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A Qualitative Analysis of Students' Errors in Fraction Word Problems Based on Polya's Stages of Problem Solving: Evidence from Papua, Indonesia

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Abstract

This study investigates the types and causes of student errors in solving fraction word problems using Polya's four-step problem-solving framework: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. Employing a descriptive qualitative design, data were collected from three Grade VII students at SMP Negeri 2 Sentani, Papua, Indonesia, through written tests and semi-structured interviews. The findings reveal that students made errors at each stage of problem solving. Misidentification of known and unknown quantities, improper selection of operations, computational mistakes, and the absence of solution verification were frequently observed. These errors were attributed to weak conceptual understanding, limited procedural fluency, representational difficulties, and insufficient metacognitive awareness. Furthermore, cultural and contextual factors—including linguistic challenges in interpreting mathematical terminology, classroom norms emphasizing speed over reflection, and limited exposure to diverse problem types—contributed to students' difficulties. The study suggests that mathematics instruction in similar educational settings should incorporate language support, structured scaffolding aligned with Polya's framework, and explicit metacognitive training to enhance students' problem-solving abilities.

Keywords: Error analysis, fractions, problem solving, Polya's model

INTRODUCTION

Mathematical problem-solving is a fundamental competence that develops through a systematic process consisting of four stages: understanding the problem, devising a plan, executing the plan, and evaluating the result (Polya, 1957). This process enables students to apply mathematical concepts in both academic and real-life situations (Amalia et al., 2024). Mastery of problem-solving strategies also supports the development of mathematical literacy, which allows students to reason logically and solve problems systematically (Kabael & Baran, 2023).

The development of students' problem-solving abilities is strongly influenced by the instructional approaches applied in the classroom. Approaches such as the concrete–semi-concrete–abstract (CSA) model help accommodate students' varying cognitive levels (GÖKTAŞ & Yazıcı, 2020). In addition, active learning methods, including problem-based learning (PBL), promote deeper engagement and improve comprehension (Difinubun et al., 2024). When students are actively involved with mathematical content through interactive and contextualized activities, their problem-solving proficiency improves significantly (Salsabila et al., 2024).

Contextual teaching also helps make mathematics more meaningful and accessible to students. By incorporating real-world contexts into instruction, students can connect abstract mathematical concepts to familiar situations, leading to deeper understanding and increased motivation (Amalia et al., 2024; Balayan et al., 2024). Additionally, visualization techniques such as bar modeling assist students in interpreting and solving complex word problems effectively (Shah et al., 2021).

Beyond cognitive development, mathematical problem-solving cultivates critical and creative thinking, which are essential skills for academic success and real-life problem-solving. According to the National Council of Teachers of Mathematics (Safrina et al., 2022), fostering strong problem-solving abilities is a core objective of mathematics education, enabling students to apply mathematical reasoning across diverse real-world situations and enhancing the practical value of mathematics.

International assessments consistently highlight students' struggles with fractions. For instance, the TIMSS 2019 report found that a significant proportion of Grade 8 students across participating countries demonstrated limited proficiency in fraction concepts, particularly in applying them to real-world problems (Mullis et al., 2020). Similarly, PISA 2018 results revealed that many 15-year-old students failed to correctly interpret or operate on fractions when embedded in contextualized tasks, underscoring a global trend in fraction-related learning difficulties (OECD, 2020). These findings suggest that fraction understanding remains a persistent challenge across educational systems, regardless of national curriculum or instructional approach.

Fractions represent one of the most fundamental yet challenging topics in mathematics learning. Mastery of fractions is essential for students' academic progression, as it serves as a prerequisite for more advanced topics such as algebra and complex arithmetic (Diputra et al., 2023; Sulistyani et al., 2021). Fractions encompass various mathematical concepts, including part-whole relationships, ratios, and operators, which are interrelated and contribute to a deeper understanding of the number system. Furthermore, a solid understanding of fractions supports students' ability to work with decimals and perform advanced calculations (Lisnani, 2023).

Despite their importance, fractions consistently present challenges for many students. Their abstract nature, multiple forms of representation (such as unit, proper, and improper fractions), and widespread misconceptions contribute to learning difficulties (Li et al., 2022; Viseu et al., 2021). Students often struggle with converting between mixed and improper fractions and performing operations involving unlike denominators (Singh et al., 2021; Unaenah et al., 2024). These difficulties can heighten mathematics anxiety, further hindering students' learning and confidence (Starling-Alves et al., 2021).

From a cognitive perspective, learning fractions is demanding because it requires students to coordinate multiple conceptual frameworks at once. Murniasih et al. (2020) note that many learners struggle with abstract ideas like fraction density due to limited meaningful learning, reflecting epistemological and didactic obstacles. Cognitive Load Theory (Blayney et al., 2024) emphasizes that excessive mental demands can hinder understanding, while math anxiety can further impair symbolic reasoning, leading to superficial strategies (Gomides et al., 2021). Prior knowledge and lived experience also shape how students approach fraction tasks (Nanna & Pratiwi, 2020), and social cognitive theory highlights the value of peer interaction and modeling (Noor & Lian, 2022). Moreover, the theory of conceptual change Vosniadou (2013) argues that learners must restructure, not simply add to, their existing knowledge, making fraction instruction cognitively complex and prone to misconceptions.

Misconceptions related to fractions are especially common. Many students view fractions only as part-whole representations, overlooking their broader mathematical roles such as ratios and operators (Unaenah et al., 2024). Kusaka (2021) emphasizes that the complexity of fraction instruction stems from its multifaceted nature, thus requiring carefully designed strategies that promote conceptual understanding. Addressing these challenges demands both systematic and culturally sensitive approaches (Braithwaite & Siegler, 2021; Kamid et al., 2023). Effective interventions include the use of visual models and contextualized learning, where real-world examples help students connect abstract concepts to concrete experiences (Nashiroh & Zainuddin, 2023; Wahyu et al., 2020).

George Polya's four-step problem-solving model remains a widely used framework in mathematics education. This model systematically guides students through the stages of understanding the problem, devising a plan, executing the plan, and reflecting on the solution (Rahmah & Darsikin, 2021). A clear understanding of the problem is crucial for selecting appropriate solution strategies (Pradana & Ekowati, 2024). Visualization techniques, including diagramming and sketching, are valuable tools that help students better comprehend problem structures at the initial stage (Bernedo & Fuentes, 2022).

The second phase, devising a plan, involves generating and evaluating multiple solution strategies. Encouraging students to develop various approaches enhances their problem-solving flexibility (Muhassanah & Setiani, 2024). In the execution phase, students are expected to accurately implement the chosen strategy while minimizing computational and procedural errors (Erlin et al., 2024; Pambudi et al., 2023). The final phase, reflection, is essential for developing metacognitive skills, as it allows students to assess their solution processes and outcomes, leading to continual improvement in problem-solving abilities (Ng & Toh, 2024; Rott et al., 2021).

Empirical evidence supports the effectiveness of Polya's model across various educational contexts. Recent meta-analyses have demonstrated that instruction grounded in this framework significantly improves students' mathematical achievement (Abdul W A, 2024). Additionally, it fosters metacognitive development and increases students' confidence in problem-solving (Chiu et al., 2022; Tay & Toh, 2023).

Although Polya's model has been extensively supported by quantitative research, there remains a significant lack of qualitative investigations, particularly within the context of Indonesian secondary education. Existing studies (Khofifah et al., 2024; Tohir et al., 2023) have confirmed the model's general effectiveness; however, few have explored in depth how students cognitively and emotionally engage with each stage of the model during problem solving. Several scholars emphasize the need for more qualitative studies to reveal the nuanced thought processes and difficulties students experience when applying Polya's framework (Gopinath & Lertlit, 2022; Widodo et al., 2021).

Furthermore, recent studies (Ndukwe et al., 2022) have shown that students' success in applying Polya's model is strongly influenced by self-efficacy and contextual factors. In regions such as Papua, Indonesia, where sociolinguistic diversity, limited educational resources, and distinct classroom cultures exist, these contextual influences may play an even more significant role. Unlike more urbanized regions of Indonesia, the Papua context is uniquely shaped by a complex interplay of local languages, limited access to mathematical enrichment materials, and instructional practices that often emphasize rote learning over reflective reasoning (Cui & Ng, 2021). These factors collectively contribute to distinctive cognitive and linguistic challenges in mathematical problem solving. Therefore, in-depth qualitative studies are essential to capture these complex interactions and to design culturally responsive instructional interventions that address students' specific needs in such settings.

In response to these gaps, this study aims to analyze the types and causes of errors made by students in solving fraction word problems using Polya's problem-solving framework, while considering the cultural and linguistic characteristics of the Papua context. Accordingly, the research questions are formulated as follows:

1. What types of errors do students at SMP Negeri 2 Sentani, Papua, make in solving fraction word problems based on Polya's stages?
2. What cognitive, linguistic, and contextual factors contribute to these errors?

METHOD

This study employed a descriptive qualitative research design to explore in depth the types and causes of student errors in solving fraction word problems using Polya's problem-solving framework. The qualitative approach was chosen because it allows the researcher to capture detailed cognitive processes, reasoning patterns, and contextual influences that cannot be fully explained through quantitative measures. This approach is particularly suitable for understanding the complex thinking strategies and cultural-linguistic factors that shape students' problem-solving behaviors.

The participants in this study were three Grade VII-B students from SMP Negeri 2 Sentani, Papua. All three students came from lower-middle socioeconomic backgrounds, as indicated by parental occupation and household income reported during initial interviews. Their mother tongue was the Sentani language and Papuan Indonesian slang, a regional variety of Bahasa Indonesia commonly spoken in informal settings. In terms of mathematics learning experience, the students had been introduced to basic fraction operations during the previous semester but had limited exposure to contextual word problems and problem-solving strategies such as Polya's model.

A purposive sampling technique was employed to select participants who could provide rich and meaningful data. The selection criteria included: (1) students who exhibited a high number of errors on a preliminary class-wide mathematics test, (2) students who were able to express their thinking verbally and in writing, and (3) students who had actively participated in previous classroom instruction on fractions. Although the number of participants was small, this limited sample size is acceptable in qualitative research to allow for an in-depth exploration of students' cognitive processes. Ethical procedures were followed by obtaining formal permission from the school principal, informed consent from the students' parents or guardians, and assent from the students themselves prior to data collection.

Two primary instruments were used for data collection. The first was a mathematics test containing three open-ended word problems involving fraction operations, including addition, subtraction, multiplication, and division. Each problem was carefully designed to stimulate students' thinking across Polya's four problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. The test items were developed and reviewed by two mathematics education experts to ensure content validity and appropriateness for the students' level. The complete set of test items is provided in the appendix.

The second instrument was a semi-structured interview protocol intended to explore students' reasoning, misconceptions, and decision-making processes related to their test responses. The interviews were conducted in two rounds for each student, with each session lasting approximately 30–45 minutes. Interviews took place in a quiet room provided by the school to ensure comfort and minimize distractions. The interview protocol allowed flexibility, enabling follow-up questions based on students' responses.

Data collection was conducted in two sequential stages. In the first stage, each student completed the written mathematics test individually under the supervision of the researcher to ensure that the responses reflected their independent problem-solving processes. The completed test responses were collected and initially reviewed to identify error patterns associated with each of Polya's problem-solving stages.

In the second stage, two rounds of semi-structured interviews were conducted with each participant. The first interview round focused on clarifying students' written responses and eliciting their reasoning for each problem-solving step. The second round allowed for deeper probing into their cognitive processes, misconceptions, and the influence of contextual factors. Each interview session lasted approximately 30–45 minutes and was conducted within one week of the written test to minimize memory decay. All interviews were audio-recorded with prior consent and subsequently transcribed verbatim for analysis.

The data were analyzed using Miles and Huberman's (2020) qualitative analysis model, which consists of three interconnected stages: data reduction, data display, and conclusion drawing/verification.

In the data reduction phase, irrelevant information was eliminated, and meaningful data segments were identified and coded according to Polya's four problem-solving stages. Initial coding was conducted by the principal researcher, followed by peer debriefing with two colleagues experienced in mathematics education research to enhance coding reliability and reduce potential bias. Any discrepancies in coding were discussed until consensus was reached.

In the data display phase, the coded data were organized into matrices, categorizing the types of errors and corresponding student reasoning. This process facilitated pattern recognition across participants.

In the conclusion drawing phase, patterns and relationships were interpreted to identify recurring themes regarding the types and causes of student errors.

To enhance the trustworthiness of the findings, multiple strategies were employed, including methodological triangulation (comparing written test data and interview data), peer debriefing, and member checking, where participants were given opportunities to review interview transcripts and verify the accuracy of interpretations.

RESULTS

The results of this study are organized according to Polya's four stages of problem-solving: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. The performances of the three participants — SP-1, SP-2, and SP-3 — are described in detail, highlighting the types of errors made at each stage. To ensure a rich description of the data, illustrative quotes from the interviews are included. For confidentiality, the students are referred to using pseudonyms: SP-1 (male, 13 years old), SP-2 (female, 13 years old), and SP-3 (male, 14 years old), all of whom are Grade VII students at SMP Negeri 2 Sentani.

In the first stage, understanding the problem, most errors occurred because students failed to correctly identify known and unknown quantities or misinterpreted the problem statements. For instance, SP-2 misunderstood the requirement of Problem 1, which asked: *"A cake is divided into 3 equal parts. If each part is further divided into 4 smaller pieces, how many pieces are given to each child if the cake is shared equally among 2 children?"*

SP-2 initially thought the problem required calculating the total number of parts rather than the amount allocated per child. In the interview, SP-2 explained:

"I thought the problem was asking for the total number of pieces, but actually it was asking how many pieces each child would get."

This indicates that SP-2 focused only on surface-level keywords without fully understanding the relational structure between the quantities.

In the second stage, devising a plan, most students struggled to select appropriate operations or to construct valid mathematical models. SP-3, for example, incorrectly applied subtraction when multiplication was required in Problem 2, which asked: *"A farmer harvested $\frac{3}{4}$ of a field. He then sold $\frac{2}{3}$ of the harvested portion. How much of the field did he sell?"*

The correct approach involved multiplying $3/4 \times 2/3 = 6/12 = 1/2$ of the field. However, SP-3 instead subtracted the two fractions and obtained $3/4 - 2/3 = (9/12 - 8/12) = 1/12$, which was entirely incorrect.

During the interview, SP-3 stated:

"I was not sure what operation to use, so I just tried subtracting first."

This response reflects a trial-and-error strategy rather than a conceptual understanding of the problem structure. The student's confusion indicates difficulties in interpreting multiplicative situations involving fractions.

In the third stage, carrying out the plan, some students who had correctly identified the appropriate operations still made computational or procedural errors when executing calculations. For example, in Problem 3, which asked: *"A recipe requires $\frac{2}{3}$ cup of sugar. If a chef makes 3 batches, how much sugar is needed in total?"*, SP-1 correctly identified the multiplication operation: 2/3 × 3.

However, SP-1 miscalculated as follows:

2/3 × 3 = (2 × 3) / 3 = 6/3, but the student mistakenly wrote the answer as 5/3 instead of 2.

During the interview, SP-1 reflected:

"I thought my answer was correct, but I made a miscalculation in simplifying the fraction."

This demonstrates that even when students can devise the correct solution strategy, procedural fluency with fraction operations remains a significant difficulty.

In the final stage, looking back or reviewing the solution, most students did not engage in verification or self-checking of their answers. This absence of metacognitive monitoring contributed to the persistence of uncorrected errors. For example, when asked whether she had reviewed her answers, SP-2 stated:

"I didn't check my answers again because I was confident that they were already correct."

This response indicates an overreliance on initial confidence and a lack of self-regulatory strategies, which are essential for error detection and correction. The failure to re-examine completed solutions highlights a common weakness in students' metacognitive awareness during problem solving.

Table 1. Summary of Error Patterns

Polya's Stage	Types of Errors	Example	Student	Interview Excerpt
Understanding the Problem	Misidentifying known and unknown quantities; Misinterpreting problem statements	Misunderstood the difference between total parts and parts per child	SP-2	I thought the problem was asking for the total number of pieces, but actually it was asking how many pieces each child would get
Devising a Plan	Selecting incorrect operations; Incorrect modeling	Subtracted fractions instead of multiplying (3/4 - 2/3 instead of 3/4 × 2/3)	SP-3	"I was not sure what operation to use, so I just tried subtracting first."
Carrying Out the Plan	Computational and procedural errors	Miscalculated 2/3 × 3 as 5/3 instead of 2	SP-1	"I thought my answer was correct, but I made a miscalculation in simplifying the fraction."
Looking Back	Skipping verification; Overconfidence	Did not check any answers	SP-2	"I didn't check my answers again because I was confident that they were already correct."

To support the qualitative findings, Table 2 summarizes the frequency of errors made by the students during each stage of Polya's problem-solving model. The errors are categorized into four main types: understanding the problem, planning the solution, carrying out the plan, and looking back (rechecking). The data reveal that the highest number of errors occurred during the stages of carrying out the plan and rechecking, indicating students' difficulties in executing solution strategies and evaluating their work. This frequency distribution highlights specific cognitive challenges faced by learners and provides insight into which stages may require more instructional attention and support.

Table 2. Error Frequency Table

Error Type	Number of Errors
Understanding the problem	5
Planning the solution	4
Carrying out the plan	6
Looking back (rechecking)	6

Figure 1 provides a visual representation of the frequency of each error type based on Polya's problem-solving stages. This visual summary complements the tabular data and helps to quickly identify critical areas for instructional intervention.

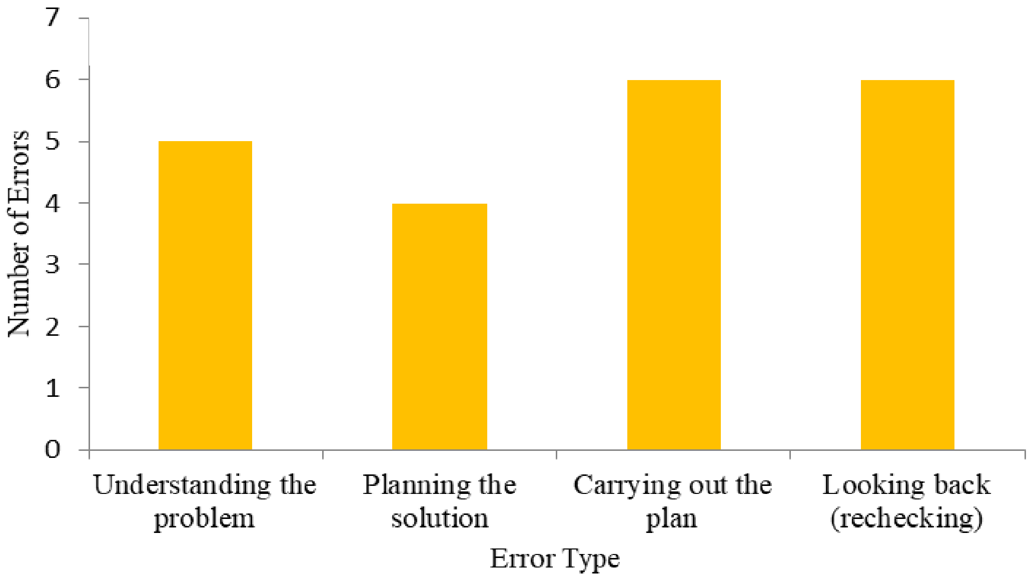

Figure 1. Visual Representation

DISCUSSION

At the first stage, understanding the problem, students demonstrated significant difficulties in interpreting the problem context and correctly identifying the known and unknown quantities. As evidenced by SP-2's confusion between total parts and parts per student, such misunderstandings suggest shallow processing of problem statements. This finding is consistent with Iilonga and Chirimbana (2024), who emphasized that limited reading comprehension and weak mathematical language proficiency are primary sources of such errors. Similarly, Cui and Ng (2021) highlight that decoding mathematical language requires both linguistic and conceptual understanding, which may be particularly challenging for students in multilingual contexts such as Papua, where students often experience interference between local dialects and the national language of instruction.

In the planning stage, most students encountered representational difficulties, often selecting incorrect operations or failing to construct accurate mathematical models. As illustrated by SP-3's use of subtraction instead of multiplication, these errors reflect students' limited ability to translate real-world problem contexts into appropriate mathematical operations. Utomo and Syarifah (2021) emphasize that the ability to develop correct problem representations is a crucial bridge between comprehension and execution. However, for many students, especially those with weak procedural foundations, this stage becomes a significant obstacle.

Furthermore, in the cultural context of Papua, limited exposure to diverse problem types and the dominance of rote instructional methods may restrict students' opportunities to practice flexible problem modeling. Gopinath and Lertlit (2022) stress that repeated engagement with varied problem structures is essential for developing students' problem-solving flexibility and reducing reliance on trial-and-error approaches.

In the carrying out of the plan stage, some students who had correctly identified the required operations still made computational or procedural errors. As demonstrated by SP-1's miscalculation when simplifying $\frac{2}{3}x3$, these errors reflect insufficient procedural fluency in fraction arithmetic. Keazer and Phaiah (2023) emphasize that procedural fluency must be developed in parallel with conceptual understanding to ensure accurate execution of problem-solving plans. Without sufficient practice in basic fraction operations, students remain vulnerable to careless mistakes, even when their conceptual reasoning is initially correct.

This difficulty may also be compounded by limited access to enrichment materials and practice opportunities, especially in geographically remote regions like Papua. Students often rely heavily on teacher-centered instruction, with limited scaffolding for independent error-checking or mastery of calculation procedures (Braithwaite & Siegler, 2021). Thus, weaknesses at this stage further suggest the need for balanced instructional strategies that strengthen both conceptual and procedural competencies.

In the final stage, looking back, most students demonstrated minimal metacognitive engagement, often failing to verify their solutions. SP-2's confidence in her answers without any verification reflects the absence of self-monitoring strategies. Fitriani et al. (2022) emphasize that developing metacognitive habits, such as routinely checking one's work, is essential to improving accuracy and fostering independent problem-solving skills.

This tendency may be partly rooted in classroom norms where students prioritize speed and correct final answers over reflective thinking. In many Indonesian classrooms, including in Papua, time-constrained assessments and limited emphasis on self-reflection may discourage students from reviewing their problem-solving processes (Ng & Toh, 2024). Therefore, fostering metacognitive awareness requires intentional scaffolding within instructional practices to help students internalize the habit of reviewing and verifying their solutions before submission.

The cultural and contextual characteristics of Papua played a significant role in shaping students' problem-solving performances. Limited access to instructional resources, minimal exposure to varied problem types, and strong reliance on teacher-centered instruction may contribute to the observed weaknesses in representation, procedural fluency, and metacognition. In addition, the linguistic diversity of Papua presents specific challenges in interpreting mathematical language. Students often struggled with terms such as *"each," "total,"* and *"remaining,"* which require precise translation between everyday language and mathematical representations (Mohammed, 2021).

These language-related challenges are amplified when students use multiple local dialects at home while learning mathematics primarily in Bahasa Indonesia at school. As Ndukwe et al. (2022) note, difficulties in verbal-to-symbolic translation are a common source of errors in solving word problems, especially for students in multilingual settings.

Furthermore, the assessment culture in many Indonesian classrooms tends to emphasize speed, accuracy, and correct final answers over reflective thinking and process-oriented learning. Such habits may discourage students from reviewing their solutions or exploring alternative problem-solving strategies (Ng & Toh, 2024). To address these issues, mathematics instruction should integrate explicit language support and provide structured opportunities for students to engage in reflective problem-solving practices that emphasize process as well as product.

In the context of Papua, specifically in Jayapura, students' understanding of fractions is shaped not only by formal instruction but also by their cultural-linguistic environment. The influence of the Papuan Indonesian slang may affect students' interpretation of mathematical terms such as "per," "whole," and "remain," which are essential for conceptualizing part-whole relationships in fractions. From a socio-cultural perspective, Vygotsky's Zone of Proximal Development (ZPD) highlights the importance of guided learning through social interaction. In this setting, peer collaboration and teacher scaffolding can help bridge the gap between students' current understanding and the expected conceptual level (Vygotsky, 1978). Compared to similar studies in other multilingual settings, such as in rural South Africa and indigenous communities in Latin America, students often exhibit similar linguistic interference patterns that lead to misinterpretation of problem structures (Iilonga & Chirimbana, 2024; Kusaka, 2021). These comparisons reinforce the need for culturally and linguistically responsive mathematics instruction tailored to the unique sociolinguistic characteristics of Papuan learners.

To address these issues, mathematics instruction should integrate explicit language support and provide structured opportunities for students to engage in reflective problem-solving practices that emphasize process as well as product.

Limitations and Suggestions for Future Research

Although this study provides in-depth insights into students' errors in fraction problem-solving, several limitations should be acknowledged. First, the small sample size of three students limits the generalizability of the findings. However, such a small sample is typical for qualitative studies that aim to explore cognitive processes in depth. Second, the study focused exclusively on fraction word problems and may not capture students' problem-solving difficulties in other mathematical domains. Third, cultural and linguistic influences were examined descriptively based on interview data; future research may benefit from a more systematic exploration of these contextual factors using mixed methods or larger sample sizes.

Future studies could investigate interventions that explicitly integrate language support, visual representations, and metacognitive training to address students' identified weaknesses. Additionally, expanding the research to include diverse schools in different regions of Papua or other multilingual settings in Indonesia may provide richer comparative insights into how contextual factors shape problem-solving behaviors.

CONCLUSION

This study explored the types and causes of students' errors in solving fraction word problems using Polya's four-step problem-solving model in a junior high school context in Papua, Indonesia. The findings revealed that students exhibited errors at each stage of the problem-solving process. Difficulties in comprehending problem statements and distinguishing known from unknown quantities reflected students' limited reading comprehension and conceptual confusion. When devising a plan, students often struggled to select appropriate operations and construct accurate mathematical models. Even when correct plans were devised, procedural errors such as calculation mistakes emerged during execution. Additionally, students rarely engaged in reviewing their solutions, indicating limited metacognitive awareness.

These patterns of errors were influenced by a combination of weak conceptual foundations, insufficient procedural fluency, and representational challenges. Cultural and contextual factors, including linguistic barriers, instructional practices, and classroom norms in Papua, also contributed to students' problem-solving difficulties. These findings suggest the need for instructional strategies that integrate language support, structured scaffolding, and metacognitive training to better support students' problem-solving development in similar educational contexts.

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DECLARATIONS

Author Contribution	:	Author 1: Conceptualization; Methodology; Data curation; Formal analysis; Investigation; Writing – original draft. Author 2: Conceptualization; Theoretical framework development; Literature review; Supervision; Writing – review & editing. All authors have read and approved the final version of the manuscript.
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Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	This study was conducted in accordance with ethical standards. Permission for data collection was obtained from the school authorities, and informed consent was secured from all participants and their guardians.

REFERENCES

Abdul W A. (2024). The Influence of the Use of Polya's Heuristic Strategies on Students' Mathematical Problem Solving: A Meta Analysis. *Jmlipare*, *3*(2), 156–167. https://doi.org/10.35905/jmlipare.v3i2.10664

Amalia, L., Makmuri, M., & Hakim, L. (2024). Learning Design: To Improve Mathematical Problem-Solving Skills Using a Contextual Approach. *Jiip - Jurnal Ilmiah Ilmu Pendidikan*, *7*(3), 2353–2366. https://doi.org/10.54371/jiip.v7i3.3455

Balayan, R., Oliveros, R. T., & Tagalog, L. B. (2024). Participation of Math Students in Online and Face-to-Face Hybrid Mathematics Instruction. *Mathematics Education Journal*, *8*(1), 21–38. https://doi.org/10.22219/mej.v8i1.29954

Bernedo, F. E. F., & Fuentes, A. M. B. (2022). *Libro: MATEMÁTICA BÁSICA*. https://doi.org/10.34893/r4514-8213-9481-k

Blayney, M., Reed, M., Masterson, J., Anand, A., Bouamrane, M., Fleuriot, J., Luz, S., Lyall, M., Mercer, S., Mills, N., Shenkin, S., Walsh, T., Wild, S., Wu, H., McLachlan, S., Guthrie, B., & Lone, N. (2024). Multimorbidity and adverse outcomes following emergency department attendance: population based cohort study. *BMJ Medicine*, *3*, e000731. https://doi.org/10.1136/bmjmed-2023-000731

Braithwaite, D. W., & Siegler, R. S. (2021). Putting Fractions Together. *Journal of Educational Psychology*, *113*(3), 556–571. https://doi.org/10.1037/edu0000477

Chiu, B., Randles, C., & Irby, S. M. (2022). Analyzing Student Problem-Solving With MAtCH. *Frontiers in Education*, *6*. https://doi.org/10.3389/feduc.2021.769042

Cui, Z., & Ng, O.-L. (2021). The interplay between mathematical and computational thinking in primary school students' mathematical problem-solving within a programming environment. *Journal of Educational Computing Research*, *59*(5), 988–1012. https://doi.org/https://doi.org/10.30191/ETS.202304_26(2).0010

Difinubun, F. A., Makmuri, M., & Hidayat, F. A. (2024). Preliminary Study on the Development of Project-Based Learning Module to Improve Students' Mathematical Problem Solving Ability. *Mathline Jurnal Matematika Dan Pendidikan Matematika*, *9*(2), 605–628. https://doi.org/10.31943/mathline.v9i2.638

Diputra, K. S., Suryadi, D., Herman, T., & Jupri, A. (2023). Analysis of the Elementary School Students' Learning Obstacles: A Case Study on the Concept of Fractions. *Al Ibtida Jurnal Pendidikan Guru Mi*, *10*(1), 13. https://doi.org/10.24235/al.ibtida.snj.v10i1.13078

Erlin, E., Rahmat, A., & Purwianingsih, W. (2024). Metacognitive Self Regulation Integrated With Science Technology Society to Improving Problem Solving Ability in Microbiology Courses. *Biosfer Jurnal Pendidikan Biologi*, *17*(1), 204–214. https://doi.org/10.21009/biosferjpb.38102

Fitriani, F., Hayati, R., Sugeng, S., Srimuliati, S., & Herman, T. (2022). Students' ability to solve mathematical problems through polya steps. *Journal of Engineering Science and Technology*, *17*, 25–32.

GÖKTAŞ, O., & Yazıcı, E. (2020). Effectiveness of Teaching Mathematical Problem-Solving Strategies to Students With Mild Intellectual Disabilities. *Turkish Journal of Computer and Mathematics Education (Turcomat)*. https://doi.org/10.16949/turkbilmat.662461

Gomides, M. R. A., Starling-Alves, I., Paiva, G. M., Caldeira, L. D. S., Aichinger, A. L. P. N., Carvalho, M. R. S., Bahnmueller, J., Moeller, K., Lopes-Silva, J. B., & Haase, V. G. (2021). The quandary of diagnosing mathematical difficulties in a generally low performing population. *Dementia & Neuropsychologia*, *15*(2), 267–274. https://doi.org/https://doi.org/10.1590/1980-57642021dn15-020015

Gopinath, S., & Lertlit, S. (2022). The Implementation of Polya's Model in Solving Problem-Questions in Mathematics by Grade 7 Students. *Suranaree Journal of Social Science*, *11*(1), 47–59. https://doi.org/10.55766/ffnz6417

Iilonga, H. K., & Chirimbana, M. (2024). Errors Made by 8th Grade Students while Solving Mathematical Word Problems. *Journal of Research in Science and Mathematics Education*, *3*(3), 120–129. https://doi.org/https://doi.org/10.56855/jrsme.v3i3.1139

Kabael, T., & Baran, A. A. (2023). An Investigation of Mathematics Teachers' Conceptions of Mathematical Literacy Related to Participation in a Web-Based PISA Course. *Bartın University Journal of Faculty of Education*, *12*(2), 315–324. https://doi.org/10.14686/buefad.1053557

Kamid, K., Dewi, R. K., Kurniawan, D. A., Azzahra, M. Z., & Nawahdani, A. M. (2023). Student Learning Difficulties in Terms of the STIF in Framework of Fractional Material. *Jurnal Penelitian Dan Pengembangan Pendidikan*, *7*(2), 187–194. https://doi.org/10.23887/jppp.v7i2.57371

Keazer, L., & Phaiah, J. (2023). Analyzing Prospective Elementary Teachers' Evidence of Conceptual Understanding and Procedural Fluency. *Investigations in Mathematics Learning*, *15*(2), 135–148. https://doi.org/https://doi.org/10.1080/19477503.2022.2139112

Khofifah, K., Rosyadi, R., Gunadi, F., Nandang, N., & Runisah, R. (2024). Students' Difficulties in Solve Trigonometry Problem Solving According to Step Polya's. *Mathline Jurnal Matematika Dan Pendidikan Matematika*, *9*(3), 919–946. https://doi.org/10.31943/mathline.v9i3.571

Kusaka, S. (2021). Analysis of Learning Difficulties With Fractions in Three African Countries: Focusing on the Scope, Sequence and Models of Fractions. *African Journal of Education and Practice*, *7*(2), 77–91. https://doi.org/10.47604/ajep.1267

Li, T., Chen, C., & Zhou, X. (2022). How Are Different Math Knowledge Presentations Associated With Math Anxiety? *Annals of the New York Academy of Sciences*, *1520*(1), 153–160. https://doi.org/10.1111/nyas.14951

Lisnani, L. (2023). Fraction Learning Using Daily Context for Pre-Service Primary School Teacher Education. *Jurnal Pendidikan Matematika (Jupitek)*, *6*(2), 73–81. https://doi.org/10.30598/jupitekvol6iss2pp73-81

Miles, M. B., Huberman, A. M., & Saldana, J. (2020). *Qualitative Data Analysis*. Sage Publications, Inc.

Mohammed, E. (2021). Arabic and computer language; Reading in Arabic linguistic geometry. *Mathematical Linguistics*, *1*(1).

Muhassanah, N., & Setiani, A. (2024). Analysis of Student Errors Based on Polya's Steps in Three-Dimensional Geometry. *Union Jurnal Ilmiah Pendidikan Matematika*, *12*(2), 340–349. https://doi.org/10.30738/union.v12i2.17575

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 International Results in Mathematics and Science*. https://timssandpirls.bc.edu/timss2019/international-results/

Murniasih, T., Muthi'ah, & Widjanarko, S. B. (2020). Optimizing antioxidant substances extraction produced by Holothuria atra using ultrasonic with response surface method Optimizing antioxidant substances extraction produced by Holothuria atra using ultrasonic with response surface method. *IOP Conference Series: Materials Science and Engineering PAPER*, *858*, 1–13. https://doi.org/10.1088/1757-899X/858/1/012026

Nanna, A. W., & Pratiwi, E. (2020). Students' Cognitive Barrier in Problem Solving: Picture-based Problem-solving. *Al-Jabar : Jurnal Pendidikan Matematika*, *11*(1), 73–82. https://doi.org/DOI:10.24042/AJPM.V11I1.5652

Nashiroh, F., & Zainuddin, A. (2023). Development of GeoGebra-Based Fraction Gap Learning Media to Improve Understanding of the Fraction Concept of Grade v Elementary School. *Didaktika Tauhidi Jurnal Pendidikan Guru Sekolah Dasar*, *10*(1), 55–69. https://doi.org/10.30997/dt.v10i1.8238

Ndukwe, Nnachi, O., Egbe, I., Ndubuisi, N., & Patrick, O. (2022). Effect of Polya Problem Solving Teaching Method on the Achievement of Students in Algebra. *RHSS*. https://doi.org/10.7176/rhss/12-6-04

Ng, Y. X., & Toh, T. L. (2024). On Some Guiding Principles of Enacting Mathematical Problem Solving for Classroom Instruction. *Dinamika Jurnal Ilmiah Pendidikan Dasar*, *16*(1), 1. https://doi.org/10.30595/dinamika.v16i1.20441

Noor, M. A. M., & Lian, L. H. (2022). Consistent or Inconsistent? Expert-based Cognitive Model vs Student-based Response Cognitive Model of Cognitive Diagnostic Assessment in Factorisation of Algebraic Fractions. *International Journal of Academic Research in Progressive Education and Development*, *11*(3), 220–231. https://doi.org/http://dx.doi.org/10.6007/IJARPED/v11-i3/14696

OECD. (2020). *OECD Economic Outlook, Volume 2020 Issue 2, OECD Publishing*. https://doi.org/https://doi.org/10.1787/39a88ab1-en.

Pambudi, D. S., Hobri, H., Putri, I. W. S., Trapsilasiwi, D., & Jatmiko, D. D. H. (2023). Analisis Pemecahan Masalah Siswa Dalam Menyelesaikan Soal Sharing Task Dan Jumping Task Berdasarkan Gaya Kognitif. *Educator Jurnal Inovasi Tenaga Pendidik Dan Kependidikan*, *3*(1), 1–13. https://doi.org/10.51878/educator.v3i1.2184

Polya, G. (1957). *How to Solve It. A New Aspect of Mathematical Method* (2nd Editio). Princeton University Press.

Pradana, D. W., & Ekowati, D. (2024). Future organizational resilience capability structure: a systematic review, trend and future research directions. *Management Research Review*, *47*(10), 1586–1605. https://doi.org/https://doi.org/10.1108/MRR-08-2023-0538

Rahmah, N., & Darsikin, D. (2021). Student's Problem-Solving Skills in Thermodynamics at Dampelas 1 Senior High School. *Jurnal Ilmiah Pendidikan Fisika*, *5*(2), 258. https://doi.org/10.20527/jipf.v5i2.2797

Rott, B., Specht, B. J., & Knipping, C. (2021). A Descriptive Phase Model of Problem-Solving Processes. *ZDM*, *53*(4), 737–752. https://doi.org/10.1007/s11858-021-01244-3

Safrina, Y., Ikhsan, M. F., & Zubainur, C. M. (2022). *Improving Student Geometry Problem-Solving Skills Through Spatial Training*. https://doi.org/10.2991/assehr.k.211229.005

Salsabila, A. Z., Yuliani, A., & Amelia, R. (2024). Literatur Review: The Effect of Distance Learning on Students' Mathematical Problem Solving Skill. *(Jiml) Journal of Innovative Mathematics Learning*, *7*(1), 11–19. https://doi.org/10.22460/jiml.v7i1.18570

Shah, M. K., Gandrakota, N., Cimiotti, J. P., Ghose, N., Moore, M., & Ali, M. K. (2021). Prevalence of and Factors Associated with Nurse Burnout in the US. *JAMA Network Open*, *4*(2). https://doi.org/https://doi.org/10.1001/jamanetworkopen.2020.36469

Singh, P., Hoon, T. S., Nasir, N. A. M., Han, C. T., Rasid, S. M., & Hoong, J. B. Z. (2021). Obstacles Faced by Students in Making Sense of Fractions. *The European Journal of Social & Behavioural Sciences*, *30*(1), 34–51. https://doi.org/10.15405/ejsbs.287

Starling-Alves, I., Wronski, M. R., & Hubbard, E. M. (2021). Math Anxiety Differentially Impairs Symbolic, but Not Nonsymbolic, Fraction Skills Across Development. *Annals of the New York Academy of Sciences*, *1509*(1), 113–129. https://doi.org/10.1111/nyas.14715

Sulistyani, D., Subekti, E. E., & Wardana, M. Y. S. (2021). Students' Learning Difficulties Review From Mathematics Problem-Solving Ability in Third-Grade Elementary School. *Indonesian Journal of Educational Research and Review*, *4*(2), 345. https://doi.org/10.23887/ijerr.v4i2.30310

Tay, Y. K., & Toh, T. L. (2023). A Model for Scaffolding Mathematical Problem-Solving: From Theory to Practice. *Contemporary Mathematics and Science Education*, *4*(2), ep23019–ep23019. https://doi.org/10.30935/conmaths/13308

Tohir, M., Muhasshanah, M., Hidayat, R., Valentino, E., & Wijaya, T. T. (2023). Mathematical Olympiad Issues to Identify Students' Reasoning Ability Using Polya's Model. *Alifmatika Jurnal Pendidikan Dan Pembelajaran Matematika*, *5*(2), 264–281. https://doi.org/10.35316/alifmatika.2023.v5i2.264-281

Unaenah, E., Suryadi, D., & Turmudi, T. (2024). Epistemological Learning Obstacles on Fractions in Elementary School. *Jurnal Elemen*, *10*(1), 1–12. https://doi.org/10.29408/jel.v10i1.18306

Utomo, D. P., & Syarifah, D. L. (2021). Examining mathematical representation to solve problems in trends in mathematics and science study: Voices from Indonesian secondary school students. *International Journal of Education in Mathematics, Science and Technology*, *9*(3), 540–556. https://doi.org/10.46328/IJEMST.1685

Viseu, F., Pires, A., Menezes, L., & Costa, A. M. (2021). Semiotic Representations in the Learning of Rational Numbers by 2nd Grade Portuguese Students. *International Electronic Journal of Elementary Education*, *13*(5), 611–624. https://doi.org/10.26822/iejee.2021.216

Vosniadou, S. (2013). Conceptual change in learning and instruction: The framework theory approach. *International Handbook of Research on Conceptual Change*, 11–30.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes. Cambridge*. MA: Harvard University Press.

Wahyu, K., Kuzu, T. E., Subarinah, S., Ratnasari, D., & Mahfudy, S. (2020). Partitive Fraction Division: Revealing and Promoting Primary Students' Understanding. *Journal on Mathematics Education*, *11*(2), 237–258. https://doi.org/10.22342/jme.11.2.11062.237-258

Widodo, S. A., Ibrahim, I., Hidayat, W., Maarif, S., & Sulistyowati, F. (2021). Development of Mathematical Problem Solving Tests on Geometry for Junior High School Students. *Jurnal Elemen*, *7*(1), 221–231. https://doi.org/10.29408/jel.v7i1.2973

APPENDIX: Word Problems Test

Problem 1:
A cake is divided into 3 equal parts. Each part is then cut into 4 smaller pieces. The entire cake will be shared equally among 2 children. How many pieces of cake will each child receive?

Problem 2:
A farmer harvested $\frac{3}{4}$of his field. He sold $\frac{2}{3}$ of the harvested portion. What fraction of the entire field did the farmer sell?

Problem 3:
A recipe requires $\frac{2}{3}$ cup of sugar for one batch of cookies. A baker wants to make 3 batches. How many cups of sugar does the baker need in total?