contributed. Moreover, although a positive association was observed between bar model quality and problem-solving success, the data do not allow for causal conclusions. Establishing causality would require more rigorous designs, such as the inclusion of control or comparison groups, randomised assignment, or process-oriented methodologies (e.g., think-aloud protocols or eye-tracking) that could capture how pupils use representations during problem-solving.

Furthermore, the interviews served only as complementary qualitative data. Nine participating pupils were volunteers, which may have introduced self-selection bias; pupils less receptive to the method may have opted not to participate. In addition, the interviews were conducted immediately after the posttest and prior to analysing the written solutions, due to time constraints. As a result, pupils discussed their perceptions of the bar model method in general terms rather than in relation to their specific performance. This limits the explanatory power of the qualitative findings, as they were not systematically linked to particular solution patterns. Future research should integrate qualitative and quantitative data more closely—for example, by interviewing pupils representing distinct performance profiles (e.g., incorrect bar with correct solution; partially correct bar with incorrect solution).

Finally, the observed association between bar model quality and solution success may reflect multiple underlying mechanisms. While constructing bar models may have supported pupils' conceptualisation of problem situations, it is also possible that pupils with stronger prior mathematical competence were more likely to produce higher-quality representations. However, the data do not allow us to explore this hypothesis. Future research is needed to explore it further.

CONCLUSIONS AND IMPLICATIONS

The primary aim of this study was to characterise the types of bar models pupils construct, examine how these representations change following an instructional intervention, and explore their association with solution correctness. Prior to the intervention, no pupils used bar models, indicating limited familiarity with visual problem-solving strategies. Following the intervention, however, pupils not only adopted bar models more frequently but also demonstrated clear improvements in their quality. This suggests that even relatively brief instructional support can foster the uptake and refinement of visual representations in WP solving.

The analysis identified five distinct types of bar models and revealed a substantial increase in the proportion of correct and partially correct representations in the posttest, particularly for inconsistent WPs. These findings indicate that visual representations may support deeper engagement with problem structure, especially in tasks that require pupils to inhibit superficial keyword-based strategies.

A central finding of the study is the association between bar model quality and problem-solving success. Pupils who constructed correct bar models consistently arrived at correct solutions, and even partially correct representations were associated with correct answers in more than 80% of cases. Although causal conclusions cannot be drawn, these results suggest that constructing

bar models may support pupils' understanding of the problem situation and the underlying mathematical relationships.

At the same time, not all pupils developed a conceptual understanding of bar models. While some readily adopted the method, others appeared to treat the bars as superficial frames around numbers rather than as representations of quantitative relationships. This highlights the importance of sustained and, where necessary, more individualised instruction to ensure that visual strategies are understood conceptually rather than applied mechanically.

This study contributes to the existing literature in several ways. First, it provides further evidence of the effectiveness of the bar model method, particularly for more complex, inconsistent WPs. Second, it offers a nuanced classification of the types of bar models pupils construct in two-step WPs, including representations that are structurally incomplete yet still associated with correct solutions. Third, it demonstrates the feasibility of introducing the bar model method in educational contexts where visual representation strategies are not traditionally emphasised.

The results have pedagogical implications. Teachers should consider integrating visual representation strategies systematically into WP instruction, with particular emphasis on inconsistent WPs. Introducing bar models earlier in schooling, including in one-step WPs, may allow pupils to build a stronger conceptual foundation before encountering more complex WPs. Notably, even partially correct bar models appeared to support problem-solving, suggesting that encouraging representational attempts may help pupils move beyond superficial strategies and engage more deeply with problem structure.

Future research should investigate how partially correct or incorrect bar models nonetheless facilitate successful solutions, as well as examine the method's effectiveness in WPs involving additional complexities, such as irrelevant or mixed-order data (Englert et al., 1987; Pongsakdi et al., 2020). Further attention should also be given to individual differences in the adoption and use of bar models, including cognitive and motivational factors.

In sum, while bar models show considerable promise as a tool for enhancing WP solving, further research employing longitudinal and controlled designs is required to clarify their precise role in supporting mathematical understanding and performance.

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AI statement: The authors stated that generative AI or AI-based tools were not used at any stage of this research.

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REFERENCES

- Bao, L. (2016). The effectiveness of using the model method to solve word problems. *Australian Primary Mathematics Classroom*, 21(3), 26-31.
- Baysal, E., & Sevinc, S. (2022). The role of the Singapore bar model in reducing students' errors on algebra word problems. *International Journal of Mathematical Education in Science and Technology*, 53(2), 289-310. <https://doi.org/10.1080/0020739X.2021.1944683>
- Berisha V., & Bytyqi R. (2020). Types of mathematical tasks used in secondary classroom instruction. *International Journal of Evaluation and Research in Education*, 9(3), 751-758. <https://doi.org/10.11591/ijere.v9i3.20617>
- Berisha, V., Thaçi, X., Jashari, H., & Klinaku, S. (2013). Assessment of mathematics textbooks potential in terms of students' motivation and comprehension. *Journal of Education and Practice*, 4(28), 33-37.
- Blum, W., & Niss, M. (1991). Applied mathematical problem solving, modelling, applications, and links to other subjects: State, trends, and issues in mathematics education. *Educational Studies in Mathematics*, 22(1), 37-68. <https://doi.org/10.1007/BF00302716>
- Boonen, A. J. H., van Wesel, F., Jolles, J., & van der Schoot, M. (2014). The role of visual representation type, spatial ability, and reading comprehension in word problem solving: An item-level analysis in elementary school children. *International Journal of Educational Research*, 68, 15-26. <https://doi.org/10.1016/j.ijer.2014.08.001>
- Daroczy, G., Wolska, M., Meurers, W. D., & Nuerk, H.-C. (2015). Word problems: A review of linguistic and numerical factors contributing to their difficulty. *Frontiers in Psychology*, 6(348), 22-34. <https://doi.org/10.3389/fpsyg.2015.00348>
- De Corte, E., Verschaffel, L., & de Win, L. (1985). Influence of rewording verbal problems on children's problem representations and solutions.

- Journal of Educational Psychology*, 77(4), 460-470. <https://doi.org/10.1037/0022-0663.77.4.460>
- de Koning, B. B., Boonen, A. J. H., Jongerling, J., van Wesel, F., & van der Schoot, M. (2022). Model method drawing acts as a double-edged sword for solving inconsistent word problems. *Educational Studies in Mathematics*, 111(1), 29-45. <https://doi.org/10.1007/s10649-022-10150-8>
- Englert, C. S., Culatta, B. E., & Horn, D. G. (1987). Influence of irrelevant information in addition word problems on problem-solving. *Learning Disability Quarterly*, 10(1), 29-36. <https://doi.org/10.2307/1510752>
- Freeman-Green, S. M., O'Brien, C., Wood, C. L., & Hitt, S. B. (2015). Effects of the SOLVE strategy on the mathematical problem-solving skills of secondary students with learning disabilities learn. *Learning Disabilities Research & Practice*, 30(2), 76-90. <https://doi.org/10.1111/ldrp.12054>
- Fuchs, L. S., Fuchs, D., Seethaler, P. M., & Craddock, C. (2019). Improving language comprehension to enhance word-problem solving. *Reading & Writing Quarterly*, 36(2), 142-156. <https://doi.org/10.1080/10573569.2019.1666760>
- Gani, M. A., Tengah, K. A., & Said, H. (2019). Bar model as an intervention in solving word problem involving percentage. *International Journal on Emerging Mathematics Education*, 3(1), 69-76. <http://doi.org/10.12928/ijeme.v3i1.11093>
- Hegarty, M., & Kozhevnikov, M. (1999). Types of visual-spatial representations and mathematical problem solving. *Journal of Educational Psychology*, 91(4), 684-689. <https://doi.org/10.1037/0022-0663.91.4.684>
- Hegarty, M., Mayer, R. E., & Green, C. E. (1992). Comprehension of arithmetic word problems: Evidence from students' eye fixations. *Journal of Educational Psychology*, 84(1), 76-84. <https://doi.org/10.1037/0022-0663.84.1.76>
- Ho, S. Y., & Lowrie T. (2014). The model method: Students' performance and its effectiveness, *The Journal of Mathematical Behavior*. 35, 87-100. <https://doi.org/10.1016/j.jmathb.2014.06.002>
- Jitendra, A. K., & Woodward, J. (2019). The role of visual representations in mathematical word problems. In D. C. Geary, D. B. Berch, & K. Mann Kopeke, *Cognitive foundations for improving mathematical learning* (pp. 269-294). Elsevier. <https://doi.org/10.1016/B978-0-12-815952-1.00011-6>
- Kaur, B. (2019). The why, what and how of the 'Model' method: A tool for representing and visualising relationships when solving whole number arithmetic word problems. *ZDM Mathematics Education*, 51(1), 151-168. <https://doi.org/10.1007/s11858-018-1000-y>
- Kho, T. H. (1987). Mathematical models for solving arithmetic problems. In *Proceedings of the 4th Southeast Asian Conference on Mathematics Education (ICMI-SEAMS)* (pp.345-351). Singapore.
- MEST. (2020). *Kurrikulat lëndore/Programet mësimore [Subject Curricula/Syllabus]*. Ministria e Arsimit dhe Shkencës. <https://masht.rks-gov.net/arsimi-parauniversitar>
- Morin, L. L., Watson, S. M. R., Hester, P., & Raver, S. (2017). The use of a bar model drawing to teach word problem solving to students with mathematics difficulties. *Learning Disability Quarterly*, 40(2), 91-104. <https://doi.org/10.1177/0731948717690116>
- Morina, Q. (2022). Word problems in Kosovo's mathematics textbooks for grade 8. In J. Fejfar & M. Flégl (Eds.), *Proceedings of the 19th International Conference on Efficiency and Responsibility in Education 2022* (pp. 75-82). Czech University of Life Sciences Prague.
- Morina, Q., & Vondrová, N. (2021). Block model approach and its effect on word problem solving, A case study. In J. Novotná & H. Moraová (Eds.), *International Symposium Elementary Mathematics Teaching, Proceedings* (pp. 310-320). Charles University, Faculty of Education.
- Morina, Q., & Vondrová, N. (2025). The fidelity of implementation and teachers' perceptions of the SIMPLE approach: Evidence from lower secondary classrooms in Kosovo. *Scientia in Education*, 16(1), 35-50. <https://doi.org/10.14712/18047106.4855>
- Murata, A. (2008). Mathematics teaching and learning as a mediating process: The case of tape diagrams. *Mathematical Thinking and Learning*, 10(4), 374-406. <https://doi.org/10.1080/10986060802291642>
- Nesher, P., & Teubal, E. (1975). Verbal cues as an interfering factor in verbal problem-solving. *Educational Studies in Mathematics*, 6(1), 41-51. <https://doi.org/10.1007/BF00590023>
- Ng, S. F. (2003). How secondary two express stream students used algebra and the model method to solve problems? *The Mathematics Educator*, 7(1), 1-17.
- Ng, S. F. (2022). The model method: Crown jewel in Singapore mathematics. *Asian Journal for Mathematics Education*, 1(2), 147-161. <https://doi.org/10.1177/27527263221107526>
- Ng, S. F., & Lee, K. (2008). As long as the drawing is logical, size does not matter. *The Korean Journal of Thinking & Problem Solving*, 18(1), 67-82.
- Ng, S. F., & Lee, K. (2009). The model method: Singapore children's tool for representing and solving algebraic word problems. *Journal for Research in Mathematics Education*, 40(3), 282-313. <https://doi.org/10.5951/jresmetheduc.40.3.0282>

- Özkubat U., Karabulut A., & Serhat Uçar A. (2021). Investigating the effectiveness of STAR strategy in math problem-solving. *International Journal of Progressive Education*, 17(2), 83-100. <https://doi.org/10.29329/ijpe.2021.332.6>
- Poch, A. L., van Garderen D., & Scheuermann, A. M. (2015). Students' understanding of diagrams for solving word problems: A framework for assessing diagram proficiency. *TEACHING Exceptional Children*, 47(3), 153-162. <https://doi.org/10.1177/0040059914558947>
- Pongsakdi, N., Kajamias, A., Veermans, K., Lertola, K., Vauras, M., & Lehtinen, E. (2020). What makes mathematical word problem-solving challenging? Exploring the roles of word problem characteristics, text comprehension, and arithmetic skills. *ZDM Mathematics Education*, 52(1), 33-34. <https://doi.org/10.1007/s11858-019-01118-9>
- Reusser, K. (1985). *From situation to equation. On formulation, understanding and solving situation problems* (Technical Report no. 143). Institute of Cognitive Science, University of Colorado.
- Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). Sage.
- Teong, S. K. (2003). The effect of metacognitive training on mathematical word-problem solving. *Journal of Computer Assisted Learning*, 19(1), 46-55. <https://doi.org/10.1046/j.0266-4909.2003.00005.x>
- Uesaka, Y., & Manalo, E. (2012). Task-related factors that influence the spontaneous use of diagrams in math word problems. *Applied Cognitive Psychology*, 26(3), 251-260. <https://doi.org/10.1002/acp.1816>
- Verschaffel, L., De Corte, E., & Pauwels, A. (1992). Solving compare problems: An eye movement test of Lewis and Mayer's consistency hypothesis. *Journal of Educational Psychology*, 84(1), 85-94. <https://doi.org/10.1037/0022-0663.84.1.85>
- Verschaffel, L., Schukajlow, S., Star, J., & Van Dooren, W. (2020). Word problems in mathematics education: A survey. *ZDM Mathematics Education*, 52, 1-16. <https://doi.org/10.1007/s11858-020-01130-4>
- Vondrová, N. (2020). The effect of an irrelevant number and language consistency in a word problem on pupils' achievement and reasoning. *International Journal of Mathematical Education in Science and Technology*, 53(4), 807-826. <https://doi.org/10.1080/0020739X.2020.1782497>
- Wong, T. T.-Y., & Ho, C. S.-H. (2017). Component processes in arithmetic word-problem solving and their correlates. *Journal of Educational Psychology*, 109(4), 520-531. <https://doi.org/10.1037/edu0000149>
- Xin, Y. P. (2019). The effect of a conceptual model-based approach on 'additive' word problem solving of elementary students struggling in mathematics. *ZDM Mathematics Education*, 51, 139-150. <https://doi.org/10.1007/s11858-018-1002-9>

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