M A T H L I N E
JURNAL MATEMATIKA DAN PENDIDIKAN MATEMATIKA
ISSN 2502-5872 (Print)
ISSN 2622-3627 (Elektronik)

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Volume 11 Number 4, November 2026, 1125-1142

PROBLEM-SOLVING ABILITY IN PERMUTATIONS BASED ON PREVIOUS SCHOOL AND LEARNING STYLES

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Received 17 August 2026; Revised 29 September 2026; Accepted 19 November 2026

ABSTRACT

This research aims to describe the mathematical problem-solving process of students related to different previous schools' backgrounds and learning styles in solving permutation problems based on Polya stages. This research uses descriptive comparative analysis of data collected from learning style questionnaires of students and the results of mathematics tests based on Polya stages. This research has 9 subjects from 3 schools; each school has 3 subjects containing one student of each learning style. The results revealed that students from SMPN 1 achieved the highest average problem-solving score (79), followed by those from SMPN 3 was 73 and MTs was 72.6. Regarding learning styles, students with a visual learning style obtained the highest average score (88), followed by auditory learners (85), while kinesthetic learners scored 51.6. At the process level, students with higher proficiency tended to navigate all four of Polya's stages more comprehensively; conversely, those with lower proficiency struggled particularly with understanding the problem, devising a plan, executing procedures, and reviewing their work. Consequently, there is a need for instruction that adapts to the diverse experiences and characteristics of students, without generalizing previous schools or learning styles as fixed determinants of ability.

Keywords: Problem-Solving Skills, Previous Schools, Learning Styles.

How to Cite: Muqarrabin, F., Dassa, A., & Asyari, S. (2026). Problem-Solving Ability in Permutations Based on Previous School and Learning Styles. *Mathline: Jurnal Matematika dan Pendidikan Matematika, 11*(4), 1125-1142. http://doi.org/10.31943/mathline.v11i4.1225

PRELIMINARY

Analysis is an investigative effort regarding a problem to determine the true situation, a process that begins with a hypothesis and proceeds to verify its validity (Magdalena et al., 2020). According to Septiani et al. (2020), analysis is a cognitive process aimed at breaking down a problem into smaller components to facilitate understanding. Fiantika et al. (2022) describe data analysis as the step of interpreting data obtained from research in a specific field. Ardi et al. (2025) define analysis as the process of examining student work to identify errors and thought patterns in solving mathematical

problems. According to the Indonesian Dictionary (2023), analysis is the investigation of an event (such as a written work, an action, etc.) to ascertain the actual circumstances (causes, the nature of the matter, etc.). Data analysis as the process of systematically searching for, organizing, and processing data obtained through interviews, observations, field notes, and documentation to gain knowledge, understanding, or in-depth findings regarding the research subject (Ahmad & Muslimah (2021; Sugiyono, 2013) describes analysis as the process of systematically searching for and organizing data obtained from interviews, field notes, and documentation. This process involves organizing data into categories, breaking it down into units, synthesizing information, identifying patterns, selecting significant elements, and drawing conclusions. Thus, it can be concluded that the analysis of mathematical problem-solving ability in this study is an effort to draw conclusions regarding students' capacity to formulate strategies consisting of specific steps to solve mathematical problems that cannot be resolved immediately and require in-depth knowledge as well as the application of appropriate strategic stages.

Problem solving is very important in mathematics because it functions to develop independent thinking skills, strengthen in-depth understanding of concepts, encourage creative processes in finding new patterns, and bridge mathematical theory so that it can be applied in real life in new situations (Fehr, 1953; Kaur, 1997; Ahmad & Kobandaha, 2026). Problem solving is defined as a situation requiring a resolution when a student lacks a clearly apparent path or method to achieve it. They emphasized that problem solving is seen as a complex process that requires individuals to coordinate knowledge, experience, intuition, and high-level abilities to deal with new situations. Students' problem-solving ability and processes are influenced by heuristic strategies, mental agility, prior knowledge, affective factors and beliefs, metacognitive skills and self-regulation, as well as the use of digital technology (Liljedahl et al., 2016). Students' problem-solving ability are influenced by their previous schools, which shape their study habits and provide learning experiences related to problem-solving ability (Garcia & Leomar, 2025). The previous school is a key external factor in problem-solving ability, as it impacts students' academic achievement (Singh et al., 2025). Similarly, Kaymakci and Can (2021) identified the previous school as a factor influencing problem-solving ability. The previous school affects learning outcomes because the quality and development of the institution shape the learning experiences students acquire; if students were accustomed to high-quality instruction and supportive extracurricular activities during their secondary education, these experiences facilitate their adaptation to the learning process at the university level (Indriyani, 2023).

This is further supported by research conducted by Harisman et al. (2021), which confirms through comparisons between school groups that the previous school is correlated with students' problem-solving ability.

Harisman et al. (2020) revealed in their study that a student's previous school influences their behavioral patterns and the effectiveness of their mathematical problem-solving process. In line with this, Nurjaman & Sari (2017) indicated that students from schools with high academic quality tend to possess better problem-solving ability. These disparities in problem-solving ability are influenced by the instructional practices and facilities of the respective schools (Choirudin et al., 2025). Students from schools with effective learning practices and supportive facilities exhibit higher levels of problem-solving proficiency, particularly when tackling complex problems (Ziliwu & Mahmudi, 2025). Differences in problem-solving ability can be observed through students' learning experiences, with the previous school serving as a primary determinant of classroom success (Rindiani et al., 2025). Therefore, it is crucial to consider schools that provide an environment conducive to supporting learners (Tondang et al., 2025). Variations in school characteristics such as instructional quality, learning resources, and prior learning experiences shape how students comprehend problems, devise strategies, and evaluate proposed solutions (Singh et al., 2025). Students from schools characterized by systematic learning approaches tend to demonstrate better problem-solving ability compared to those from schools with limited learning quality.

Besides the influence of the previous school, students' problem-solving ability is also influenced by their learning styles. Shaputra & Supardi (2021) found a significant influence of learning styles on mathematical problem-solving ability, noting that students with a visual learning style outperformed those with auditory or kinesthetic styles; this was attributed to instructional media that relied heavily on visual input. However, contrasting findings were reported by Naiborhu et al. (2025), who stated that kinesthetic students achieved the highest scores, while visual students obtained the lowest. Similarly, Safira et al. (2024) concluded that the highest average scores were observed among students with a kinesthetic learning style. Beyond these inconsistent findings, broader methodological issues warrant scrutiny. Similar problems frequently arise regarding claims about the impact of learning styles on problem-solving ability, particularly when the cited sources are based on qualitative studies, which in practice offer explanatory insights rather than definitive assessments.

Some studies have examined mathematical problem-solving ability in relation to learning styles (Setiyowati et al., 2024; Ardi et al., 2025) and school backgrounds (Ding et al., 2024). Other studies have focused on students' understanding of counting principles and related concepts (Kairuddin et al., 2025; Rokhmawati et al., 2023). However, these studies have not specifically addressed how previous-school backgrounds and learning-style categories can be considered together in analyzing students' problem-solving processes on permutation problems through four Polya stages. This gap provides an opportunity to examine these aspects within a specific educational context.

Consequently, the problem-solving ability of students can be influenced by their previous school and their learning styles. However, there are limited studies that have considered these aspects together. Several studies have discussed the relationship between mathematical problem-solving ability and the context of learning styles. These studies were only reviewing a variable, learning styles, with qualitative rather than comparative descriptive approach (Setiyowati et al, 2024; Ardi, 2025), and focus on the relationship between learning styles and mathematical achievement in general through a systematic review wherein concentrate to relation between two variables quantitatively (Hariri et al, 2025). Another study conducted by Sinaga et al. (2023) examined the influence of problem-solving ability on mathematics learning outcomes; this study focused on the relationship between two variables quantitatively. Although Ding et al. (2024) discussed the relationship between students' mathematical problem-solving abilities based on public and private school backgrounds, this study focused on the context of self-confidence. This study directly looked at two variables but was still limited in comparing the problem-solving ability of private and public schools quantitatively. However, there has been no research that connects three variables: mathematical problem-solving ability, previous school, and students' learning styles, especially in Sirenja. Sirenja was chosen because it is one of the areas that is located far from downtown. In addition, it has several new junior high schools have also been established that add the diversity of schools and community choices. This gap makes researchers consider it necessary to conduct research in this place.

Therefore, the researchers consider it important to conduct research to determine the problem-solving ability of students from different types of previous schools and how these relate to learning styles; this aims to provide an overview of the existing school backgrounds, serve as a reference for the public and school authorities, and offer a basis for teachers to evaluate and improve the learning process. This research novelty is connecting three variables. They are students' mathematical problem-solving ability,

previous schools, and learning styles. This research was conducted in Sirenja where is still rarely a research location in the fields of mathematics education. Unlike previous studies that discussed previous schools or learning styles separately, this research examines these two variables simultaneously by looking at students' ability to solve permutation problems by analyzing students' answers based on the four Polya stages of problem solving, namely understanding problems, developing plans, implementing plans, and re-examining answers. The research involves 9 subjects selected based on previous schools and learning styles. It provides an overview of the differences in how students solve problems and the difficulties they encounter at each Polya stage. Thus, this research does not aim to determine students' mathematical ability, but describes the variation in students' ability and problem-solving process based on these two aspects.

METHODS

The subjects of this research consisted of 9 students, three students from each school, each representing each learning style. The students selected for each learning style met the questionnaire criteria by achieving the highest scores and demonstrating dominance in one of the VAK learning styles. This research instrument consists of a learning styles questionnaire and a problem-solving ability test. This research began by administering a problem-solving ability test based on Polya's stages that had been validated by 2 orang validators. The test was developed based on a grid test that was compiled with references to four stages of problem-solving ability according to Polya stages. The grid is a guide to ensure that the test and its assessment criteria are aligned with the problem-solving ability aspects researched in this research. This instrument was not developed through empirical testing but rather through a follow-up review based on two expert validations.

Students' written responses were assessed using an assessment rubric that refers to the four stages of problem-solving ability according to Polya's stages. Each stage was assessed based on the indicators that have been set in the rubric by paying attention to the accuracy and completeness of the students' answers. The score obtained was then used to describe the mathematical problem-solving ability of each research subject. The results were analyzed quantitatively to explore the extent to which students from different previous schools and different learning styles performed in mathematical problem-solving ability on permutation materials. Subsequently, students from each previous school representing visual, auditory, and kinesthetic learning styles were selected for descriptive

comparative analysis to describe each student's problem-solving process based on 4 Polya stages. This research is conducted in Sirenja District, Donggala Regency, Central Sulawesi Province, during the odd semester of the 2026/2027 academic year.

The subjects for this research were selected based on their previous schools and learning styles determined via a questionnaire and were subsequently administered a problem-solving ability test aligned with Polya's stages. Following the learning style assessment, the researcher selected three students from each school representing visual, auditory, and kinesthetic learning styles, resulting in a total of nine subjects. The research then proceeded to evaluate the students' problem-solving test results, thereby yielding a description of their problem-solving ability categorized by previous school and learning styles.

RESULT AND DISCUSSION

The results of this research describe the mathematical problem-solving ability of nine selected subjects regarding their previous schools and learning styles. In this research, a learning style questionnaire was administered to students from three different schools. Students exhibiting the most dominant learning style were selected as research subjects. The results are presented in Table 1 below:

Table 1. Learning Styles Scores

	Visual		**Auditory**		**kinesthetic**	
	Subject	***Result***	***Subject***	***Result***	***Subject***	***Result***
SMPN 1	RS	19	RA	19	MA	15
SMPN 3	RM	20	IA	19	NR	27
MTs	AI	19	BA	19	AA	16

Table 1 shows that students from SMPN 1 are represented by three subjects, each with a different learning style: RS (score of 19, visual learning style), RA (score of 19, auditory learning style), and MA (score of 15, kinesthetic learning style). Furthermore, students from SMPN 3 are represented by RM (score of 20, visual learning style), IA (score of 19, auditory learning style), and NR (score of 27, kinesthetic learning style). Finally, students from MTs are represented by AI (score of 19, visual learning style), BA (score of 19, auditory learning style), and AA (score of 16, kinesthetic learning style).

The test results above indicate that the scores reflecting a visual learning style preference among students from the respective schools do not differ significantly; students from SMPN 1 and MTs achieved identical scores, trailing those from SMPN 3 by only one point. Regarding the auditory learning style, all students recorded the same score of 19. In

contrast, a substantial difference was observed in the kinesthetic learning style: students from SMPN 1 and MTs scored 15 and 16, respectively, whereas students from SMPN 3 scored 27.

As shown in Table 1, students from SMPN 3 scored higher in visual and kinesthetic learning styles, whereas the scores of students from the other two schools differed by only one point from each other.

The differences in the mathematical problem-solving ability test scores across schools in this research do not constitute direct evidence that the previous school causes variations in students' mathematical problem-solving ability. This is due to the limited sample size, comprising only three subjects from each school. However, the previous school is linked to established problem-solving ability. Differences in school characteristics such as instructional quality, learning resources, and prior learning experiences influence how students comprehend problems, devise strategies, and evaluate proposed solutions (Singh et al., 2025). As noted by Harisman et al. (2020), the previous school influences behavioral patterns and the effectiveness of students' mathematical problem-solving processes. Consistent with this, research by Nurjaman and Sari (2017) indicates that students from schools with high academic quality tend to demonstrate superior problem-solving ability. These disparities in problem-solving ability are influenced by the instructional practices and facilities of the respective schools (Choirudin et al., 2025). Students from schools with effective learning practices and supportive facilities demonstrate higher levels of problem-solving ability, particularly when tackling complex problems (Ziliwu & Mahmudi, 2025). Differences in problem-solving ability can be observed through students' learning experiences, with the previous school serving as a key determinant of classroom learning success (Rindiani et al., 2025). Therefore, it is crucial to consider schools that provide an environment conducive to supporting learners (Tondang et al., 2025).

Furthermore, this research administered a mathematical problem-solving ability test to the nine selected students. The results obtained from the assessment of this test are presented in Table 2.

Table 2. Problem-Solving Ability Scores

	Visual		**Auditory**		**Kinesthetic**	
	Subject	***Result***	***Subject***	***Result***	***Subject***	***Result***
SMPN 1	RS	91	RA	91	MA	55
SMPN 3	RM	91	IA	73	NR	55
MTs	AI	82	BA	91	AA	45

Table 2 presents the mathematical problem-solving ability test scores for students from each of the respective schools. Among the subjects representing SMPN 1, subject RS (visual learning style) achieved a score of 91; subject RA (auditory learning style) also scored 91, while subject MA scored 55. Regarding subjects from SMPN 3, subject RM (visual learning style) scored 91, subject IA (auditory learning style) scored 73, and subject NR (kinesthetic learning style) scored 55. Finally, among the subjects from MTs, subject AI (visual learning style) scored 82, subject BA (auditory learning style) scored 91, and subject AA (kinesthetic learning style) scored 45.

The mathematical problem-solving ability test scores for SMPN 1 students shown in Table 2 indicate that subjects RS and RA achieved identical scores, despite having different learning styles. However, subject MA, who has a kinesthetic learning style, scored lower than the subjects with visual and auditory learning styles. At SMPN 3, subject RM (visual learner) achieved the highest score compared to subject IA (auditory learner) and subject NR (kinesthetic learner). At the same school, subject IA obtained a moderate score, while subject NR recorded the lowest score among the three. Meanwhile, subject BA from the MTs, an auditory learner, achieved the highest score among the subjects from that school; subject AI obtained a moderate score, and subject AA recorded a very low score.

Based on Table 2 above, subjects from SMPN 1 achieved an average test score of 79, subjects from SMPN 3 had an average of 73, and subjects from MTs had an average of 72.6. Thus, SMPN 1 recorded a higher average mathematical problem- solving ability test score compared to the other two schools. However, when considering learning styles, subjects with a visual learning style achieved the highest average test score (88), followed by those with an auditory learning style (85), while subjects with a kinesthetic learning style had the lowest average (51.6). These data indicate that the mathematical problem-solving ability test scores for subjects with a kinesthetic learning style were lower than those for visual and auditory learners; notably, among the three subjects with a kinesthetic learning style, subject AA from MTs obtained the lowest score.

Based on the mathematical problem-solving ability test scores regarding permutation problems in this research, visual and auditory subjects tended to perform better than kinesthetic subjects. These results align with the study by Shaputra & Supardi (2021), which found that mathematical problem-solving ability associated with a visual learning style was superior to that associated with auditory or kinesthetic styles. This is attributed to the fact that learning media rely more heavily on visual input compared to

other modalities. Conversely, these findings differ from other studies indicating that students with auditory and kinesthetic learning styles are more active and creative during learning and complete tasks more quickly. Naiborhu et al. (2025); Safira et al. (2024) reported that learning style significantly influences problem-solving ability, with kinesthetic students achieving the highest average scores, followed by auditory students, while visual students scored the lowest. Therefore, the low mathematical problem-solving ability test scores of the subjects in this research do not imply a general rule that students with a kinesthetic learning style possess poor problem-solving ability. Such discrepancies may be influenced by factors such as learning experiences, the format of problem representations, and the strategies students employ when solving mathematical problems; hence, it cannot be considered a general pattern.

These research results provide implications for the meaning of learning style theory, especially visual, auditory, and kinesthetic (VAK) classification. The results do not indicate that there is one learning style that is consistently superior to other learning styles. Contrary, the grouping of learning styles can provide an overview of students' tendencies of preferences in learning. This is because students' actual ability to solve mathematical problems can also be related to various factors such as initial knowledge, mathematical understanding, learning experience, and the characteristics of the problems encountered.

Therefore, teachers need to avoid rigidly grouping students based on learning style categories or limiting learning methods based on only one specific learning style label. Mathematics learning should provide opportunities for students to understand the material through various forms of representation, such as visual representations, verbal explanations, and direct problem-solving activities. In addition, further research is recommended to involve a larger and diverse number of samples, use different types of mathematics problems, and examine the student learning process more deeply. Thus, the relationship between learning preferences and mathematical problem-solving ability can be understood more comprehensively.

The test scores presented in Table 2 were obtained after evaluating all the research subjects' responses. The research utilized mathematics problems involving permutations and instructed the subjects to apply Polya stages when solving them. The responses of the nine research subjects are described below;

1) Visual Learning Style

First, subject RS, a student from SMPN 1. He provided answer that indicated, he was able to accurately write down the given information and what was being asked in the

problem (Figure 1). He was also able to formulate a correct plan but did not present a complete sequence of solution steps (Figure 2). Then, he was able to execute the correct procedure and arrive at the correct answer (Figure 3). He was able to state the correct conclusion and verify the accuracy of the process (Figure 4).

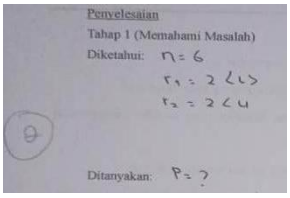


Figure 1. Stage 1 subject RS

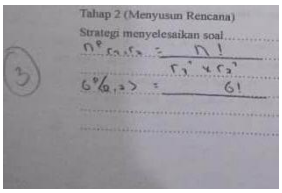


Figure 2. Stage 2 subject RS

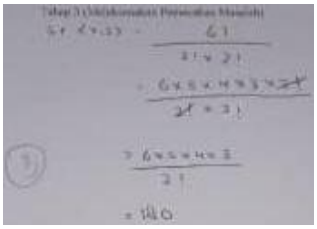


Figure 3. Stage 3 subject RS

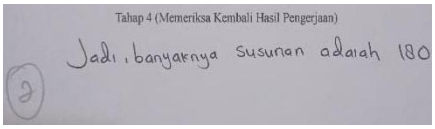


Figure 4. Stage 4 subject RS

Second, subject RM, a student from SMPN 3. His mathematical problem-solving ability results indicated his understanding of the problem, with the ability to accurately state the given information and what was being asked (Figure 5), and he was able to formulate a correct, although incomplete, plan (Figure 6). Then, he successfully executed the correct procedure and obtained the correct answer (Figure 7). Hence, he was able to state a correct conclusion and verify the accuracy of the process (Figure 8)

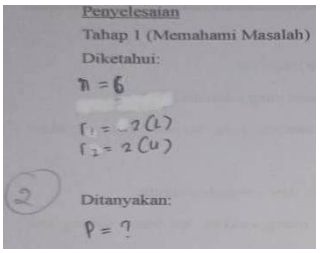


Figure 5. Stage 1 subject RM

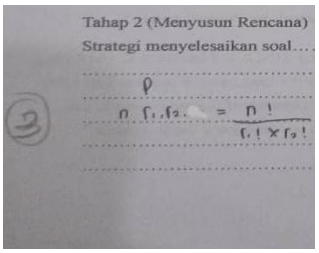


Figure 6. Stage 2 subject RM

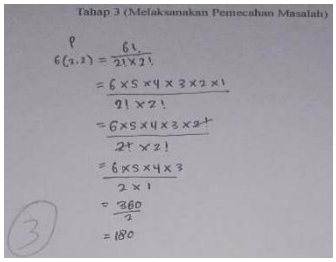


Figure 7. Stage 3 subject RM

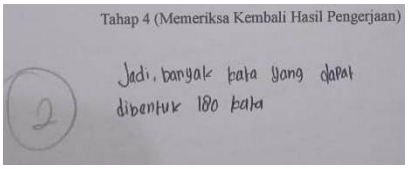


Figure 8. Stage 4 subject RM

Third, subject AI from MTs was able to write down what was known and what was asked about the question correctly (Figure 9). Even though she had relevant plans

(Figure 10). She was able to carry out the correct procedure but produced the inaccurate answer (Figure 11). At the end stage, she wrote wrong conclusions and did not carry out re-examination.

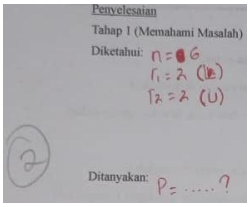


Figure 9. Stage 1 subject AI

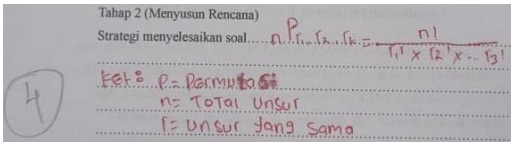


Figure 10. Stage 2 subject AI

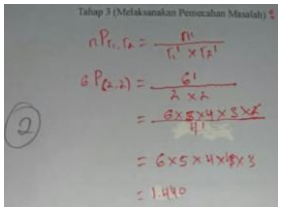


Figure 11. Stage 3 subject AI

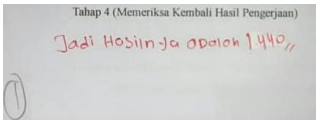


Figure 12. Stage 4 subject AI

2) Auditory Learning Style

Subject RA from SMPN 1 was able to write down what he knew and what was asked about the question correctly (Figure 13) and also present the correct but incomplete sequence of completion steps (Figure 14). He was able to carry out the correct procedure and produce the correct answer (Figure 15). Then, he could write the correct conclusions and carried out checks to see the correctness of the process (Figure 16).

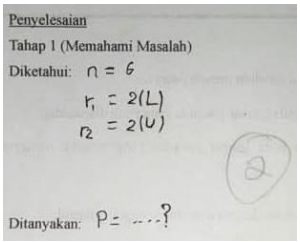


Figure 13. Stage 1 subject RA

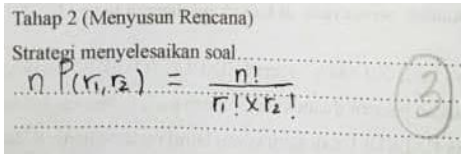


Figure 14. Stage 2 subject RA

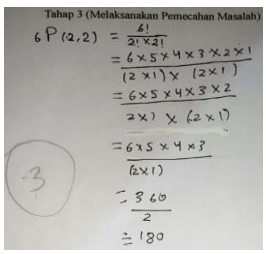


Figure 15. Stage 3 subject RA

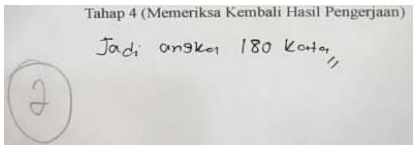


Figure 16. Stage 4 subject RA

Subject IA, a student of SMPN 3, indicated her ability to understand the problem and gave information and what was being asked accurately (Figure 17). She could formulate a correct but incomplete plan. Thus, she followed an incorrect procedure,

resulting in an incorrect answer (Figure 19). Finally, she wrote an incorrect conclusion and did not perform a review

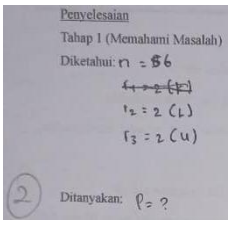


Figure 17. Stage 1 subject IA

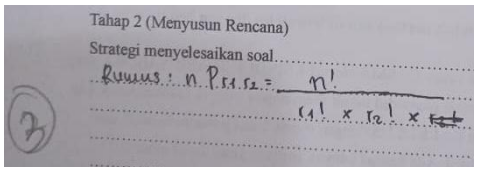


Figure 18. Stage 2 subject IA

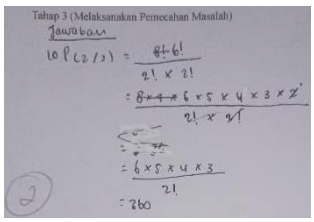


Figure 19. Stage 3 subject IA

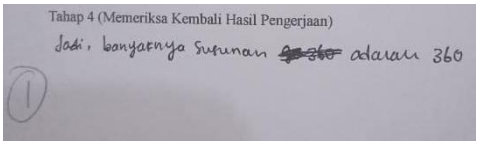


Figure 20. Stage 4 subject IA

Subject BA comes from an MTs and showed he could accurately write down what was known and what was being asked in the problem (Figure 21). He formulated a correct but incomplete plan (Figure 22). He executed the correct procedure and arrived at the correct answer (Figure 23). Unfortunately, he wrote an incorrect conclusion and did not perform a review.

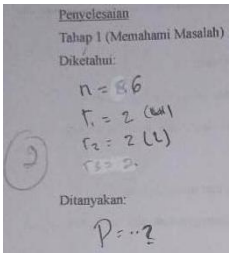


Figure 21. Stage 1 subject BA

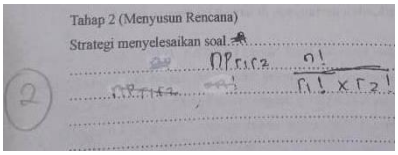


Figure 22. Stage 2 subject BA

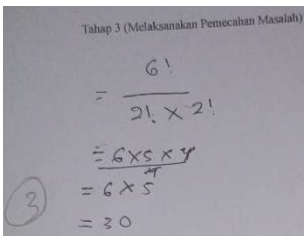


Figure 23. Stage 3 subject BA

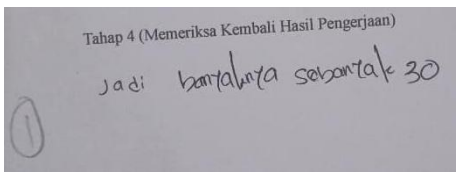


Figure 24. Stage 4 subject BA

3) Kinesthetic Learning Style

Based on the subject MA's response, a student from SMPN 1 misinterpreted the social conditions (Figure 25). She could formulate a correct plan but produced no result (figure 26). She was able to carry out a procedure, although an incorrect one, and

complete it, yielding an incorrect result (Figure 27). Thus, she was able to state a conclusion, but it was incorrect (Figure 28).

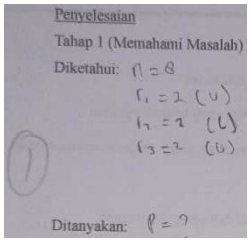


Figure 25. Stage 1 subject MA

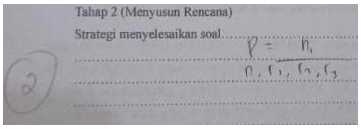


Figure 26. Stage 2 subject MA

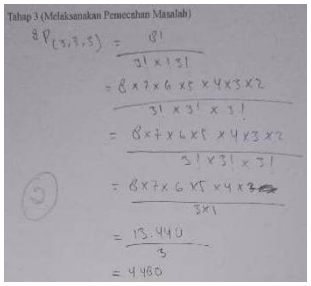


Figure 27. Stage 3 subject MA

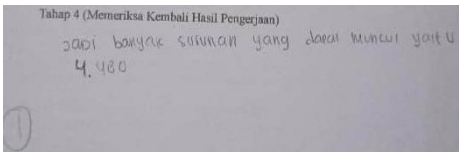


Figure 28. Stage 4 subject MA

NR, SMPN 3 student. He got a misinterpretation of the problem, leading to an inaccurate statement of the given information and what was being asked. He formulated a correct plan but failed to produce a result (Figure 31). He executed an incorrect procedure, resulting in an incorrect answer. He wrote an incorrect conclusion and did not perform a review.

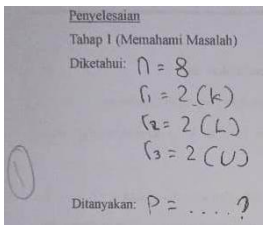


Figure 29. Stage 1 subject NR

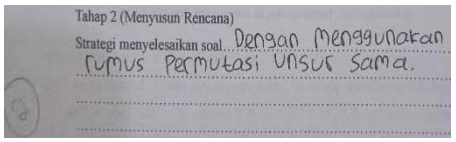


Figure 30. Stage 2 subject NR

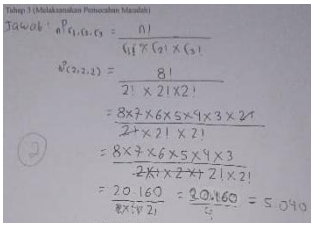


Figure 31. Stage 3 subject NR

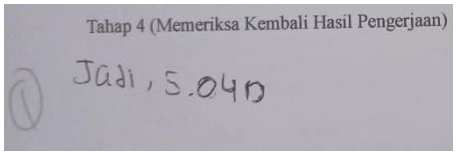


Figure 32. Stage 4 subject

AA, a student from MTs. He got a misinterpretation of the social situation. He devised an unfeasible solution plan (Figure 34). He was able to carry out a procedure, although an incorrect one, and complete it, resulting in an incorrect outcome (Figure 35). He wrote an incorrect conclusion and failed to review the work.

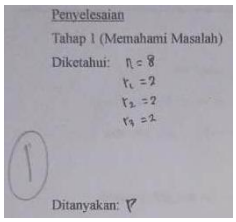


Figure 33. Stage 1 subject AA

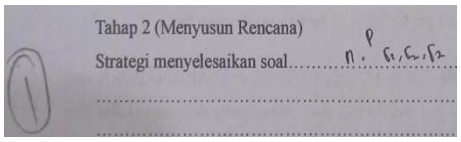


Figure 34. Stage 2 subject AA

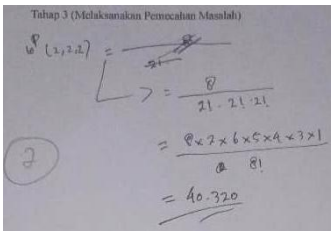


Figure 35. Stage 3 subject AA

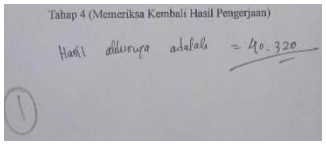


Figure 36. Stage 4 subject AA

Based on Polya's stages, this research illustrates that subjects capable of thoroughly understanding the problem can formulate a solution plan and execute the complete procedure, thereby drawing a correct conclusion. Conversely, subjects who struggle from the initial stage, specifically in comprehending the problem and the given conditions, proceed to incomplete or erroneous planning and execution phases, ultimately failing to draw a valid conclusion. These findings are supported by Ramziah & Sutiarso (2022), who highlight that the primary obstacles students face in solving trigonometry problems stem from a lack of reading literacy and unfamiliarity with systematic solution procedures ranging from data comprehension to final answer verification, resulting in generally low problem-solving ability. Furthermore, Khofifah et al. (2024) explain that teachers need to provide step-by-step guidance rather than focusing solely on the final answer, as many students encounter difficulties at specific stages of Polya's framework. This is exemplified by the current research, where six out of nine subjects made errors starting as early as the second stage, the planning phase.

CONCLUSION

Overall, the mathematical problem-solving ability of Grade XII students at SMA Negeri 1 Sirenja varied based on their previous schools and learning styles. Regarding previous schools, the differences are seen in the ability to understand information, strategize, implement the result obtained with each subject having different problem-solving ability characteristics that can be seen from students from SMPN 1 achieved the highest average problem-solving score (79), followed by those from SMPN 3 (73) and MTs (72.6). In terms of learning styles, students with a visual learning style obtained the

highest average score (88), followed by those with an auditory learning style (85), while students with a kinesthetic learning style scored 51.6. At the process level, students with higher proficiency tended to navigate all four of Polya's stages more comprehensively, whereas those with lower proficiency demonstrated difficulties, particularly in understanding the problem, devising a plan, executing procedures, and reviewing their work.

However, this research is limited to the factors of previous schools and learning styles in SMA Negeri 1 Sirenja, which cannot be generalized, considering various factors might be influenced. Therefore, it is important to improve mathematics learning that focuses on strengthening. Thus, mathematics instruction in schools needs to focus on strengthening the problem-solving thought process rather than merely achieving a final answer. At the same time, the results of this research provide a basis for teachers in Sirenja to deliver instruction that is more adaptive to the diverse experiences and characteristics of students, without viewing learning styles as fixed categories of ability. Particularly for students with a kinesthetic learning style, they can be supported through teaching methods that allow them space to participate more actively.

DECLARATIONS

Author Contribution	:	Fajar Muqarrabin : Conceptualization, Investigation, Data Curation, Formal Analysis Writing - Original Draft, Editing and Visualization. Awi Dassa : Conceptualization, Methodology, Supervision, Writing - Review & Editing. Syahrullah Asyari : Methodology, Supervision, and Writing - Review & Editing.
Funding Statement	:	No funding.
Conflict of Interest	:	The authors declare no conflict of interest.
Additional Information	:	Additional information is available for this paper.

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