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Pre-Service Mathematics Teachers' Responses to Mathematics Word Problem with Contradictory Information in Context

***S F Saleh[1], M Mutmainnah[2], A H Abdullah[3], B Baharullah[1], M Akbar[1], N N Mohamad[3]**
[1]Master of Mathematics Education, Postgraduate Program, Universitas Muhammadiyah Makassar, Indonesia
[2]Mathematics Education Study Program, Faculty of Teacher Training and Education, Universitas Muhammadiyah Makassar, Indonesia
[3]School of Education, Faculty of Social Sciences and Humanities, Universiti Teknologi Malaysia, Johor Bahru, Malaysia

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ABSTRACT

Most mathematics word problems contain real-life context, but not all are relevant to real-life reality. Despite the mathematical solvability of these problems, their contexts may be contrary to the facts in the real world. This study explored the responses of pre-service mathematics teachers while facing the mathematics word problem containing contradictory information within a real-life context. A total of 48 pre-service mathematics teachers from various cohorts participated in this study. The participants were asked to solve a mathematics word problem that was designed to be solvable mathematically but presented a situation that contradicted to real-life context. The findings reveal that while the participants are adept at mathematical procedures, many did not realize and some were confused by the anomalies within the problem context. Only a few of them recognized the contradictory information and stated that the problem was illogical or impossible. This study specifically explores the gap between mathematical solvability and the relevance of real-world contexts in word problems. Most previous research has primarily focused on pre-service teachers' ability to solve mathematical problems without examining whether they notice the anomalies in the problem's context. This study emphasizes raising pre-service mathematics teachers' awareness of the real-life context in mathematics word problems.

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INTRODUCTION

Mathematics word problems with real-life context play a crucial role in mathematics education. It is bridging the mathematical concepts with the real-world situation. It helps students to understand mathematics concepts through the familiar context better and provides opportunities for them to apply their mathematical knowledge to everyday situations (Contreras & Martínez-Cruz, 2011; Emanuel et al., 2021; Suseelan et al., 2022; Verschaffel et al., 2020). Mathematics word problems can strengthen students' logical, critical, and creative thinking (Nofrianto et al., 2022). Solving mathematics word problems is not only beneficial to mathematic learning but also can improve students' text comprehension skills (Hadianto et al., 2021; Pongsakdi et al., 2020). Furthermore, solving it requires students' cognitive skills, such as verbal, arithmetic, spatial, and general reasoning skills (Reinhold et al., 2020; Strohmaier et al., 2022).

Not all mathematics word problems serve as well-structured problems. Some problems may have real-life context without real meaning (Sepeng, 2013), missing information (Chang et al., 2020; Krawitz et al., 2018), and others may have contradictory information (Hariati et al., 2022;

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Wulan et al., 2024; Rohmah et al., 2022). These types of problems can challenge the students and enhance their critical thinking. Students not only have to perform their mathematical proficiency but also their ability to analyze and be aware of the context. For pre-service mathematics teachers (PSTs), solving these types of problems presents an opportunity to develop their critical thinking skills and contextual awareness that can impact their future teaching practices.

The mathematics word problems typically solved by PSTs in their course often come in a well-structured form. They assume that the problems in textbooks or those provided by lecturers are always correct (Kurniati et al., 2020; Thalib et al., 2021). They are not accustomed to critically examining the problem. In working on problems with a close connection to reality, learners, even PSTs, often disregard the real-world context and immediately seek solutions using mathematical concepts without checking for plausibility (Wisenöcker et al., 2024). The inability to fully comprehend problems can lead to errors in solving them (Hanifah & Abadi, 2018; Indriani, 2020). The previous studies (Isik & Kar, 2012; Kilic, 2015; Prayitno et al., 2018; Saleh et al., 2020; Saleh et al., 2022) have shown how PSTs focus on mathematical concepts and tend to overlook the relevance of real-life context when asking to pose a mathematics word problem. Whereas they have to be able to select or pose meaningful problems to foster their future students' mathematical understanding and its application in real-life situations.

Given the critical role of PSTs in shaping their future students' mathematical understanding, it is essential to explore their responses to mathematics word problems with contradictory information in context. Understanding how they approach such problems can serve as valuable insight for teacher education programs. Furthermore, the findings of this study could potentially contribute to the advancement of the education of PSTs in preparing them for their future roles. This study aims to explore the responses of PSTs when encountering mathematics word problems containing contradictory information within a real-life context.

RESEARCH METHOD

Research Design

This study used specific cases to reveal PSTs' responses to word problems with real-life contradictory information. Their responses in facing contradictory information were analyzed to gain valuable insight. Thus, using a qualitative case study, specifically of the instrumental case type (Corcoran et al., 2004; Creswell, 2012; Fraenkel et al., 2012), is an appropriate research tool for this study.

Participants

Forty-eight PSTs in the Mathematics Education Department of Universitas Muhammadiyah Makassar, a private university in Indonesia, volunteered for this study. They were from various cohorts, namely 13 (27,08%) first-year students, 17 (35,42%) second-year students, and 18 (37,50%) third-year students. This different academic level allows the study to capture a range of responses from the participants' different educational journeys. The determination of research participants uses critical sampling (Creswell, 2012). PSTs were selected and critically analyzed to describe how they handled the contradictory information in the given problem.

Data Collection

Data were collected using the Mathematics Word Problem Test (MWPT), Content and Context Questionnaire (CCQ), and interview guidelines. The mathematics word problem employed in this study is designed to be solvable mathematically but presents a situation that contradicts real-life context. By using the MWPT, the PSTs' competence in recognizing and comprehending the mathematical content and real-life context can be revealed. This problem was inspired by problems posed by PSTs in the research conducted by (Kilic, 2015; Prayitno et al., 2018; Saleh et al., 2022). This problem challenged participants to think critically in navigating the tension

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between mathematical procedure and real-world plausibility. Figure 1 shows the mathematics word problem employed in this study.

Wati menawarkan satu piring kacang rebus kepada Budi dan Nia. Jika Budi memakan setengah piring kacang dan Nia memakan dua per tiga piring kacang, berapa banyak kacang yang dihabiskan Budi dan Nia?
Wati offers Budi and Nia a plate of boiled peanuts. If Budi eats half a plate of peanuts and Ani eats two-thirds, how many peanuts did Budi and Nia eat?

Figure 1. The Mathematics Word Problem

The mathematics word problem given to participants is solvable mathematically by adding the fraction. The context of the problem is intricately linked to tangible real-life, namely a plate of peanuts, and the characters (Wati, Budi, Nia) were familiar to the PSTs. However, it is a real-world implausibility. The number of boiled peanuts that Wati gave Budi and Nia was a plate, but they ate more than a plate.

Following the MWPT, the PSTs were asked to fill out the CCQ to express their opinion regarding the problem they had just encountered. Specifically, they were asked whether the word problem could be solved mathematically, whether it contained context that aligns with real-life situations, and whether they noticed any inconsistencies.

After completing the MWPT and CCQ, task-based interviews were conducted. The PSTs were interviewed to gain deeper insight into their thoughts regarding the contradictory information and how they reconcile it to solve the word problem. The study participants comprised seven PSTs to be interviewed. Each fell into three categories of responses based on CCQ: PSTs who did not realize the contradictory information (DR), confused (CF), and recognized it (RC). Additionally, participants were selected considering their communication skills and willingness to be interviewed. This additional criteria setting was chosen to ensure smooth progression during the interview. The participants' demographics are presented in Table 1.

Table 1. Participants' demographics

Year	Categories of Responses			Total
	DR	CF	RC	
1st year	7	5	1	13
2nd year	11	4	2	17
3rd year	6	8	4	18
Total	24	17	7	48
Percentage (%)	50,00	35,42	14,58	
Be Interviewed	2	3	2	

Data Analysis

The researchers reviewed the PSTs' answers to the MWPT and the CCQ and classified them into categories: did not realize the contradictory information (DR), confused (CF), and recognized it (RC). Also, the researchers constructed the transcript of the interview. After organizing and transcribing the data, the researchers developed codes. The codes were used to build descriptions and themes (Creswell, 2012). Hereafter, the researchers conduct descriptive analysis to determine PSTs' responses to contradictory information in the word problem. Finally, the findings were

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represented in descriptive reporting (Bassey, 1999) supported by figures and interview excerpts to enrich its texture and contribute to a better understanding of the case. This study used triangulation by data source and method to ensure that data findings and interpretations were accurate (Miles et al., 2014). The data source was more than one PST from each category. The PSTs' answers to the MWPT and the CCQ, as well as interview documents, complemented each other.

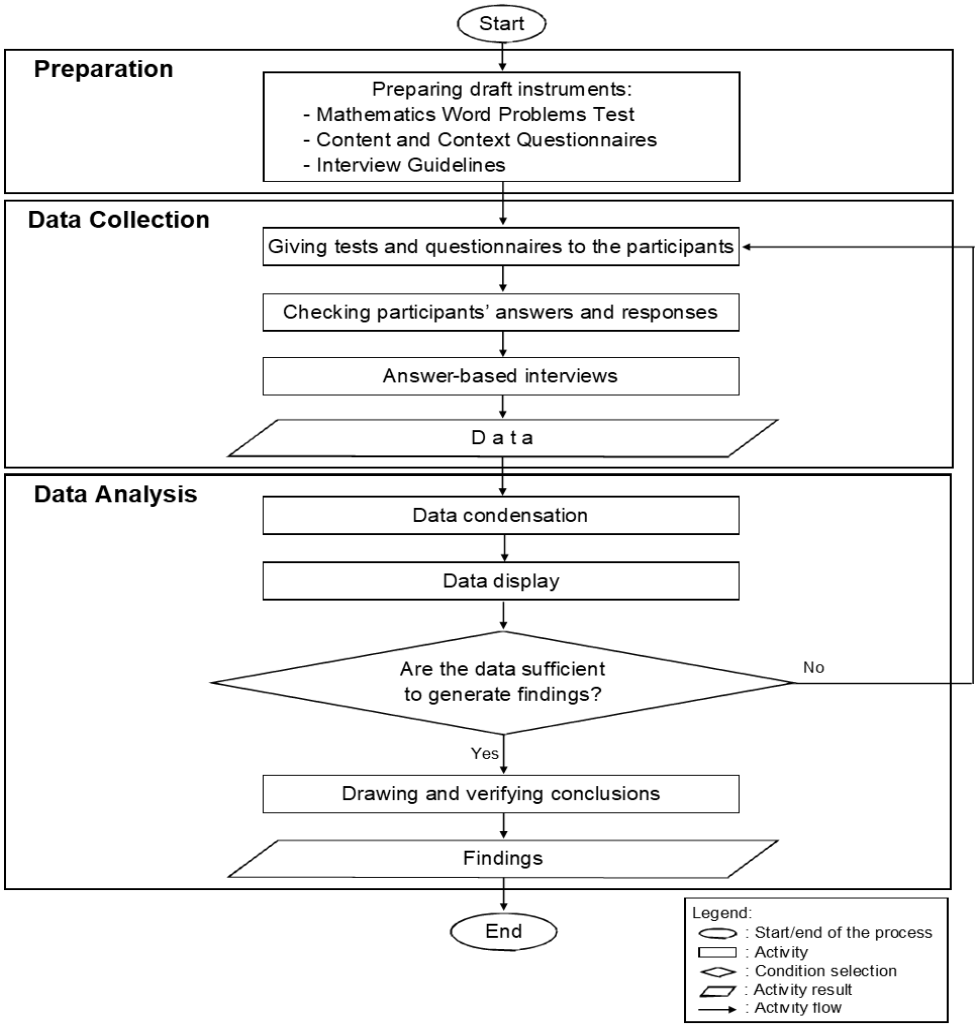

Figure 2. Research flowchart

RESULTS AND DISCUSSION

Half of the participants in this study did not realize the contradictory information in the mathematics word problem given to them. Only seven participants recognized it, while the remaining 17 showed confusion.

PSTs Did Not Realize the Contradictory Information

Most of the participants immediately added up the number of boiled peanuts eaten by Budi and Nia, and ignored the information about a plate offered by Wati. It was revealed from the questionnaire that they did not see anything odd in the word problem. Figure 3 presents an example of the response from the PSTs who did not realize the contradictory information in the problem.

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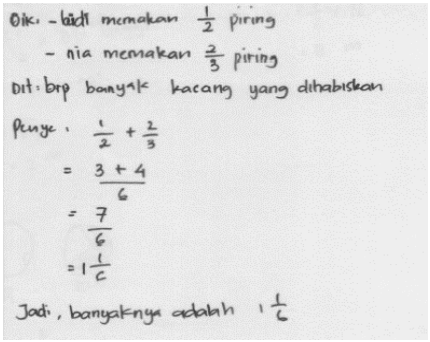

Given: - Budi ate $\frac{1}{2}$ of plate
- Nia ate $\frac{2}{3}$ of plate
Unknown: How many peanuts were ate
Solution: $\frac{1}{2} + \frac{2}{3}$
$= \frac{3+4}{6}$
$= \frac{7}{6}$
$= 1\frac{1}{6}$
So, the number is $1\frac{1}{6}$

Figure 3. Response of the PST who did not realize the contradictory information

Figure 3 shows that the PSTs did not write down the number of boiled peanuts offered by Wati as the given information. The PSTs only wrote the number of boiled peanuts Budi and Nia ate. In the interview, AN, one of the PSTs, stated that she only focused on the question, "How many peanuts did Budi and Nia eat?". The following is an excerpt from an interview between the interviewer (I) and AN.

I : What is your idea about the problem?
AN : I thought of solving the problem by adding up the number of peanuts Budi and Nia ate. They were $\frac{1}{2}$ plus $\frac{2}{3}$, so I got $\frac{7}{6}$ or $1\frac{1}{6}$
I : What about the information "Wati offers a plate of boiled peanuts"?
AN : I did not pay attention to that, Ma'am. I just focused on the question, "How many peanuts did Budi and Nia eat?"

AN and most study participants focused more on obtaining the solution to the problem rather than critically evaluating the entire problem statement. In solving mathematics word problems, PSTs often strongly emphasize mathematical concepts, procedures, and computation, but overlook plausibility in real-life contexts (Abdullah et al., 2024; Saleh et al., 2020). Several previous studies (Isik & Kar, 2012; Kilic, 2015; Prayitno et al., 2018; Saleh et al., 2020; Saleh et al., 2022) have shown how PSTs prioritize mathematical procedures over contextual relevance while they pose and solve the word problem they posed. Thus, PSTs may solve mathematics word problems correctly from a purely mathematical standpoint, but in a way that does not make sense in the real world.

PSTs are Confused about the Contradictory Information

As many as 35,42% of participants showed confusion. It was revealed from the questionnaire that they see something odd in the word problem. They realized the contradictory information but were confused by it. This study revealed three types of responses from the PSTs who were confused by the contradictory information. Type A confusion is the response shown by those who were aware of the contradictory information but finally solved the problem by ignoring it. Type B confusion is the response shown by those who change some of the information in the problem to obtain an answer. Type C confusion is shown by those who wrote more than one answer in their Answer Sheet.

Twelve confused PSTs came up with $\frac{7}{6}$ or $1\frac{1}{6}$ as their answer. However, it differs from the PSTs who did not realize the contradictory information. These confused PSTs explained their confusion in the questionnaire. Figure 4 presents an example of the type A confusion.

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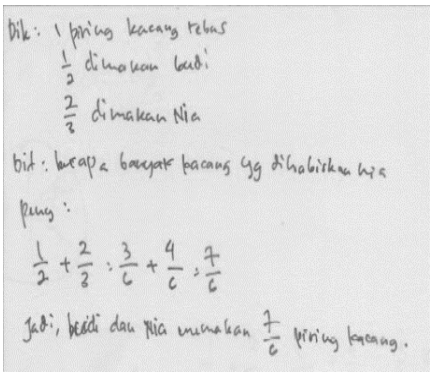


Given: - 1 plate of boiled peanuts
- $\frac{1}{2}$ eaten by Budi
- $\frac{2}{3}$ eaten by Nia

Unknown: How many peanuts did Nia and Budi eat?

Solution: $\frac{1}{2} + \frac{2}{3} = \frac{3}{6} + \frac{4}{6} = \frac{7}{6}$

So, Budi and Nia ate $\frac{7}{6}$ of the plate of peanuts

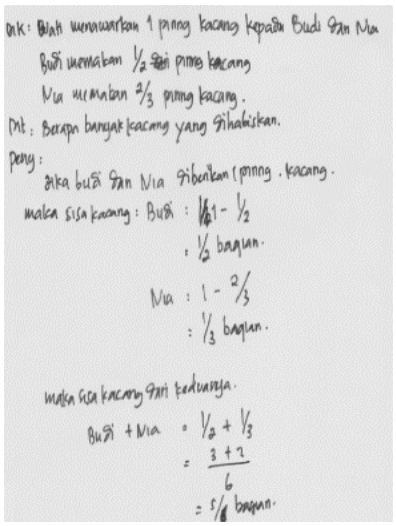
Figure 4. Response of the PST with type A confusion

As shown in Figure 4, the PSTs wrote down the given information in the word problem completely, including the information about a plate of boiled peanuts offered by Wati. However, the PSTs did not use all of this information in the calculation. In the questionnaire, one of the confused PSTs wrote, "This word problem seems odd because Wati only offered a plate of peanuts, but Budi and Nia ate more than a plate". In the interview, FL, one of the PSTs with type A confusion response, stated that she felt confused after relating the result of the calculation to the context of the problem. The following is an interview excerpt between the interviewer (I) and FL.

I : What is your idea about the problem?

FL : Actually, I am confused, Ma'am, because after adding it up, apparently, there were more boiled peanuts eaten by Budy and Nia than the number of boiled peanuts offered by Wati. Anyway, I still just solved it by adding it up. Actually, I asked myself where the extra boiled peanuts came from, but … that's all… I am confused.

Four confused PSTs gave type B confusion responses. They changed the information about Wati offering a plate of boiled peanuts to Budi and Nia with two plates for each Budi and Nia. Figure 5 provides an example of the type B confusion.



Given:
Wati offers 1 plate of boiled peanuts to Budi and Nia
Budi eats $\frac{1}{2}$ of the plate
Nia eats $\frac{2}{3}$ of the plate

Unknown: How many peanuts were eaten?

Solution:
If Budi and Nia are given 1 plate of peanuts, then the remaining peanuts will be:
Budi = $1 - \frac{1}{2} = \frac{1}{2}$ part
Nia = $1 - \frac{2}{3} = \frac{1}{3}$ part
So, the remaining peanuts from both of them will be:
Budi + Nia = $\frac{1}{2} + \frac{1}{3} = \frac{3+2}{6}$
= $\frac{5}{6}$ part

Figure 5. Response of the PST with type B confusion

As can be seen from Figure 5, the PSTs carried out separate calculations for Budi and Nia. This means Wati offered Budi a plate of boiled peanuts, and another plate to Nia. When asked about the answer, SH, one of the PSTs with a type B confusion response, revealed her confusion.

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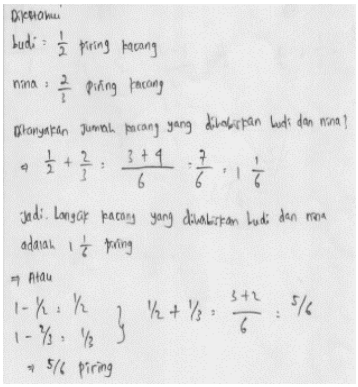
She admitted that she tried to solve the problem in a way that made sense. The following is an excerpt from an interview between the interviewer (I) and SH.

I : What is your idea about the problem?

SH : I felt this problem is not apparent, Ma'am, whether one plate for both Budi and Nia or whether each of them gets a plate. But it is not logical if it is just a plate for two. Budi eats half of the plate and Nia eats two-thirds of it. If you subtract the result, it will be a minus. The plate of peanuts can not be a minus. So, I calculated it like this. Each of them was given a plate. So, the remaining are five-sixths

SY is the only participant who gave a type C confusion response. She wrote two answers in her Answer Sheet. The first answer is $1\frac{1}{6}$, the same as those who express type A confusion. The second answer is $\frac{5}{6}$, the same as those who express type B confusion. SY felt confused between the two answers. She was not sure which one was right. So, she decided to write both of them. Figure 6 presents SY's answer.



Given:
Budi : $\frac{1}{2}$ of the plate of peanut
Nia : $\frac{2}{3}$ of the plate of peanut
Unknown: How many peanuts did Budi and Nia eat?
→ $\frac{1}{2}+\frac{2}{3}=\frac{3+4}{6}=\frac{7}{6}=1\frac{1}{6}$
So, Budi and Nia ate $1\frac{1}{6}$ of the plate of peanuts
→ or
$1-\frac{1}{2}=\frac{1}{2}$, $1-\frac{2}{3}=\frac{1}{3}$ } $\frac{1}{2}+\frac{1}{3}=\frac{3+2}{6}=\frac{5}{6}$
$=\frac{5}{6}$ plate of peanuts

Figure 6. Response of the PST with type C confusion

FL, SH, and SY felt confused and tried to solve the problem in their own way. FL continued doing addition and kept her confused. SH changed the information in the problem as she thought it made sense. SY was unsure about between two answers that came to her mind and decided to write both. The PSTs' confusion arose after they saw that the number of boiled peanuts eaten by Budi and Nia exceeded the number of peanuts offered by Wati, which is impossible. However, they kept trying to solve the problem. This fact indicates that the PSTs not only pay attention to the mathematical procedure they have to do to solve the problem, but also to the context of the story.

PSTs recognized the contradictory information

There were only seven participants who recognized the contradictory information in the problem. Three of them left their Answer Sheet blank, one wrote "illogical", while the remaining participants kept adding $\frac{1}{2}+\frac{2}{3}$ and included an explanation in their Answer Sheet that it was impossible to happen. Figure 7 shows an example of the response from the PSTs who recognized the contradictory information.

The problem used in this study is actually a simple daily problem, but it requires the PSTs to be sensitive and critically analyze the contradictory information embedded within it. This study found that PSTs were not used to criticizing problems with contradictory information but solving them immediately or experiencing confusion but still solving them. Only a few of them were aware of the oddity of the problem. This finding aligns with Kurniati et al., (2020), Thalib et al., (2021), Basri et al., (2023).

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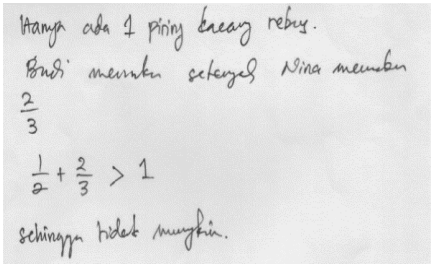	There was only a plate of boiled peanuts. Budi ate half, Nia ate $\frac{2}{3}$ $\frac{1}{2}+\frac{2}{3}>1$ So, it is impossible.

Figure 7. Response of the PST who recognized the contradictory information

The mathematics problem with contradictory information is one type of problem that can be used to enhance critical thinking in mathematics, while the other is the problem with no specific universal set (As'ari et al., 2019). However, the problems typically given to PSTs often contain complete information, and they tend to assume that the problems given by the lecturer are always correct (Kurniati et al., 2020; Thalib et al., 2021). They may need to be well-prepared to handle problems with contradictory or incomplete information. When faced with such problems, some immediately do the mathematics calculations, while others are suspicious but do not criticize it (Kurniati et al., 2020). The suspicious one made an assumption and solved the problem by applying mathematical concepts they had learned (Kurniati et al., 2020; Thalib et al., 2021). This assumption leads them not to realize that there were many solutions or even no solutions at all to the problem.

This study underscores the importance of enhancing PSTs' capability to think critically when solving a problem and improving the plausibility of real-life contexts in mathematics word problems. PSTs need to be aware of real-life context in a mathematics word problem. By fostering this awareness, PSTs will be better equipped to pose or choose meaningful mathematics problems related to real-life contexts for their future students (Ellerton, 2013; Mallart et al., 2018; Saleh et al., 2020). This study further supports the suggestions of As'ari et al. (2019), Kurniati et al. (2020), Thalib et al., (2021) that PSTs must be regularly exposed to problems with contradictory or incomplete information and encouraged to discuss such problems.

CONCLUSION

This study explored the responses of pre-service mathematics teachers (PSTs) to mathematics word problems that contain contradictory information. The mathematics word problem given to the PSTs is designed to be solvable mathematically but presents a situation that contradicts real-life context. The findings revealed that most PSTs did not realize the contradictory information. They focus more on mathematical procedures over the contextual relevance of the problem. Some PSTs are confused about the problem but keep trying to solve the problem mathematically. Only a few PSTs recognized the contradictory information and stated that the problem was illogical or impossible. This study reveals that PSTs are not used to criticize mathematics problems. When faced with a problem containing contradiction, they immediately use the known mathematical procedures to solve it. This study underscores the importance of raising PSTs' awareness of real-life context in mathematics word problems. Future studies could investigate specific interventions or training programs aimed at enhancing pre-service teachers' awareness of real-world contexts in mathematics problems.

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Author (s):

* Sitti Fithriani Saleh (Corresponding Author)
Master of Mathematics Education, Postgraduate Program,
Universitas Muhammadiyah Makassar,
Jl. Sultan Alauddin No. 259, Makassar, Indonesia
Email: fithriani.saleh@unismuh.ac.id

Mutmainnah
Mathematics Education Study Program, Faculty of Teacher Training and Education,
Universitas Muhammadiyah Makassar,
Jl. Sultan Alauddin No. 259, Makassar, Indonesia
Email: mutmainnah@unismuh.ac.id

Abdul Halim Abdullah
School of Education, Faculty of Social Sciences and Humanities,
Universiti Teknologi Malaysia,
81310 Johor Bahru, Johor, Malaysia
Email: p-halim@utm.my

Baharullah
Master of Mathematics Education, Postgraduate Program,
Universitas Muhammadiyah Makassar,
Jl. Sultan Alauddin No. 259, Makassar, Indonesia
Email: baharullah@unismuh.ac.id

Muh. Akbar
Master of Mathematics Education, Postgraduate Program,
Universitas Muhammadiyah Makassar,
Jl. Sultan Alauddin No. 259, Makassar, Indonesia
Email: akbarmattata690@gmail.com

Nurain Nadhirah Mohamad
School of Education, Faculty of Social Sciences and Humanities,
Universiti Teknologi Malaysia,
81310 Johor Bahru, Johor, Malaysia
Email: nurain99@utm.my