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Mathematical literacy of senior high school students on different multiple intelligences groups

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Abstract: Mathematical literacy is one of the mathematical skills that must be mastered. However, students' mathematical literacy in Indonesia is still fairly low. This study aimed to analyze and describe the mathematical literacy of senior high school students on different multiple intelligences groups in solving PISA problems. The research method used was qualitative with a case study design. The research subjects were 15-year-olds 10th-grade students in one of the senior high schools in Karawang, Jawa Barat. The subjects consisted of two students in the linguistic intelligence group and two students in the logical-mathematical intelligence group who were selected through a purposive sampling technique. Data collection techniques were carried out by filling out a multiple intelligence questionnaire, PISA test, and interviews then analyzed by reducing data, presenting it, and drawing conclusions. The results showed that: 1) students in the linguistic intelligence group are able to interpret the problem, but not able to formulate and employ mathematics to the problem; and 2) students in the logical-mathematical intelligence group are able to employ mathematics and interpret the problem, but not able to formulate the problem. The results emphasize the necessity for customized instructional strategies that address students' different multiple intelligences.

Keywords: linguistic intelligence; logical-mathematical intelligence; mathematical literacy; multiple intelligences; PISA problems

1. Introduction

Mathematical literacy, or what is known as numeracy in the Merdeka Curriculum, is one of the primary focuses in mathematics in Indonesia, aiming to enhance students' abilities in understanding and utilizing mathematical concepts in everyday life (Kemdikbudristek, 2024). In various countries, particularly in the Commonwealth of the United Kingdom, the term numeracy is also used to refer to mathematical literacy (Stacey, 2011). Internationally, the Programme for International Student Assessment (PISA) highlights the importance of mathematical literacy to prepare students for the increasingly competitive global (Bolstad, 2023; Chen, 2022; OECD, 2023).

In Indonesia, the results of the 2022 PISA study indicate that students' mathematical literacy remains relatively low, with an average score of 366, far below the international average score of 472 (OECD, 2023) whereas mathematical literacy encompasses the ability to formulate, employ, and interpret mathematical problems in various life contexts. The results of another study show that the mathematical literacy of junior high school students is still relatively low because students have difficulty dealing with PISA problems with levels 1 and 2 (Masfufah & Afriansyah, 2021). This low level of mathematical literacy suggests that Indonesian students are not yet fully capable of comprehending, applying, and utilizing mathematical concepts to solve everyday problems. De Lange (2006) defines mathematical literacy as the ability of individuals to solve real problems, namely problems that are not only purely mathematical but can be mathematically positioned in certain situations. While other publications define mathematical literacy as the knowledge to know and use basic mathematics in everyday life (Chen et al., 2022; Köysüren & Üzel, 2018). Based on the three previous opinions, the researchers concluded that mathematical literacy is the ability of students to formulate, employ, and interpret everyday problems mathematically.

A systematic literature review on the mathematical literacy of Indonesian students shows that their ability remains low across all educational levels, from elementary to college (Aisyah & Juandi, 2022; Sari and Wijaya, 2017). This deficiency is due to students' inability to achieve the three key indicators of mathematical literacy set by PISA: the ability to formulate, employ, and interpret mathematics to solve problems. This challenge necessitates continuous efforts to improve students' numeracy competencies across all levels of education.

One effort to enhance students' mathematical literacy in Indonesia is through government policies set forth in the Merdeka Curriculum and Asesmen Kompetensi Minimum (AKM) Numeracy (Kemdikbudristek, 2024). These policies establish assessment indicators aligned with mathematical literacy needs, such as the ability to know, apply, and reason through mathematical concepts (Kemdikbudristek, 2023). With this curriculum, students are expected to sharpen their competencies in aspects closely tied to everyday applications.

Previous research has shown a link between mathematical literacy skills and students' internal factors, one of which is multiple intelligences. Studies have found a positive and significant effect of multiple intelligences on students' ability to solve mathematical literacy problems (Purnama & Suparman, 2020; Septyaningsih & Kutoarjo, 2018). Then, multiple intelligence-based learning was able to develop each student's unique intelligence so that students could improve their mathematical abilities (Putri & Widjajanti, 2019). This learning model also showed to improve academic achievement in mathematics compared to traditional learning methods (Çelen, 2019; Hasmiwati & Widjajanti, 2020). After that, the research by Aini et al. (2019) about mathematical literacy of junior high school students in solving mathematical problems on the subject of number patterns based on multiple intelligences. Therefore, it can be concluded that multiple intelligences affect students' mathematical literacy. However, studies that connect multiple intelligences with mathematical literacy among high school students in the context of PISA problems remain scarce.

There are several previous research results that are relevant to the topic of mathematical literacy. There is the research by Kusuma et al. (2022) about mathematical literacy of junior high school students based on executive function. Then, Harisman et al. (2023) examined the mathematical literacy of junior high school students in urban areas in solving PISA problems. However, these studies have not involved multiple intelligences as a variable in their research. Therefore, this study aims to analyze and describe the mathematical literacy of senior high school students with different multiple intelligences in solving PISA problems.

This research is important to reveal how the conjecture between mathematical literacy and multiple intelligences on linguistic and logical-mathematical ones, particularly on senior high school level. The findings are expected to provide insights for educators to develop teaching strategies that align with students' diverse intelligences, thereby enhancing their mathematical literacy skills more effectively.

2. Materials and Methods

Based on the research objectives, namely analyzing and describing the mathematical literacy of senior high school students on different multiple intelligence groups in solving PISA problems, a qualitative research method with a case study design was chosen. The technique of selecting locations and subjects in this study used purposive sampling technique (Cohen et al., 2018; Gall et al., 2014; Marshall & Rossman, 2016; Miles & Huberman, 1994). Purposive sampling that was used in this study limited the location and subject according to the research objectives.

The research location was one of the senior high schools in Karawang, Jawa Barat. The research subjects were taken from 10th-grade senior high school students who were 15-year-old. The reason was that students in this category were among the research subjects in the PISA framework. This was in accordance with the PISA study (OECD, 2023; Stacey, 2011), which selected 15-year-old students spread across grades 8 junior high school to 11 senior high school as research subjects. This was quite complicated to implement in the field, because when data collection must bring several students from different grade levels to the same place. Therefore, the researchers focused on 10th-grade students in one of the senior high schools as research subjects in consideration of the ease of data collection in the field. This was a limitation of this study.

This study used data collection techniques in the form of age sorting, questionnaire filling, test completion, and interviews. First, the researchers asked the age of the students. Then, the researchers selected students who were 15-year-old to fill out the multiple intelligence questionnaire. This questionnaire consists of statements related to multiple intelligences using a Likert scale with codes 1 (strongly disagree) to 5 (strongly agree). Then, the results of the questionnaire were analyzed and students were grouped according to their type of multiple intelligences, namely linguistic or logical-mathematical intelligence. After that, the data was processed by ranking from the highest to the lowest score on each multiple intelligence questionnaire result. Then, two students with the first and second ranked questionnaire results in each type of multiple intelligence were selected so that two students were obtained in the linguistic intelligence group and two students in the logical-mathematical intelligence group so that four students were obtained as research subjects.

The four research subjects were directed to complete the PISA test. The PISA test was used to measure students' mathematical literacy level. The PISA problems were taken from the official PISA problems in 2012 that were translated and contextualized to adjust the logic of the research subjects. Five numbers of PISA problems in the form of descriptions were selected. The five numbers of problems were then expertly validated by English mathematics expert (certified) to ensure the correctness of the translation and mathematical context of the problems. The PISA problems represent indicators and cognitive levels of mathematical literacy adapted to the PISA study. In this study, researchers took 3 indicators and 5 levels to be tested with details in Table 1.

Table 1. PISA problem levels based on PISA Framework (OECD, 2023)

No	Experts	Sum
1	Interpretation	1
2	Application	2
3	Application	3
4	Application	4
5	Formulation	5

After the test was completed, students were interviewed one by one to confirm how they worked in solving the PISA test. The interviews were conducted using a semi-structured technique by referring to the interview guidelines that were prepared. However, this did not limit the researchers if they wanted to develop questions to explore students' answers. The interview guidelines were prepared based on mathematical literacy indicators of students' ability to formulate, employ, and interpret mathematical problems. After the entire data collection process was carried out, the researchers analyzed the data that had been collected.

The data analysis technique used in this research is the qualitative data analysis technique from Miles and Huberman (1994), which consists of: 1) data reduction; 2) data presentation; and 3) conclusion drawing and verification. In this study, data reduction was carried out on questionnaire data results. While the test and interview data were not reduced. After reducing the data, researchers presented the data.

Data are presented in various ways. The multiple intelligences questionnaire results are presented using tables of multiple intelligences questionnaire results. The PISA problem test results are presented in the form of a two-column image with the left column containing the scanned results of student test answers while the right column contains the translation. Meanwhile, the interview results are presented in the form of interview transcripts. After presenting the data, the researchers then draw conclusions and verification.

Drawing conclusions and verification is the end of the data analysis technique. In drawing conclusions, researchers used the triangulation method by comparing the data presentation of test and interview results to be elaborated by referring to the indicators of mathematical literacy so that hypothetical conclusions were obtained regarding the description of students' mathematical literacy in both linguistic and logical-mathematical intelligence groups. Furthermore, to strengthen the researchers' confidence and reduce research bias, the researchers verify by discussing the data processing process to hypothetical conclusions with experts or other researchers. After verifying, the researchers concluded the research to answer the problem formulation.

3. Results

This study's findings include the results of linguistic and logical-mathematical multiple intelligence questionnaire scores. The mean score of the linguistic type and the logical-mathematical type multiple intelligence questionnaire are presented in Table 2. Furthermore, the subjects who obtained the first and second rank scores were selected for further stage.

Table 2. Average scores of linguistic and logical-mathematical multiple intelligence questionnaires

Intelligences Type	Number of Research Subjects	Mean Score
Linguistic	26	31.73
Logical-mathematical	26	32.00

Table 3 shows the results of reducing multiple intelligence questionnaire score results, which only took four research subjects. These four research subjects became the selected subjects for further research. Based on Table 3, four subjects representing each type of multiple intelligences were obtained. These four subjects are the subjects of further research. Subjects SL-1 and SL-2 represent the first and second rank of linguistic type multiple intelligences, respectively. Then, subjects SM-1 and SM-2 represent the first and second rank of logical-mathematical type multiple intelligences, respectively. These four subjects were then given the PISA test to find out the description of their mathematical literacy.

Table 3. Selected multiple intelligence questionnaire score results

No.	Subject	Score	Description
1	SL-1	39	First-rank linguistic intelligence questionnaire score result
2	SL-2	37	Second-rank linguistic intelligence questionnaire score result
3	SM-1	39	First-rank logical-mathematical intelligence questionnaire score result
4	SM-2	38	Second-rank logical-mathematical intelligence questionnaire score result

In general, SL-1 and SL-2 subjects were mostly able to complete the PISA test. This PISA test was used to determine the mathematical literacy of the two subjects. However, there are some problem numbers that are not able to be answered properly by SL-1 and SL-2 subjects. The PISA Problems' test results of both subjects can be seen in Table 4.

Table 4. Linguistic type multiple intelligence PISA problems test results

Subject	**No.**				
	1	**2**	**3**	**4**	**5**
SL-1	✓	✓	✓	✓	-
SL-2	✓	-	✓	-	✓

Furthermore, SM-1 and SM-2 subjects were mostly able to solve the PISA problems test, which was used to determine their mathematical literacy. However, some problem numbers could not be answered properly by subjects SM-1 and SL-2. Both subjects' mathematical literacy test results can be seen in Table 5.

Table 5. Logical-mathematical multiple intelligence PISA problems test results

Subject	**No.**				
	1	**2**	**3**	**4**	**5**
SM-1	✓	✓	✓	✓	-
SM-2	✓	✓	✓	✓	✓

4. Discussion

4.1 Mathematical literacy of students in linguistic type multiple intelligence group

Based on Table 4, subject SL-1 was able to solve problems number 1, 2, 3, and 4 well, but had difficulty in solving problem number 5. Based on the indicators of mathematical literacy, the subject is able to employ mathematics to problems and interpret problems, but has not been able to formulate problems properly. As for the cognitive level of mathematical literacy, subject SL-1 was able to solve level 1, 2, 3, and 4 problems well, but had difficulty in solving level 5 problem.

The difficulty of SL-1 subjects in formulating problems in level 5 problem is mainly in formulating the sentence of the thing asked in the problem. This is not in accordance with the research of Aini et al. (2019) which states that students with linguistic intelligence are able to write answers in language that is easy to understand. This happens because students are too hasty in finding the final answer. Figure 1 illustrates the subject's test results in solving problem number 5. Figure 1 is supported by the interview data of problem number 5 subject SL-1 which is presented as follows.

P : "What do you know from problem number 5?"

SL-1 : "the average speed of climbing mountain is 1.5 km per hour and the average speed down the mountain is twice of the speed of going up, which means two times 1.5 equals 3 km per hour. Then, the distance of all climbs is 18 km, which means 9 km up and 9 km down."

P : "What is the problem of number 5?"

SL-1 : "The problem number 5 asks about when to start climbing the mountain if for example you have to have to return at eight o'clock at night."

P : "Why did you write on the answer sheet what was asked, when climber must return to the foot of the mountain no later than the foot of the mountain 20:00 at the latest?"

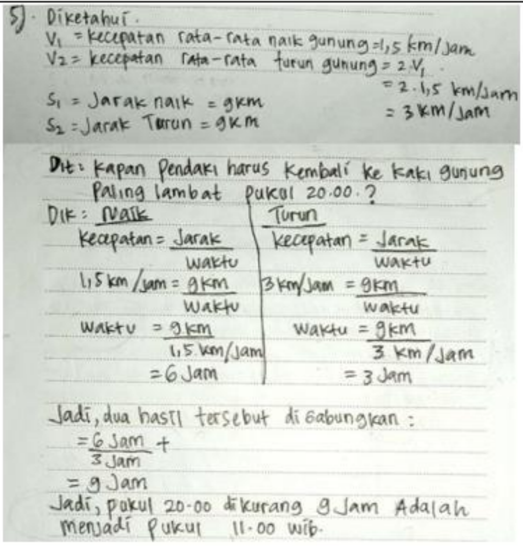
SL-1 : "It's complicated, bro, the writing is confused. The point is like that."

P : "What is the answer to problem number 5?"

SL-1 : "11 o'clock you have to start hike."

P : "Why is that? How did you get the answer?"

SL-1 : "We first counted each time between up and down. Then add up them and get the number 9. Now 9 is subtracted from 20.00 to 11.00."


5) Diketahui:
V_1 = kecepatan rata-rata naik gunung = 1,5 km/jam
V_2 = kecepatan rata-rata turun gunung = 2.V_1 = 2 · 1,5 km/jam = 3 km/jam
S_1 = Jarak naik = 9 km
S_2 = Jarak Turun = 9 km
Dit: Kapan Pendaki harus kembali ke kaki gunung paling lambat pukul 20.00 ?
Dik: Naik | Turun
Kecepatan = Jarak / waktu | Kecepatan = Jarak / waktu
1,5 km/jam = 9 km / waktu | 3 km/jam = 9 km / waktu
waktu = 9 km / 1,5 km/jam = 6 Jam | waktu = 9 km / 3 km/jam = 3 Jam
Jadi, dua hasil tersebut di gabungkan:
= 6 Jam + 3 Jam
= 9 Jam
Jadi, pukul 20.00 dikurang 9 Jam Adalah menjadi pukul 11.00 wib.

Number 5

We know:

v_1 = average speed when climbing a mountain = 1.5 km/hour

v_2 = average speed down the mountain = $2v_1$ = 2 (1.5) km/h = 3 km/h

s_1 = distance when climbing = 9 km

s_2 = distance on descent = 9 km

Ask:

When should the climber return to the foot of the mountain no later than 20:00?

Answer:

Climbing

Speed = distance / time

1.5 km/h = 9 km/time

Time = 9 km / 1.5 km/h = 6 hours

Down

Speed = distance / time

3 km/h = 9 km/time

Time = 9 km / 3 km/h = 3 hours

So, the two results are combined:

= 6 hours + 3 hours = 9 hours

So, at 20:00 minus 9 hours it is 11:00 pm

Figure 1. Number 5 subject SL-1 PISA problem test result

Based on the test and interview results of problem number 5, the SL-1 subject was able to write down the known things and the steps for solving them. However, the subject is not able to compose sentences about what is asked and draw conclusions according to the context.

The researchers presented the results and discussion of SL-1 subject of research. Furthermore, the researchers present the results of the mathematical literacy test and interview of subject SL-2. Based on Table 3, subject SL-2 was able to solve problems number 1, 3, and 5 well, but had difficulty in solving problems number 2 and 4. Based on mathematical literacy indicators, the subject was able to formulate and interpret the problems well. However, the subject is not able to employ math to the problem. As for the cognitive level of mathematical literacy, SL-2 subject was able to solve level 1, 3, and 5 problems well, but had difficulty in solving level 2 and 4 problems.

Figure 2 illustrates the subject's test result in solving problem number 2. Figure 2 is supported by interview data on problem number 2 SL-2 subject which is presented as follows.

P : "What do you know from problem number 2?"

SL-2 : "Helen has a new bicycle and used for cycling. First speed, the distance traveled was 4 km in time 10 minutes. In the next speed, speed distance traveled is 2 km in 5 minutes."

P : "Then, what is being asked from problem number 2?"

SL-2 : "This problem asks about Helen's cycling speed between the first speed and the second speed. Is it faster, slower, or the same."

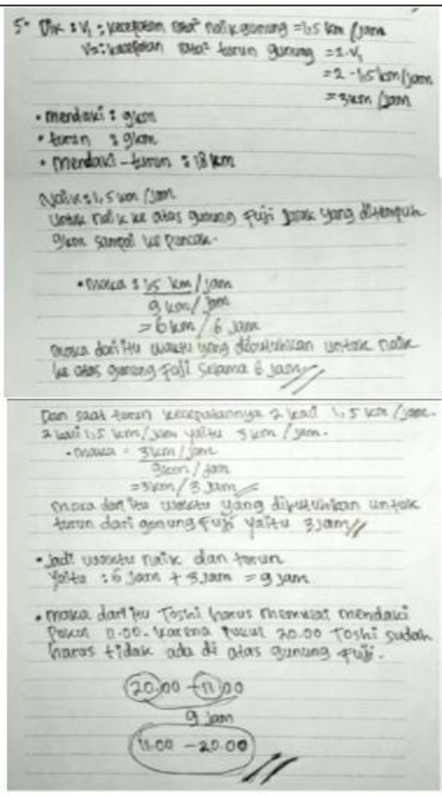
P : "So, what's your answer?"

SL-2 : "The answer is the same."

P : "Why is it the same?"

SL-2 : "Since the first speed is 4/10 km per minute and the secondis 2/5 km per minute. Hence, 4/10 and 2/5 are the same.

Based on the test and interview results of problem number 2, the SL-2 subject was able to conclude well. However, the subject is not able to design and implement strategies to find solutions because the subject is less precise in communicating the distance traveled at a certain time. The subject symbolized the distance of 4 km in 10 minutes with 4 km = 10 m and the distance of 2 km in 5 minutes with 2 km = 5 m. In addition, they are not used to symbolize the minute unit with m, even though the m symbol is used for the meter unit. The student is also not able to employ mathematical procedures because they cannot decompose "4/10 = 2/5".



Number 5

We know:

v_1 = average speed when climbing a mountain = 1.5 km/hour

v_2 = average speed down the mountain = $2v_1$ = 2 (1.5) km/h = 3 km/h

climb = 9 km

down = 9 km

climb - down = 18 km

climbing: 1.5 km/h

To climb Mount Fuji, the distance to the top of the mountain is 9 km.

Then, $\frac{1.5\ km/h}{9\ km/h} = \frac{6\ km}{6\ h}$

Therefore, the time required to climb Mount Fuji is 6 hours.

And when descending, the speed is 2 times 1.5 km/h.

2 times 1.5 km/h is 3 km/h

Then, $\frac{3\ km/h}{9\ km/h} = \frac{3\ km}{3\ hours}$

Therefore, the time required to descend Mt. Fuji is 3 hours

So, the climbing and descending times are:

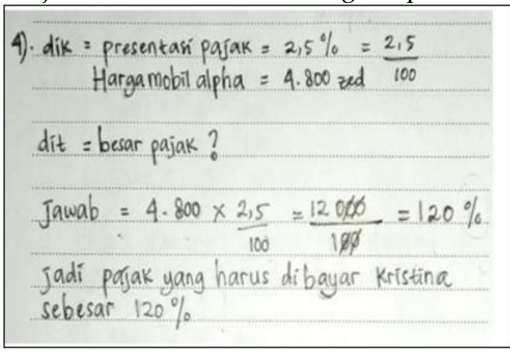
6 hours + 3 hours = 9 hours

Then, Toshi had to start climbing at 11 a.m., because by 8 p.m. Toshi was no longer at the top of Mount Fuji.

20.00 - 11.00 = 9 hours =11.00-20.00

Figure 2. Number 2 subject SL-2 PISA problem test result

The researchers have presented the results and discussion of SL-2 subject research on the problem number 2. Furthermore, the researchers present the test results and interview of the mathematical literacy subject SL-2 on the problem number 4. Figure 3 illustrates the subject's test results in solving the problem number 4.



Number 4

We know:

Tax presentation = 2.5% =2.5/100

Alpha car price = 4,800 zed

Ask:

Tax amount

Answer:

$4{,}800\frac{2.5}{100} = \frac{12{,}000}{100} = 120\%$

So, the tax payable by Kristina is 120%.

Figure 3. Number 4 subject SL-2 PISA problem test

Figure 3 is supported by the interview data on problem number 4 of SL-2 subject which is presented as follows.

P : "What do you know from problem number 4?"

SL-2 : "Kristina wants to buy an Alpha car for 4,800 zeds with 2.5% tax or 2,5/100."

P : "What is asked from problem number 4?"

SL-2 : "the amount of tax."

P : "What's your answer?"

SL-2 : "120%"

P : "The reason?"

SL-2 : "4,800 multiplied by 2.5/100 equals with 12,000/100. Then the two zeros above and below can be crossed out so 120/1 equals 120 bro."

P : "Why did you take unit as answer in percent?"

SL-2 : "Because it adjusts the tax unit, which is in the form of percent.

Based on the test and interview results of the problem number 4, SL-2 subject is able to design and implement strategies to find solutions and apply mathematical procedures but cannot conclude solutions within the context of the problem. This can be seen from the answer unit used is 120% even though the amount of tax calculated is in zed units.

Based on the discussion in the previous paragraph, it can be concluded that students in the linguistic intelligence group are able to interpret problems but are not able to formulate the problems and employ the mathematics to the problems properly.

Students in the linguistic intelligence group were able to interpret the problem well. This is in accordance with research Aini et al. (2019), which states that students with linguistic intelligence were able to interpret problems in detail and were able to write answers by writing answers in language that is easy to understand. This ability was supported by Armstrong (2009), who defines linguistic intelligence as a person's ability to use words effectively both orally and in writing. Therefore, students with linguistic intelligence are able to interpret the problem in detail due to their proficiency in language.

4.2 Mathematical literacy of students in the logical-mathematical type multiple intelligence group

Based on Table 5, subject SM-1 was able to solve problems number 1, 2, 3, and 4 well but had difficulty in solving problem number 5. Based on mathematical literacy indicators, the subject was able to employ mathematics and interpret the problems but was not able to formulate the problems properly. As for the cognitive level of mathematical literacy, subject SM-1 was able to solve level 1, 2, 3, and 4 problems well, but had difficulty in solving level 5 problems.

The difficulties of subject SM-1 in formulating problems are mainly in mathematization, designing strategies, and using language and symbolic operations both formal and technical. While OECD (2017) suggests the importance of seven basic mathematics skills with three of them being the ability to mathematize, design strategies, and use language and symbolic operations. Figure 4 illustrates the subject's test results in solving problem number 5. Figure 4 is supported by the interview data of subject SM-1 which is presented as follows.

P : "What do you know from problem number 5?"

SM-1 : "the average speed over mountain is 1.5 km per hour and average speed in the downhill of the mountain is twice of that. Two times 1.5 equals to 3 km per hour."

P : "What is the problem of number 5?"

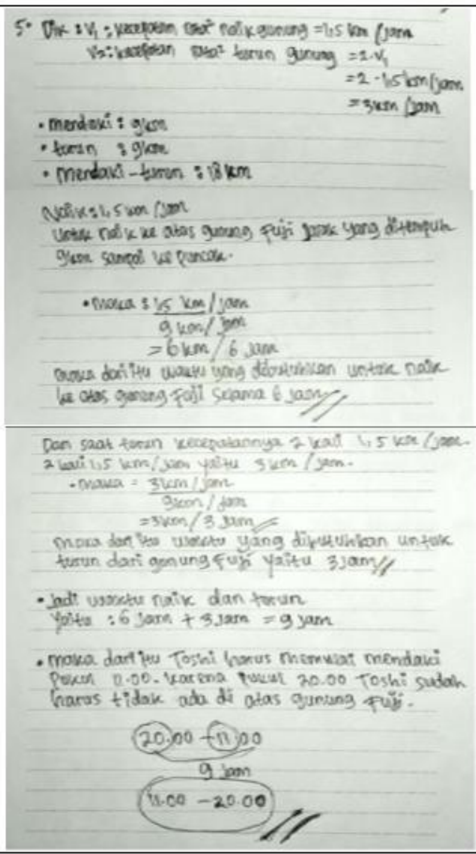
SM-1 : "when should Toshi start climbing."

P : "What is the answer to problem number 5?"

SM-1 : "Toshi can start climbing at 11:00."

P : "How did you get that answer?"

SM-1 : *"first we calculate time to climb the mountain. It is for 1.5 km needs 1 hour. It means 9 km needs 1.5 times 6, which means 6 hours. Then, we calculate the time to go down the mountain. It is 3 km for 1 hour. It means 9 km needs 3 km multiplied by 3 means 3 hours. Now we add so we get 6 + 3 = 9 hours. Then count backwards from 20:00 to get 11.00."*



Number 5
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climb = 9 km
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To climb Mount Fuji, the distance to the top of the mountain is 9 km.
Then, $\frac{1.5\ km/h}{9\ km/h} = \frac{6\ km}{6\ h}$
Therefore, the time required to climb Mount Fuji is 6 hours.
And when descending, the speed is 2 times 1.5 km/h.
2 times 1.5 km/h is 3 km/h
Then, $\frac{3\ km/h}{9\ km/h} = \frac{3\ km}{3\ hours}$
Therefore, the time required to descend Mt. Fuji is 3 hours
So, the climbing and descending times are:
6 hours + 3 hours = 9 hours
Then, Toshi had to start climbing at 11 a.m., because by 8 p.m. Toshi was no longer at the top of Mount Fuji.
20.00 - 11.00 = 9 hours =11.00-20.00

Figure 4. Test result number 5 of subject SM-1

Based on the test and interview results of problem number 5, subject SM-1 was able to write down the known things. However, the subject was not able to write down what was asked, describe the solution steps properly and correctly, and draw conclusions.

The researchers have presented the results and discussion of the research of subject SM-1 on problem number 5. Next, the researchers present the research results of subject SM-2. Based on the Table 5, subject SM-2 was able to solve problems number 1, 2, 3, 4, and 5 well. Based on the mathematical literacy indicators, the subject was able to formulate, employ mathematics to problems and interpret problems well. As for the cognitive level of mathematical literacy, subject SM-2 was able to solve level 1, 2, 3, 4, and 5 problems well.

Subject SM-2 was able to fulfill each mathematical literacy indicator and 5 levels of problems tested well. This is in accordance with the research of Aini et al. (2019), which states that students with logical-mathematical intelligence are able to complete all mathematical literacy indicators well.

4.3 Mathematical literacy of students in linguistic and logical-mathematical multiple intelligence group

The similarity of students' mathematical literacy in the linguistic and logical-mathematical intelligence groups is that they are both able to interpret the problems and are not able to formulate the problems properly. As for the difference, in the indicator of employing mathematics to the problems, students in the logical-mathematical intelligence group are better at solving problems than students in the linguistic intelligence group.

Students in the linguistic and logical-mathematical intelligence groups both are not able to fulfill the indicators of the ability to formulate the problems. This is supported by research results of Edo et al. (2013) which states that one of the factors that cause students' low mathematical literacy is students' difficulty in formulating mathematical problems in everyday life into mathematical models. This is reinforced by the research results of Dewantara et al. (2015) which showed that students' mathematical literacy achievement in fulfilling the indicator of formulating the problems was the lowest (39.63%) compared to the indicator of employing mathematics to the problems (40.74%) and the indicator of interpreting problems (52.55%). Furthermore, the research result of Sa'diyah et al. (2024) showed that the students have difficulty in formulating mathematical problems from contextual mathematical problems. The thing that causes the low ability to formulate problems is the level of difficulty of the problem.

The difficulty level of the problems with indicators of formulating problems is the problem with the highest difficulty level when compared to the other four problems tested in this study. The problem is categorized as level 5. Level 5 is a level that is included in Higher Order Thinking Skill (HOTS) (OECD, 2023). HOTS is a student's thinking ability that not only requires the ability to apply concepts in a situation, but also requires this ability in various situations (Kurniati et al. 2016). High-level thinking skills are complex abilities that include various perspectives of thinking at the same time. The results showed that students are able to solve HOTS mathematical literacy problems if they have effective understanding and reasoning skills (Heryani et al., 2023).

This study highlights mathematical literacy from a multiple intelligence perspective. This competency needs to be possessed by every student from any intelligence background considering its usefulness in the current era. With good mathematical literacy, students not only understand mathematical concepts but can also use them when facing real-world problems by involving problem-solving, reasoning, and mathematical communication skills (Köysüren & Üzel, 2018). In line with this statement, mathematical literacy is not only an educator's skill in the academic field, but also a fundamental competency for decision-making in everyday life (Chen et al., 2022). The education curriculum should prioritize the empowerment of this literacy as capital for students to face today's rapidly changing world (Nurgabyl, 2023). Therefore, educators need to apply learning approaches that accommodate various learning styles and background types of student intelligence.

The findings indicate a distinct possibility for educational interventions aimed at enhancing the ability to conceptualize mathematical problems, especially among students with varying types of intelligence. A potential advancement involves creating targeted instructional strategies that develop problem formulation skills by integrating real-life situations and scenarios relevant to students' everyday experiences. This method may assist students in transitioning from issue interpretation to precise mathematical formulation. Moreover, incorporating progressively challenging problem-solving activities, beginning with basic settings and advancing to higher-order thinking skills (HOTS) problems, could enhance students' abilities, fostering both confidence and competence. By correlating these tasks with the competences specified in the Merdeka Curriculum and the indications of AKM Numeracy, educators can more effectively tackle the issues identified in this study.

Future study may examine customized interventions that utilize students' diverse intelligences, assessing the efficacy of certain educational methods for groups with linguistic or logical-mathematical intelligence. This research may establish a basis for curricular enhancements that foster increased mathematical literacy among various intelligence groups, thereby aiding Indonesia's initiatives to develop mathematical competences both nationally and internationally.

Eventually, there are limitations to the research: 1) the researchers are not able to explore the factors that cause students in the linguistic intelligence group not to be able to formulate and employ mathematics to the problems; 2) the researchers have also not been able to explore the factors that cause students in the logical-mathematical intelligence group not to be able to formulate the problems. Therefore, the researchers suggest the other researchers with the same field of interest can consider continuing this research by exploring the factors that cause students in both multiple intelligence groups to be unable to fulfill those mathematical literacy indicators.

Based on the conclusions of the study, the researchers suggest the other researchers with the same field of interest can consider further research related to the factors that cause the students have not been able to communicate the answers in writing, mathematize well and use language and symbolic operations both formal and technical. Based on the limitations of the research in terms of methods, including the use of a case study design. This causes the results of this study to be limited to the space or time the research was conducted. Therefore, the researchers suggest the other researchers with the same field of interest can consider conducting similar research with another perspective such as grounded theory.

The cases in this study only used two types of multiple intelligences, while there are currently eight types of multiple intelligences. The researchers hope that the other researchers with the same field of interest can consider examining the other six types of multiple intelligences. Another limitation of this study is that the subjects of this study are 10th-grade senior high school students who are 15-year-old. Based on the PISA framework, 15-year-old students are generally spread from grade 9 in junior high school to grade 10 in senior high school. Therefore, the researchers suggest that other researchers with the same field of interest can consider examining 15-year-old 9th-grade junior high school students. Furthermore, this study is the limited use of the PISA problems instrument. The PISA problems, which was used in this study were the 2012 PISA problems, considering the aspects of the problem-solving process and the difficulty level of the problems. The researchers suggest to the other researchers with the same field of interest that the instrument be updated with the latest PISA problems and also consider the content and context aspects. The researchers hope that this study can open a dialog amongst the researchers, educators and the government in developing mathematical literacy when viewed from the type of multiple intelligences of students.

5. Conclusions

Based on the research results on the mathematical literacy of senior high school students on different multiple intelligence groups in solving PISA problems, it can be concluded that: 1) the mathematical literacy of students in the linguistic intelligence group are able to interpret the problem but are not able to formulate and employ mathematics to the problems; and 2) the mathematical literacy of students in the logical-mathematical intelligence group are able to employ mathematics and interpret the problem but are not able to formulate the problems. Students' difficulties in solving PISA problems are formulating problems and interpreting the problems. The contributing factors include: 1) students have not been able to communicate answers in writing; 2) students have not been able to mathematize well; and 3) students have not been able to use language and symbolic operations both formal and technical.

The researchers hope that this study can inspire fellow educators to conduct authentic assessments in the form of analyzing student answers and confirming answers through oral exams, as done in this study. In addition, researchers also hope that this research can be taken into consideration by the government, especially the Ministry of Education, Culture, Research, and Technology, in order to ground mathematical literacy (numeracy) as adapted by the Ministry of Education, Culture, Research, and Technology through the implementation of the Merdeka Curriculum and National Assessment (AKM Numeracy).

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