

Analyzing Student Difficulties on Geometric Translation through Polya's Stages

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Abstrak

Rendahnya kemampuan pemecahan masalah siswa dalam translasi geometri ditunjukkan oleh kesulitan memahami arah pergerakan, representasi koordinat, dan strategi penyelesaian. Penelitian ini bertujuan menganalisis jenis dan penyebab kesulitan siswa berdasarkan tahapan Polya. Metode yang digunakan adalah kualitatif deskriptif dengan subjek 20 siswa kelas IX SMP Negeri di Tasikmalaya. Instrumen penelitian berupa dua soal tes uraian berbasis translasi geometri yang divalidasi ahli serta wawancara semi-terstruktur. Analisis data dilakukan melalui reduksi, penyajian, dan penarikan kesimpulan. Hasil menunjukkan kesulitan dominan pada tahap memahami masalah (65%) dan memeriksa kembali (65%), diikuti merencanakan penyelesaian (25%) dan melaksanakan rencana (17,5%). Temuan ini menegaskan perlunya pembelajaran berbasis soal kontekstual dan strategi reflektif. Penelitian ini berkontribusi dengan memberikan gambaran terarah mengenai letak kesulitan siswa yang dapat dijadikan dasar perbaikan pembelajaran translasi geometri.

Kata Kunci: Kesulitan Siswa; Pemecahan Masalah; Tahapan Polya; Translasi Geometri

Abstract

Students' low problem-solving ability in geometric translation is reflected in their difficulties in understanding movement direction, representing coordinates, and applying solution strategies. This study aims to analyze the types and causes of students' difficulties based on Polya's problem-solving stages. A qualitative descriptive method was employed with 20 ninth-grade students from a public junior high school in Tasikmalaya as subjects. The research instruments included two essay-based problem-solving tests on geometric translation, validated by experts, and semi-structured interviews. Data were analyzed through reduction, display, and conclusion drawing. The findings revealed that the dominant difficulties occurred in understanding the problem (65%) and looking back (65%), followed by devising a plan (25%) and carrying out the plan (17.5%). These results highlight the need for contextual problem-based tasks and reflective strategies. The study contributes by providing a structured overview of students' difficulties, which can serve as a foundation for improving instructional practices in teaching geometric translation.

Keywords: Student Difficulties; Problem Solving; Polya's Stages; Geometric Translation

I. INTRODUCTION

Problem-solving ability is one of the key competencies in 21st-century mathematics education. It has long been recognized as a core competency in mathematics education, both in terms of academic learning outcomes and as a means of fostering logical, critical, and reflective thinking (Alashwal & Barham, 2025; Rehman *et al.*, 2024; Szabo *et al.*, 2020). In this context, geometry plays a significant role because it integrates spatial, symbolic, and visual aspects into the process of mathematical thinking (Fujita *et al.*, 2020; Harris *et al.*, 2021; Octaviyanti & Wahyuni, 2023). One of the more complex aspects of transformational geometry is the topic of translation, as it requires students to accurately understand direction of movement, displacement distance, and coordinate representation within an appropriate system (Flores & Yanik, 2016; Karagöz Akar *et al.*, 2023). Several previous studies have shown that students continue to face recurring challenges in solving problems related to geometric translation (Gianto *et al.*, 2018; Karagöz Akar *et al.*, 2023).

Although educational policies and curricula in many countries have positioned problem solving as a central component, its implementation in the field indicates that students are still unable to effectively apply a systematic approach, particularly in solving non-routine problems based on spatial geometry (Gilligan-Lee *et al.*, 2022; NCTM, 2000; Nguyen *et al.*, 2020; Polya, 1973). Polya's problem solving theory, which includes four stages understanding the problem, devising a plan, carrying out the plan, and looking back has been

theoretically proven effective, yet its practical application remains suboptimal (Amrullah *et al.*, 2024; Ignacio *et al.*, 2020). Field findings also reinforce the urgency of this study. Student learning outcomes in geometric translation at a public junior high school in Tasikmalaya over the past few years have not yet reached the KKTP (Learning Objectives Achievement Criteria). This challenge is faced not only by low-achieving students but also by high-achieving ones, who often make mistakes due to overconfidence, lack of metacognition, and a tendency to solve problems using instant procedural approaches (ARGAEN, 2020; Giovanni *et al.*, 2023; Qi, 2024).

This condition indicates a gap between the expected learning process and actual classroom practice, highlighting the need for a more in-depth investigation into students' problem-solving difficulties. Previous studies have examined students' difficulties in solving geometry problems, the importance of visual-spatial skills in geometric reasoning, and the application of Polya's approach in mathematics learning (Giovanni *et al.*, 2023; Sholihah & Afriansyah, 2017; Maulani & Zanthly, 2020; Nurizlan *et al.*, 2022; Pitriyani, Sundayana, & Maryati, 2024). Several studies have also identified conceptual, procedural, and representational difficulties in translation topics (Adu-Gyamfi *et al.*, 2012; Maryati & Prahmana, 2020; Maulani & Zanthly, 2020; Paradesa, 2019; Sunariah & Mulyana, 2020; Afhami, 2022; Nizar *et al.*, 2025). However, very few studies have specifically examined students' problem-solving difficulties in translation geometry tasks using Polya's

problem-solving stages as the analytical framework.

This study is therefore essential to fill this gap by providing an in-depth analysis of students' difficulties based on Polya's problem solving framework; while also offering a real depiction of the obstacles they experience at each stage of problem solving. The findings are expected to contribute not only to the academic discourse on mathematics learning difficulties but also to provide practical implications for teachers in designing more targeted instructional interventions, thereby significantly improving the quality of mathematics learning, particularly in the topic of geometric translation.

II. METHOD

This study employed a qualitative approach with a descriptive method, conducted from March to April 2025. The purpose of the study was to provide an in-depth description of the types of difficulties experienced by students in solving geometric translation problems, based on Polya's problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and looking back.

The subjects of this study were 20 grade IX students from a junior high school in the city of Tasikmalaya. From this group, six students with varying types of difficulties, identified through purposive sampling, were selected as the main subjects for in depth interviews. The choice of ninth-grade students as participants was based on the consideration that geometric translation, as part of the geometry transformation topic, is included in the Grade IX curriculum of the

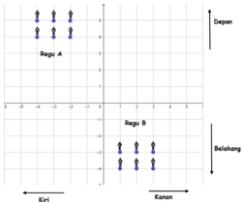
Merdeka curriculum, making it relevant to the context of this study.

The data collection techniques included: (1) a problem-solving test, consisting of two essay questions on geometric translation designed according to Polya's stages and validated by experts; (2) semi-structured interviews, conducted with six selected students to explore in greater depth the reasons, strategies, and thought processes underlying their difficulties; and (3) direct observation, carried out while students were working on the problems to identify their solution patterns, errors, and obstacles encountered.

The data analysis technique used in this study followed the model by Huberman & Miles (1992) which includes three stages, namely: (1) data reduction, carried out by identifying and classifying various forms of students' difficulties based on test results, interviews, and observations; (2) data presentation, in the form of descriptions of students' work, interview transcripts, and observation notes; and (3) conclusion drawing/verification, by comparing findings from multiple data sources to obtain a valid picture of students' difficulties at each stage of Polya's problem solving process. The test questions used as research instruments in this study are presented in Table 1 as follows.

Table 1.
Test Instrument

No.	Test item
1.	 <p>A boy named Rafi is initially located at the coordinate position $(x, y) = (2, -1)$. He first moves $2x$ steps to the left and $(y + 3)$ steps forward. His journey then continues with a movement of $(x + 1)$ steps to the left and (2</p>

No.	Test item
	– y) steps backward. If both x and y are integers as given in the initial position, at which coordinate does Rafi stop and find Wildan, who is hiding? Will the shape and size of Rafi’s body remain the same before and after he finds Wildan? Explain and conclude how you define a Translation in this context!
2.	<p>In commemoration of Indonesia’s Independence Day, two representative teams from SMPN 6 Tasikmalaya Team A and Team B each consisting of six members, conducted a flag-raising rehearsal. The figure below shows the initial positions of each team member at the beginning of the practice session.</p>  <p>To perform the flag-raising movement, Team A moves 2 steps to the left and 1 step forward. Meanwhile, Team B performs twice the movement of Team A. Determine the final position of each team after the movement, and illustrate the result on a Cartesian coordinate plane!</p>

III. RESULT AND DISCUSSION

The analysis of students’ responses indicates that they experienced difficulties at several stages, particularly in understanding the problem and looking back. The difficulties encountered by students according to Polya’s stages are presented in Table 2.

Table 2.
Polya’s Problem-Solving Difficulties

Types of Difficulties Based on Polya’s Stages	Test Items		Percentage
	1	2	
<i>Understand the problem</i>	65%	-	65%
<i>Devising a Plan</i>	25%	-	25%
<i>Carrying Out the Plan</i>	20%	15%	17,5%
<i>Looking Back</i>	80%	50%	65%

Subsequently, a more detailed analysis was conducted on students’ responses that demonstrated dominant difficulties at each stage of problem-solving based on Polya’s framework. Several student responses were selected for in depth analysis, each representing a specific difficulty in understanding the problem, devising a plan, carrying out the plan, and looking back.

Overall, the types of difficulties experienced by students based on Polya’s problem-solving stages in solving geometric translation problems are presented in Table 3.

Table 3.
Types of Students Difficulties

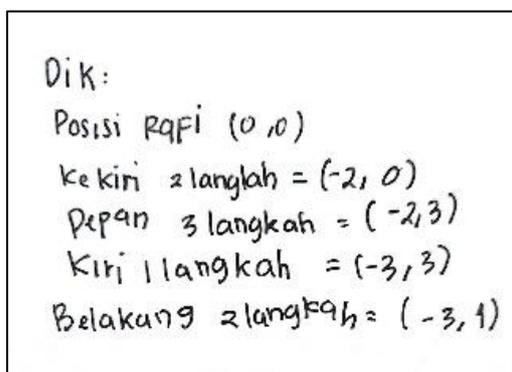
Polya’s Four Steps of Problem Solving	Types of Student Difficulties
<i>Understand the problem</i>	Failing to understand the meaning of the problem Inability to interpret or identify the given and required information in the problem
<i>Devising a Plan</i>	Uncertainty about which method or strategy should be applied.
<i>Carrying Out the Plan</i>	Making calculation or procedural errors.
<i>Looking Back</i>	Not performing a re-evaluation of the obtained results.

The explanation regarding students’ difficulties in solving problems on geometric translation material based on problem-solving skills, along with an in-depth analysis of the written test results and interviews, is presented as follows.

A. Understand the problem

A total of 65% of students experienced difficulties at the stage of understanding the problem. These difficulties were characterized by the inability to identify key information, such as the known and

unknown variables, failure to interpret the problem within the Cartesian coordinate system, and an inability to convert verbal information into meaningful visual or symbolic representations. These challenges were evident in the students' responses, as illustrated in the following example.



Dik:
Posisi Rofi (0,0)
Kekiri 2 langkah = (-2, 0)
Depan 3 langkah = (-2, 3)
Kiri 1 langkah = (-3, 3)
Belakang 2 langkah = (-3, 1)

Figure 1. Difficulty in Understanding the Problem

In addition, the researcher conducted interviews with students to explore the underlying causes of their difficulties in answering the questions. The following is an excerpt from a dialogue between the researcher and one of the students.

- R : Can you explain how you answered this question?
S : I wrote the movement based on the steps mentioned in the question, Miss.
R : Okay. Did you understand the question that was given?
S : Not really, Miss.
R : Previously, was what you wrote already aligned with the information given in the problem?
S : Hmm... no, Miss. I was confused. Since the exact number of steps wasn't mentioned, I didn't know the initial and final positions.

Based on the results of the test and interviews, it was found that students' lack of understanding of the problem and the question posed led to difficulties in formulating solution steps. Students expressed confusion due to the absence of

specific numerical values in the problem, which hindered their ability to determine the initial and final positions required in the geometric translation process. The primary causes of these difficulties were a limited comprehension of the information presented in the problem and the inability to identify appropriate steps for solving it. These findings are consistent with Wongsa & Cojorn (2024) who reported that students often struggle to analyze problem information, making it difficult for them to construct a systematic problem-solving plan.

Difficulty in understanding mathematical problems is a major barrier to effective problem-solving. Low proficiency in mathematical language literacy has been identified as a key factor contributing to students' failure to comprehend problems, as many struggle to interpret the language used in mathematics tasks, which negatively affects their ability to process and make sense of information (Agusfianuddin et al., 2024; Samosir et al., 2024). Moreover, students are generally not accustomed to writing down the initial information from a problem, such as the given data and the question being asked. This finding aligns with the perspective of Hagge & Appova (2025) who argue that students often have difficulty understanding word problems because they are not in the habit of outlining the problem-solving steps, including identifying the known and unknown components. In addition, they frequently struggle with the vocabulary used in the problem, which further impedes their comprehension of its meaning.

B. Devising a Plan

A total of 25% of students experienced difficulties at the stage of devising a plan, specifically in formulating appropriate strategies to solve the problem. These difficulties included the inability to outline solution steps systematically, confusion in determining the direction of the translation movement, improper use of coordinates, and challenges in identifying changes in point positions. This difficulty is clearly reflected in students' written work, as shown in Figure 2, which illustrates their confusion in interpreting the movement coordinates when formulating a problem-solving strategy.

Diketahui:
Rafi mulai dari $(x, y) = (2, -1)$
lalu jalan ke kiri sebanyak $2x$ langkah,
terus ke depan $y+3$.
Lalu dia jalan lagi ke kiri $x+1$ dan ke
belakang $2-y$
Jawab:
tetap di $(2, -1)$ karena dia jalan ke kiri
terus ke kanan, jadi bisa balik

Figure 2. Difficulty in Devising a Plan

In addition, the researcher conducted interviews to gain further insight into the difficulties students encountered during the problem-solving process.

- R : Your answer shows the position remains at $(2, -1)$. Why is that?
S : Because the path goes left and then right again, Miss. So, I thought it would return to the original position.
R : In the problem, it says that Rafi starts from $(x, y) = (2, -1)$. Did you use that value?
S : I was confused, Miss. I thought the x was still just a letter. I didn't know whether the x stays 2 or if it would change because it's also used in the steps.
R : Try reading the question again what is the instruction?

- S : (Student reads and identifies the question) Yes, Miss. The instruction says to calculate the coordinates where Rafi meets Wildan.
R : That's right. So, to find Rafi's position when he meets Wildan, what needs to be calculated?
S : I'm not sure, Miss.

Based on the results of the test responses and student interviews, it was evident that students experienced confusion in interpreting the given information to formulate appropriate solution steps. Students failed to understand that the initial coordinates serve as the reference point for performing a translation, and as a result, they did not calculate the shift of points according to the required movement. This indicates that students struggled to determine a suitable problem-solving strategy when they lacked an understanding of the relationship between the initial position, direction of movement, and final position within the context of translation. This difficulty is further supported by findings that show students were often unable or failed to systematically develop a strategy or work plan that would lead to a correct solution in accordance with Polya's problem solving stages. Consequently, this led to confusion and errors in the subsequent steps (Pebriyanti & Amelia, 2023; Ramnarain, 2014; Saputri et al., 2024).

This difficulty is also rooted in students' incomplete understanding of coordinate concepts and geometric transformations. This finding is consistent with the study by Sudirman et al (2023) which asserts that an inadequate grasp of the concept of geometric translation can lead to significant challenges in visualizing the displacement

involved in the translation process. Moreover, students were unable to connect the verbal description of a translation movement with the symbolic or numerical change in point positions on the Cartesian plane. One contributing factor to this difficulty is students' inability to translate symbolic representations into verbal or visual forms. Additionally, their inability to identify the direction and magnitude of displacement further hindered their capacity to develop an appropriate solution strategy (Sa'dijah & Muksar, 2021).

C. Carrying Out the Plan

A total of 17.5% of students encountered difficulties at the stage of carrying out the plan, particularly in the form of procedural errors. These errors included the incorrect application of the direction of movement (such as adding when they should have been subtracting), confusion in determining positive and negative signs during the translation process, and inconsistent use of the translation formula across different points. A concrete example of students' procedural errors can be seen in Figure 3, which illustrates a mistake in determining the mathematical operation signs related to the direction of translation shifts.

$(x', y') = (x + a, y + b)$
 Pergerakan ke -1
 $2x = 2 \times 2 = 4 \rightarrow a$
 $y + 3 = -1 + 3 = 2 \rightarrow b$
 $(x + a, y + b)$
 $(x + 4, y + 2)$
 $(2 + 4, -1 + 2)$
 $(6, 1) \rightarrow (x, y) \text{ baru}$

Pergerakan ke -2
 $x + 1 = 2 + 1 = 3 \rightarrow a$
 $2 - y = 2 - (-1) = 2 + 1 = 3 \rightarrow b$
 $(x + a, y + b)$
 $(x + 3, y + 3)$
 $(6 + 3, 1 + 3)$
 $(9, 4)$

Grup A (original)
 $A: (-4, 5); (3, 5); (-1, 5)$
 $(-2, 5); (-3, 5); (-4, 5)$
 Terjemahan grup A:
 $(x + a, y + b)$
 $(x - 2, y + 1)$
 Grup B (original)
 $B: (1, -1); (2, -1); (3, -1)$
 $(5, -4); (2, -4); (1, -4)$
 Terjemahan Grup B:
 $x (x + a, y + b)$
 $x (x - 2, y + 1)$
 $B = 2(-5, -4); 1(0, -1); 2(1, -1)$
 $2(1, -1); 1(0, -1); 2(1, -1)$
 Grup A: $(-6, 6); (-5, 6); (-4, 6)$
 Grup B: $(-6, -4); (2, -4); (1, -4)$
 $(1, -4); (2, -4); (3, -4)$

Figure 3. Difficulty in Carrying Out the Plan

In addition, the researcher conducted interviews to explore the difficulties students experienced during the problem solving process.

Dialogue for Problem 1.

- R : Here, you already calculated $2 \times 2 = 4$, and $y + 3$ becomes 2. That's good.
- S : Yes, Miss. I got that from the question. The x is 2 and the y is -1.
- R : But why did you write $(2 + 4, -1 + 2)$? Wasn't the movement to the left?
- S : Huh? Oh, right, Miss. I thought all movements could just be added.
- R : Well, the question says "to the left," which means you have to subtract the x -value, not add it. So, from $(2, -1)$, it should be $(2 - 4, -1 + 2)$.
- S : Ooh... yes, Miss. I got it reversed. I thought you just had to add everything up.
- R : That's okay, you already arranged the steps well. Just be more careful next time in paying attention to the direction of the movement.

Dialogue for Problem 2.

- R : Can you explain how you did the movement for Group B?
- S : I just applied the translation formula directly, Miss, like I did for Group A.

- R : Did you calculate the movement of Group B first?
- S : Yes, Miss. I also used $x - 2$, $y + 1$ for Group B to make it simpler.
- R : But the problem says Group B moves twice the movement of Group A. So, what should it be?
- S : Oh... I thought it was the same, Miss. I assumed "twice" meant all the points moved the same way as Group A, just repeating the movement, not multiplying the vector by two.

Based on the results of students' written responses and interview data, it was evident that students continued to struggle with understanding the operational meaning of translation, particularly when it involved directional movement and intergroup relationships in contextual problems. Errors in addition or subtraction of coordinates indicated that students had not yet fully internalized the concept of position change within the coordinate system. Students also failed to grasp that movements to the left or downward should be represented by subtraction rather than addition, and that doubling a movement does not imply repeating the direction, but rather adjusting the magnitude of the displacement by multiplying the translation vector. These findings align with the views of Yim & Lee (2022) who noted that many students face challenges in understanding and applying the concept of geometric translation, especially in interpreting direction and magnitude of movement.

This difficulty reflects a weakness in mastering fundamental mathematical procedures, which are crucial for solving problems related to geometric transformations. Many students tend to memorize formulas without understanding their operational meaning, making them

prone to procedural errors (Kop et al., 2021; Rodríguez-Sánchez et al., 2020). Bandara et al (2022) describe such errors as "procedural misconceptions," which refer to the mechanical application of formulas without proper conceptual understanding. Moreover, students frequently encounter difficulties with algebraic operations when solving transformation geometry problems, especially when they lack a structured understanding of translation vectors (Hernández, 2016; Sumartono, 2023). These findings are consistent with those of Hapsari et al (2024) who revealed that students often struggle with calculations due to a lack of accuracy during the problem-solving process.

D. Looking Back

A total of 65% of students experienced difficulties in the looking back stage, as indicated by their failure to re-evaluate the answers they had obtained. This stage was the most frequently overlooked by students in the process of solving problems, particularly within the context of mathematical problem-solving related to geometric translation. Many students assumed that their task was complete once they arrived at a final answer, without considering the possibility of errors either in the process or in the result. Unlike the previous stages, in the looking back stage, there was almost no written evidence in students' answers indicating an attempt to re-evaluate their solutions. Most students stopped immediately after obtaining the final answer. Therefore, the analysis of difficulties at this stage was primarily derived from interviews and direct observations, as illustrated in the excerpts

of conversations between the researcher and the students. This difficulty is further illustrated by the following interview findings.

- R : *You completed the task earlier, right? After finishing, did you try to check your final answer?*
- S : *No, Miss. I didn't, because I didn't really know how to check it. Like... once I got an answer, I just left it at that.*
- R : *If you wanted to check it, which part would you usually review?*
- S : *I'm not sure, Miss. Sometimes I get even more confused when I reread it. So, I usually just glance at it briefly.*
- R : *So, you're not used to reviewing each step one by one yet?*
- S : *No, Miss. I feel like once I get a final answer, it must be correct. I don't think about going back through it again.*
- R : *But it's possible that what you thought was correct might actually have a small mistake. You just haven't learned how to review your work properly yet, right?*
- S : *Yes, Miss. I thought checking meant just looking at the numbers, not the steps too.*

Based on the students' test responses and interview results, it was evident that most students had neither developed strategies nor formed habits for reflecting on and evaluating their problem-solving steps. Students tended to perceive the process of checking as merely verifying the final numerical answer, rather than reviewing the entire logical progression of the solution including understanding the problem, planning steps, and executing procedures. Many students expressed confidence that their answers were correct, or admitted that they did not know how to systematically review their own work. This indicates a tendency among students to underestimate the importance of result

verification, particularly when they believe their answer is correct (Balaban, 2024; Barana et al., 2022).

This phenomenon indicates that students have not yet understood the importance of the "looking back" stage as an integral part of the mathematical problem-solving cycle. Polya (2014) emphasized that the fourth stage reviewing the solution plays a critical role in ensuring the accuracy and completeness of the answer, as well as in allowing students to identify errors or logical flaws in earlier stages of their thinking. In this context, students are often unaccustomed to reflecting on their mathematical thought processes, either due to time constraints or the absence of metacognitive habits fostered during instruction (Monteleone et al., 2023; Wang et al., 2022). On the other hand, failure to revisit their work is also driven by a fear of discovering mistakes, which in turn can cause students to feel uncertain or confused, as revealed through interview responses.

IV. CONCLUSION

This study identified various problem-solving difficulties experienced by students when working on geometric translation problems based on Polya's problem solving stages. The most prevalent challenges occurred at the understanding the problem and looking back stages, each affecting (65%) of students, followed by difficulties in the planning stage (25%), while the fewest difficulties were observed in the carrying out the plan stage (17.5%). Students' difficulties in solving geometric translation problems according to Polya's stages

include: challenges in interpreting contextual problems, lack of conceptual understanding of geometric translation, inability to develop a problem solving plan due to uncertainty about the appropriate formulas, procedural errors in carrying out the plan due to lack of accuracy in mathematical operations, and failure to review both the solution steps and the final answer, resulting in several incorrect responses.

The main contribution of this study lies in its in-depth analysis of students' problem-solving difficulties based on each stage of Polya's framework. This analysis provides a systematic overview that can serve as a foundation for teachers in identifying students' specific areas of difficulty more accurately, thereby enabling them to design instructional interventions that align with students' needs. Practically, this study emphasizes the importance of familiarizing students with contextual problems and reflective strategies in learning, so that they do not merely focus on procedures but are also able to understand, plan, execute, and re-examine solutions comprehensively.

Furthermore, this study opens opportunities for further research to explore factors influencing students' problem-solving difficulties in geometric translation, such as differences in student characteristics, the teaching approaches employed by teachers, or the integration of alternative problem-solving models beyond Polya's steps. Thus, the findings of this study are expected to contribute to the development of theory and practice in mathematics education, particularly in enhancing students' understanding of geometric translation concepts.

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