Visual, Auditory, and Kinesthetic Students: How They Solve PISA-Oriented Mathematics Problems?

Naufal Ishartono¹, Nuqthy Faiziyah², Sri Sutarni³, Amalia Budiana Putri⁴, Lina W S Fatmasari⁵, Muh Sayuti⁶, Rita Rahmaniati⁷, Melor Md Yunus⁸

¹-⁵Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta, Indonesia
⁶Vocational Education and Training, Ahmad Dahlan University Yogyakarta, Indonesia
⁷Faculty of Education and Teacher Training, Universitas Muhammadiyah Palangkaraya, Indonesia.
⁸Faculty of Education, Universiti Kebangsaan Malaysia, Malaysia

Corresponding author’s e-mail: nuqthy.faiziyah@ums.ac.id

Abstract. Mathematical problems are given to students to train themselves in their thinking skills and to find out the level of thinking that each student has. Mathematical problem solving is influenced by the level of students' thinking ability. The purpose of this study was to analyze students' high-order thinking skills in solving PISA-oriented math problems in terms of learning styles. This type of research is a mix method with a Concurrent Triangulation Strategy design. The population of all students of class X SMA Negeri 2 Surakarta samples in the study of several students in the population. The sampling technique used purposive sampling. Data collection techniques using interviews, documentation, and tests. The results of the study: 1) There was no difference in ability between students' visual, auditory and kinesthetic learning styles in solving PISA-oriented math problems. 2) There are 23 students who have a visual learning style or 70% of the population. 30% of them are in the high category, 44% are in the medium category, and 26% are in the low category. 3) There are 8 students who have an auditory learning style or 24% of the population. 62.5% of them are in the medium category, and 37.5% are in the low category. 4) There are 2 students who have a kinesthetic learning style, the two students are one in the medium category and one in the low category. In general, each visual auditory and kinesthetic student has the ability to analyze, evaluate, and create as part of the higher order thinking component. However, each of them has a weakness in these abilities.

1. Introduction
Problem solving ability is one of the basic competences of mathematics that students must have. This is a very high demand and cannot be achieved only by memorizing, routine problem-solving exercises, and the usual learning process. Broadly speaking, through problem solving type problems, it is hoped that students can develop the ability to solve math problems.

The teaching and learning process in schools needs to be directed to better master students' higher order thinking skills. One of the solutions that are seen as being able to optimize higher-order thinking skills in mathematics in learning mathematics through problem solving. Mutual problem solving abilities related to the ability to think critically and creatively because it is in the learning process
teaching does not directly learn the material but requires critical and creative thinking to solve a problem[1]. Higher order thinking skills (HOTS) are the use of higher level thinking processes to gain new insights and new challenges in problem solving. HOTS is a very important aspect of learning mathematics, especially for solving real problems that are not routine for students [2]. Therefore, it is highly recommended for teachers and pre-service teachers to develop HOTS mathematics problems and implement them in learning[3]. High-order thinking skills are the Analyze, Evaluate and Create Ability [4] [5].

To measure the ability to analyze in this study, three indicators were used, namely 1) analyzing incoming information and dividing or structuring information into simpler parts to recognize existing patterns or relationships, 2) being able to recognize and differentiate factors of cause and effect from a complicated scenarios 3) identify or formulate questions. Meanwhile, to measure the ability to evaluate, namely 1) Providing an assessment of solutions, ideas, and methodology, using suitable criteria or existing standards to ensure the value of its effectiveness or benefits, 2) making hypotheses, criticizing and testing, 3) accepting or rejecting something statement based on predetermined criteria. Indicators for the ability to create are 1) generalizing an idea or perspective on something, 2) designing a way to solve problems, organizing elements or parts into new structures that have never existed [6].

PISA is an international study where one of the activities is to assess the literacy, mathematics and science achievement of school students aged 15 years. OECD states that mathematical literacy is defined as a person's ability to formulate, apply and interpret mathematics in various contexts, including the ability to mathematically reason and use concepts, procedures, and facts to describe, explain or predict phenomena. Mathematical literacy skills help a person to understand the role or use of mathematics in everyday life and at the same time use it to make decisions right on the various phenomena that occur [7]. The 2018 PISA results show that Indonesia's math literacy score is 379 from the OECD average of 489. This puts Indonesia in 7th place from the bottom [8].

Learning style is the easiest way that students have in absorbing, organizing and processing the information received. Each individual learns in different ways to capture and understand the contents of the learning material, and all the same ways. Each method has its own strengths. In reality, all of us have that learning style, it's just that usually one style dominates [9]. There are three different learning and communication styles, namely: Visual Learning Style, learning through seeing something in order to understand it, Auditory Learning Style which is learning through hearing something by relying on the senses of listeners, and Kinesthetic Learning Style, learning through physical activity and direct involvement in order to understand the material optimally [10].

Students with visual learning styles have visual modalities to access visual images that are created or remembered, such as colors, spatial relationships, mental portraits, and images. The indicators are neat and orderly appearance, respond to something calmly, speak quickly. In addition, planning for something well in the long term, being able to skim through or grasp only the general picture, prefers to read alone rather than read aloud. Furthermore, visual students make lots of symbols and pictures in notes, remember what they see better than what they hear, memorize associations in visual form and have difficulty remembering spoken commands rather than written comprehension. Generally, they prefer other arts to music [9].

Auditorial students have an auditory modality to access all kinds of sounds and words that are created or remembered, such as music, tone, rhythm, rhyme, internal dialogue, and voice. Their characteristic is to speak to themselves at work, are usually fluent speakers, move their lips and pronounce the writing on the book while reading. They find it difficult to write, but are great at storytelling learning by listening to and remembering what was discussed rather than seen. In art, they prefer music to other arts [9].

Kinesthetic students have the modality of accessing all kinds of motion and emotions that are created or remembered, such as movement, coordination, rhythm, emotional responses, and physical comfort. Their characteristics are unable to sit quietly for long periods, make decisions with feelings, speak slowly and quietly, standing close while talking to someone. They use fingers when reading, touch something they find, are physically oriented and move a lot, like to learn by practice. Loves to use body gestures. They make time for sports and other physical activities [9].
2. Methods
This research is a mix method of quantitatif and qualitative research conducted at SMA Negeri 2 Surakarta Indonesia Senior High School. The population in this study were students of class X. The sample in this study consisted of one class, namely class X IPA 3 as the sample class with a total of 33 students.

For qualitative research data were collected using questionnaires dan tests. Meanwhile, for qualitative research, data were collected from tests and interviews [11]. The questionnaire instrument was used to determine the type of student learning style. Before being used to retrieve data, first the questionnaire was tested for validity using the Pearson Bivariate correlation test and the reliability test using the Alpha Cronbach formula. The test instrument is used to measure the ability to solve PISA-oriented problems. The test consisted of 2 items with a pisa-oriented math test item type which previously carried out the content validity test for two experts to obtain expert judgment. In the instrument, there are suggestions for improvement from the experts, especially in improving the question stem.

Analysis of student abilities is seen from higher order thinking skills which refer to analyzing, evaluating, and creating. Interviews were conducted to confirm the answers to these students' abilities. The quantitative data analysis technique uses the one-way analyze of variance test by fulfilling the prerequisites.

3. Results and Discussion
This research was conducted by presenting PISA-oriented mathematics questions to determine students' higher order thinking skill. includes logic and reasoning skills, analysis, evaluation, and creation. The data on the ability to solve math problems is data on high-order thinking skills taken from the students' scores in the form of test questions. The data is divided into three groups, namely the visual group, the kinesthetic group and the auditory group based on learning style.

The results of the math problem test obtained the lowest score of 11.63 and the highest score 83.23. Furthermore, the accumulated scores are categorized into higher order thinking abilities. The categorization results obtained by 7 students with high category level, 16 students with medium category level, and 10 students with low category level. The following is the percentage of the results of categorizing students' metacognition abilities as presented in table 1.

| Category   | Percentage |
|------------|------------|
| High       | 21 %       |
| Medium     | 49 %       |
| Low        | 30 %       |

Student learning styles were identified through a questionnaire that was distributed prior to the study. Based on the learning style questionnaire given, it was found that 23 students had a visual learning style, 8 students had an auditory learning style, and 2 students had a kinesthetic learning style (see Table 2).

| Learning Style | N  | Percentage |
|----------------|----|------------|
| Visual         | 23 | 70 %       |
| Auditory       | 8  | 24 %       |
| Kinesthetic    | 2  | 6 %        |

Hypothesis testing is used to determine whether there is a difference in ability between students with visual, auditory and kinesthetic learning styles on the results of PISA-oriented mathematics problems. The results show that there is no difference in students' higher thinking abilities in terms of learning
styles. There is no difference in high-order thinking skills in this study can be seen from the scores obtained from each group which shows that each category of learning styles has students who get moderate and low scores, for high scores only exist in the group of students with visual learning styles.

This is because the number of students who fall into the category of visual learning styles is the largest compared to the other two learning style categories. In addition, one of the factors that causes no difference in higher-order thinking skills in terms of student learning styles is the application of the same learning model to all students in one class. So that with the diversity of student learning styles in one class and the application of the same learning model without considering the characteristics of student learning styles, the material being taught cannot be accepted optimally by students. For example, students with a visual learning style should be taught a learning model that involves visualization.

Although the learning style affects understanding mathematics problem [12], the mathematics learning achievement of high school students [13] [14] and affect students' ability to solve math problems [15], these results are consistent with the research conducted by Hartati (2015) which shows that each student has a different learning style. For this reason, in delivering mathematics subject matter, the creativity of a teacher is needed so that it can create fun teaching for all students according to the learning style [16]. To analyze the differences in each component of higher order thinking in students with different learning styles, is presented in the description below.

3.1. Visual Student on Solving PISA-oriented Problems

This study contained 23 students who were included in the visual learning style category, meaning that 70% of students had a visual learning style. Of these students with a visual learning style 30% of them are in the high category, 44% are in the medium category, and 26% are in the low category. Only students with visual learning styles have a high category, this is because the number of students who fall into the visual learning style category is the largest compared to the other two learning style categories. In visual learning style students, there are differences in value because they have different understandings of the images seen in PISA-oriented math problems.

Students can visually analyze incoming information and divide or structure information into simpler parts. They are able to distinguish the causes and effects of a complex scenario and identify questions. This can be seen in Figure 1.

![Figure 1. Visual Student Answer](image-url)

Visual students are able to describe problems well. They can understand and explain the concepts involved in the problem. In addition, they are able to explain the steps for completion in a detailed and systematic way. In terms of evaluating, visual students can do well with appropriate, clear, and complete arguments. They sometimes fail to make analogies, which results in them being wrong in making conclusions.

For question number 2, students are asked to provide an assessment of whether the conclusions stated by someone in the question are correct or not. Visual students are able to provide the evaluation
correctly, starting from identifying the problem and then solving it so that the results can be used to provide an evaluation of solutions, ideas, and methodologies using suitable criteria or existing standards to ensure the value of their effectiveness or benefit.

However, one visual student made an error in the calculation, namely writing the number should be 2.5 but written 25 so that an error occurred in the final result. This resulted in an incorrect evaluation of the conclusions stated in the questions.

3.2. Auditory Student on Solving PISA-oriented Problems

There were 8 students who were included in the category of auditory learning styles, meaning that 24% of students had an auditory learning style. Of the 8 students with an auditory learning style, 62.5% of them are in the medium category, and 37.5% are in the low category. In students' auditory learning styles, there are differences in values due to the condition of the class atmosphere which is crowded and not conducive so that students have different understandings of students seen in PISA-oriented mathematics questions.

Auditory students can analyze questions well as seen in Figure 2. Not so different from visual students. Starting by mentioning the information obtained on the questions and identifying them. Then design the solution, this is part of the creating component. Meanwhile, in evaluating, one student made a mistake when determining whether the conclusions stated in the questions were true or false As seen in figure 3. The error was later confirmed during an interview. Students can identify the on which the error is, namely rounding off the results of the square rooting.

The ability of auditory students to express explanations through writing is not as good as visual students. In addition, they are not good at sketching the problems that must be solved. in evaluating, or checking the validity of an argument given, auditory students do well. They can write down the evidence correctly and accurately and are able to provide the document. In other words, visual students like to convey ideas, ideas, arguments, and explanations in comprehension way.

These results are in accordance with another research that students with auditory learning styles tend to be good speakers. Easy to discuss with friends about a certain material. In learning activities based on auditory learning styles, students need an atmosphere that can optimize their listening ability. One way is to provide opportunities for group discussions and present the findings [9][17].

3.3. Kinesthetic Student on Solving PISA-oriented Problems

There are only 2 students who enter the kinetics learning style category, which means there are 6% of students who have a kinesthetic learning style. Of the 2 students with a kinesthetic learning style, 50% of them are in the medium category, and 50% are in the low category. In students' kinesthetic learning styles there are differences in values due to the condition of each student who tends to have to touch something to remember information in working on PISA-oriented mathematics problem.

Kinesthetic students are able to carry out the analysis, which begins with interpreting the problem based on the mathematical concepts involved. They can rewrite the information collected in the sola and this is confirmed through interviews. Apart from that, they make well sketched drawings but can't do it in detail. Sometimes, they do it not as neatly as a visual student.
In evaluating, visual students are able to check and evaluate the truth of a question based on known concepts. It can be seen in Figure 4, in addition to writing down information that is known, kinesthetic students are able to compile a mathematical model formulation of the given problem. However, kinesthetic students did not write down how to solve their math problems. They went straight to the final answer. This is in accordance with the research of Jaenudin et al. (2017), that kinesthetic students tend to prefer to go straight to the final answer. However, they are actually able to explain the process for obtaining these answers, which are generally obtained intuitively. This was confirmed in the interview results [18], [19].

![Image](image.png)

**Figure 4.** Answer of a Kinesthetic Student

Students with kinesthetic learning styles learn through moving, touching, and doing. Kinesthetic students can not stand to sit for long listening to lessons but it is better if the learning process is accompanied by physical activity. Kinesthetic learning style students speak slowly, respond to physical attention, touch people to get their attention, stand close when talking to people. They learn through manipulation and practice, memorizing by walking and seeing, using fingers as pointers when reading, using lots of body gestures, using words that contain action, like books that are plot-oriented [17].

4. Conclusion
Based on the results of the analysis in the study, the following conclusions were obtained: 1) There was no difference in ability between students in visual, auditory and kinesthetic learning styles in solving PISA-oriented mathematics problems, 2) There are 23 students who have a visual learning style or 70% of the population, 30% of them are in the high category, 44% are in the medium category, and 26% are in the low category. 3) There are 8 students who have an auditory learning style or 24% of the population. 62.5% of them are in the medium category, and 37.5% are in the low category. 4) There are 2 students who have a kinesthetic learning style, the two students are one in the medium category and one in the low category. In general, each visual auditory and kinesthetic student has the ability to analyze, evaluate, and create as part of the higher order thinking component. However, each of them has a weakness in these abilities.

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