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Characteristics of Algebraic Problem Solving Based on Learning Styles in PISA Content-Type Questions *Change and Relationship*

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Abstract

This study aims to describe the characteristics of algebraic problem solving based on students' learning styles on PISA content type questions change and the study used a descriptive qualitative approach with a population of students at SMA Negeri 1 Kediri. Subjects were selected using a learning style questionnaire, resulting in three research subjects, each representing visual, auditory, and kinesthetic learning styles. The research instruments included a learning style questionnaire, PISA-type content questions, and a questionnaire change and relationship Level 4 with a moderate level of difficulty, along with interview guidelines. The analysis of problem-solving characteristics is based on Polya's problem-solving indicators: understanding the problem, planning a solution, implementing the plan, and reexamining the solution. The results showed that subjects with a kinesthetic learning style were able to complete all stages of problem-solving and achieved the highest score compared to other learning styles. These findings also indicate that PISA content-type questions change, and relationships reveal the characteristics of students' algebraic problem solving based on learning styles.

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1. INTRODUCTION

Problem-solving skills are a key competency in mathematics learning, particularly in algebra. Problem-solving requires not only the ability to perform mathematical calculations but also involves higher-order thinking processes such as understanding the problem, planning a strategy, implementing the solution, and re-evaluating the results. Lubur (2021) states that problem-solving is a crucial element in the mathematics curriculum. This is because students gain experience in utilizing their knowledge and skills to solve unfamiliar problems. Rato (2021) emphasizes that the learning process is directed towards enabling students to solve problems systematically and logically. This ability is an important indicator in measuring students' success in understanding mathematical concepts meaningfully and contextually. Algebra, as one of the core topics in school mathematics, is often considered difficult by students because it requires abstract thinking and mathematical modeling skills. Students' difficulties in solving algebra problems are not only caused by limited conceptual mastery but also influenced by differences in individual characteristics, one of which is learning style. Achieving effective learning outcomes is a desired outcome. Each student essentially has a unique learning method, and this causes variations in how they understand the material. (Darmayani et al., 2023).

Learning style is a tendency towards attitudes or habits adopted by students in absorbing, processing, and organizing information to acquire knowledge and skills. (Budi et al., 2021)Learning styles describe the tendency of students to receive, process, and understand information, which are generally classified into visual, auditory, and kinesthetic learning styles. These differences in learning styles have the potential to influence how students understand problems and their problem-solving strategies. Learning styles are crucial in the mathematics learning process. Each student should recognize their own learning style so they will be more confident in exploring and discovering various methods for solving mathematical problems. (Syarah et al., 2024). In the context of evaluating mathematics learning, the Program *for International Student Assessment* (PISA) emphasizes students' mathematical literacy skills in solving contextual problems related to real life. However, mathematics remains a highly problematic subject, as evidenced by the low average scores of Indonesian students in the PISA study (OECD, 2023). (Eko Septiansyah Putra, 2024).

One of the PISA contents that is relevant to algebra material is change *and relationship* emphasizes understanding the relationships between variables, patterns of change, and algebraic representations in various contexts. PISA-type questions in this content require students to systematically deepen their understanding of concepts, reasoning, and problem-solving strategies so that they can be used to identify students' problem-solving characteristics. The mathematical abilities assessed in PISA are communication, mathematization, representation, reasoning and argumentation, formulating strategies for solving problems, using formal symbolic language and techniques and operations, and using mathematical tools. (Putra et al., 2024).

To examine the problem-solving process in depth, this study used Polya's steps. These steps consist of four steps: understanding the problem, planning a solution, implementing the plan, and reviewing. Previous studies have shown that students' mathematical problem-solving abilities vary based on learning styles. However, most studies have focused on quantitative outcomes or ability levels, without delving deeply into the problem-solving processes and characteristics demonstrated by students at each stage. Furthermore, studies specifically linking learning styles to the characteristics of algebraic problem-solving on PISA-type questions, particularly content, have not been widely studied *change and relationship* is still relatively limited.

Based on this description, there is a need to examine in more depth how the characteristics of students' algebraic problem solving are viewed from the differences in learning styles in solving PISA content-type questions *change and relationship.* This study has the novelty of qualitatively revealing students' problem-solving processes based on problem-solving stages, thus providing a more comprehensive picture of students' thinking styles with visual, auditory, and kinesthetic learning styles. Therefore, the purpose of this study is to describe the characteristics of students' algebra problem-solving based on visual, auditory, and kinesthetic learning styles in solving PISA content-type questions, *change, and relationship*. The results of this study are expected to be a consideration for teachers in designing mathematics learning that is more adaptive to differences in student learning styles and in developing questions that can train problem-solving skills optimally.

2. METHOD

This study uses a descriptive qualitative approach that aims to describe the characteristics of students' algebraic problem solving based on learning styles in solving PISA content-type questions, *change, and relationship.* This approach was chosen because the research focuses on students' problem-solving process based on Polya's indicators. This research was conducted at SMA Negeri 1 Kediri City. The research subjects were determined by administering a learning style questionnaire to students to group them into visual, auditory, and kinesthetic learning styles. Based on the questionnaire results, three students were selected as research subjects, each representing one learning style.

Subject selection was conducted purposively, taking into account students' learning styles and their ability to describe problem-solving based on Polya. The research instruments used included a learning style questionnaire and PISA-type content test questions, *change and relationship,* and interview guidelines. The learning style questionnaire was used to identify students' learning styles. The PISA test was used to obtain data on algebraic problem-solving abilities based on Polya's indicators, namely understanding the problem, planning a solution, implementing the plan, and reviewing the solution. The interview guidelines were used to delve deeper into students' thought processes in solving problems.

All research instruments were first validated by experts to ensure content suitability, language clarity, and relevance to the research objectives. Furthermore, the PISA test items were tested in a small group with 14 students to ensure empirical validity and item clarity before being used on the main research subjects. Data collection was conducted through a learning style questionnaire, a written test with PISA-type items, and in-depth interviews. The written test was administered to the research subjects to obtain data on algebraic problem solving, while interviews were conducted after the test to confirm and strengthen the data on student work. Data analysis was conducted qualitatively through the stages of data reduction, data presentation, and conclusion drawing. The test and interview data were analyzed based on Polya's problem-solving indicators to describe the characteristics of students' algebraic problem-solving in each learning style. Data validity was ensured through technical triangulation, which compared the written test results with the interview results.

3. RESULTS AND DISCUSSION

In this study, data were collected from two classes: XI-J and XI-K. Students from these two classes completed a learning style questionnaire. The following results were obtained:

Learning Style	Number of Students
Visual	21
Auditorium	9
Kinesthetic	33

From the data, one student in each learning style category was selected as the primary sample. The subjects in this study were SV, representing the visual learning style, SA, representing the auditory learning style, and SK, representing the kinesthetic learning style. This study used one PISA-type question in the intermediate category, namely level 4, on the content, *change, and relationship with* a medium level of difficulty.(Yuliyani & Setyaningsih, 2022)In his research, he argued that the ability to read and write mathematics helps people understand the role or use of mathematics in everyday actions, as well as in making the right choices or agreements as respected and rational members of society. The questions have been validated by 3 expert validators and tested on small or limited groups to obtain the interpretation category of the validity coefficient of the limited trial $0{,}60 \leq 0{,}739 < 0{,}80$. So it can be said to be high. (SasongkoTito et al., 2016) said that the question package is said to be valid if the interpretation of the minimum validity coefficient is categorized as valid with a validity coefficient of more than 0.6 or equal to that.

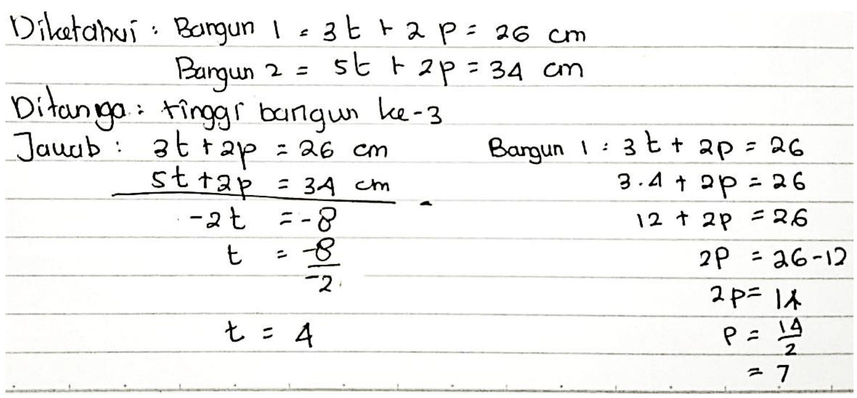
According to Anggraeni Pratiwi et al. (n.d.), problems at this level require mathematical literacy criteria, namely, students can solve problems efficiently in certain ways in complex but real-world situations that may contain obstacles or raise suspicions. They can select and utilize various forms of representation, including symbols. They can apply their skills and knowledge in clear situations. They can explain their views based on understanding, logic, and statements they have formulated. Furthermore, the assessment of algebraic problem-solving skills is based on Polya's indicators. Utomo et al. (2020), in (Yuliyani & Setyaningsih, 2022), explain that mathematical literacy is not only the ability to understand material, but also plays a role in applying design, critical thinking, facts, and mathematical tools to solve problems that exist in life. One strategy to facilitate students to be skilled in problem solving is to use Polya's steps, that's what was expressed by Mufidah (2025). With the assessment of Polya's problem-solving abilities according to (Pardimin et al., 2007) in (Achmad et al., 2024) as follows:

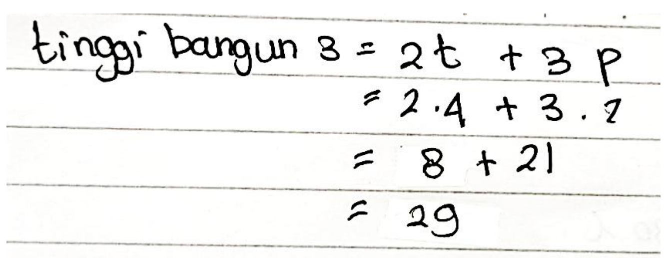
Polya Stages	Score	Scoring Indicators
Understand Problem	3	Students can write (express) what they know and asked about the problem that was raised clearly.
	2	Students only write (express) what they know or just what is asked (not complete).
	1	Students write down data/concepts/knowledge that is not related to the problem presented, so that students do not understand the problem being asked (still wrong in writing).
	0	Students do not write anything down, so students do not understand the meaning of the problem being asked.
Planning the Settlement	2	Students write down sufficient and necessary conditions (formulas) for the problem being proposed and use all the information that has been collected.
	1	Students tell/write down the steps to solve the problem, but not in sequence.
	0	Students do not tell/write the steps to solve the problem.
Carry out Plan	4	Students carry out the plans that have been made, use the steps to solve the problem correctly, do not make procedural errors, and do not make algorithmic/calculation errors.
	3	Students carry out the plans they have made, use the correct steps to solve the problem, and no procedural errors occur, but algorithmic/calculation errors occur.

	2	Students carry out the plans they have made, but procedural errors occur.
	1	Students carry out the plans they have made, but procedural errors and algorithmic/calculation errors occur.
	0	Students are unable to carry out the plans they have made.
Checking Again	1	Students recheck their answers.
	0	Students do not recheck their answers.

Therefore, the maximum score for this question is 10 if all problem-solving steps are completed correctly. After the PV, PA, and PK completed the questions, interviews were conducted to strengthen and validate the analysis of students' algebraic problem-solving characteristics based on Polya's learning style. The following is an analysis of Polya's problem-solving characteristics, along with the interview results:

A. PV Subject

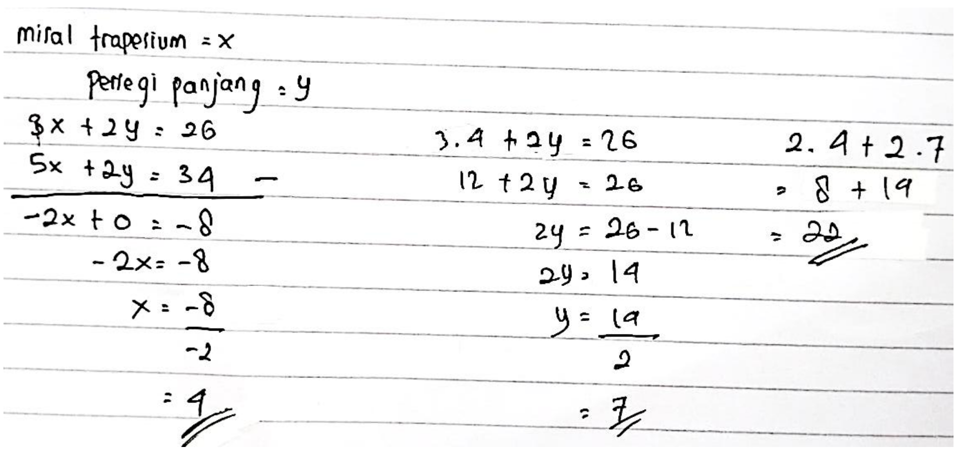




The Visual Subject (PV) was able to understand the problem well, as demonstrated by their ability to identify important information from the problem. At the understanding stage, PV was relatively able to write down what was known and what was asked, although not in full detail. However, at the planning stage, PV tended not to write a complete solution plan. PV went directly to the calculation process without explaining the initial strategies that would be used. This indicates that PV relied more on mental understanding or visual images than on systematic writing. At the implementing and reviewing stages, PV was still able to obtain the correct answer, although the solution steps were not always written coherently. Overall, the problem-solving abilities of visual students were classified as good, but less than optimal at the planning stage.

From the interview, PV stated that he understood the problem by observing the shapes, numbers, or patterns in the problem. However, PV tended not to be accustomed to writing a complete solution plan, because he felt he already understood the solution steps mentally. This finding supports the test results that showed that PV was not optimal in the planning stage of the solution according to Polya. In the solution design phase, students with a visual learning style can formulate a plan to be implemented, namely by converting the received data into a mathematical model. In addition, students with visual tendencies can also grasp the essence of the problem by writing and expressing existing information, although not yet fully comprehensively (Nurhikmah et al., 2025).

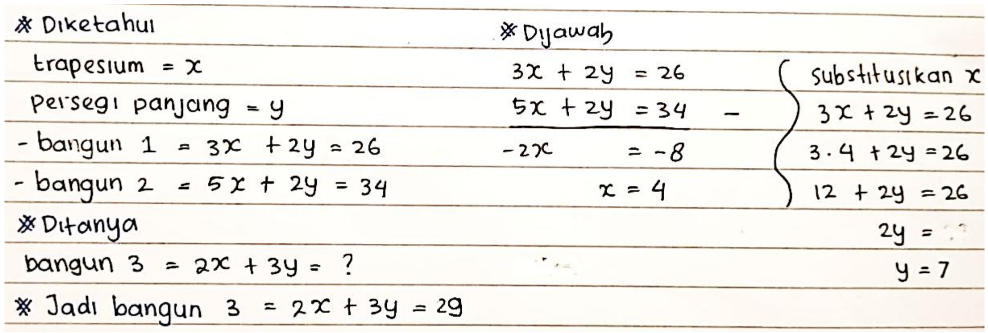
B. PA subjects



The PA subjects exhibited distinct characteristics. At the problem-understanding stage, the PAs did not write down the known and requested information completely and clearly. This indicates that the PAs relied more on verbal understanding or verbal explanations than on written representations. At the planning and implementation stage, the PAs began to demonstrate the calculation process, but errors were found in the final results. These errors occurred despite the appropriate concept, indicating a lack of precision in the solution process. Furthermore, at the rechecking stage, the PAs tended not to double-check their answers. As a result, any calculation errors were not identified, affecting the accuracy of the final results.

Interviews with the PAs revealed that PAs found it easier to understand problems when they were explained verbally or discussed. In the interviews, PAs admitted to often performing calculations directly without writing down the known and requested information in full. Furthermore, PAs were aware of calculation errors in the final results but failed to double-check them. This aligns with test results, which indicated PAs' weaknesses in understanding written problems and double-checking their results. (Amalia & Hadi, 2021) reported that auditory students can explain problem solutions well, but even though they are good at solving problems, auditory students are still less effective at explaining the solution to the problem. This can lead to errors in the final calculations.

C. Subject PK



PK demonstrated the most coherent and comprehensive problem-solving skills. At the problem-understanding stage, PK was able to clearly write down what was known and what was asked. At the planning stage, PK subjects developed a sound solution strategy and wrote it down systematically. Furthermore, at the implementing stage, PK performed calculations using coherent steps and in accordance with the plan that had been made. At the rechecking stage, PK also demonstrated a habit of checking the results obtained, both by reviewing the calculation steps and by matching the answers to the context of the problem. This indicates that PK tends to be active and thorough in each stage of problem-solving based on Polya.

Then, during the interview with the PK, the subject stated that it was easier to solve the problem by writing down the steps sequentially and systematically. PK felt that the activity of writing and working in stages helped them understand and solve the problem correctly. This interview finding supports the test results, which showed that PK was able to carry out all stages of problem solving based on Polya completely. (Ardi et al., 2025) In their research explained that in the process of designing a solution to a problem, students with a kinesthetic learning style can develop a plan efficiently and then outline the necessary steps through physical actions to create a mathematical model, so this is useful in getting the right answer based on the existing data.

4. CONCLUSION

Based on the results of the research and discussion, it can be concluded that the characteristics of students' algebraic problem solving on PISA content type questions change, *and relationship between* Different learning styles differs based on learning style. Subjects with a kinesthetic learning style demonstrate correct and systematic problem-solving abilities according to Polya. Subjects with a visual learning style can solve problems well, but are not yet fully complete in their written implementation. Meanwhile, subjects with an auditory learning style show weaknesses in the stages of implementing the plan and checking the final results. Although subjects with kinesthetic and visual learning styles both answered correctly, the difference in problem-solving abilities did not show a significant difference. Meanwhile, subjects with an auditory learning style show a significant difference compared to other learning styles. In the process of solving algebraic problems at each step of Polya, the characteristics of each learning style category in solving problems are clearly visible. The results of this study indicate that the use of PISA-type questions with content change *and relationship Level* 4 can clearly reveal the characteristics of students' algebraic problem-solving.

Therefore, teachers are advised to provide a variety of contextual problems with varying levels of difficulty and emphasize the problem-solving process, not just the final result or student answers. Students' learning styles should also be considered to optimize their mathematical problem-solving abilities.

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