

Students' Mathematical Literacy in Solving PISA Problems Observed by Learning Styles

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Abstract

Mathematical literacy helps an individual recognize the role or use of mathematics in everyday life. One of the factors supporting mathematical literacy is the learning style of the student. This study aimed to describe the mathematical literacy of students in the context of SMP Negeri 1 Palopo based on their answers to PISA test questions by observing their learning styles. The subjects in this study were three eighth graders each representing visual, auditory, and kinesthetic learning styles. The data instruments used were a learning style questionnaire, a mathematical literacy test based on the 2012 PISA test draft, and an interview guide. The results of the learning style questionnaire were analyzed by referring to the indicators of the three learning styles under study, while the results of the PISA test were analyzed by referring to the indicators for each PISA level. The results of this study indicated that the visual student and the auditory student had mathematical literacy at level 3 as shown by their ability to connect and reflect things involved in interpretation and basic reasoning, while the kinesthetic student had mathematical literacy at level 4 as shown by their ability to build and communicate explanations and argumentation based on interpretations, arguments, and actions. Based on the research results, it is suggested that students be accustomed to working on PISA-like problems to improve their mathematical literacy.

Keywords: Mathematical Literacy, PISA Questions, Visual, Auditory, Kinesthetic Learning Styles

Abstrak

Kemampuan literasi matematika membantu seseorang untuk mengenali peran atau kegunaan matematika dalam kehidupan sehari-hari. Salah satu faktor pendukung kemampuan literasi matematika adalah gaya belajar peserta didik. Penelitian ini bertujuan untuk mendeskripsikan kemampuan literasi matematika peserta didik dari hasil tes soal PISA dengan meninjau dari gaya belajar di SMP Negeri 1 Palopo. Subjek dalam penelitian ini adalah 3 peserta didik kelas VIII yang masing-masing memiliki gaya belajar visual, auditori dan kinestetik. Instrumen data yang digunakan adalah angket gaya belajar, tes kemampuan literasi dan wawancara. Data dianalisis secara deskriptif. Hasil penelitian ini menunjukkan bahwa peserta didik dengan gaya belajar visual dan peserta didik dengan gaya belajar auditori memiliki kemampuan literasi matematika pada level 3 dimana mereka sudah mampu menghubungkan serta mencerminkan hal-hal yang terlibat dalam interpretasi dan penalaran dasar sedangkan peserta didik dengan gaya belajar kinestetik memiliki kemampuan literasi matematika pada level 4 dimana dia sudah mampu membangun dan mengomunikasikan penjelasan dan argumen berdasarkan interpretasi, argumen dan tindakan. Berdasarkan hasil penelitian disarankan agar peserta didik dibiasakan mengerjakan soal-soal tipe PISA untuk meningkatkan kemampuan literasi matematisnya.

Kata kunci: Kemampuan Literasi Matematika, Soal PISA, Gaya Belajar Visual, Auditori, Kinestetik

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INTRODUCTION

The Programme for International Student Assessment (PISA) was initiated by the Organization for Economic Cooperation and Development (OECD) in 1990 to provide information to governments

and other interested parties about the effectiveness of the education system, especially in preparing students to face the challenges of their future lives (Stacey & Turner, 2015). PISA aims to test students' literacy competence in three areas: reading, mathematics, and science (Heine, 2022; Lestari & Putri, 2020). PISA assessment was first carried out in 2000, from which point Indonesia has been a participant. Indonesia's participation in the PISA study provides useful feedback for policymaking to improve and change the quality of mathematics learning in schools as well as benefits for students in competing on an international scale (Nizar, 2018). A person's mathematical literacy can be seen from the skills to formulate, apply, and interpret mathematics in various contexts, including the ability to reason mathematically and use concepts, procedures, and facts to describe, explain, or estimate phenomena or events (OECD, 2015). The inability to solve mathematical problems will have an impact on the development of the fundamental mathematical abilities that individuals must have (Oktaviyanthi & Agus, 2019).

In solving daily life problems related to certain contexts, it is not enough to only use the mathematical abilities of counting and performing mathematical operations; abilities that involve broad mathematical knowledge under mathematical literacy are needed (De Lange, 2003; Fadillah & Ni'mah, 2019). Selan et al. (2020) described a learner as having good literacy not only if they are able to analyze, reason, and communicate their mathematical knowledge and skills effectively, but also if they are able to solve and interpret mathematical problems. Therefore, mathematical literacy is critical for students to be able to use mathematics in everyday life.

Indonesian students' mathematical literacy is constantly at low levels. Indonesia's average mathematical literacy score decreased from 386 points in 2015 to 379 points in 2018, compared to the OECD average of 489 points; only 28 percent were able to acquire level two proficiency or higher, compared to the OECD average of 76 percent (OECD, 2019). The low PISA results are attributed to a multitude of factors (Heine, 2022). One of such factors is the fact that students are generally less trained in solving questions with characteristics alike to PISA mathematical questions. Machromah et al. (2020) stated that students' weak ability to solve PISA mathematical problems is caused by the students' being not used to the stages in a correct problem-solving process, i.e., understanding problems, planning, problem-solving, and checking the results. Other determinant factors in the mathematical literacy achievement of Indonesian students are personal, instructional, and environmental ones (Masjaya & Wardono, 2018). None of the existing studies mentioned learning styles as a factor that influences mathematical literacy.

Lehmann & Ifenthaler (2012) defined learning style as a student's unique way of learning. Oftentimes, students are not aware of this distinctive way of learning, which after being formed will tend to last for a long time. Therefore, introducing or directing students to recognizing learning styles will help them absorb information properly, optimally, and effectively and in turn increase their achievement (Isnanto, 2022).

A learner's academic achievement depends not only on their intellectual ability, but also on their unique learning style. Human learning styles are generally divided into three groups, namely, visual, auditory, and kinesthetic (DePorter & Hernacki, 2007; Hasanudin & Fitriani, 2019; Hertiandito, 2016). Students with a visual learning style tend to learn through what they see, take a liking in reading, observe rather than act or speak, usually spell well, memorize by looking at graphs or pictures, have a tolerance to distractions, have a difficulty accepting verbal instructions, and have a good handwriting. Meanwhile, students with an auditory learning style tend to learn by what they listen to, like to talk to themselves out loud, get distracted easily, have difficulty with written instructions, like to read, memorize sequentially, like music, and whisper to themselves when reading. Unlike the first two types, students with a kinesthetic learning style learn a lot through movement, touching, and doing such as moving frequently, like physical rewards, like touching people when talking, tap pencils or feet while studying, like doing activities, see reading not as a priority, have bad spellings, like solving problems by working on them physically, have a willingness to try new things, come out naturally, express emotions in a physical way, and use the hands when speaking (Hertiandito, 2016).

There are several Indonesia-based research findings regarding mathematical literacy based on PISA assessment. One explored problem-solving abilities based on the categories of a mathematical literacy process. This study showed that the low-ability student was at the average level with an assessment achievement of 62.5%, the moderate-ability student was at the average-good level with an assessment achievement of 87.5%, and the high-ability student was at the good level with an assessment achievement of 93.75% (Oktaviyanthi & Agus, 2019). Meanwhile, Hidayah et al. (2020) found that a purely visual student, as opposed to their visual-auditory and visual-kinesthetic counterparts, could solve all PISA questions on three basic mathematical abilities. Subjects with visual-auditory and visual-kinesthetic learning styles, on the other hand, shared the same mathematical abilities only in two aspects. Therefore, it is interesting to investigate whether information on learning styles affects how a person determines strategies to solve PISA mathematical problems. Where Hidayah's research focused on different types of the visual learning style, this research did on three learning styles to find out how students would solve PISA mathematical questions.

METHODS

Using a descriptive qualitative approach, this study was carried out on eighth graders of SMP Negeri 1 Palopo. The subjects were selected based on Deporter's three learning styles, i.e., visual, auditory, and kinesthetic. Three subjects were selected after a learning style questionnaire was disseminated to twenty-seven students. Students were categorized based on the highest score for each learning style category.

In addition to the learning style questionnaire, data collection also employed PISA questions. The learning style questionnaire used was adopted from the learning style questionnaire developed by

O'Brien in his work entitled "Learning Styles: Make the Student Aware" (Pratiwi et al., 2020), which was then validated by two experts in educational psychology. This questionnaire contains thirty questions, including ten denoting the visual learning style, ten denoting the auditory learning style, and ten denoting the kinesthetic learning style. The questionnaire results were used to determine the research subjects to be involved. Meanwhile, the PISA questions used were taken from the 2012 PISA draft. The PISA test consists of 10 questions, detailed as follows: questions 2 and 7 are level 1 questions, questions 3 and 4 are level 2 questions, questions 1 and 5 are level 3 questions, questions 8 and 9 are level 4 questions, question 6 is a level 5 question, and question 10 is a level 6 question. This instrument was used to measure the level of mathematical literacy of each student in solving PISA questions based on learning styles. Table 1 presents a grid of PISA questions by question aspect.

Table 1. PISA mathematical questions grid

No	Description	Question Aspect			
		Process	Content	Context	Level
1	Apply area understanding to deriving value for money comparisons	Formulate	Shape and Space	Personal	3
2	Read a bar chart and compare the heights of two bars	Interpret	Uncertainty and data	Social	1
3	Read a bar chart	Interpret	Uncertainty and data	Social	2
4	Calculate the travel time required at a given speed for a given average travelled distance	Use mathematical concepts	Change and relationships	Personal	2
5	Choose a value that satisfies four defined numerical conditions/statements in a financial context.	Interpret	Uncertainty and data	Personal	3
6	Determine the start time for a trip at two given speeds, the total distance travelled, and the finish time	Formulate	Change and relationships	Social	5
7	Identify average daily rates with totals and specific time periods (date provided)	Use concepts, facts, and others	Uncertainty and data	Social	1
8	Apply proportionality based on a data set	Use mathematical concepts	Uncertainty and data	Social	4

No	Description	Process	Question Aspect		
			Content	Context	Level
9	Interpret floor plans and calculate the area of a rectangle using the Pythagorean theorem or measurements	Use mathematical concepts	Shape and Space	Occupational	4
10	Understand the specific situation and choose the appropriate mathematical model	Formulate	Change and relationships	Occupational	6

In analyzing data with the descriptive qualitative analysis, the three stages in Miles and Huberman's (Selan et al., 2020) model were used: data reduction; data presentation; and conclusion drawing. The data reduction stage involved some data from the learning style questionnaire and PISA test questions. The results of the student learning style questionnaire were analyzed by referring to the indicators of the three learning styles, while the PISA test results were analyzed by referring to the indicators for each PISA level. At this stage, the visual subject was coded PD-V, the auditory subject was PD-A, and the kinesthetic subject was PD-K. At the data presentation stage, the data that were collected from the learning style questionnaire and PISA test are presented in the forms of narrative descriptions. The final stage was drawing conclusions, where the mathematical literacy levels of the research subjects were concluded based on the indicators for each PISA level.

RESULTS AND DISCUSSION

The results from the mathematical literacy test will be described and analyzed. The results of the test for each subject are to be described and analyzed according to the indicators for each level of mathematical literacy in PISA. The following are the descriptions of the data obtained from the mathematical literacy test in PISA.

The Ability of the Student with the Visual Learning Style (PD-V)

<p>2. c. Alasannya : sesuai dengan grafik pada soal</p> <p>4. a. Waktu $\frac{16 \text{ km}}{15 \frac{\text{km}}{\text{jam}}} = \frac{1}{2} \text{ Jam} = 20 \text{ Menit}$</p> <p>5. Bolte, karena chris ingin mobil yang memenuhi semua kondisi</p> <p>1. Pizza yang lebih baik dengan murah adalah 40 cm dan biaya 40 zeds karena pizza 40 cm lebih besar dari pada 30 cm</p> <p>6. Butuk Waktu 2 jam untuk kembali mendaki gunung tersebut</p> <p>7. Rata-rata banyak orang yang mendaki gunung setiap hari adalah 3400 1 Juli \rightarrow 27 Agustus = 58 hari $\frac{200.000}{58} = 3458 \text{ hari/orang}$ Jawaban c</p> <p>3. b. 500, karena jumlah Meltafokres terjual pada bulan april adalah 500</p> <p>8. 680.8 karena jumlahnya sebesar 85,8%.</p> <p>9. 6.25 karena luas atap tersebut adalah 2,50 jika digabung menjadi 6,25</p> <p>10. a. $P = 10.000 \times (1,5 \times 0,2)^7$</p>	<p>Translated into English:</p> <p>2. c. Reason: according to the graph in the question</p> <p>4. a. Time : $\frac{16 \text{ km}}{15 \text{ km/hour}} = \frac{1}{2} \text{ hour} = 20 \text{ minutes}$</p> <p>5. bolte, because chris wants a car that fulfils all conditions</p> <p>1. the better and cheaper pizza is 40 cm, that is sold for 40 zeds. because a 40 cm pizza is bigger than a 30 cm one.</p> <p>6. It takes 2 hours to climb back up the mountain</p> <p>7. The average number of people who climb a mountain every day is 3400. 1 July \rightarrow 27 August = 58 days $\frac{200.000}{58} = 3458 \text{ days/person,}$ answer c.</p> <p>3. b. 500, because the number of meltafokies sold in april was 500</p> <p>8. 680.8. because it amounts to 85.8%</p> <p>9. 6.25. because the area of the roof is 2.50. when combined it becomes 6.25</p> <p>10. a. $P = 10,000 \times (1,5 \times 0,2)^7$</p>
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Figure 1. The answer of the student with the visual learning style

Figure 1 shows the answers of the student with the visual learning style, the student was able to provide answer to all questions, but only a were correct.

The Ability of the Student with the Auditory Learning Style (PD-A)

1. Pizza 1 $d = 30 + r = 15$ cm
 Pizza 2 $d = 40 + r = 20$ cm

Pizza 1 = πr^2
 $= 3,14 \times 15 \times 15$
 $= 706,5 \text{ cm}^2$

Pizza 2 = πr^2
 $= 3,14 \times 20 \times 20$
 $= 1256 \text{ cm}^2$

8.

3. c. Alasannya sesuai grafik pada soal

4. 18 km c. Helen membutuhkan waktu 3 jam untuk sampai ketumahnya bibingnya

2. CD No one darling dan the metalfolkies juga ditulis dengan jumlah yang sama yaitu 250. pada bulan beberapa band No one's darling menjual CD lebih banyak dari pada band the Kicking Kangaroos untuk pertama kalinya

a. tidak ada

5. 105.000 alpha

6. dari jalan kaki sejauh 18 km sebelum jalan di dalam

7. rata-rata yang mendekati
 1 Juli hingga 27 Agustus = 58 hari
 jadi $\frac{200.000}{58} = 3448,14$ hari/orang
 jawaban: c

9. luas atap = $\sqrt{2,50^2 + 1,00^2}$
 $= \sqrt{7,25 \text{ m}^2}$

10. pada awalan tahun suatu koloni terdiri dari 10.000 penguin 5000 pasangan penguin memelihara satu anak di musim semi setiap tahun a. p = $10.000 \times (1,5 \times 0,2)^7$

Translated into English:

1. Pizza 1 $d = 30 + r = 15$ cm
 Pizza 2 $d = 40 + r = 20$ cm
 Pizza 1 = $\pi r^2 = 3,14 \times 15 \times 15$
 $= 706,5 \text{ cm}^2$
 Pizza 2 = $\pi r^2 = 3,14 \times 20 \times 20$
 $= 1256 \text{ cm}^2$

8.

3. c. The reason is that it is in accordance with the graph in the question

4. 18 km c. It takes Helen 3 hours to reach her aunt's house.

2. No One's Darling and The Metalfolkies CDs were also released in the same number of 250. In which month did the band No One's Darling sell more CDs than the band The Kicking Kangaroos for the first time?
 a. none

5. 105.000 alpha

6. From an 18 km walk before 8 pm

7. The average number of hikers, 1 July to 27 August = 58 days
 So, $\frac{200000}{58} = 3448,4$ days/person,
 answer: c

9. Roof area = $\sqrt{2,50^2 + 1,00^2}$
 $= \sqrt{7,25 \text{ m}^2}$

10. At the beginning of the year a colony consists of 10,000 penguins with 5000 pairs. Each penguin pair raises one chick in spring each year.
 a. $P = 10,000 \times (1,5 \times 0,2)^7$

Figure 2. The answer of the student with the auditory learning style

Figure 2 shows the answers of the student with the auditory learning style. It can be seen that the student was able to give answers to nine of ten questions, but only a few were correct.

The Ability of the Student with the Kinesthetic Learning Style (PD-K)

1. Pizza yang lebih baik dan murah adalah 40 cm karena lebih besar dari pada 30 cm.

2. Jawaban : c. April

3. Jawaban : c. 500

5. Jawaban : D.

8. 2,8 juta

6. Mulai Mendaki jam 9 pagi

7. Jawaban b. 710

10. Jawaban a.

4. Waktu = $\frac{18 \text{ km/jam}}{6 \text{ m}}$
 $= 3 \text{ Jam}$
 Jadi Jawaban c.

9. Lebar = $\sqrt{2,50^2 + 1,00^2}$
 $= \sqrt{7,25}$
 $= 2,69$
 Luas = p x l
 $= 6,00 \times 2,69$
 $= 16,14 \text{ m}^2$
 Jadi Luasnya adalah 16,14 m²

Translated into English:

- The better and cheaper pizza is the 40-cm one because it is bigger than the 30-cm one
- Answer: c. April
- Answer : c. 500
- Answer : b.
- 2.8 million
- Start hiking at 9 am
- Answer: b. 710
- Answer: a.
- Time = $\frac{18 \text{ km/hour}}{6 \text{ km}} = 3 \text{ hours}$
So Answer c.
- Width = $\sqrt{2,50^2 + 1,00^2}$
Area = L x W
 $= \sqrt{7,25 \text{ m}^2}$
 $= 6,00 \times 2,69$
 $= 16,14 \text{ m}^2$
 So, the area is 16,14 m²

Figure 3. The answer of the student with the kinesthetic learning style

Figure 3 shows the answers of the student with the kinesthetic learning style. It can be seen that the student was able to give answers to all questions, but only a few were correct (Table 2).

Based on the Figure 1, Figure 2, and Figure 3, each student was only able to answer a few questions correctly. It was figured out that the student with the visual learning style (PD-V) and the student with the auditory learning style were at level 3, while the student with the kinesthetic learning style (PD-K) was already at level 4. To confirm the mathematical literacy level of each student, a further analysis was carried out. The results are provided by level below.

Table 2. Results of the analysis of students' answers by question level

Levels	About	Description of PISA Problems	Analysis of Students' Answers		
			PD-V	PD-A	PD-K
1	2	Apply area understanding to deriving value for money comparisons	Answered correctly with the right reason In this question students were required to read and interpret a bar chart and compare the heights of the two bars.	Answered correctly	Answered correctly
	7	Read a bar chart and compare the heights of two bars	Answered correctly In this question students were required to use concepts or facts in identifying average daily rates with a total number and specific time periods.	Answered incorrectly	Answered incorrectly
2	3	Read a bar chart	Answered correctly with the right reasons In this question students were required to read and interpret a bar chart.	Answered correctly with the right reasons	Answered correctly with the right reasons
	4	Calculate the travel time required at a given speed for a given average travelled distance	Answered correctly In this question students were required to use mathematical concepts in calculating the time taken at a given speed for a given average travelled distance.	Answered incorrectly	Answered incorrectly
3	1	Choose a value that satisfies four defined numerical conditions/statements in a financial context	Answered correctly but neither explained orally nor converted the problem into a mathematical form In this question students were required to be able to work effectively and formulate models in complex real situations.	Answered incorrectly	Answered incorrectly
	5	Determine the start time for a trip at two given speeds, the total distance travelled, and the finish time	Answered correctly In this question students were required to know and interpret things that meet existing conditions.	Answered incorrectly	Answered incorrectly
4	8	Identify average daily rates with totals and specific time periods (date provided)	Answered incorrectly In this question students were required to be able to apply concepts, facts, and others in proportionality based on the data provided.	Did not answer question	Did not answer question

Levels	About	Description of PISA Problems	Analysis of Students' Answers		
			PD-V	PD-A	PD-K
	9	Apply proportionality based on a data set	Answered inaccurately In this question students were required to use mathematical concepts such as the Pythagorean theorem and measurement in interpreting plans and calculating the area of a rectangle	Answer incorrectly	Answered incorrectly
5	6	Interpret floor plans and calculate the area of a rectangle using the Pythagorean theorem or measurements	Answered incorrectly In this question students were required to calculate the start time for a given trip at two different speeds, the total distance travelled, and the finish time.	Answered incorrectly	Answered incorrectly
6	10	Understand the specific situation and choose the appropriate mathematical model	Answered incorrectly In this question students were required to formulate and understand certain situations and choose those that are appropriate to the mathematical model	Did not answer the question	Did not answer the question

Based on [Table 2](#), students with different learning styles answered the questions differently, and based on PISA level indicators, their literacy levels were different too. The students' abilities to solve problems based on the PISA level indicators are described by learning style below.

The Student with the Visual Learning Style (PD-V)

The student with the visual learning style achieved mathematical literacy level 3, meaning that they were able to connect and reflect on things involved in interpretation and basic reasoning. In this case, the more the visual learning style was used, the better the result obtained. A student with the visual learning style basically understands a subject matter through seeing and observing an object that they see. Supriyomo and Ahmadi (2004) pointed out that a person who is of a visual type will quickly learn materials presented in writing, charts, graphs, or pictures; in other words, it is easier for the person to learn materials that can be seen with their visual aids. They can choose and apply simple problem-solving strategies (Imam et al., 2020).

The student with the visual learning style in this study was only able to solve PISA problems that only involve typical contexts where all information is available and clearly identifiable, carry out routine procedures according to the instructions and stimulation given, interpret and recognize situations requiring direct conclusions, give precise reasons for their solutions, work using formulas, make literal interpretations of the results, and carry out procedures including those that require a sequence of decisions clearly.

The Student with the Auditory Learning Style (PD-A)

The student with the auditory learning style was able to achieve mathematical literacy level 3, meaning that they were able to connect and reflect on things involved in interpretation and basic reasoning. In this case, the more the auditory learning style was used, the better the result obtained. A student with the auditory learning style finds it easier to digest, process, and convey things related to direct listening. They tend to receive information by listening or orally (Soleh & Yanti, 2019; Widayanti, 2013). This helps the student absorb and process information with good listening skills to achieve good results, both in terms of problem-solving and others. They can work effectively with concrete but complex models and situations (Imam et al., 2020).

The student with the auditory learning style in this study was only able to solve PISA problems that involve typical contexts where all information is available, carry out routine procedures in accordance with the instructions given, interpret and recognize situations requiring direct conclusions, give appropriate reasons, solve problems, and implement simple strategies, and interpret and use representations based on direct information sources.

The Student with the Kinesthetic Learning Style (PD-K)

The student with the kinesthetic learning style had achieved mathematical literacy level 4, meaning that they were able to build and communicate explanations and argumentation based on interpretations, arguments, and actions. In this case, the more the kinesthetic learning style was used, the better the result obtained. A student with the kinesthetic learning style learns through physical activity and direct involvement, which can be in the form of moving, touching, and feeling/experiencing (Hertiandito, 2016; Widayanti, 2013). By directly doing something that is learned, the student will always remember the learning experience, which will have a positive impact both in terms of problem-solving and others.

The student with the kinesthetic learning style could conceptualize and generalize using information in complex problems and situations (Imam et al., 2020). They were already able to solve PISA questions that only involve typical contexts where all information is available and clearly identified, carry out routine procedures according to the instructions and stimulation given, interpret and recognize situations that require immediate conclusions, provide reasons precisely for the solutions, work with formulas, make literal interpretations of the results, clearly execute procedures including those requiring a sequence of decisions, work effectively with explicit models for complex concrete situations that may involve constraints or calls to make assumptions, and select and integrate different representations, including symbolic ones.

CONCLUSION

Based on the results of the research, it is concluded that the student with the visual learning style was able to solve PISA questions at levels 1, 2, and 3 well even though there were some errors in the solutions. Therefore, it can be said that in solving PISA questions the student with the visual learning style demonstrated mathematical literacy at level 3. The student with the auditory learning style, too, was able to solve PISA questions at levels 1, 2, and 3 well even though there were some errors in the solutions. Therefore, it can be said that in solving PISA questions the student with the auditory learning style demonstrated mathematical literacy at level 3. Meanwhile, the student with the kinesthetic learning style was able to solve PISA questions at levels 1, 2, 3, and 4 well even though there were some errors in the solutions. Therefore, it can be said that in solving PISA questions the student with the kinesthetic learning style demonstrated mathematical literacy at level 4. Based on these conclusions, educators are suggested to be more familiar with various learning styles and implement learning activities that are appropriate with the learning styles of the students to facilitate their understanding, especially in terms of problem-solving in the context of PISA.

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