INTERNATIONAL JOURNAL
APPLIED LEARNING AND RESEARCH IN ALGEBRA
Vol. 02 No. 2, (2025), 67-76
https://journals.eduped.org/index.php/Algebra
E-ISSN 3063-9824

Identification of Junior High School Students' Mathematical Problem-Solving Abilities on Number Patterns

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Article Info

Received February 12, 2025
Revised April 17, 2025
Accepted June 09, 2025

Abstract

This study aims to analyse the mathematical problem-solving abilities of middle school students in the context of number patterns. Using a descriptive qualitative method, the research was conducted on eighth-grade students at SMP Negeri 3 Tualang. The instruments used included problem-solving tests in the form of essay questions and interviews. Subjects were selected using purposive sampling, consisting of 6 students with varying abilities (high, medium, low). The results show that students have varying abilities in four problem-solving indicators: understanding the problem (50% - medium), planning the solution (8.33% - very low), solving the problem (100% - very high), and reviewing the solution (25% - low). The data indicates that while students are capable of solving problems and understanding the questions, they struggle with planning solutions and reviewing their answers. It is recommended to enhance teaching strategies with more flexible approaches, such as problem-based learning (PBL), to improve students' mathematical problem-solving skills.

Keywords: Algebra; Number patterns; Problem-based learning; Problem-solving skills.

To cite this article

Parindang, E. A., Ramlan, W., Wahyuni, R., & Salman, M. (2025). Identification of Junior High School Students' Mathematical Problem-Solving Abilities on Number Patterns. *Journal of Algebra Research and Education,* 02(2), pp, 67-76, doi. https://doi.org/10.56855/algebra.v2i2.1487

1. Introduction

Mathematics serves as a foundational discipline that permeates various aspects of daily life, offering structured tools for solving practical problems while cultivating cognitive abilities essential to scientific and technological advancement. A growing body of research emphasizes that engagement in mathematical thinking significantly enhances higher-order cognitive functions, including analytical reasoning, abstraction, and problem structuring (Giofrè et al., 2022). Beyond cognitive gains, mathematics also fosters critical dispositions such as mental flexibility, open-mindedness, and adaptive thinking—traits considered vital for navigating the complexities of contemporary society (Hanifah et al., 2024).

The development of reasoning ability is recognised as the core of mathematical competence and a primary goal of mathematics education. As Peretz (in Sari et al., 2016) notes, reasoning lies at the heart of all educational thinking tasks, acting as the foundation for higher-order thinking. In parallel, Permatasari & Marlina (2023) posit that mathematical reasoning nurtures intelligent, creative, and responsive individuals who are better equipped to engage with dynamic societal changes.

In the Indonesian context, mathematics education is not only intended to develop technical proficiency but also to foster intellectual, affective, and social growth. According to the Ministry of Education and Culture (Kemendikbud, 2013), the objectives of mathematics education include: enhancing students' intellectual capacity, especially in advanced thinking; nurturing progressive problem-solving ability; optimising academic outcomes; strengthening mathematical communication; and supporting character formation.

Problem-solving, in particular, occupies a central role in instructional design. Empirical studies (e.g., Davita & Pujiastuti, 2020; Tanjung & Nababan, 2019) affirm that problem-solving activities enable students to transfer their mathematical knowledge across familiar and unfamiliar contexts. Such tasks demand not only conceptual understanding but also strategic thinking, interpretation, and reflection—skills essential for mathematical maturity.

Despite these aspirations, numerous Indonesian studies consistently report challenges in students' problem-solving performance. For instance, Putri & Hidayati (2022) observed that many junior high school students struggle to formulate mathematical models, interpret quantitative data, and derive appropriate conclusions. Similarly, Simanungkalit & Peranginangin (2021) identified substantial variability in students' abilities to recognize problem elements, choose suitable strategies, and critically evaluate solutions—challenges further exacerbated by the transition to online learning modalities.

Syntheses of pedagogical research suggest that instructional models greatly influence students' mathematical problem-solving capabilities. Hanifah et al. (2024), in a comprehensive review, found consistent improvement in student outcomes under Problem-Based Learning (PBL) strategies. Likewise, Setiawan & Wahyuni (2021) demonstrated that the Realistic Mathematics Education (RME) approach significantly improved student achievement, with over 94% of learners reaching problem-solving proficiency in classroom interventions.

Among mathematical domains, number patterns (including arithmetic and geometric sequences) hold strategic importance within the Indonesian curriculum (Inastuti et al., 2021). Number pattern tasks serve as a conceptual bridge from concrete arithmetic operations to abstract algebraic thinking. Proficiency in identifying and generalizing number patterns not only supports curriculum mastery but also enhances students' capacity to engage in structured reasoning and systematic thinking in everyday contexts.

However, field-based observations in a junior high school in Siak Regency revealed a disconnect between curriculum goals and actual classroom practices. Although instructional activities formally align with national standards, there is limited emphasis on systematically assessing students' problem-solving competencies—particularly in the area of number patterns. Anecdotal feedback from teachers suggests that prevailing pedagogical practices, often centred around rote instruction, limit student engagement and reduce opportunities for reasoning, modelling, and reflective evaluation.

Furthermore, national assessments and classroom-based studies indicate persistent weaknesses in key problem-solving indicators. Agustina & Munandar (2022) report that only 22% of students exhibit adequate performance in solution review tasks. Amaliatunnisa & Hidayati (2023) highlight similarly low proficiency rates—9% for reasoning and 8% for model-building—underscoring a widespread need for targeted instructional redesign.

Given these empirical gaps and theoretical imperatives, this study seeks to explore and characterise the mathematical problem-solving abilities of junior high school students in Siak Regency, with a particular focus on number pattern tasks. Specifically, the study aims to document students' proficiencies in reasoning, modelling, argumentation, and reflective review, while also identifying critical areas of weakness. The findings are expected to inform future instructional practices, curricular adaptations, and professional development initiatives for mathematics educators.

2. Methods

This study employed a qualitative descriptive research design aimed at providing a comprehensive and detailed account of the phenomena under investigation. In this approach, the researcher serves as the primary instrument for data collection and analysis, allowing for an in-depth exploration and understanding of the research context. The main objective was to describe various facts and insights related to students' mathematical problem-solving abilities, focusing specifically on how these abilities manifest and vary among different learners. The research was conducted on May 21, 2024, targeting eighth-grade students at SMP Negeri Tualang, located in Siak Regency, Riau Province. The study took place during the even semester of the 2023/2024 academic year. Data collection was carried out in a traditional face-to-face setting, facilitating direct interaction between the researcher and the participants, which enhanced the reliability of observations and the clarity of responses.

Two main data collection instruments were utilised in this study: a mathematical problem-solving test and a semi-structured interview. The problem-solving test consisted of two descriptive questions designed to assess various dimensions of students' mathematical reasoning and problem-solving skills, particularly related to number pattern material. The interview component aimed to delve deeper into the students' thought processes, allowing the researcher to clarify answers and understand the reasoning behind each student's approach to the problems.

To select the participants, the purposive sampling method was employed. This technique allowed the researcher to intentionally choose a sample that represented a diverse range of abilities within the population. From two classes, a total of six students were selected, three from each class, categorised based on their academic performance into high, medium, and low ability groups. This stratification ensured that the study captured a wide spectrum of problem-solving competencies, providing richer data and more nuanced analysis. During the data collection phase, the selected students first completed the problem-solving test. Subsequently, each student participated in an individual interview where they were asked to explain their reasoning and the steps taken to arrive at their solutions. This twofold process enabled triangulation, strengthening the validity of the findings by cross-verifying the test results with verbal explanations.

The analysis of the students' mathematical problem-solving ability was carried out using a scoring system based on predetermined indicators reflecting key components of problem-solving skills, such as understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. Each student's performance was quantified, and the resulting scores were calculated into percentages. These percentages were then classified into five distinct categories, providing a clear framework for interpreting the level of problem-solving proficiency demonstrated by each participant. The categorisation of these ability levels facilitated a systematic comparison among students, highlighting patterns of strengths and weaknesses in their mathematical problem-solving approaches. This methodical analysis aimed to offer insights into how students at different performance levels approach mathematical challenges and where targeted interventions might be needed to improve overall learning outcomes. The table is as follows:

Table 1 - Qualification Percentage Score

Persentage	Category
0%-20%	Very low
21%-40%	Low
41%-60%	Medium
61%-80%	High
81%-100%	Very High

3. Results and Discussion

3.1 Results

Based on the data analysis from the research results obtained from the students' problem-solving ability test in the form of two descriptive questions, the following percentage data was obtained.

Table 2 - Percentage of Mathematical Problem-solving Ability Indicators

Indicator	Percentage	Category
Identifying known elements from the question	50%	Medium
Planning problem-solving	8,33%	Very Low
Solving problems	100%	Very High
Check again	25%	Low

Based on Table 2, students were able to identify the known elements of the problem by 50%, which shows that most students were able to identify the known elements. In the indicator of planning problem solving, the percentage was only 8.33%, which means that students were not yet able to plan problem solving well. For the indicator of solving problems, the percentage reached 100%, indicating that students were very capable of solving problems using the plan that had been prepared. However, in the indicator of rechecking, the percentage was only 25%, indicating that most students were not yet able to write conclusions from the results obtained. This is in line with the research of Kintoko & Hendrianus (2021), which found that in the indicator of preparing a problem-solving plan, the average was 54.17%, and in the indicator of rechecking, the average was 33.33%. For question 1, the percentage was 44.87%, indicating that most students were able to understand the problem correctly, but there were still errors in solving it. For question 2, the percentage obtained was 47.43%, which means that some students were able to understand the problem and solve it well.

This section presents a detailed analysis of the students' responses to mathematical problem-solving tasks centred around number pattern material. The analysis is structured according to Polya's problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. Each student's performance is evaluated based on these stages to provide a comprehensive view of their problem-solving abilities.

Question 1: House Number Pattern Problem

The first problem posed to the students involved understanding and predicting the numbering pattern of houses in a residential complex. The problem stated:

"In a housing complex, house numbering is arranged in an orderly manner.
The houses on the left side use odd numbers, as shown in the image below.
What is the house number of the 15th house from the row on the left side?"

Student T1 demonstrated a strong grasp of the problem-solving process. At the initial stage of understanding the problem, T1 successfully identified and listed the known information and the question's requirement, albeit without using formal mathematical symbols or notation. This suggests that the student has a clear conceptual understanding, even if their symbolic representation skills are still developing. Moving to the planning phase, T1 applied an appropriate strategy by reasoning through the pattern logically. Although the student did not explicitly write down the general formula for the nth odd number, the method used effectively led to the correct solution. In the execution or problem-solving stage, T1 followed through the plan accurately, resulting in a correct answer. However, during the final stage of re-checking or reviewing the solution, T1 did not provide a formal conclusion or summary of the findings, indicating a gap in communicating the solution comprehensively. The overall score for T1 on this problem was 76.92%, which places this student firmly within the high ability category in mathematical problem solving.

Conversely, Student R1 exhibited several challenges throughout the problem-solving process. In the first stage of understanding the problem, R1 struggled to properly identify the known and asked components. This lack of clarity hindered the ability to model the problem mathematically, especially when it came to formulating the correct general term or formula for the sequence of odd numbers, which is $Un = 2n - 1$. Despite this, R1 was able to solve the problem through a more procedural or manual approach by counting odd numbers sequentially until reaching the 15th house number. This indicates that while the student lacked formal mathematical modeling skills, they could still reach the correct answer through brute force calculation. In the re-checking phase, similar to T1, R1 did not write a formal conclusion summarizing the solution. The final score obtained by R1 was 30.76%, which categorizes this student as having a low level of mathematical problem-solving ability for this task.

Question 2: Doll Store Pattern Problem

The second question introduced a pattern recognition task in the context of a doll store. The question was as follows:

> *"In a doll store, several types of dolls are sold, including SpongeBob dolls, Patrick dolls, and Nobita dolls. These dolls are neatly arranged in a glass cabinet as shown in the image above. If the store owner wants to add a new product, the Tayo doll, at the 12th position, how many Tayo dolls should the store prepare?"*

Student T2 showed a mixed level of understanding and problem-solving ability in this task. At the initial stage, the student inaccurately described the known information by interpreting the pattern as an odd number sequence rather than correctly recognizing it as a sequence of square numbers. This misinterpretation affected the planning stage, where T2 was unable to write down the correct formula for the sequence, which should have been $Un = n^2$. Despite this, T2 was able to correctly apply a methodical approach in solving the problem by manually multiplying the sequence numbers up to the 12th term. Importantly, unlike T1 and R1, T2 did provide a clear and appropriate conclusion in the final review stage, demonstrating some reflective capacity about the solution. The student earned a score of 61.53%, which places T2 within the high problem-solving ability category.

Student S2 exhibited a stronger understanding of the problem compared to T2, accurately identifying both what was known and what was asked. However, the planning stage revealed a key weakness: the student was unable to formulate the correct algebraic expression for the problem. Again, the formula $Un = n^2$ was not properly written. Despite this, S2 successfully executed the problem-solving phase using a valid method and arrived at the correct solution. Similar to other students, the re-checking stage was incomplete, as S2 did not document a conclusion summarising the findings. An interview with this student revealed a lack of familiarity with similar problem types, suggesting limited prior exposure to this form of mathematical modelling. Additionally, the student exhibited challenges related to mathematical literacy, particularly in interpreting and analysing problem statements. This affected the ability to develop an accurate mathematical model. The score of 46.15% places S2 in the moderate category for problem-solving ability.

3.2 Discussion

The findings of this study reveal considerable variation in the mathematical problem-solving abilities of junior high school students, particularly in tasks involving number patterns. These differences can be effectively analyzed through Polya's four-stage framework of problem-solving: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. Students who exhibited higher proficiency, such as T1 and T2, showed a solid ability to comprehend and engage with the problem context, even when their formal use of mathematical notation and formulas was somewhat limited. This observation resonates with contemporary research emphasizing the critical role of conceptual understanding and flexible reasoning in mathematics learning (Smith & Stein, 2020; Lee, Park, & Kim, 2022). These students demonstrated what Koedinger et al. (2021) describe as adaptive expertise the capacity to apply knowledge flexibly across different contexts, which is increasingly recognized as vital for real world problem solving beyond rote formula application.

In contrast, students like R1 and S2 struggled notably at the initial phases of understanding the problem and planning an appropriate solution strategy. Their difficulties in translating verbal problem statements into accurate mathematical models underscore a prevalent challenge documented in recent literature: the widespread difficulty students face with mathematical literacy and problem representation skills (Liu & Wang, 2019; Gómez, Ramírez, & Castillo, 2021). The inability to formulate problems mathematically hinders deeper conceptual learning and effective problem resolution, as noted by Polly et al. (2020). This gap suggests that interventions aimed at strengthening students' capacity to model real-world problems mathematically are essential.

A particularly striking pattern emerged regarding the final stage of Polya's model, the reviewing or re-checking phase. Across ability levels, many students failed to formally articulate conclusions or reflect critically on their solutions. This lack of metacognitive engagement aligns with findings from Hassan, Saleh, and Al-Harthy (2019), who identified reflection and verification as weak points in students' problem-solving processes. Given that the review stage is crucial for reinforcing understanding and ensuring solution accuracy, this gap points to an urgent need for educators to emphasise reflective practices more deliberately in their instruction (Martínez, Sánchez, & Ortega, 2022).

Furthermore, some students relied heavily on manual or heuristic approaches rather than conceptual reasoning. For example, R1's use of counting odd numbers sequentially and T2's iterative multiplication indicated reliance on procedural knowledge over deep understanding. This reliance on rote methods has been critiqued in the literature for limiting students' problem-solving flexibility and undermining long-term retention of concepts (Nguyen & Kulm, 2021). These findings highlight the importance of encouraging strategies that foster conceptual insight alongside procedural fluency.

Interviews with the students revealed a broader issue: many students do not habitually document known information or questions explicitly, nor do they consistently apply formulas in their problem-solving process. This practice impedes systematic planning and execution and is a common theme in recent studies advocating for the development of metacognitive skills and mathematical literacy (Chang, Lee, & Chiu, 2023; Kumar, Sinha, & Singh, 2020).

Encouraging students to externalize their thought processes by writing down key information and modeling problems mathematically could enhance their ability to devise effective plans and solve problems more confidently.

Finally, the focus on number patterns as the material for problem solving is particularly important because it serves as a foundational topic for algebraic thinking. Mastery of number patterns equips students with essential skills and conceptual frameworks that underpin more advanced mathematics topics (Fernández & Álvarez, 2019). Wang and Hsieh (2022) further argue that strong problem-solving abilities in early algebraic contexts are critical predictors of success in higher-level mathematics and overall academic achievement. Thus, strengthening students' mathematical problem-solving skills with number patterns not only addresses immediate learning needs but also builds a solid base for future mathematical competence (Santika et al., 2025; Apriliani et al., 2025; Loska et al., 2024; Islamiyah et al., 2024).

4. Conclusions

Based on the results and discussion of the research that has been carried out, the mathematical problem solving ability of grade VIII students on the number pattern material was obtained from 6 students studied, there are 3 categories of mathematical problem-solving ability, namely low, medium, and high categories. The percentage of the indicator identifying known elements of the problem is 50%, including the medium category, and then the indicator planning problem solving is 8.33%, including the very low category. Then the indicator solving the problem is 100%, including the very high category, and the last indicator, namely re-checking, is 25%, including the low category. Based on the conclusions of this study, it is recommended that teachers provide intensive and varied training to improve students' ability to identify important elements of the problem. For the development of problem-solving strategies, it is necessary to teach various techniques explicitly and provide opportunities to practice planning steps to solve. Although students' problem-solving abilities are very good, it is important to continue to provide more complex challenges. In addition, the habit of re-checking work results must be improved through routine practice and checking guidelines. More interactive learning approaches, such as group work and class discussions, can also help students understand and master mathematical problem-solving skills more thoroughly.

Acknowledgments

The researcher would like to express sincere gratitude to Universitas Islam Riau for their invaluable support and facilitation throughout this research. The resources, guidance, and encouragement provided by the institution have greatly contributed to the successful completion of this study. Special thanks also go to all the staff and participants who generously shared their time and insights, making this research possible. Without the continuous support from Universitas Islam Riau, this study would not have been accomplished.

Conflict of Interest

The authors declare no conflicts of interest.

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