EDUCOFA: Jurnal Pendidikan Matematika
Vol 2 (2), December (2025) 119-130
Available online https://jurnal.uinsyahada.ac.id/index.php/Educofa/index
DOI : 10.24952/ejpm.v2i2.17402

Analysis of HOTS Problem Solving Ability in Lineup and Series Materials of SMA Negeri 1 Barumun Tengah Students

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ARTICLE INFO | **ABSTRACT**

Keywords:
Troubleshooting; HOTS Questions; Rows and Rows

This study aims to analyze the ability to solve mathematical problems in 25 grade XI students of SMA Negeri 1 Barumun Tengah in solving Higher Order Thinking Skills (HOTS) problems in row and series material. This study uses a qualitative descriptive approach with data collection techniques in the form of written tests, interviews, and observations. The results of the study show that most students have difficulty in solving HOTS questions systematically. Based on the stages of problem solving, according to Polya, as many as 80% of students are able to understand problems, 60% can design strategies, 52% are able to implement strategies, and only 36% evaluate results independently. The greatest difficulties occur at the evaluation and planning stages, which are caused by low critical thinking skills, lack of contextual practice problems, and dominance of procedural learning. These findings confirm the importance of integrating HOTS problems in continuous mathematics learning to develop students' high-level thinking skills.

INTRODUCTION

Mathematics is one of the subjects that has an important role in developing logical, analytical, critical, and creative thinking skills. Mathematics learning is not only aimed at mastering procedural concepts and skills, but also to practice problem-solving skills in real life. In the context of the Independent Curriculum and the vision of 21st Century Education, mathematics learning is directed to develop Higher Order Thinking Skills (HOTS) which are high-level thinking skills that include analysis, evaluation, and creation skills (Anderson & Krathwohl, 2001) The purpose of mathematics learning as stated in Permendikbud No. 21 of 2016 is for students to be able to understand concepts, use reasoning, solve problems, and communicate ideas effectively. Furthermore, the National Council of Teachers of Mathematics also emphasized the importance of developing problem-solving skills as the core of meaningful mathematics learning.

However, the facts on the ground show that there is a gap between the learning objectives and the reality of learning in the classroom. Students often have difficulty in solving problems that require high-level thinking skills. Based on the results of initial observations in grade XI of SMA Negeri 1 Barumun Tengah, it was found that most students were not able to understand the context of non-routine and contextual questions. They tend to rely only on memorizing formulas and solving problems mechanically, without understanding the meaning behind the process. For example, in questions about rows and sequences, when students are faced with questions that contain the context of gradual savings or investment growth, many are confused in identifying patterns, devising solution strategies, and evaluating their answers. This shows that students' critical and creative thinking skills are still low, especially in connecting mathematical concepts with real-world problems.

These findings are in line with the research of Fatimah and Handayani (2021) which stated that students' weak HOTS abilities are caused by a lack of contextual practice and limited critical thinking experience in learning. Similarly, Syahrir and Alimuddin (2022) found that teachers often gave problems with low cognitive levels that emphasized procedure rather than concept understanding and problem-solving. This certainly contributes to the low ability of students to solve HOTS questions.

The Independent Curriculum emphasizes the importance of differentiated learning and strengthening high-level thinking competencies. However, the practice of learning mathematics in many schools is still conventional. Teachers focus more on achieving material targets, not on deepening concepts or developing students' reasoning. In addition, many teachers are not used to or trained in compiling and using HOTS questions in daily learning. As a result, students are not used to thinking analytically or creatively, and even feel pressured when faced with problems that do not immediately show the steps to completion. This gap has an impact on students' low problem-solving skills. In fact, this ability is crucial because in real life, problems do not always have a single solution and fixed procedures. Therefore, there is a need for an in-depth study of students' problem-solving skills in dealing with HOTS problems, especially in row and series materials that have great potential to be contextualized in daily life.

Within the framework of a revised taxonomy, HOTS questions lead to high-level cognitive processes—analyzing (C4), evaluating (C5), and creating (C6)—that demand cross-contextual knowledge transfer, representation integration, and the formation of accountable arguments (Anderson & Krathwohl, 2001). Recent evidence suggests that designing HOTS math tasks not only measures conceptual performance, but also mobilizes metacognition—planning, monitoring, and self-evaluation—which impacts problem-solving strategies and learning resilience (Mudrika dkk., 2024);(Ndiung, 2024). In the context of global mathematical literacy, the PISA 2022 framework affirms the importance of "mathematical reasoning" as a core component that links representation, inferences, and justification of solutions—in line with the achievements of HOTS (OECD, 2023); (Ingram, 2020).

Procedurally, the Polya stages—understanding the problem, drawing up a plan, executing a plan, and reviewing it—provide a methodological "spine" for constructing reflective and systematic thinking. Recent qualitative and quasi-experimental studies have shown that learning that combines HOTS grains with Polya-based scaffolding improves the clarity of problem representation, strategy selection (e.g. algebra/diagram modeling), and the quality of solution justification and verification (Purnomo, 2024; Maysaroh, 2023). In other words, Polya is not just a procedural step, but a metastrategic framework that encourages students to move from "trial-and-error" to explicit and auditable mathematical arguments (WJARR, 2024). At the stage of "understanding the problem", the dominant challenge for students—especially in Indonesian field studies—is to transform the narrative context into a mathematical form (mathematisation) and identify implicit limits/provisions (Jurnal Cendekia, 2023; JPD UNS, 2024). Effective interventions at this stage include the use of self-explanation prompts and visual organizers to extract relevant information, classify data, and connect with prerequisite concepts. When a "solution plan" is synthesized, teachers need to encourage strategy comparisons (e.g., elimination vs. substitution; graph vs. table modeling) so that students learn to evaluate the efficiency and generalization of strategies—activities that are intrinsic at the C5 level (Jannah, 2024); (Mudrika dkk., 2024).

The "execute plan" stage demands error control and tactical flexibility. The findings of the Polya-based error analysis study show that students with different cognitive styles (field-dependent vs field-independent) show typical error profiles—from unit inconsistencies, parameter substitution, to jumping logical inferences—that can be reduced through step verification rubrics and structured peer-review (Jannah et al., 2024). Looking back deepens C5–C6: students compare alternative solutions, test parameter sensitivity, and generalize (extension) so that "creation" (C6) is achieved in the form of new methods/representations that are more elegant or efficient (Purnomo, 2024) From a curriculum and assessment policy perspective, PISA 2022 math literacy emphasizes performance consistency gaps on complex reasoning tasks and multi-step problem-solving—implying the need for an item design that blends authentic context, realistic limitations, and interdependent data (OECD, 2023). To answer this, the development of valid-reliable HOTS instruments (analysis of Aiken's V/CVI, Rasch/IRT, differentiation, and level of difficulty) is a prerequisite, while ensuring alignment between the HOTS indicator and the Polya stage on the grid map (blueprint) (Cendekia, 2024) When the quality of the instruments is assured, the interpretation of learning outcomes—including N-gain, size effect (Hedges g), and relative contribution of strategies—becomes more valid for learning decision-making.

Pedagogically, the combination of Project-Based Learning (PjBL) and Problem-Based Learning (PBL) enriched by HOTS items—and supported by digital media such as Wordwall and GeoGebra—has consistently been reported to strengthen creative thinking, problem-solving, and dialogical participation in mathematics classes. A multi-context study in Indonesia shows that PjBL increases students' creativity and problem-solving, while providing a richer conceptual exploration space than procedural learning. In the realm of PBL, the integration of Wordwall with HOTS questions has been proven to increase critical thinking and problem-solving skills through interactive quiz activities, motivational strengthening, and active student involvement. More recent findings show that Wordwall in a student-centered learning approach is effective in encouraging participation, numeracy, and self-regulation because the feedback cycle is fast and the form of activity is varied (Diana & Asriyadin, 2025) On the other hand, recent meta-analyses and studies on GeoGebra confirm significant improvements in modeling, representation, and problem-solving capabilities; even the feedback pop-up feature in GeoGebra can act as a micro-formative assessment that provides immediate correction of misconceptions during the construction of mathematical objects (Anajihah & Adha, 2025);(Sebsibe, 2025); (Alwi & Maharani, 2024).

The quality of structured classroom discourse is an important lever to shift students from simply "answering the truth" to epistemic accountability—that is, the ability to make claims that can be accounted for by evidence and reason. The practice of evidence-based mathematical debate, solution gallery walks, and Claim-Evidence-Reasoning (CER) protocols add to the density of arguments, expand justification, and facilitate peer judgment. Recent literature shows that CER is effective in fostering scientific/argumentative reasoning; adaptation to mathematics clarifies the path from claims to property/theorem-based representations and reasons (Massita, 2025) Meanwhile, the gallery walk provides a metacognitive trajectory: students compare strategies, critique representations, and revise solutions before final publication (Shinde & Gore, 2021) At the level of micro-interaction, classroom research shows how teachers negotiate epistemic authority so that students' "know/don't know" is managed as an opportunity to construct common knowledge, not just an evaluation of answers (Hofmann et al., 2025; Ingram, 2020). Thus, the practice of structured discourse facilitates learning outcomes at the C5–C6 level (evaluate-create) in a more auditable manner.

However, local diagnostics still warn of the existence of typical "stumbling blocks": (a) prerequisite misconceptions (e.g. generalization of patterns, rationalization of operations in rows/sequences), (b) weak literacy of representation (alternating between symbolic-graphic-verbal), and (c) the habit of "memorizing procedures" without conceptual justification. An article in the Journal of Scholars (2023–2024 edition) documents Newman's difficulties in representation and errors in row-series material; The results confirm that the preparation of multi-level tasks that require translation between modes of representation is an urgent need (Hisyam dkk., 2023); (Khairani dkk., 2024). Other research shows that students' representation profiles on row-series topics tend to be moderate-low, so interventions need to target bridging representation (verbal↔visual↔symbolic) and worked-example fading to reduce cognitive load (Suciaty, 2023); (Lestari & Nurfitriyanti, 2023).

An effective handling strategy is a gradual release of responsibility (GRR) which is combined with feedback-rich formative assessments. In the I do–We do–You do together–You do alone–You do alone–you do alone, the initial focus is placed on sense-making: examining definitions, properties, and relationships between concepts before algorithmic procedures. Each phase is inserted with checks for understanding (e.g. exit tickets, two-minute papers) and technology-assisted micro-feedback (GeoGebra/Wordwall) so that misconceptions are immediately detected and corrected. Recent evidence shows that teacher formative assessment literacy in Indonesia is shifting from a summative emphasis to a sustainable formative one—in line with national assessment policies and assessment for learning practices (Suherman, 2025); (Rofi'ah dkk., 2021). At the same time, automatic/directional feedback from digital devices has been shown to accelerate the feedback loop and improve student learning strategies. GRR provides its pedagogical "train tracks", while formative assessments provide "signals" to ensure the pace of learning remains on the right conceptual track.

To lock in the C5–C6 achievements, summative tasks should mimic the practices of the mathematician community: problem posing, structured proofs, and modeling mini-projects. The rubric needs to contain indicators of representation accuracy, CER argument coherence, validation of results (boundary test/case check), and metacognitive reflection. Downstream, post-discussion consolidation in the form of whole-class synthesis that links various strategies to key ideas (invariants, structures, generalizations) strengthens the epistemic accountability of the class (Hofmann dkk., 2025); (Ingram, 2020). Finally, the integration of the HOTS-Polya framework can be positioned not only as a pedagogical strategy, but as a scientific ethos in mathematics education: intellectual honesty in assessing evidence, epistemic humility when reviewing solutions, and responsible creativity when making generalizations. This ethos is in line with educational values that foster perseverance (academic sabri), argumentative justice (epistemic adl), and ihsan (beauty/quality) in the presentation of solutions—directing students not only to "answer correctly," but to "reason correctly" in the face of real-world complexity.

Through HOTS-based problem-solving, students are encouraged to become active learners who are able to explore, argue, and create creative solutions to complex problems. Therefore, it is important for educators to provide a challenging learning experience through HOTS questions consistently. This study aims to analyze the problem-solving ability of grade

XI students in solving HOTS problems in row and series material, identify the stages of problem solving carried out by students based on the Polya stages, Know the factors that affect the success or difficulty of students in solving HOTS problems.

METHODE

This study uses a qualitative descriptive approach, with the aim of describing in depth the problem-solving ability of students in working on Higher Order Thinking Skills (HOTS) questions on row and series material. This approach was chosen because it can reveal students' thinking processes in detail and contextual. The subjects in this study are 25 grade XI students of SMA Negeri 1 Barumun Tengah for the 2024/2025 academic year. The selection was carried out purposively, taking into account that they had learned the material of the row and series and were willing to take part in the entire series of research, including tests and interviews. The instruments used in this study consisted of: 1) HOTS question test as many as 2 questions, which were developed referring to the Revised Bloom Taxonomy indicators at the C4 level (analyze) and C5 (evaluate). Questions are designed to be context-based and require critical thinking and problem-solving skills, 2) Semi-structured interview guidelines, used to explore students' understanding, solution strategies, and reflections on the problems they are working on, 3) Observation sheets, which record students' behaviors and processes while working on the questions, including notes, scribblings, or special strategies.

Data collection was carried out through: 1) A two-item written test of HOTS questions carried out by 25 students in a limited time, 2) In-depth interviews conducted with several students representing the high, medium, and low ability categories, 3) Direct observation, used to observe the problem-solving process of students when doing the test. Data was analyzed using the model of Miles and Huberman (2014), which includes: 1) Data reduction: simplifying and organizing data from tests, interviews, and observations, 2) Data presentation: compiling data in the form of tables, citations, and descriptive narratives, 3) Drawing conclusions: interpreting data and drawing conclusions related to students' problem-solving skills in HOTS questions. To maintain validity, triangulation techniques are used, namely comparing data from three sources (tests, interviews, and observations), as well as member checking to several students to ensure the accuracy of the researcher's interpretation.

RESULT AND DISCUSSION

Based on the results of the test given to 25 grade XI students of SMA Negeri 1 Barumun Tengah with two HOTS questions on row and series material, it was found that the majority of students still had difficulty in solving the questions completely according to the problem-solving steps. The test was developed to measure aspects of high-level thinking through the Polya step approach, namely: understanding the problem, designing strategies, executing plans, and evaluating results. The following are the results compiled based on a qualitative approach, in accordance with the data of 25 students and 2 items of HOTS questions for row and series material:

Table 1. Problem-solving ability score results

Category	Score Range	Number of Students	Percentage
Excellent	7–8	5	20%
Good	5–6	9	36%
Enough	3–4	5	20%
Less	1–2	4	16%
Very Less	0	1	4%
Total		25	100%

According to Polya (in Sulastri & Nurfadillah, 2020), problem solving consists of four steps: 1) Understanding the Problem: Many students are unable to identify what is known and asked from the question. This indicates a weak ability to read and interpret contextual mathematical information. Most students tend to skip this stage and just write down the formulas they have memorized. 2) Plan Completion: Few students attempt to devise logical completion steps. Those who are able to do so are students with good analytical skills. Meanwhile, most students only use one strategy that is usually taught in class without considering the context of the problem, 3) Implementing the Plan: Common mistakes occur in the application of formulas that do not match the context of the question or incorrect data substitution. This shows the weak mastery of concepts and the low procedural skills of students in working on non-routine questions, 4) Evaluating Results: Almost all students do not check or reflect on the answers. Evaluation of answers is still the most often overlooked stage.

Here is one of the students' answers

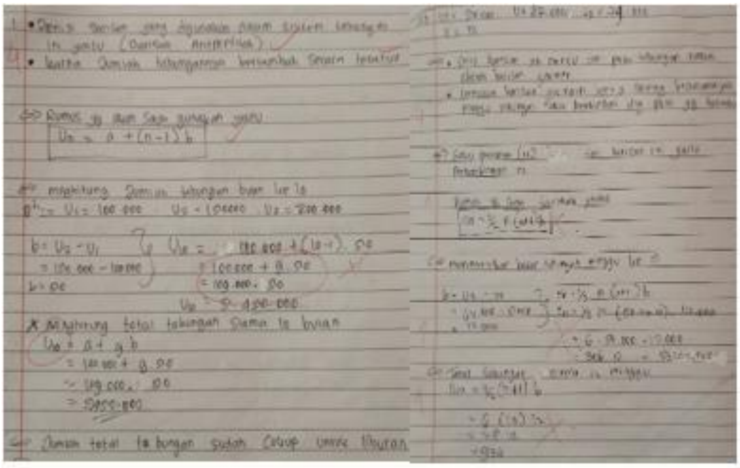

Figure 1. Student Answer Results

Understanding the Problem. Students mention information from the question directly, such as the first quarter and ratio. This shows that students understand what is known and asked. Achieved – Students show understanding of the content of the questions. Plan a Strategy. Students try to use geometric row formulas and apply them to the problem. The strategy chosen is right in type (using the geometric row formula), but the calculation and application are not precise. Partially Achieved – The strategy has been chosen correctly, but it has not been developed systematically. Implementing the Strategy. In the calculation process, it can be seen that students mistakenly substitute data and calculations, for example errors in multiplication steps or tribal sequencing. This shows that procedural mastery is still weak, even if students try to complete it to the end. Not Achieved – An error in the execution of the step causes the final answer to be incorrect.

Evaluate the results. There is no indication that the student double-checked his answers or tried another approach. No record of evaluation or reflection on possible errors was found. Not Achieved – Results evaluation was not performed. The following is a recapitulation of student achievements at each step of problem solving according to Polya:

Table 2. Recapitulation of student achievements at each step of problem solving according to Polya

Polya Steps	Number of Students Achieved	Percentage (%)
Understanding the Problem	20 Students	80%
Planning a Strategy	15 Students	60%
Implementing the Strategy	13 Students	52%
Evaluating Results	9 Students	36%

Analysis Based on Polya Steps

Understanding *the Problem*. As many as 80% of students are able to understand the information provided in the questions. This shows that in general students are able to identify the elements that are known and those that are asked. However, some still experience difficulties when the questions are in the form of narrative or use real-life contexts, according to the findings of Syahrir & Alimuddin (2022), that low understanding of context is the main obstacle to HOTS questions. Devising *a Plan*. Only 60% of students are able to design the right strategy. Many students are used to using formulas without analyzing the patterns first. This is in line with the results of Fatimah & Handayani's (2021) research, that students tend to rely on mechanical procedures and are not used to developing independent strategies in problem solving.

Implementing the Strategy (*Carrying Out the Plan*). As many as 52% of students were able to implement the strategies that had been designed, but not all of the results were right. Some students make calculation errors or do not complete until the end. This shows the weakness of precision and basic mathematical skills, as explained by Suparman (2020), that the limitations of numerical skills also affect the success of solving HOTS problems. Evaluating the Results (*Looking Back*). This was the lowest success, with only 36% of students re-evaluating their results. Most students do not re-check, even though evaluation is the key to strengthening reflective thinking (Anderson & Krathwohl, 2001). This shows that reflective attitudes have not yet become a common learning culture among students. The following diagram illustrates the number of students who succeeded in each problem-solving step based on the Polya model:

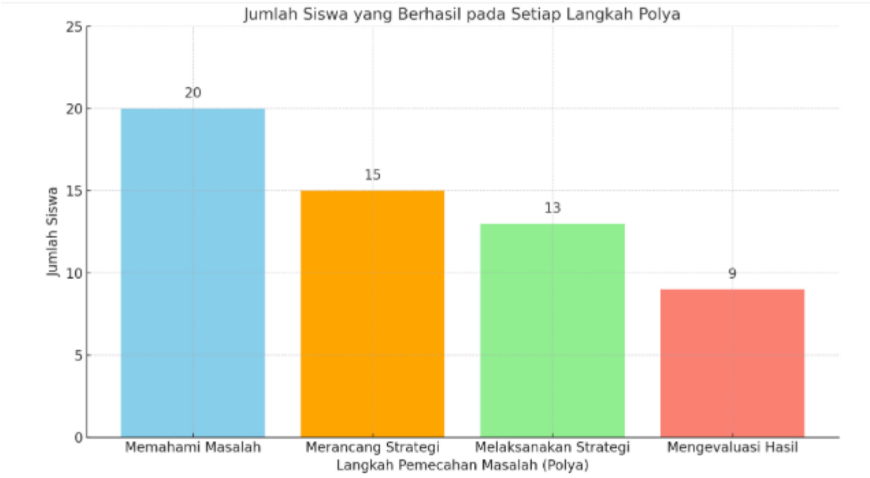

Figure 2. Troubleshooting steps diagram

This graph shows a decrease in the number of students who succeed from the beginning to the end, indicating that the more complex the thought process, the fewer students are able to execute it well. This reinforces the importance of continuous practice and guidance in developing higher-level thinking skills. The results of in-depth interviews with nine students of various ability levels showed that: They were not used to dealing with context-based problems, Most only relied on memorization of formulas and sample questions from books, Students with good results showed strategies such as sketching, arranging tables, or trying value substitution to understand patterns. Observations show that most students hesitate when reading questions and take a long time to start writing. This indicates a lack of confidence in solving math problems independently.

The results of the study showed that most of the students in grade XI of SMA Negeri 1 Barumun Tengah had difficulties in solving *Higher Order Thinking Skills* (HOTS) questions in row and series material. Of the 25 students who were tested using two HOTS questions, only 4 students were able to solve correctly and show a systematic thought process. The rest show various forms of errors, ranging from misunderstanding the problem to incorrectly applying strategies. This phenomenon strengthens the findings of Syahrir & Alimuddin (2022) who stated that students' low HOTS skills are often influenced by learning that tends to be procedural and lacks a contextual approach. HOTS questions are different from routine questions because they require analytical, evaluative, and creative thinking skills (Anderson & Krathwohl, 2001). In the context of rows and sequences, HOTS questions can involve the recognition of complex patterns, logical reasoning between concepts, and decision-making based on specific conditions. However, the main challenges faced by students are as follows: Difficulty in Understanding the Language of Questions. Students are not used to reading questions critically. Many students are just looking for important keywords and numbers without understanding the context, as a result of which the strategies they build are not right. Understanding the text in mathematics problems is a crucial factor in solving high-level thinking problems (HOTS), because students must be able to process information rationally. Unfortunately, many students are not used to using non-routine completion strategies. The HOTS problem requires innovation in solving problems, not just applying memorized formulas. However, students tend to only imitate patterns from sample questions or guess answers, which shows a lack of habituation in dealing with problems that require thinking flexibility. It is also mentioned by Krulik and Rudnick (1995) that problem solving involves a metacognitive process in designing and choosing a solution strategy. Weak Reflection Ability. Reflection or evaluation of results is not a common practice in math classes. Only a few students re-check their answers. In fact, according to Polya, reflection is an important stage to assess the validity and efficiency of solutions. Without reflection, mistakes are not recognized and do not become learning.

From interviews and observations, several main causative factors were found: Memorization-Based Learning and Formulas. Teachers often give standard-type questions, not challenging questions that encourage concept exploration. As conveyed by Fatimah & Handayani (2021), learning that emphasizes memorization causes students to be less able to apply concepts flexibly. Lack of practice HOTS questions. Students rarely get questions that challenge critical thinking. As a result, they are not used to devising new strategies or connecting different concepts. Lack of Contextual Approaches and Real Problems. The questions presented are often unrelated to daily life. In fact, contextual questions are very effective in fostering HOTS because they challenge students to understand real problems (Suparman, 2020). Lack of Scaffolding or Staged Support When students are struggling, there is often no staged support that helps them develop a thinking strategy on their own. Teachers need to guide students through guide questions, not directly give answers.

Teachers have a central role in creating a learning environment that supports the development of HOTS. According to Nurjanah (2020), teachers need to: Design questions that challenge analysis and evaluation, Teach students to interpret the problem thoroughly before answering, Encourage students to discuss solution strategies, not just final results, Provide reflective feedback so that students are able to evaluate their solutions. Teachers also need to introduce various problem-solving strategies, such as creating tables, drawing diagrams, or creating patterns. The more strategies are introduced, the more likely students are to choose the right strategy when solving HOTS questions.

Based on findings in the field, the application of Polya's steps is very relevant to train students in solving HOTS questions systematically. Each step (understanding the problem, designing a plan, executing, and evaluating) needs to be explicitly taught in class. Learning must be complemented by gradual and reflective practice of HOTS questions. Getting used to using Polya's steps not only helps students solve problems, but also trains them to become independent thinkers who can draft, run, and revise their own solutions.

CONCLUSION

Berdasarkan hasil penelitian terhadap 25 siswa kelas XI SMA Negeri 1 Barumun Tengah dalam menyelesaikan soal Higher Order Thinking Skills (HOTS) pada materi barisan dan deret, dapat disimpulkan kemampuan siswa secara umum masih tergolong rendah dalam menyelesaikan soal HOTS, terutama dalam aspek berpikir tingkat tinggi yang melibatkan analisis, evaluasi, dan kreasi. Berdasarkan analisis menggunakan tahapan pemecahan masalah Polya, diperoleh hasil: 80% siswa mampu memahami masalah, 60% siswa mampu merancang strategi. 52% siswa mampu melaksanakan strategi. Hanya 36% siswa yang mampu mengevaluasi hasilnya secara mandiri. Siswa mengalami kesulitan terbesar pada tahap evaluasi hasil, yang menunjukkan lemahnya keterampilan reflektif dan metakognitif. Faktor-faktor penyebab rendahnya kemampuan HOTS meliputi: Minimnya pembiasaan soal HOTS dalam pembelajaran harian, Dominasi pembelajaran prosedural dan berorientasi hafalan, Kurangnya strategi pembelajaran berbasis masalah dan kontekstual, Rendahnya motivasi belajar dan kepercayaan diri siswa dalam mengerjakan soal non rutin.

Berdasarkan temuan tersebut, maka diberikan saran sebagai berikut. Bagi guru. Sebaiknya secara konsisten mengintegrasikan soal HOTS dalam proses pembelajaran dan evaluasi, Menggunakan pendekatan pembelajaran berbasis masalah, kontekstual, dan eksploratif yang mendorong siswa berpikir kritis dan kreatif, Memberikan scaffolding atau pendampingan dalam membangun strategi pemecahan masalah serta evaluasi diri siswa, Melatih siswa untuk terbiasa menjelaskan alasan dan proses berpikir mereka secara tertulis dan lisan. Bagi sekolah. Menyelenggarakan pelatihan guru secara berkala dalam penyusunan dan implementasi soal HOTS. Menyediakan sarana pendukung seperti bank soal HOTS, modul, dan media pembelajaran interaktif. Bagi siswa. Didorong untuk aktif bertanya, berdiskusi, dan mengeksplorasi berbagai cara penyelesaian soal. Diberikan motivasi dan ruang untuk mengembangkan kemampuan berpikir kritis, tidak hanya dalam matematika tetapi juga lintas mata pelajaran.

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