

ANALYSIS OF ELEMENTARY SCHOOL STUDENTS' NUMERATION ERRORS AT EACH STAGE OF POLYA PROBLEM SOLVING IN SOLVING MATHEMATICS STORY PROBLEMS

Aan Nurhasanah^{1*}, Rahayu Syafari²

^{1,2} Universitas Kuningan, Indonesia

^{1*} aan.nurhasanah@uniku.ac.id, ² rahayu.syafari@uniku.ac.id

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Abstract

This study aims to analyze students' numeracy errors in solving contextual mathematical problems based on Polya's problem-solving stages and numeracy literacy framework. The research employed a qualitative descriptive approach by analyzing students' written responses to a contextual problem involving calculation of total purchase cost. Data were analyzed using Polya's four stages: understanding the problem, devising a plan, carrying out the plan, and looking back. The findings revealed that students' errors predominantly occurred in the early stages of problem solving, particularly in understanding the problem and devising a solution strategy. Students demonstrated partial identification of relevant information and showed difficulties in mathematical modelling, especially in connecting unit price concepts with quantity relationships. Despite these difficulties, students exhibited adequate procedural skills during arithmetic calculations. However, metacognitive reflection was absent, as students did not verify or evaluate their solutions. These findings suggest that numeracy difficulties are more closely related to conceptual understanding and modelling processes rather than computational skills. The study highlights the importance of instructional approaches that emphasize contextual interpretation, mathematical modelling, and reflective thinking to enhance students' numeracy literacy

Keywords: *Numeracy Literacy, Polya Problem Solving, Mathematical Modelling, Contextual Problems, Student Errors.*

Abstrak

Penelitian ini bertujuan untuk menganalisis kesalahan berhitung siswa dalam menyelesaikan masalah matematika kontekstual berdasarkan tahapan pemecahan masalah Polya dan kerangka literasi berhitung. Penelitian ini menggunakan pendekatan deskriptif kualitatif dengan menganalisis tanggapan tertulis siswa terhadap masalah kontekstual yang melibatkan perhitungan total biaya pembelian. Data dianalisis menggunakan empat tahap Polya: memahami masalah, menyusun rencana, melaksanakan rencana, dan melihat ke belakang. Temuan penelitian menunjukkan bahwa kesalahan siswa sebagian besar terjadi pada tahap awal pemecahan masalah, khususnya dalam memahami masalah dan merancang strategi solusi. Siswa menunjukkan identifikasi parsial informasi yang relevan dan menunjukkan kesulitan dalam pemodelan matematika, terutama dalam menghubungkan konsep harga satuan dengan hubungan kuantitas. Meskipun terdapat kesulitan-kesulitan ini, siswa menunjukkan keterampilan prosedural yang memadai selama perhitungan aritmatika. Namun, refleksi metakognitif tidak ada, karena siswa tidak memverifikasi atau mengevaluasi solusi mereka. Temuan ini menunjukkan bahwa kesulitan berhitung lebih erat kaitannya dengan pemahaman konseptual dan proses pemodelan dibandingkan keterampilan komputasi. Studi ini menyoroti pentingnya pendekatan pembelajaran yang menekankan interpretasi

kontekstual, pemodelan matematika, dan pemikiran reflektif untuk meningkatkan literasi berhitung siswa.

Kata Kunci: Literasi Numerasi, Pemecahan Masalah Polya, Pemodelan Matematika, Masalah Kontekstual, Kesalahan Siswa.

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INTRODUCTION

Numeracy literacy is a key competency in 21st-century mathematics learning (Fajriyah, 2022; Geiger et al., 2015), as it emphasizes not only numeracy skills but also the ability to understand, interpret, and use mathematical concepts in various real-life contexts. Numeracy literacy encompasses the ability to formulate, apply, and interpret mathematics in contextual situations, as emphasized in the 2019 OECD Programme for International Student Assessment (PISA) framework (Herman et al., 2024). However, various studies indicate that students still experience difficulties in solving contextual word problems, particularly in connecting available information with appropriate mathematical models. This difficulty suggests that the primary challenge in mathematics learning lies not only in the computational aspect, but also in the ability to understand problems and construct mathematical representations.

From a problem-solving perspective, Polya (1957) in (Murdiana, 2015) proposed four main stages: understanding the problem, developing a plan, implementing the plan, and revisiting. This stage provides a systematic framework for analyzing students' thought processes in solving mathematical problems (Siregar et al., 2024; Wardhani et al., 2016). Several studies have shown that student errors often occur in the early stages, particularly in understanding problem situations and determining appropriate solution strategies. This indicates a gap between students' procedural abilities and conceptual understanding, where students are able to perform arithmetic operations but experience difficulty in modeling contextual problems mathematically.

When linked to PISA mathematical literacy, this difficulty can be understood as a barrier at the formulate stage, namely the process of translating real-world situations into formal mathematical representations (OECD, 2019). This process is closely related to mathematical modeling skills, which require students to identify relevant information, determine relationships between variables, and choose appropriate mathematical operations (Riduan et al., 2024; Wulandari et al., 2025). However, in learning practice, the modeling aspect often receives less attention than procedural exercises, resulting in students tending to focus on calculations without a deeper understanding of the problem structure.

Although extensive research on student errors in mathematical problem-solving has been conducted, most studies still focus on procedural errors or analysis of solution steps without explicitly linking them to the numeracy literacy framework and mathematical modeling. Therefore, a study that integrates error analysis based on Polya's problem-solving stages with a numeracy literacy perspective is needed to gain a more comprehensive understanding of the sources of students' difficulties in solving contextual problems.

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Based on this background, this study aims to analyze students' numeracy errors in solving contextual mathematical problems using Polya's problem-solving stages framework and the PISA mathematical literacy perspective. The results are expected to contribute to understanding the characteristics of students' numeracy errors and form the basis for developing more effective learning strategies to improve numeracy literacy skills.

METHOD

Research Approach and Design

This research uses a descriptive qualitative approach which aims to analyze students' numeration errors in solving contextual mathematics problems based on Polya's problem solving stages. A qualitative approach was chosen because the research focused on exploring students' thought processes and interpreting errors that emerged in written answers in depth (Creswell & Creswell, in Sumilih et al., 2025). The research design involved error analysis using Polya's problem-solving stages framework as the basis for the analysis.

Research Subjects

Research subjects were selected using a purposive sampling technique, based on the relevance of students' answers to the research objective of identifying patterns of numeracy errors in the context of mathematical problem-solving (Dewi & SH, 2025; Mulyana et al., 2024). The subjects were elementary school students who provided written responses to contextual numeracy problems.

Research Instrument

The research instrument consisted of contextual mathematics problems designed to measure numeracy literacy skills, specifically the ability to formulate, apply, and interpret mathematical concepts in real-life situations in accordance with the PISA mathematical literacy framework (OECD, 2019). Furthermore, documentation of students' written answers served as the primary data source in this study (Susanto et al., 2023).

Data Collection Technique Data

Data were collected through documentation of students' written responses to the given problems. This documentation was used to identify students' mathematical thinking processes through written representations of solution steps (Sarina, 2024).

Data Analysis Technique

The data analysis technique used the interactive analysis model (Miles in Qomaruddin & Sa'diyah, 2024), which includes four stages: data collection, data reduction, data presentation, and verification and conclusion drawing, as shown in the following chart:

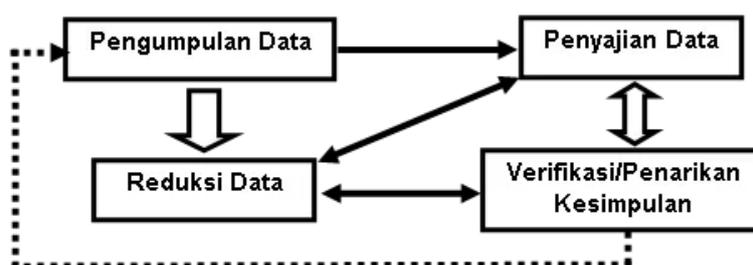


Figure 1. Analysis Stages

In the data collection stage, researchers collected students' written responses. The data reduction stage was carried out by selecting and grouping parts of the answers based on Polya's problem-solving stage indicators, namely understanding the problem, developing a plan, implementing the plan, and reviewing (Polya, in (Kania et al., 2022; Purba et al., 2021). The data presentation stage was carried out in the form of narrative descriptions and analysis tables to clarify the error patterns found. Next, the verification and conclusion-drawing stage was carried out by repeatedly interpreting the research findings and linking them to numeracy literacy theory and mathematical modeling. The analysis process was carried out interactively and cyclically throughout the research.

RESULTS AND DISCUSSION

Results

Analysis of students' answers to contextual questions about calculating the total purchase price of fruit shows variations in numeracy abilities that can be identified through Polya's problem-solving stages, namely understanding the problem, developing a plan, implementing the plan, and reviewing (Polya, 1957). The analyzed student answers are shown in Figure 2.

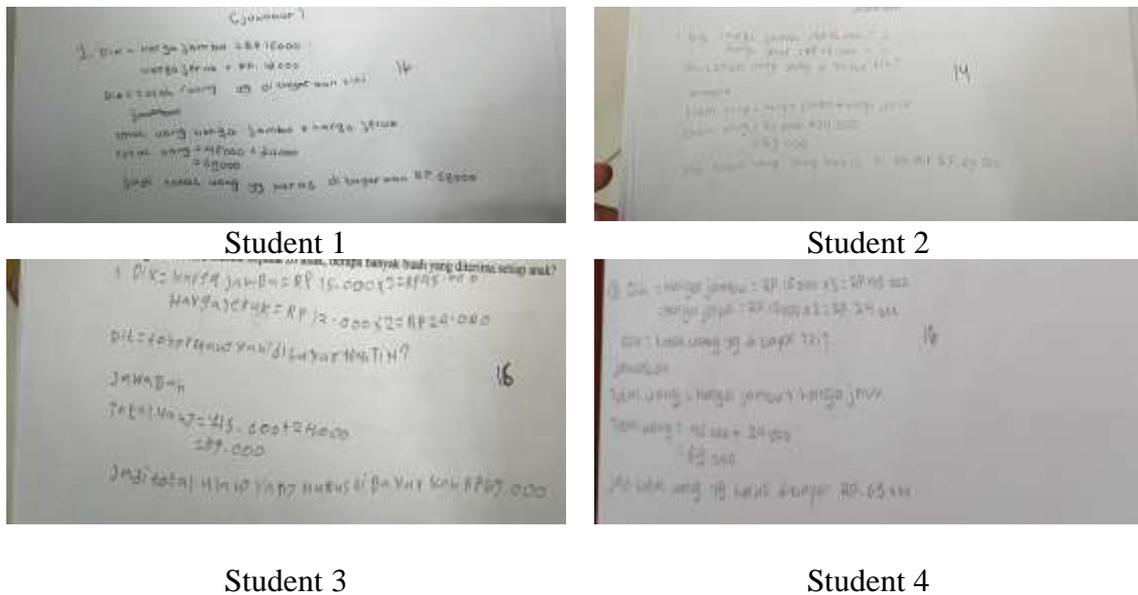


Figure 2. Students' Written Answers in Solving Numeracy Problems

At the understanding the problem stage, students were able to identify some known information (Saparwadi, 2022), namely the price of guavas at IDR 15,000 per kilogram and the price of oranges at IDR 12,000 per kilogram, and rewrite the questions posed in the problem. This demonstrates that students have acquired initial skills in extracting basic information from contextual problems. However, students did not explicitly include important information regarding the purchase quantities, namely 3 kg of guavas and 2 kg of oranges. This incompleteness in recording quantitative data indicates that the problem understanding process has not been carried out thoroughly. As a result, the problem representation constructed by students is incomplete, potentially affecting the accuracy of subsequent solution steps.

At the devising a plan stage (Enlisia et al., 2020), students demonstrated an error in selecting a solution strategy. Students stated that the total money was obtained by directly adding the prices of guavas and oranges, without first multiplying the unit price by the number of items purchased. This indicates a misconception in understanding the relationship between unit price and quantity in the context of purchasing. These errors indicate that students are unable to model

A. Nurhasanah and R. Syafari (2026). *Analysis Of Elementary School Students' Numeration Errors At Each Stage Of Polya Problem Solving In Solving Mathematics Story Problems* contextual situations in appropriate mathematical forms. Furthermore, the strategies chosen indicate that students tend to use simple procedures without considering the overall structure of the problem, resulting in a less than adequate solution plan.

In the "carrying out the plan" stage (Pertiwi et al., 2020), students were able to implement the chosen strategy by correctly performing arithmetic operations, achieving a final result of Rp69,000. This demonstrates that students possess adequate procedural skills in carrying out calculations according to the solution plan. However, the multiplication process, a crucial part of the solution steps, was not explicitly explained, making the students' thought process less visible. This lack of clarity can reduce the readability of the mathematical reasoning process and make it difficult for teachers to assess students' conceptual understanding in depth.

Furthermore, in the "looking back" stage (Normalasari et al., 2022), students demonstrated no effort to reflect on or verify the solution they obtained. Activities such as double-checking calculation steps, evaluating the reasonableness of results, or trying alternative solution strategies were absent. These steps play a crucial role in ensuring the accuracy of answers and developing students' metacognitive skills. This lack of reflection indicates that students tend to focus on obtaining the final answer without evaluating the process and results achieved, thus reducing the opportunity to deepen understanding and reduce the likelihood of errors.

Discussion

The results of the study indicate that students' numeracy errors do not lie in their arithmetic computational abilities, but rather in the initial stages of problem-solving, specifically in understanding the problem and developing a solution plan. This finding reinforces Polya's (1957) view in Aulia et al., 2025, that failure in mathematical problem-solving often stems from a lack of understanding of the problem's structure before the calculation process begins. Students in this study were able to produce numerically correct final answers, but the written solution steps indicated a gap between procedural knowledge and conceptual understanding.

From the perspective of PISA mathematical literacy (OECD, 2019), students' errors can be interpreted as failures at the formulate stage, namely the ability to translate contextual situations into appropriate mathematical models. Students immediately added unit prices without first modeling the relationship between price per kilogram and purchase quantity, indicating that the mathematical modeling process was not optimally developed. This aligns with the mathematical modeling framework proposed by Blum and Leiss (2007) in (Anwar et al., 2022), which emphasizes the importance of the transformation stage from real-world contexts to formal mathematical representations as the foundation for problem-solving (Zaini, 2025).

Furthermore, research findings demonstrate the dominance of procedural knowledge over conceptual knowledge, as explained by (Intan, 2020). Students are able to perform arithmetic operations correctly, but do not demonstrate a deep understanding of the rationale for using these operations. This condition indicates that the mathematics instruction students receive likely still emphasizes procedural aspects rather than exploring the meaning of concepts and relationships between mathematical representations. In the context of numeracy literacy, the ability to explain strategies and represent the solution process is an important indicator of meaningful understanding, not simply obtaining the correct final result.

The absence of a reflection or looking-back stage in students' answers also indicates limitations in metacognitive aspects, as explained by (Schoenfeld, 2020), who argues that reflection is a key component in regulating mathematical thinking processes. Without reflection, students tend

not to evaluate the appropriateness of the strategies used to the problem context, thus potential conceptual errors go undetected.

Conceptually, the findings of this study contribute by demonstrating that numeracy errors in elementary school students are not solely related to weak numeracy skills, but rather to difficulties in constructing mathematical models from contextual situations. Therefore, strengthening numeracy literacy needs to focus on developing contextual interpretation skills, mathematical modeling, and metacognitive strategies. Problem-based learning and differentiated learning approaches can be relevant alternatives because they provide students with opportunities to deeply understand problem structures, explore various solution strategies, and reflect on their thinking processes.

CONCLUSION

Based on the analysis, it can be concluded that students' numeracy errors in solving contextual problems occurred more frequently at the stages of understanding the problem and developing a solution plan than at the calculation implementation stage. Students demonstrated fairly good procedural skills in arithmetic operations, but still experienced difficulties in identifying important information, constructing appropriate mathematical models, and selecting appropriate solution strategies. Furthermore, the absence of a reflection stage indicates that students' metacognitive abilities in problem solving still need to be developed. These findings confirm that strengthening numeracy literacy should not only focus on numeracy skills, but also on the ability to interpret context, mathematical modeling, and reflect on the solution process. Therefore, mathematics learning needs to be designed in a more contextual and reflective manner to comprehensively improve students' numeracy skills.

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