

Exploring Self-Efficacy Profiles and Their Influence on Undergraduate Students' Geometry Problem-Solving Processes: A Qualitative Case Study

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Abstrak

Pemecahan masalah geometri menuntut integrasi antara kemampuan kognitif dan aspek afektif, khususnya efikasi diri. Penelitian ini bertujuan mengidentifikasi profil efikasi diri mahasiswa pendidikan matematika serta menganalisis pengaruhnya terhadap proses pemecahan masalah geometri berdasarkan tahapan Polya. Menggunakan desain studi kasus kualitatif, penelitian ini melibatkan 33 mahasiswa. Data dikumpulkan melalui skala efikasi diri, tes geometri berbasis empat tahap Polya, dan wawancara semi-terstruktur dengan subjek yang merepresentasikan tingkat efikasi diri tinggi, sedang, dan rendah. Hasil penelitian mengungkap tiga profil berbeda: mahasiswa dengan efikasi diri tinggi mampu menunjukkan pemahaman mendalam hingga evaluasi reflektif; mahasiswa dengan efikasi diri sedang mampu melaksanakan prosedur namun tidak stabil pada tahap perencanaan dan evaluasi; sedangkan mahasiswa dengan efikasi diri rendah kesulitan dalam merumuskan strategi dan verifikasi hasil. Temuan ini menegaskan bahwa efikasi diri berpengaruh signifikan terhadap kualitas pemecahan masalah geometri, sehingga perlu diintegrasikan dalam perancangan pembelajaran matematika yang komprehensif.

Kata Kunci: Efikasi Diri; Geometri; Pemecahan Masalah Polya; Studi Kasus Kualitatif.

Abstract

Geometric problem-solving demands the integration of cognitive abilities and affective readiness, notably self-efficacy. This study aims to identify the self-efficacy profiles of mathematics education students and analyze their influence on the geometric problem-solving process based on Polya's stages. Employing a qualitative case study design, the research involved 33 students. Data were collected through a self-efficacy scale, geometric problem-solving tests structured according to Polya's four stages, and semi-structured interviews with subjects representing high, moderate, and low self-efficacy levels. The findings reveal three distinct profiles: students with high self-efficacy demonstrate deep understanding followed by reflective evaluation; those with moderate self-efficacy execute procedures correctly but show instability during the planning and evaluation stages; while students with low self-efficacy struggle with strategy formulation and result verification. These findings underscore that self-efficacy significantly influences the quality of geometric problem-solving, highlighting the necessity of integrating affective factors into the design of comprehensive mathematics instruction.

Keywords: Self-Efficacy; Geometry; Polya's Problem-Solving; Qualitative Case Study.

I. INTRODUCTION

Geometry occupies a central position in higher education mathematics because it requires integrating conceptual understanding, visual representation, and deductive reasoning (Serin, 2018). In geometry problem solving, students are expected not only to identify known information but also to interpret relationships among geometric elements, design appropriate strategies, and evaluate the validity of their solutions (Polya, 1957; Schoenfeld, 1985). Nevertheless, empirical studies consistently indicate that undergraduate students experience persistent difficulties with non-routine geometry problems, particularly during the planning and evaluation stages (De Araujo et al., 2023; Facciaroni et al., 2023). These difficulties suggest that challenges in geometry learning extend beyond content mastery and are closely related to how students regulate their cognitive processes during problem solving.

Several studies have shown that although students may correctly identify information in geometry problems, they often fail to connect it to relevant concepts and strategies in a coherent manner (Ernawati & Sutiarso, 2020; Hilf & Samovol, 2025). Such difficulties frequently arise during the planning stage, when students are required to formulate appropriate solution strategies, as highlighted by Mason & Singh (2016) and Schoenfeld (1985). When this stage is not adequately managed, subsequent processes—namely, strategy implementation and solution verification—tend to be fragmented or superficial. This condition reflects a discrepancy between the expected competencies in geometry

problem-solving and students' actual performance in higher education, indicating that geometry problem-solving should be understood as a complex cognitive activity involving strategic decision-making and reflective control (De Araujo et al., 2023).

Beyond cognitive aspects, affective factors have increasingly been recognized as critical determinants of students' problem-solving performance (Pihlap et al., 2023; Golding & Verrier, 2021). Self-efficacy, as conceptualized by Bandura (1997), influences how students perceive task difficulty, select strategies, and persist when encountering obstacles. Students with high self-efficacy are more likely to demonstrate confidence in exploring solution pathways, maintaining strategy consistency, and evaluating their results, whereas students with low self-efficacy tend to hesitate, abandon strategies prematurely, or neglect solution verification (Usher & Pajares, 2020; Zimmerman, 2002). This evidence suggests that geometry problem-solving is inseparable from students' affective readiness to engage in complex reasoning tasks, particularly those requiring sustained reflection and evaluation.

Various instructional approaches, including problem-based learning and technology-enhanced geometry instruction, have been implemented to improve students' problem-solving abilities (Chivai et al., 2022; Yi & Jeon, 2023; Sitthiworachart et al., 2022). Although these approaches have contributed to improved visualization and engagement, their effectiveness remains inconsistent across learners (Lidiastuti, 2024). Such variation implies that instructional design alone cannot fully

account for differences in students' geometry problem-solving performance. Without considering internal affective factors, particularly self-efficacy, instructional innovations may not consistently lead to meaningful improvements in students' strategic reasoning and reflective processes.

A closer examination of existing literature reveals that studies on self-efficacy in mathematics have largely focused on general achievement or overall problem-solving outcomes (Schunk, 2012; Schunk & Pajares, 2002; Usher & Pajares, 2020). Other studies have investigated geometry problem-solving by analyzing errors, strategy use, or procedural difficulties, without explicitly examining students' affective profiles (Ernawati & Sutiarso, 2020; Facciaroni et al., 2023). Although self-efficacy has been widely acknowledged as an important factor in mathematics learning (Bandura, 1997; Baran, 2023) limited research has systematically explored how different levels of self-efficacy shape students' cognitive processes across each stage of Polya's problem-solving model in undergraduate geometry contexts. Consequently, the interaction between self-efficacy profiles and the qualitative structure of geometry problem-solving processes remains underexplored.

- This study moves beyond outcome-oriented analyses by qualitatively mapping undergraduate students' geometry problem-solving processes across Polya's stages through distinct self-efficacy profiles. Therefore, this study aims to explore the role of self-efficacy in shaping students'

geometry problem-solving processes by identifying self-efficacy profiles and analyzing how these profiles influence each stage of Polya's model, including understanding the problem, planning the solution, implementing strategies, and evaluating results (Polya, 1957). By focusing on qualitative differences in cognitive and strategic behaviors among students with high, moderate, and low self-efficacy, this study is expected to contribute to a more comprehensive understanding of geometry problem-solving that integrates cognitive and affective perspectives in higher education mathematics.

II. METHOD

This study employed a qualitative descriptive research approach with a multiple-case analytic design to investigate variations in geometry problem-solving processes based on students' self-efficacy profiles (Creswell & Poth, 2018). In this study, a case is defined as an individual undergraduate student whose geometry problem-solving process is examined in relation to a specific level of self-efficacy. Accordingly, this research does not focus on a single bounded case but rather on multiple individual cases, analyzed comparatively to capture qualitative differences across self-efficacy profiles.

Participants in this study were undergraduate students enrolled in a geometry course. A self-efficacy questionnaire was administered to identify students' self-efficacy levels, which were subsequently categorized into high, moderate, and low self-efficacy groups (Bandura, 1997; Schunk & Pajares, 2002).

The categorization of students' self-efficacy levels was conducted using a mean and standard deviation approach. Students whose self-efficacy scores were one standard deviation above the mean were classified as having high self-efficacy, those whose scores were one standard deviation below the mean were classified as having low self-efficacy, and students whose scores fell within one standard deviation of the mean were categorized as having moderate self-efficacy. Based on this categorization, one representative student from each self-efficacy level (high, moderate, and low) was purposively selected as an individual case for in-depth qualitative analysis of geometry problem-solving processes.

From each category, selected students were examined as individual cases. Data were collected through geometry problem-solving tasks designed to elicit reasoning across Polya's four stages, complemented by semi-structured interviews to capture students' cognitive strategies and reflective considerations during the problem-solving process (Polya, 1957; Miles & Huberman, 1994).

Specifically, students were given three non-routine geometry problems designed for undergraduate mathematics education students, requiring conceptual reasoning, strategic planning, and reflective evaluation rather than direct formula application. The complete problems are presented in Text Box 1 to ensure clarity and replicability.

Problem 1: Central and Inscribed Angles

Triangle ABC is inscribed in a circle with center O .

Given $AB = AC$ and $\angle BAC = 40^\circ$:

1. Determine $\angle BOC$.
2. Explain the geometric reasoning used.
3. Assess whether the result holds if the triangle is not isosceles.

Problem 2: Cyclic Quadrilateral

A quadrilateral $ABCD$ is inscribed in a circle.

1. Identify the relationship between its opposite angles.
2. Provide a geometric justification.
3. Examine whether the relationship holds for a non-cyclic quadrilateral.

Problem 3: Geometric Transformation

Triangle ABC is reflected across a line l , forming triangle $A'B'C'$.

1. Identify the geometric properties invariant under reflection.
2. Explain how these invariants support problem solving.
3. Verify your conclusions using diagrams or symbolic reasoning.

These tasks enabled the identification of qualitative differences in students' problem-solving processes across high, moderate, and low self-efficacy profiles.

Data analysis examined students' written solutions and interview transcripts to identify patterns in behavior, strategy selection, and evaluation across the stages of Polya's problem-solving model. Cross-case analysis was then performed to compare similarities and differences in problem-solving processes among students with different self-efficacy profiles (Miles & Huberman, 1994). This methodological approach was selected to align with the study's objective of providing an in-depth qualitative account of how self-efficacy shapes geometry problem-solving processes, rather than to generate statistical generalizations.

III. RESULT AND DISCUSSION

Result

1. Description of Mathematics Education Students' Problem-Solving Ability Achievement Based on Self-Efficacy Level

The results of the self-efficacy questionnaire analysis show three main categories, namely high, medium, and low self-efficacy, each of which is grouped based on the range of scores obtained by students as shown in Table 1:

Table 1.

Problem-Solving Ability Based on Self-Efficacy Levels

Self-Efficacy Category	Number of Students	Lowest Score	Highest Score
Low	9	42	59
Medium	12	60	73
Height	12	75	94

The distribution of students across self-efficacy categories presented in Table 1 indicates a clear differentiation in geometry problem-solving performance among mathematics education students. Students classified in the low self-efficacy category obtained scores ranging from 42 to 59, those in the moderate category from 60 to 73, and those in the high self-efficacy category from 75 to 94. This structured distribution demonstrates that higher levels of self-efficacy are consistently associated with higher problem-solving achievement. The increasing score range across categories reflects not only quantitative differences in performance but also

variations in students' readiness to engage with geometric reasoning tasks that require conceptual interpretation and strategic decision making.

The proportional distribution of students across categories further strengthens the validity of this classification, with nine students in the low self-efficacy group and 12 in both the moderate and high groups. This distribution suggests that most students possess sufficient affective and cognitive capacity to engage in geometry problem solving, although a smaller subgroup remains vulnerable due to limited self-confidence. The minimal overlap between score ranges across categories confirms that self-efficacy grouping provides a meaningful analytical framework for examining differences in problem-solving processes. These findings provide a solid empirical basis for subsequent analyses exploring how distinct self-efficacy profiles correspond to variations in students' cognitive behaviors across the stages of Polya's problem-solving model.

2. Profile of Students with High Self-Efficacy

Students with high self-efficacy demonstrate the ability to understand problems comprehensively, with a coherent, structured thinking style and stable self-confidence, as reflected in the mapping in Figure 1, which shows the density of problem-understanding indicators.

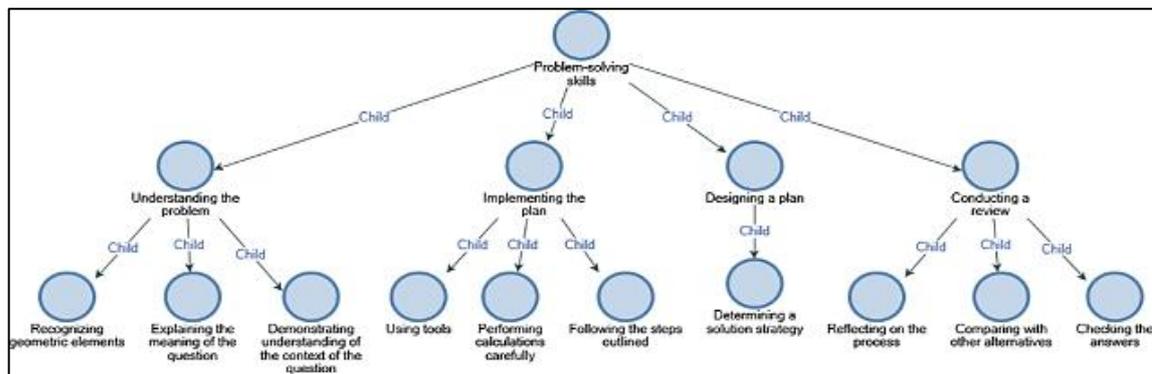


Figure 1. Output Project Map Nvivo High Self-Efficacy Level Students and Mathematical Understanding Ability of Mathematics Education Students.

From Figure 1, hypothesis 1 is obtained, namely that the problem-solving ability of mathematics education students with high self-efficacy can be described by the students' ability to:

1. explaining the meaning of the problem,
2. recognizing geometric elements,
3. demonstrate understanding of the problem context,
4. following the steps designed,
5. using tools,
6. performing calculations carefully,
7. determining a solution strategy,
8. rechecking the answers,
9. reflecting on the work process,
10. comparing with other alternatives

Students with high self-efficacy demonstrated a strong, consistent ability to engage in geometry problem-solving across all stages of Polya's model. Their problem-solving process was characterized by a clear understanding of the problem's meaning, accurate identification of geometric elements, and a coherent interpretation of the problem's context. These students were able to translate verbal information into appropriate visual representations and mathematical expressions, enabling them to effectively recognize relationships among geometric components. Their confidence

enabled them to follow the planned steps systematically, apply relevant tools, and perform calculations with high accuracy. This pattern indicates that high self-efficacy supports students in constructing a stable cognitive framework that guides their reasoning from the initial understanding of the problem to the execution of solution procedures.

In addition to procedural accuracy, students with high self-efficacy exhibited reflective and evaluative behaviors that strengthened the quality of their solutions. They consistently determined suitable solution strategies, monitored the coherence of each step, and rechecked their answers to ensure both procedural and conceptual correctness. Reflection on the problem-solving process was evident through their ability to compare alternative strategies and assess the effectiveness of the approaches used. This evaluative awareness suggests that high self-efficacy not only facilitates persistence and confidence but also promotes metacognitive regulation throughout the problem-solving process. As a result, students in this category demonstrated comprehensive mastery of geometry problem solving, marked by strategic

consistency, conceptual clarity, and systematic verification of results.

3. Profile of Students with Moderate Self-Efficacy

Students with moderate self-efficacy demonstrate a fairly good ability to

understand problems, although the quality is not as high as that of students in the high category, as illustrated in the mapping in Figure 2, which shows a less-dense distribution of problem-understanding indicators.

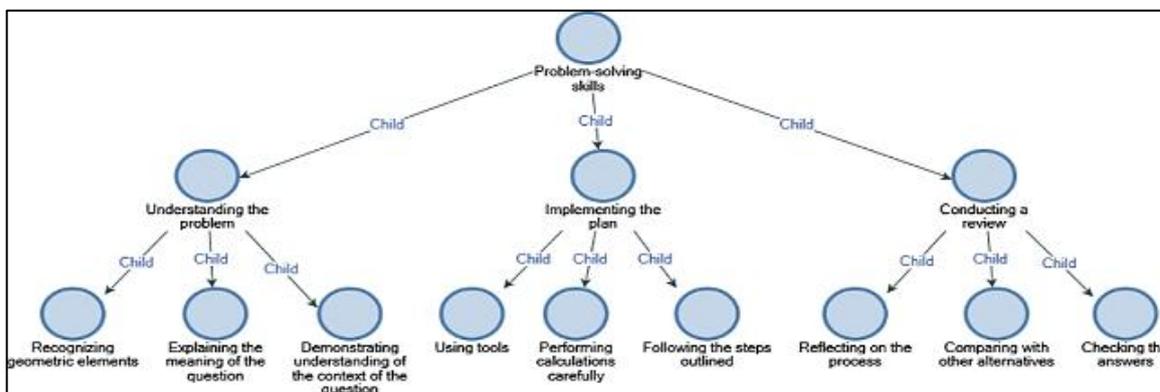


Figure 2. Output Project Map Nvivo Students with Moderate Self-Efficacy Levels and Mathematical Comprehension Abilities of Mathematics Education Students.

From Figure 2, hypothesis 2 is obtained, namely that the problem-solving ability of mathematics education students with moderate self-efficacy can be described by the students' ability to:

1. explaining the meaning of the question,
2. recognizing geometric elements,
3. demonstrate understanding of the problem context,
4. following the designed steps,
5. using tools,
6. performing calculations carefully,
7. checking the answers,
8. reflecting on the work process.
9. comparing with other alternatives

Students with moderate self-efficacy demonstrated adequate understanding of geometry problems, although their performance was less stable than that of students with high self-efficacy. They were generally able to identify known information, recognize relevant geometric

elements, and explain the basic context of the problem. However, their visual representations and conceptual connections were often incomplete, particularly when dealing with more complex geometric relationships. While they could follow the general structure of the problem-solving process, their understanding tended to fluctuate when multiple concepts needed to be integrated simultaneously. This indicates that moderate self-efficacy supports functional problem comprehension but does not consistently sustain deep conceptual interpretation across varying levels of task complexity.

In terms of strategy use, students in this category were able to implement planned steps and perform calculations with reasonable accuracy, yet their strategic consistency remained limited. They often selected appropriate procedures but

hesitated to maintain these strategies throughout the solution process, especially when encountering unfamiliar or demanding steps. Evaluation of results was present but typically focused on checking final answers rather than reviewing the entire solution process. Reflective activities, such as comparing alternative strategies or reassessing earlier decisions, were performed inconsistently. These patterns suggest that students with moderate self-efficacy possess sufficient procedural competence but lack the confidence to regulate their problem-solving strategies in a stable, reflective manner across all stages of Polya's model.

Students with moderate self-efficacy represent a critical group for targeted pedagogical intervention, as they demonstrate initial engagement in problem solving but tend to disengage when encountering cognitive impasses. Structured scaffolding strategies can be

implemented, particularly during the planning and evaluation stages of Polya's problem-solving model. Guided planning prompts—such as identifying known information, selecting relevant geometric relationships, and outlining solution steps—may help strengthen strategic consistency. In addition, reflective prompts after solution attempts, including justifying each step or considering alternative strategies, can enhance metacognitive regulation. Gradual withdrawal of support through worked-example fading may further assist students in developing stable, self-regulated problem-solving behaviors similar to those demonstrated by students with high self-efficacy.

4. Profile of Students with Low Self-Efficacy

Students with low self-efficacy show the least ability to understand problems, as seen in the mapping in Figure 3, which shows that indicators of problem understanding appear in very few cases.

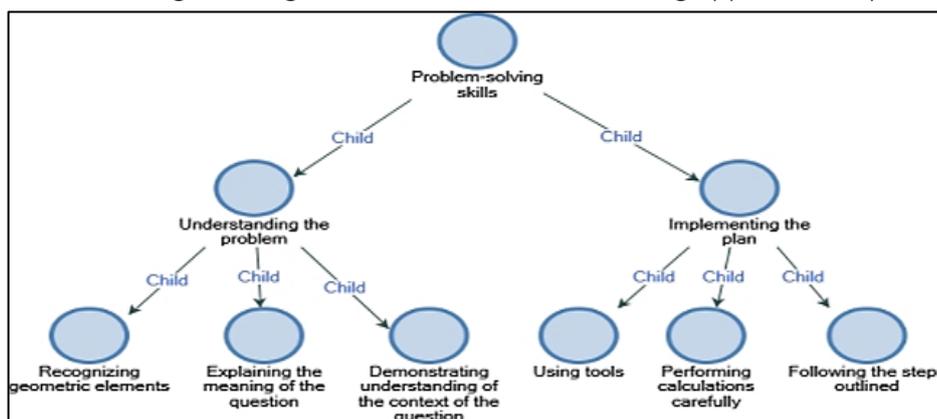


Figure 3. Output Project Map Nvivo Low Self-Efficacy Level Students and Mathematical Understanding Ability of Mathematics Education Students.

From Figure 3, we obtain hypothesis 3, namely that the problem-solving ability of mathematics education students with low self-efficacy can be described by the students' ability to:

1. explaining the meaning of the question,
2. recognizing geometric elements,
3. demonstrate understanding of the problem context,
4. following the designed steps,
5. using tools,
6. performing calculations carefully.

Students with low self-efficacy demonstrated the least effective performance in geometry problem-solving compared to the other categories. Their understanding of the problems was generally superficial, as they could identify only a small portion of the given information without constructing a coherent representation of the geometric relationships involved. Visual representations, when produced, were often incomplete or inaccurate and did not effectively support reasoning. These students often restated the problem statements without meaningful interpretation, indicating difficulties in transforming verbal information into conceptual or mathematical forms. As a result, their comprehension of the problem lacked the clarity needed to guide subsequent stages of problem solving.

The limitations of students with low self-efficacy were particularly evident in the planning and evaluation stages of Polya's model. They struggled to formulate clear solution strategies and frequently relied on familiar procedures without understanding their relevance to the problem context. Strategy implementation was fragmented and inconsistent, with steps often disconnected from a coherent plan. Moreover, evaluative activities were minimal, as students rarely reviewed their solution processes or verified the correctness of their results. When errors occurred, they tended to terminate the problem-solving process rather than revise their approaches. These patterns indicate that low self-efficacy limits students' ability to regulate their thinking, leading to

unstructured problem-solving and limited engagement in reflective mathematical reasoning.

Discussion

The findings of this study confirm that variations in students' self-efficacy levels significantly influence the quality of their performance across all stages of Polya's problem-solving model. This result is consistent with Bandura (1997) social cognitive theory, which posits that self-efficacy shapes how individuals process information, regulate cognition, and make decisions. Students with high self-efficacy demonstrated stable engagement in understanding problems, planning strategies, implementing procedures, and evaluating results, whereas students with moderate and low self-efficacy exhibited increasing fluctuations as task complexity intensified. This pattern reinforces the view that academic self-efficacy develops through mastery experiences, social persuasion, and affective conditions, all of which strongly affect persistence and strategic quality (Usher & Pajares 2020).

The observed differences across self-efficacy categories also highlight the close relationship between self-efficacy and metacognitive regulation. Students with high self-efficacy consistently monitored and evaluated their solution processes, while students in the lower categories showed limited reflective control. This finding aligns with Nilson & Zimmerman (2023), who argue that self-regulated learners tend to exhibit more stable self-efficacy, enabling them to manage cognitive processes more effectively during complex

tasks. The contrast between high- and low-self-efficacy groups underscores that self-efficacy is a crucial psychological variable in geometry learning, particularly because geometric reasoning requires confidence in interpreting abstract relationships and visual representations (Schunk, 2012).

At the problem-understanding stage, students with high self-efficacy demonstrated an ability to construct accurate representations and identify essential geometric relationships, indicating that conceptual interpretation requires not only cognitive competence but also epistemic confidence. This supports the NCTM (2020) perspective that conceptual understanding must be grounded in strong mathematical reasoning. When students trust their own abilities, they are better able to abstract relevant information and organize complex geometric structures. Conversely, students with moderate and low self-efficacy often failed to construct a complete representation of the problem, resulting in inconsistencies in subsequent stages, a pattern also reported by De Araujo et al. (2023).

These differences in problem comprehension reinforce prior findings that misunderstanding geometric problems is a primary source of conceptual and procedural errors (Febriyanti et al., 2022). Visual-spatial competence, which plays a central role in geometry, appears closely tied to self-efficacy because constructing and validating representations requires confidence in one's judgments. As Wahyuni et al., (2024) emphasize that stable mathematical self-confidence is essential for accurate geometric interpretation. Without such confidence, students tend to

hesitate in validating their representations, which weakens the foundation for effective strategy development.

The planning stage revealed the most pronounced contrast among self-efficacy categories. Only students with high self-efficacy systematically formulated and maintained coherent solution strategies in accordance with Polya (1957) principles. Students with moderate self-efficacy could propose partial strategies but struggled to sustain them, while students with low self-efficacy were generally unable to develop executable plans. This finding supports Ernawati & Sutiarto (2020), who identified strategy selection as a major source of difficulty in higher-order problem solving. Planning thus appears to require not only procedural and declarative knowledge but also strong internal motivation and confidence (Baran, 2023).

During strategy implementation, students with high self-efficacy demonstrated consistent execution and procedural fluency, rarely deviating from their planned approaches. Their confidence enabled them to continuously monitor steps and correct minor errors efficiently. In contrast, students with moderate self-efficacy showed declining consistency when encountering unfamiliar steps, while students with low self-efficacy often discontinued the process due to uncertainty. This pattern confirms that implementation is not a purely mechanical activity but a cognitively regulated process that depends on clarity of purpose and self-confidence (Mangaroska et al., 2022).

The evaluation stage further distinguished the self-efficacy profiles. Students with high self-efficacy engaged in

comprehensive reflection by reviewing both processes and results, consistent with (Zimmerman, 2002) model of metacognitive regulation. Students with moderate self-efficacy performed limited checks focused on final answers, while those with low self-efficacy rarely evaluated their work at all. This lack of evaluation reduced their ability to identify and correct errors, supporting Saikia & Roy (2024) assertion that reflective evaluation is essential for developing critical thinking. These differences highlight that effective problem solving depends on affective readiness as much as on knowledge and strategy (Flavell, 1979).

From an instructional perspective, these findings have important implications for geometry education. Geometry requires visual reasoning, spatial decision making, and conceptual integration, all of which are highly sensitive to students' self-efficacy levels (Usiskin, 1987). Students with high self-efficacy demonstrated competencies aligned with professional standards for future mathematics teachers (NCTM, 2020), while students with moderate self-efficacy showed strong potential for improvement through targeted interventions. Consistent with Shmigirilova et al. (2025) and Yi & Jeon (2023), learning environments that provide structured problem-based experiences, scaffolding, and motivational support may strengthen both self-efficacy and problem-solving competence. Overall, this study reinforces self-efficacy as a key predictor of geometry problem-solving quality and underscores the need for pedagogical designs that integrate cognitive and affective development in mathematics education.

IV. CONCLUSION

This study suggests that undergraduate students' geometry problem-solving processes differ qualitatively across Polya's stages, depending on their self-efficacy profiles. Students with high self-efficacy tended to demonstrate stable problem comprehension, coherent strategic planning, accurate execution, and reflective evaluation. Students with moderate self-efficacy showed adequate but unstable performance, particularly during the planning and evaluation stages, whereas students with low self-efficacy exhibited fragmented problem-solving behaviors characterized by weak strategy formulation and limited reflection. These patterns suggest that self-efficacy may play an important role in supporting strategic continuity and metacognitive regulation during geometry problem-solving.

From a theoretical perspective, the findings highlight self-efficacy as an affective factor that shapes how students engage with each stage of Polya's problem-solving model, reinforcing the view that problem solving is not merely procedural but also influenced by students' confidence in interpreting representations, selecting strategies, and evaluating outcomes. Given that this study is a qualitative multiple-case analysis involving a limited number of participants, the findings are not intended to establish universal generalisations but rather to provide in-depth insights into potential patterns of interaction between self-efficacy and geometry problem-solving processes in undergraduate contexts.

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