

## RESEARCH ARTICLE

# Understanding word problems: Pre-service math teacher proficiency

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## ABSTRACT

Mathematics holds a pivotal role in education, empowering students to apply mathematical principles across various domains. This study investigates the proficiency of 100 pre-service mathematics teachers enrolled in a Bachelor of Science with Education (Mathematics) Honors program at Yarmouk University in identifying content and context within mathematical word problems. Employing a case study approach and utilizing the Mathematics Word Problems Test and the Content and Context Questionnaire, the research underscores challenges in error detection and content comprehension. Pre-service mathematics teachers exhibited difficulties recognizing inaccuracies, emphasizing the importance of integrating practical context and enhancing critical thinking in pre-service teacher education. This study advocates for further research to develop strategies addressing these challenges and fostering a more holistic approach to mathematical problem-solving.

**Keywords:** mathematics education; pre-service teachers; mathematical word problems; content and context in mathematics; critical thinking in teacher education

## 1. Introduction

Mathematics serves as a foundational element in various aspects of our daily lives, influencing fields such as commerce, pharmaceuticals, software development, and space exploration. The exponential growth of technology and information underscores the escalating need for mathematical proficiency <sup>[1,2]</sup>. While school curricula often compartmentalize mathematical topics, it is essential to recognize the intricate interconnections within this discipline <sup>[3,4]</sup>. The ability to forge links between diverse mathematical concepts and apply them beyond mathematical domains is known as mathematical connection ability <sup>[5,6]</sup>.

In the pursuit of enhancing students' comprehension and practical appreciation of mathematics, educators play a pivotal role in nurturing mathematical connection ability <sup>[7,8]</sup>. This involves elucidating interrelationships among mathematical topics, demonstrating their transcendence of traditional disciplinary boundaries, and presenting challenges that inherently involve these intricate connections <sup>[9]</sup>.

One arena where these interconnected concepts manifest is in mathematics word problems—complex scenarios integrating mathematical content with real-life context <sup>[10,11]</sup>. While these problems are invaluable

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for promoting mathematical connection ability, research highlights challenges arising from insufficient information or flawed connections between data points<sup>[12]</sup>. For instance, a pre-service teacher posed a query where mathematical precision was crucial, illustrating the need for careful consideration of known and requested information<sup>[13-15]</sup>. Similarly, another pseudo-problem presented unrealistic scenarios, emphasizing the importance of relevance to everyday life<sup>[16,17]</sup>.

Unfortunately, many mathematics word problems, plagued by information deficits or pseudo-contexts, fall short of aiding students' comprehension within real-world contexts<sup>[18]</sup>. This deficiency can perpetuate the misconception that mathematics and real-life situations exist in isolation. To address this, educators, including those in the pre-service phase, must excel in discerning both mathematical content and contextual relevance within these problems<sup>[19]</sup>.

This research aims to scrutinize the proficiency of pre-service teachers in identifying content and context within mathematics word problems. By providing a comprehensive evaluation, this study lays the groundwork for potential enhancements in the competence of pre-service teachers, contributing to the ongoing discourse on meaningful mathematical education<sup>[20]</sup>.

### **1.1. Study purpose**

The purpose of this study is to systematically investigate and assess the proficiency of pre-service mathematics teachers in identifying both the mathematical content and contextual elements embedded within mathematics word problems. By delving into the intricacies of these problem-solving scenarios, the research aims to provide a comprehensive understanding of the capabilities and challenges faced by pre-service teachers in making meaningful connections between mathematical concepts and real-world situations. The ultimate goal is to contribute valuable insights that can inform educational strategies and potential enhancements in pre-service teacher training programs, fostering a more effective and contextually relevant approach to teaching mathematics.

### **1.2. Research questions**

(1) How proficient are pre-service mathematics teachers in accurately identifying and understanding the mathematical content within word problems?

(2) To what extent do pre-service mathematics teachers demonstrate the ability to connect mathematical concepts within the context of real-life scenarios presented in word problems?

(3) What challenges do pre-service mathematics teachers encounter in discerning accurate information and establishing relevant connections between mathematical concepts and contextual elements in word problems?

(4) How do pre-service mathematics teachers navigate and address pseudo-contexts or unrealistic scenarios within mathematics word problems?

(5) What strategies can be identified or recommended to enhance the proficiency of pre-service mathematics teachers in recognizing both mathematical content and contextual relevance within word problems?

### **1.3. Study importance**

This study holds significant importance for several reasons:

(1) Educational Enhancement: By scrutinizing the proficiency of pre-service mathematics teachers in identifying both mathematical content and contextual elements within word problems, the study contributes

valuable insights for improving educational practices. The findings can inform the development of more effective teaching strategies and curricula, enhancing the overall quality of mathematics education.

(2) **Real-world Application of Mathematics:** Understanding how pre-service teachers connect mathematical concepts with real-life scenarios in word problems is crucial for promoting the practical application of mathematics. This study addresses the gap between theoretical knowledge and its real-world relevance, ensuring that future educators can impart this understanding to their students.

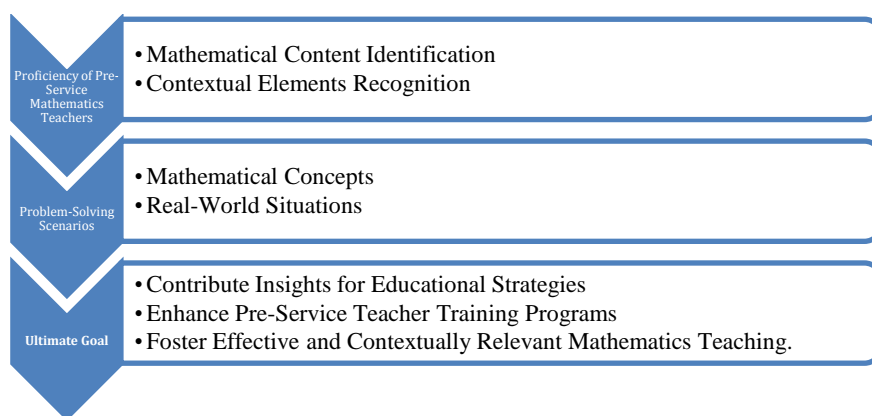
(3) **Critical Analysis Skills:** Investigating the challenges faced by pre-service teachers in discerning accurate information and establishing relevant connections fosters the development of critical analysis skills. Identifying and addressing these challenges contributes to the cultivation of a more discerning and reflective teaching approach.

(4) **Addressing Pseudo-contexts:** The study's exploration of how pre-service teachers navigate pseudo-contexts or unrealistic scenarios within word problems addresses a common issue in mathematics education. By recognizing and rectifying such situations, educators can create more authentic and meaningful learning experiences for students.

(5) **Strategic Recommendations:** The research aims to identify strategies to enhance the proficiency of pre-service mathematics teachers. These recommendations can be applied in teacher training programs to better prepare future educators, ensuring they possess the necessary skills to guide students effectively in understanding and applying mathematical concepts.

(6) **Contribution to Educational Discourse:** The study contributes to the ongoing discourse on meaningful mathematical education. By delving into the challenges and capabilities of pre-service mathematics teachers, it adds valuable knowledge to the broader conversation on pedagogy and teacher preparation in the field of mathematics.

In summary, this study has the potential to shape and improve the way mathematics is taught by addressing specific challenges faced by pre-service teachers, ultimately benefiting the learning experiences of students and fostering a more proficient and contextually relevant approach to teaching mathematics (see **Figure 1**).



**Figure 1.** Proficiency investigation framework for pre-service mathematics teachers.

#### **1.4. Literature review**

The previous studies provide an overview of existing research and scholarly works relevant to the study of pre-service mathematics teachers' proficiency in identifying content and context within word problems. This

section explores key themes, methodologies, and findings from previous studies, highlighting gaps in the current understanding and setting the stage for the present investigation.

Previous research emphasizes the central role of word problems in mathematics education <sup>[21,22]</sup>. Word problems bridge the gap between abstract mathematical concepts and real-world applications, fostering a deeper understanding of mathematical principles <sup>[23]</sup>. However, challenges arise when these problems lack authenticity or fail to connect with students' everyday experiences <sup>[24]</sup>.

The ability to make connections between different mathematical ideas and apply them in diverse contexts is termed mathematical connection ability <sup>[25]</sup>. Educators recognize the importance of cultivating this skill, as it enhances students' comprehension and appreciation of the practical utility of mathematics.

Studies have identified common challenges in mathematics word problems, such as insufficient information, unrealistic scenarios, and pseudo-contexts <sup>[26]</sup>. These challenges hinder students' ability to extract meaningful mathematical content and apply it to solve real-world problems <sup>[27]</sup>.

The literature underscores the critical role of pre-service teacher education in preparing educators to effectively teach mathematics <sup>[28]</sup>. The focus extends beyond content knowledge to encompass pedagogical strategies, including the ability to recognize and address challenges in word problems <sup>[29]</sup>.

Critical analysis skills, including error detection in mathematical reasoning, are essential for effective teaching <sup>[29]</sup>. Pre-service teachers need to develop a keen awareness of mathematical content and the ability to discern inaccuracies within problems, ensuring accurate information transmission to students <sup>[28]</sup>.

Research advocates for contextualizing mathematics education by embedding mathematical concepts within real-world scenarios<sup>[30]</sup>. This approach enhances students' engagement and comprehension, emphasizing the relevance of mathematical principles in various life situations <sup>[26]</sup>.

The literature highlights the interconnectedness of mathematical content and contextual relevance within word problems <sup>[31]</sup>. To be effective educators, pre-service teachers must demonstrate proficiency in both areas, ensuring that mathematical concepts are not only understood but also applied meaningfully in diverse contexts<sup>[27]</sup>.

Despite existing research, there remains a gap in understanding the specific challenges and proficiency levels of pre-service mathematics teachers in identifying content and context within word problems. This study seeks to address this gap and contribute to the ongoing discourse on enhancing mathematics education.

In summary, the previous studies establish the foundational knowledge and identify gaps in the current understanding of pre-service mathematics teachers' proficiency in dealing with content and context within word problems. The insights gained from previous research inform the rationale for the present study and underscore its contribution to the broader field of mathematics education.

## **2. Methodology**

The principal aim of this study is to conduct an extensive exploration of pre-service teachers' proficiency in recognizing both content and context within mathematical word problems. The research focuses on pre-service mathematics educators associated with Yarmouk University, emphasizing a case study approach for in-depth analysis.

**Case Study Design:** Adopting the instrumental case study methodology, as categorized by (Tran et al., 2020) <sup>[32]</sup>, this research seeks to illuminate and gain a comprehensive understanding of a specific issue—in this instance, the capacity to identify content and context within mathematical word problems.

Participant Selection: The selection of participants followed a critical sampling approach . While not chosen for comparative purposes, 60 pre-service teachers enrolled in the Bachelor of Science in Education (Mathematics) Honors program at Yarmouk University were purposefully selected. Their inclusion aimed to serve as illustrative examples of proficiency in navigating content and context within mathematical word problems.

## **2.1. Research phases**

The research unfolded in three distinct stages: preparation, data collection, and data analysis.

- **Preparation phase:**

Development of Research Instruments: The Mathematics Word Problems Test and Content and Context Questionnaires were crafted during this phase. Collaboration with mathematics and mathematics education researchers at Yarmouk University, along with validation by content experts, ensured the instruments' validity and appropriateness.

- **Data collection phase:**

Implementation of Assessments: Tests and questionnaires were administered to the 60 pre-service teachers to collect relevant data.

- **Analysis phase:**

Data condensation, display, and drawing conclusions: Guided by the framework proposed by (Tran et al., 2020) <sup>[32]</sup>, the analysis unfolded in three stages, ensuring a systematic approach to derive meaningful insights.

- **Validity and reliability measures:**

To enhance the credibility of findings, the triangulation method was applied, combining multiple data sources. Member checking was employed to validate the findings, contributing to the overall reliability of the research.

- **Sample demographics:**

Demographic information, including semester of study, was systematically collected and subjected to descriptive analysis. Table 1 presents the frequency and percentage distributions for each semester of study, offering valuable insights into the composition of the sample population.

## **2.2. Assessment tools**

The research employed two assessment tools:

- **Mathematics word problems test:**

Evaluates participants' proficiency in solving mathematical word problems, emphasizing accuracy and error detection.

- **Content and context questionnaire:**

Gauges participants' awareness of mathematical content and contextual relevance within word problems, providing qualitative insights into their thought processes.

- **Ethical considerations:**

The study adheres to ethical standards, ensuring participant confidentiality, voluntary participation, and informed consent. Participants were fully briefed on the research's purpose, procedures, and potential implications before providing consent.

- **Limitations:**

While the study provides valuable insights, the findings may be context-specific to the selected pre-service teacher education program. Additionally, the cross-sectional design offers a snapshot of participants' abilities, limiting exploration of developmental aspects over time.

- **Significance:**

This methodology aims to uncover nuanced aspects of pre-service mathematics teachers' proficiency in dealing with content and context within word problems, contributing to the broader field of mathematics education.

**Table 1.** Distribution of pre-service teachers by semester of study.

Semester	Frequency (f)	Percentage (%)
2	59	59%
4	41	41%
Total	100	100

The data presented in **Table 1** reveals that the sample of 100 pre-service teachers (Pre-service mathematics teachers) included in this study originated from two distinct semesters: the second and the fourth. To be precise, 59 Pre-service mathematics teachers, constituting 59% of the total sample, were enrolled in their second semester, while the remaining 41 Pre-service mathematics teachers (41 %) were in their fourth semester.

### 2.3. Mathematics word problems test

- **Description:**

This test comprises a series of mathematical word problems designed to evaluate participants' proficiency in problem-solving, accuracy, and error detection. The problems cover various mathematical concepts and are structured to reflect real-world scenarios.

- **Sample Questions:**

**Example 1:** “A store sells apples at \$3 per kilogram. If a customer buys 2.5 kilograms of apples, how much will they pay?”

**Example 2:** “A car travels at a speed of 60 km/h. How long will it take to cover a distance of 180 kilometers?”

- **Grading Criteria:**

Each problem is scored based on accuracy, the method used, and the ability to detect and correct errors. Partial credit is awarded for demonstrating correct problem-solving steps even if the final answer is incorrect.

### 2.4. Content and context questionnaire

- **Description:**

This questionnaire assesses participants' awareness of the mathematical content and the contextual relevance of word problems. It provides qualitative insights into their thought processes and understanding.

- **Sample Questions:**

**Example 1:** “How does the context of a word problem influence your approach to solving it?”

**Example 2:** “Can you describe a situation where understanding the context helped you solve a mathematical problem more effectively?”

- **Areas Covered:**

The questionnaire includes sections on mathematical concepts, real-world applications, problem-solving strategies, and the importance of context in understanding and solving word problems.

### 3. Results and discussion

#### 3.1. Gaining insights into practical applications through mathematical word problems

A mathematics word test featuring three distinct problems was administered to pre-service mathematics teachers. Each question highlighted a unique mathematical concept and integrated real-world contexts. However, the test encountered challenges, including issues such as incomplete information and difficulties in connecting the provided data with the question's requirements. The primary objective of this test was to evaluate the pre-service teachers' competence in recognising and comprehending both the context and content of mathematical word problems. The analysis aimed to unveil their proficiency in navigating the contextual elements within mathematics and their aptitude for bridging the gap between mathematical theory and real-world applications.

The analytical process involved categorising pre-service teachers into distinct groups based on their proficiency in identifying the mathematical content embedded within the problems. These categories encompassed the following:

(1) (incorrect) - Representing those pre-service teachers who could promptly identify incorrect mathematical information in a problem and, as a result, refrained from answering due to the detected error.

(2) (recognize) - Comprising pre-service teachers who exhibited the ability to recognize mathematical content through the solutions they devised.

(3) (inaccurate) - Encompassing those pre-service teachers who failed to identify inaccurate mathematical information within the questions.

(4) (unable) - Designating pre-service teachers who were unable to provide an answer to the presented question.

These categories establish a structured framework for assessing the skills and capabilities of pre-service teachers when grappling with mathematical word problems, commencing with their capacity to swiftly pinpoint errors in the questions.

**Table 2**, presented below, illustrates the outcomes of the analysis, providing insights into the pre-service teachers' competency in recognizing mathematical content within the context of all three questions.

**Table 2.** Percentage distribution of pre-service mathematics teachers' proficiency in identifying mathematical content.

Term	No. of Students	NO. 1				NO. 2				NO. 3			
		Inco rrec t	Rec ogni ze	Not aware	Not appl icab le	Inco rrec t	Recog nize	Not aware	N/A	Inco rrec t	Recog nize	Not aware	Not appl icab le
2	59	0	2	31	0	0	15	33	0	3	18	20	6
4	41	0	8	30	0	4	20	16	3	6	40	16	0
Total	100	0	0	61	0	4	35	49	3	9	58	36	6
%		0	0	60	0	4	35	49	3	9	58	36	6

The depicted table offers a visual insight into a significant pattern discerned among pre-service mathematics teachers, specifically their proficiency in identifying errors related to mathematical content, particularly categorizing them as (Not Aware) across all three posed questions. Notably, the initial question stands out with the highest percentage, reaching 61%. This category comprises 59 pre-service mathematics teachers from each semester, indicating a unanimous inability among second-semester participants to accurately perceive the mathematical content within the first question.

The primary objective of the inaugural question was to evaluate comprehension in computing the perimeter of a land plot. However, the provided side lengths deviated from the triangular inequality theorem, preventing them from constituting a valid triangle and thereby rendering the calculation of a perimeter impractical.

Surprisingly, as illuminated by the data in **Table 3**, a total of 100 pre-service teachers (61%) remained oblivious to the erroneous mathematical information in the problem. They proceeded to solve it using the perimeter formula, despite the fundamental issue at hand. Notably, some justifications provided by respondents suggested a belief that the mathematical problem could be resolved as long as the perimeter formula was applicable.

This observation is particularly noteworthy given the substantial percentage (61%) of participants who failed to recognize that the side lengths presented in a problem, pertaining to the calculation of a land parcel's perimeter, did not adhere to the triangular inequality theorem. Consequently, the formation of a valid triangle, and consequently the calculation of its perimeter, was rendered impossible. This underscores a critical gap in understanding and highlights the need for targeted interventions to enhance conceptual clarity among pre-service mathematics teachers.

### **3.2. Exploring real-world scenarios via mathematical word problems**

In this research, we delve into the notion of real-world context embedded within mathematical word problems, which relates to elements of everyday life seamlessly integrated into the presented problems. Specifically, the mathematical word problems employed in this study are intricately linked to tangible real-life scenarios, encompassing situations such as designing a garden, establishing a catfish farming pond, and personal life contexts. These three distinctive contexts were chosen to evaluate the Pre-Service Teachers' (Pre-service mathematics teachers ) ability to discern extraneous details within the everyday life contexts presented within mathematical word problems.

The table presented below furnishes the percentage distribution of students categorized into three distinct groups: (Aware), (Not Aware), and (Not Applicable). The criteria used for categorizing Pre-service mathematics teachers under (Not Aware), and (Not Applicable) align with those previously employed in the preceding section, where we assessed teachers' capability to identify mathematical content. In this context, (Not Aware) and (Not Applicable) denote the inability of Pre-service mathematics teachers to recognise inconsistencies embedded within the real-life context presented. Conversely, Pre-service mathematics teachers demonstrating the acumen to identify contextual disparities are classified under the (Aware) category, signifying their awareness of the contextual intricacies interwoven within the mathematics word problems.



**Table 3.** Analysis of pre-service mathematics teachers' proficiency in recognizing real-world contexts in word problems.

Term	No of Students	NO. 1			NO. 2			NO. 3		
		Aware	Not Aware	Not Applicable	Aware	Not Aware	Not Applicable	Aware	Not Aware	Not Applicable
2	59	4	28	0	20	16	2	25	16	3
4	41	30	15	5	30	15	1	40	9	0
Total	100	34	43	5	50	31	3	65	25	3
	%	34	43	5	50	31	3	65	25	3

**Table 3** provides insights into the percentage of Pre-Service Teachers (Pre-service mathematics teachers) who demonstrated the ability to discern intricacies within real-life contexts presented in mathematical word problems. Notably, the results reveal a lower percentage for the first question (34%) when compared to the second (50%) and third (65%) questions. The first question revolves around the planning of a garden on triangular land. However, the units assigned to each side of the land are deemed impractical and excessively small for the purpose of creating a garden. The study found that the majority of second-semester Pre-service mathematics teachers failed to recognise this peculiarity and considered the question to be pertinent to real-life scenarios.

In contrast, fourth-semester Pre-service mathematics teachers exhibited a heightened level of awareness (Aware) concerning the incongruity related to the units used in the first question. Specifically, 30 fourth-semester Pre-service mathematics teachers fell into the (Aware) category, while only 15 were classified as (Not Aware). Significantly, the semester of study emerged as a crucial factor, with fourth-semester Pre-service mathematics teachers displaying greater accuracy in identifying the impracticality within the first question compared to their second-semester counterparts.

Effective mathematics instruction is inherently tied to a profound comprehension of mathematical content. For pre-service mathematics teachers (Pre-service mathematics teachers), this foundational understanding is especially pivotal as it underpins their ability to deliver clear and comprehensive instruction, as emphasized by previous research<sup>[33]</sup>. Beyond merely mastering core content, the cultivation of critical thinking in students often involves the incorporation of word problems. These problems, enriched with real-life contexts, function as a bridge between abstract mathematical concepts and tangible real-world applications. Consequently, training pre-service teachers with a dual emphasis on mathematical content and real-world context ensures that they impart not only the mechanics of mathematics but also its practical relevance, logical reasoning, and overarching significance<sup>[34]</sup>.

This study integrated three word problem questions, each weaving together mathematical topics with diverse real-world scenarios. Pre-service mathematics teachers were categorized based on their levels of understanding, ranging from (Incorrect), signifying immediate awareness, to (Recognize), indicating the need for some time to attain awareness, (Not Aware), denoting a lack of awareness, and (Not Applicable), representing no response provided due to perceived inaccuracies in the provided question.

The primary objective of the first question was to assess understanding in calculating the perimeter of a land plot. However, the question presented side lengths that violated the triangular inequality theorem, rendering it impossible to form a triangle and subsequently calculate the perimeter. Surprisingly, the research findings unveiled that 61% of responses fell into the (Not Aware) category, signifying that the majority of pre-service teachers were oblivious to the mathematical inaccuracies within the problem. They proceeded to tackle

the problem by applying the perimeter formula. Their rationale for doing so centered on the belief that if the perimeter formula could be employed, the problem was solvable, disregarding the necessity for the triangle's side lengths to conform to the theorem.

In contrast, the second question revealed a different dynamic, with only 34% of pre-service mathematics teachers categorized as (Not Aware), while the remaining pre-service mathematics teachers fell into the (Recognize) category. Despite both questions centering around the same theorem, the study yielded diverse outcomes. This discrepancy arose from the calculation of the land area, resulting in a value of 0 for the second question. This outcome prompted pre-service mathematics teachers to identify an error in the provided question. Most pre-service mathematics teachers in the (Recognize) category acknowledged that when the resulting side length of a triangle is 0, it is impossible to form a triangle, and consequently, the area cannot be calculated<sup>[34]</sup>.

The findings highlighted above underscore a significant revelation in the study: the answers derived from their solutions wield substantial influence over the pre-service teachers' capacity to detect errors within the questions themselves. This reliance on the final answer illuminates a deeper issue concerning their comprehension of the questions' underlying aspects. This perspective aligns with the findings of previous research by Pagiling et al. (2020)<sup>[35]</sup>, which have pointed out that pre-service mathematics teachers grapple with various challenges when tackling mathematical word problems. These challenges encompass a limited understanding of the posed problems, a deficiency in strategic knowledge, hurdles in translating problems into mathematical terms, difficulties in executing precise mathematical applications, and struggles in employing the appropriate mathematical concepts.

Furthermore, given that the triangular inequality theorem falls within the domain of geometry concepts, the results also signify that pre-service mathematics teachers' grasp of mathematical content, particularly in geometry, is at a suboptimal level. Pagiling et al. (2020)<sup>[35]</sup> emphasize the significance of proficient geometric skills, which encompass not only the ability to articulate geometric concepts with confidence but also the competence to utilize and derive the relevant theorems effectively in mathematical problem-solving<sup>[36]</sup>.

The significance of this observation becomes even more pronounced when examining the outcomes of the third question. In this case, 65% of pre-service teachers asserted that the third word problem could be resolved simply by applying the principle of fraction addition, disregarding the apparent mathematical discrepancy embedded within the question. The subject matter of this problem revolved around a plate of boiled beans. Any answers that surpassed the total quantity of beans presented in the question clearly indicated an error in the details provided. Surprisingly, even when potential answers were still expressed as fractions, 65% of pre-service mathematics teachers proceeded with the assumption that the problem could be solved without subjecting their conclusions to critical evaluation.

This pattern of behavior mirrors the findings from the first and second questions, suggesting that pre-service mathematics teachers often base their comprehension of mathematical content more on the answers they generate rather than on the intrinsic details or logical consistency of the question.

These results underscore the paramount importance of holistic comprehension. Even when a word problem revolves around a fundamental mathematical concept, a thorough understanding of its complete narrative context is essential. This approach ensures that comprehension is rooted in the foundational principles being emphasized, rather than being solely reliant on the derived answers. This perspective aligns with the findings of Dewi & Asnawati (2019)<sup>[34]</sup>, who contend that while solving word problems, a blend of abilities, including text comprehension, computational proficiency, and the aptitude to establish connections between the provided narrative and pertinent mathematical content, is indispensable. This multifaceted approach

underscores the value of holistic understanding, transcending mere computation, as underscored by Van Dooren et al. (2003) <sup>[37]</sup>.

Moreover, another critical competence that evolves when dealing with word problems is the ability to choose the most appropriate problem-solving strategy. One highly effective approach centers on the category classified under the incorrect mathematical classification, who adeptly identified errors in the third question by employing visualization techniques. As demonstrated, these graphical tools can aid pre-service mathematics teachers in simplifying complex word problems, making them more digestible and enhancing their ability to spot any inconsistencies within the question.

However, while this reliance on visuals suggests a proficiency in spatial skills among pre-service mathematics teachers, research conducted by Dewi & Asnawati (2019) <sup>[34]</sup> indicates that a significant portion of pre-service mathematics teachers encounter challenges in effectively translating word problems into visual representations. Furthermore, Pongsakdi et al. (2020) <sup>[37]</sup> have added that in order to swiftly and accurately convert narrative details into visual formats, strong text comprehension remains vital, even when utilizing a visualization approach. This underscores the fundamental concept that the adoption of any problem-solving method hinges on a comprehensive understanding of the fundamental nature of the term “problem.”

In addition to assessing the understanding of mathematical content, the study also delved into the capacity of pre-service teachers to detect inconsistencies within the real-life contexts presented in the questions. The results indicate that the percentage of pre-service mathematics teachers capable of identifying incongruities in everyday life contexts is relatively low for the first question, standing at 30%, as compared to the second and third questions, which were at 43.33% and 60%, respectively.

The first question centered around the task of creating a garden on triangular land, with the units assigned to each side of the land being impractically small for such a purpose. The study revealed that the majority of second-semester pre-service mathematics teachers, totaling 28, failed to recognize the incongruity embedded in this question. In contrast, among fourth-semester pre-service mathematics teachers, a total of 13 were categorized as (Not Aware), indicating a lack of awareness, while 17 were classified as (Aware), indicating an awareness of the incongruity related to the units employed in the question. Those who displayed awareness noted that the unit, centimeter, used for the garden's construction was unsuitably minuscule for the task <sup>[38]</sup>.

According to Leong et al. (2015) <sup>[39]</sup>, questions of this nature can be categorized under the “tapestry category.” These problems necessitate pre-service mathematics teachers to navigate between tangible situations and abstract mathematical concepts. While the computed perimeter for a land parcel may make sense from a mathematical standpoint in an abstract sense, the implausibility becomes evident when considering the real-world units involved. Therefore, such problems call for meticulous scrutiny and put the pre-service mathematics teachers' ability to recognize and evaluate disparities in both the mathematical and real-world domains to the test. This underscores the importance of comprehensive comprehension, where mathematical solutions must align with their context, as emphasized by Özsoy (2018) <sup>[39]</sup>.

In addition to the results discussed in the section pertaining to mathematical content, for the second question, pre-service mathematics teachers exhibited an awareness of the peculiarity within the given question due to the resultant value of 0 from comprehensive calculations. Indeed, constructing a pond with a side length of 0 is an impossibility. However, it's noteworthy that the percentage of the (Not applicable) category for the second question is notably higher when compared to the first and third questions. To be specific, three pre-service mathematics teachers, comprising 5%, including two from the second semester and one from the fourth semester, were classified under this group. All three pre-service mathematics teachers acknowledged that the second question did not appear irrelevant when considered in the context of daily life. Nevertheless, they failed

to provide any explanation, signifying their inability to identify the incongruity within the context of daily life presented<sup>[40]</sup>.

These findings underscore the pre-service mathematics teachers' capacity to employ mathematical reasoning to substantiate their conclusions. Reasoning ability is emphasized as a vital skill in solving word problems. It demands more than just the ability to arrive at solutions; it also necessitates the capability to logically justify the derived answers. This discovery aligns with the research conducted by Faradillah et al. (2018)<sup>[40]</sup> and Barham (2020)<sup>[41]</sup>, which also suggests that pre-service mathematics teachers' reasoning abilities frequently remain at an intermediate level, particularly when the arguments provided lack precision<sup>[42]</sup>.

Furthermore, the research outcomes pertaining to the third question unveil that a higher percentage of pre-service teachers, amounting to 61%, demonstrated an awareness of the incongruity in terms of the everyday life context when compared to the first and second questions. These pre-service mathematics teachers, based on their provided explanations, concurred that the word problem presented appeared illogical due to the inclusion of irrelevant data. This was primarily attributed to the fact that the sum of the fractions, which represented the quantity of boiled beans consumed, exceeded the initial quantity of one plate of beans. Pre-service mathematics teachers categorized under the (Aware) classification showcased their ability to establish a connection between this incongruity and the real-life context, as evidenced by the results of their calculations<sup>[43]</sup>.

This underscores that the problem-solving approach employed by pre-service mathematics teachers not only aids in recognizing the mathematical concepts utilized but also assists in evaluating the question's relevance from the standpoint of everyday life<sup>[44]</sup>. The findings of this study imply that pre-service mathematics teachers are more proficient at connecting with real-life contexts that closely align with their everyday experiences, such as eating. However, they appear to be less attuned to situations that fall outside the realm of typical daily activities for most individuals, such as constructing a pond. This suggests a potential limitation in their ability to generalize mathematical concepts across a broader spectrum of real-world scenarios<sup>[41]</sup>.

The study by Tran et al. (2020)<sup>[32]</sup> emphasizes the importance of deep mathematical understanding for effective teaching, aligning with our findings that pre-service teachers' proficiency in content and context directly impacts their instructional capabilities. Similarly, Dewi and Asnawati (2019)<sup>[34]</sup> highlight the necessity of integrating text comprehension and mathematical reasoning, which supports our observation that holistic understanding is crucial for solving word problems. Moreover, research by Pagiling et al. (2020)<sup>[35]</sup> on the challenges faced by pre-service teachers in word problem-solving resonates with our findings on the difficulties in error detection and logical consistency. These comparisons underscore the consistency of our findings with broader educational research and emphasize the need for comprehensive training approaches that address both mathematical content and contextual understanding in teacher education programs<sup>[36]</sup>.

## **4. Conclusions**

In summary, the rationales articulated by pre-service mathematics teachers heavily hinge on their problem-solving methodologies and are intricately tied to their comprehension of the underlying mathematical content. Those who can accurately discern the mathematical content exhibit a heightened proficiency in identifying intricacies and incongruities within presented mathematical problems when viewed through the prism of everyday life.

This study accentuates the imperative for pre-service mathematics teachers to possess a dual capability: a profound understanding of mathematical concepts coupled with the ability to contextualize these concepts

within real-life scenarios. The findings illuminate a specific challenge encountered by pre-service mathematics teachers, particularly those in the second semester, in detecting errors and inconsistencies within the provided mathematical problems. Difficulties often arise in connecting computational results with real-world contexts. Consequently, augmenting these competencies among pre-service mathematics teachers holds substantial promise for enhancing their effectiveness as educators.

This preparation equips them to adeptly guide students in comprehending and applying mathematical concepts in real-life situations, thereby cultivating a more comprehensive and practically grounded grasp of mathematics. Ultimately, the study underscores the pivotal role of pedagogical training in shaping the next generation of educators, ensuring they navigate the complexities of mathematical problem-solving with precision and foster a deeper, more practical understanding of mathematics among their students.

## **5. Limitations**

While the study provides valuable insights into the proficiency of pre-service mathematics teachers in solving word problems, there are several limitations to consider:

### **1. Context-Specific Findings:**

The results of this study are specific to the pre-service teacher education program at Yarmouk University. Therefore, the findings may not be generalizable to other institutions or educational contexts.

### **2. Cross-Sectional Design:**

The study employs a cross-sectional design, offering only a snapshot of the participants' abilities at a single point in time. This design limits the exploration of how these abilities develop or change over time.

### **3. Sample Size and Diversity:**

The sample size is limited to 100 pre-service mathematics teachers, which may not fully capture the diversity of experiences and backgrounds present in larger populations. Additionally, the study includes participants only from the second and fourth semesters, potentially overlooking the experiences of those at other stages of their education.

### **4. Self-Reported Data:**

Some data were collected through self-reported questionnaires, which may be subject to biases such as social desirability or inaccurate self-assessment.

### **5. Focus on Specific Mathematical Concepts:**

The study focuses on specific mathematical concepts, such as the triangular inequality theorem, which may not represent the full spectrum of mathematical skills and knowledge required for effective teaching.

### **6. Lack of Longitudinal Data:**

The study does not include longitudinal data, which would provide insights into the long-term impact of the educational interventions and the development of problem-solving skills over time.

### **7. Limited Scope of Assessment Tools:**

While the Mathematics Word Problems Test and the Content and Context Questionnaire provide valuable information, they may not capture all aspects of mathematical proficiency and teaching readiness. Additional assessment tools could provide a more comprehensive evaluation.

## **8. External Validity:**

The study's findings may be influenced by the specific cultural and educational context of Jordan, which could limit the applicability of the results to other regions or countries with different educational systems and cultural norms.

## **6. Recommendations**

The manuscript provides valuable recommendations for integrating practical context and critical thinking into pre-service teacher education. Expanding on specific strategies or interventions that have been successful in other contexts could offer actionable insights for educators and policymakers. Here are some additional strategies and interventions:

### **1. Contextualized Learning Modules:**

Develop learning modules that embed mathematical concepts within real-world scenarios. For instance, incorporating projects that require students to apply geometry to design structures or use statistics to analyze real data sets can make learning more relevant and engaging.

### **2. Collaborative Problem-Solving:**

Encourage collaborative learning by having pre-service teachers work in groups to solve complex word problems. This not only promotes critical thinking but also helps them learn from different perspectives and develop teamwork skills.

### **3. Use of Technology:**

Integrate technology tools such as dynamic geometry software or online simulation tools that allow pre-service teachers to visualize and manipulate mathematical problems. This can enhance their understanding of abstract concepts and improve their ability to detect errors.

### **4. Reflective Practice:**

Incorporate reflective practice sessions where pre-service teachers analyze their problem-solving processes and outcomes. Reflecting on what strategies worked, what didn't, and why, can deepen their understanding and improve their teaching practices.

### **5. Professional Development Workshops:**

Offer workshops focused on effective strategies for teaching mathematical word problems. These workshops can provide pre-service teachers with hands-on experience and expose them to best practices in the field.

### **6. Mentorship Programs:**

Establish mentorship programs where experienced teachers guide pre-service teachers in developing their problem-solving and instructional skills. Mentors can provide valuable feedback and support as pre-service teachers navigate the complexities of teaching mathematics.

### **7. Assessment and Feedback:**

Implement formative assessment techniques to provide ongoing feedback to pre-service teachers. Using rubrics that highlight key components of effective problem-solving can help them identify areas for improvement and track their progress.

## 8. Case Studies and Real-Life Examples:

Use case studies and real-life examples to illustrate the application of mathematical concepts. Discussing how mathematics is used in various professions can help pre-service teachers appreciate its relevance and inspire them to make connections in their teaching.

## Author contributions

Conceptualization, R.A. and Y.W.; methodology, N.A.; software, M.H.; validation, R.A., Y.W. and M.H.; formal analysis, R.A.; investigation, Y.W.; resources, N.A.; data curation, S.S.; writing—original draft preparation, R.A.; writing—review and editing, Y.W.; visualization, N.A.; supervision, N.A.; project administration, R.A.; funding acquisition, Y.W. All authors have read and agreed to the published version of the manuscript.

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## Conflict of interest

The authors declare no conflict of interest.

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