Mathematical literacy of students in solving PISA-like problems based on cognitive styles of field-dependent and field-independent

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Abstract. This qualitative-descriptive study aims to describe students’ mathematical literacy in field-dependent and field-independent styles in solving PISA-like mathematics problems. Based on the GEFT test, math ability test, and were of the same gender and communicated well, two students were obtained as subjects. Mathematical Literacy Task-based Interview was used to collect student’s mathematical literacy data. The results indicated the field-dependent student, when formulating, was able to identify information by mentioning using sentences in the questions and represented using verbal, symbols, and mathematical models representation. He was able to design and implement strategies, use procedures and mathematical reasoning when looking for solutions, but he was less precise in determining problem-solving. In interpreting, he was able to interpret mathematical solutions contextually, check again by working backward. On the other hand, when formulating, the independent field student was able to identify the information required by mentioning using their own language and using verbal representations, symbols, and appropriate modeling. In employ, he designed and implemented concise strategies, procedures, and mathematical reasoning to find solutions. In interpreting, he interpreted mathematical solutions in a profound contextual manner and checked again by repeating the problem-solving process.

1. Introduction
Mathematics learning should provide opportunities for students to solve mathematical problems in various situations. Not only requires memorizing skills and the ability to use procedures but also requires mathematical literacy skills. Mathematical literacy skills are essential abilities in students that need to be developed to deal with a problem, both in math problems and real-life problems [1]. The importance of mathematical literacy skills requires efforts to develop these abilities to face the realities of life.

Mathematical literacy is one of the abilities tested in PISA. PISA provides information to the government or other parties about the effectiveness of the particular education system in preparing for students’ future [2]. Assessment in PISA measures knowledge achievement and measures how well students can extrapolate from the knowledge they acquire and apply it to the real world [3].

Based on the 2018 PISA study in Indonesia, the average score of math literacy among Indonesian students is 379 and is ranked 73 out of 79 participants. This score has decreased compared to 2015 where Indonesia obtained a score of 386 for Mathematics [4]. This position shows the lower mathematical literacy of Indonesian students. One of the reasons for this is the lack of training of Indonesian students...
in solving problems with the characteristics of the PISA model [5]. In general, the questions prepared present an instrument for assessing learning outcomes whose substance is less related to students' life context and does not facilitate students in expressing thought processes and arguing. This situation is not in line with the characteristics of PISA questions whose substance is contextual, requiring reasoning and argumentation in solving them. Problems related to mathematical literacy require students to use the ability to formulate, apply and interpret mathematics in various contexts.

Several studies have concluded that students have difficulty formulating mathematical problems in everyday life, presented in the form of a mathematical model [6]. Only 7.7% of students can answer questions with valid explanations [7], and only 15% of students succeeded in solving the PISA problem on the material of space and shape [8]. Hendroanto et al. showed that 61.8% of students could not answer correctly on space and shape content [9]. It is proven that the student's ability to solve mathematical literacy problems in space and shape content is still low. Likewise, the most significant student difficulties in solving math literacy problems are carelessness, problem identification, and wrong calculations [10-12].

In solving mathematical literacy problems, three mathematical literacy processes have been determined to see students' abilities, namely formulating, employing, and interpreting. Formulating indicates how well students identify aspects of mathematics used in solving problems, and they represent a contextual problem in mathematical form. The process of employing can indicate how well students can perform calculations and use the concepts, facts, and procedures they know to get mathematical solutions. The interpreting process indicates how well students reflect or conclude contextually mathematical solutions, interpreting them in the context of real-world problems and determining whether the results or conclusions make sense [13]. The three processes of mathematical literacy allow students to organize processes in dealing with problems, starting from connecting the context of everyday problems with the context of mathematics to solving these problems [14].

Mathematical literacy skills are strongly influenced by the student's ability to solve a contextual mathematical problem. When solving a problem, each student must have different characteristics in processing the information provided. When there are differences in information processing, the way students respond to the information presented to them will also be different. The differences between students in compiling and processing information are known as cognitive styles.

In this study, researchers tested the cognitive style factor on students' mathematical literacy abilities. The student's cognitive style will provide an important picture for the teacher about how students organize and process the information provided [15]. Based on psychological differences, cognitive styles are divided into two types: field-independent (FI) and field-dependent cognitive styles (FD). Students with the FI cognitive style tend to choose individual learning, respond well, and are free (not dependent on others). In contrast, students with the FD cognitive style tend to be influenced by others and accept the problem's information according to what it is [16,17]. As a result, FD students have difficulty separating the incoming information from its contextual environment [18]. FI students focus on something in detail because they accept something as part of the environment and tend to arrange the material they receive themselves to be more analytical [19]. Both cognitive styles' essential characteristics are suitable for applying research that involves thinking processes in mathematical literacy abilities.

2. Methods
This research is a descriptive study with a qualitative approach. To obtain the data needed in this study using test and interview techniques. The research instrument used was the GEFT cognitive style test which was divided into 7 practice questions and 18 main questions to determine students' cognitive styles, mathematical literacy assignments to reveal high school students' mathematical literacy, and interview guidelines. This study's subjects were two class X high school students aged 15 years 3 months to 16 years 2 months consisting of those selected from the GEFT cognitive style test results consisting of one student with a field-dependent cognitive style and one student with a field-independent cognitive style. Mathematical abilities are relatively the same, and gender is also the same. Furthermore, the two
subjects were given interviews carried out in conjunction with the assignment of mathematical literacy assignments to describe students' mathematical literacy in solving math problems using the PISA model of space and form content.

To describe students' mathematical literacy in solving space and shape problems. Indicators are needed in analyzing the formulate, employ and interpret processes. The indicators used to analyze the three processes are presented in Table 1.

Table 1. Mathematical Literacy Indicators

| Mathematical Literacy Process | Indicators                                                                 |
|-----------------------------|-----------------------------------------------------------------------------|
| Formulate                   | Identify important aspects of the given problem                              |
|                             | Represent the problem using appropriate variables, symbols, diagrams, and modeling |
|                             | Design and implement strategies for finding mathematical solutions.          |
| Employ                      | Use facts, concepts, procedures, and mathematical reasoning when looking for solutions. |
|                             | Interpret a mathematical solution contextually.                              |
| Interprete                  | Re-check the mathematical solution obtained.                                 |
|                             | Explain why a mathematical solution makes sense or not.                      |

3. Results and Discussion

In revealing student’s mathematical literacy in solving PISA-like problems, an instrument known as a Mathematical Literacy Task (MLT) is used. The following is a Mathematical Literacy Task (MLT) instrument given to both subjects to describe the process of formulating, employ and interpret in solving math problems with the PISA model.

WATER WHEEL ROTATION

A waterwheel has the lowest point at the wheel, which is at a depth of 0.5 meters below the river water surface. The outer diameter is 3 meters. There are 12 blades. Turn the waterwheel counterclockwise at a constant speed, as indicated by the purple arrow in Figure 2. At 17.57 the blade A occupies the highest point, then after rotating for 30 seconds, blade A occupies the position of blade C. What time will blade A return to its highest point for the third time?
3.1. Mathematical Literacy of Students in Solving PISA-like Problem with Cognitive Style Field Dependent

Based on Figure 3 and the interview results, the research results on the field-dependent subject mathematical literacy process are obtained.

In formulating process, the students identified the information needed. The waterwheel had 12 blades with a constant rotation speed, and at 17.57, blade A had the highest height. After turning 30 seconds the blade A occupied position C. In contrast, the information asked in the question is at what time blade A will return to its position at the highest point for the third time. Students represent the information they know and ask about the questions by writing them into a verbal representation. Students represent the movement of each blade within a specific time with a letter symbol. The student represents a round of 15 times 12 which is 180 seconds or 3 minutes, and blade A’s position is at the highest point for the third time using the hour number multiplication and addition model.

In the employing process, students design and implement strategies to find mathematical solutions by writing down available information and asking questions. The student determines its time for a blade to move to a particular blade position and determines its time for a blade to move one turn and occupy its position again. Students determine the number of rounds to be asked and the time it takes to go through with the multiplication procedure. Still, students are not proficient in understanding the meaning of what is being asked in the questions, so that students are not precise in determining the problem-solving.

In the interpreting process, students interpret that 180 seconds is needed to take one round, so 540 seconds for 3 turns. Students are less selective in absorbing information on questions that should be point A back to the highest point the third time, which takes 360 seconds. Students believe that the solution obtained, which is 18.06, is correct by arguing that the solution obtained makes sense with the explanation. The initial time is 17.57. The time occupies the highest point for the third time must be more than 17.57.

Figure 3. Answer to the Field Dependent Subject Task

3.2. Mathematical Literacy of Students in Solving PISA-like Problem with Cognitive Style Field Independent

Based on Figure 4 and the interview results, the results of research on the mathematical literacy process of the independent field subject are obtained.

In formulating process, students can identify the required information. Namely, when the waterwheel starts to rotate at 17.57 and its rotation, the information asked in the question is at what time blade A will return to its position at the highest point for the third time. Students mention it in their language. Students can represent the information contained in the questions into a verbal representation. Students
represent the initial rotation interval, namely 17.57 plus 6 minutes, with the hours' summing model and represent each blade's displacement in a specific time interval with letter symbols.

**Figure 4. Answer to the Field Independent Subject Task**

In the employing process, students design and implement strategies to find mathematical solutions by writing down available information and asking questions. The student determines its time for a blade to move to a particular blade position and determines its time for a blade to move one turn and occupy its position again. Students use mathematical reasoning to connect the known time intervals to move from one blade to another by applying them to other blades crossing the same distance. The time interval required to move one turn is obtained. Students use the conversion of time units from seconds to minutes to make calculations easier. In calculating, the students use the procedure of adding the number of hours. Students interpret that 6 minutes is an interval of time in the interpreting process, so that blade A is already in position 3 times. Students believe in the solution obtained and argue that the results obtained are reasonable with the explanation that, for example, if 17.57 plus 6 minutes, then the result is 18.03, it is impossible to exceed that time.

Based on the description of the research results obtained from the two subjects regarding students' mathematical literacy in solving math problems with the PISA model.

When Field Dependent students mention important information in the PISA model math problems, they tend to use the language or sentences in the questions. In this formulating process, individuals with field-dependent cognitive styles tend to receive information according to the problem [17]. The employing process findings that students are less proficient in determining problem-solving shows that students with cognitive style FD tend to be influenced by others and accept the information contained on the problem according to what it is [16][17]. This means that the confusing elements easily influence a person with an FD cognitive style in a problem. In the interpreting process, the lack of selectivity of FD students in absorbing information on the questions shows what Guisande et al. has argued that FD students tend to have difficulty separating incoming information from their contextual environment and are more likely to be influenced by external cues and they become not selective in absorption information [18].

In formulating, using his language in mentioning important information on the problem shows that if FI student is given a problem that is not organized, he will apply their structure [17]. In employing, FI students designed a settlement strategy following Witkin et al.’s explanation that individuals with field independence quickly divide the whole pattern into several parts. An independent field worker works more effectively in solving problems [20]. The FI subject's interpreting process reveals that a field independent can focus on something in detail because he accepts something as part of the environment tends to arrange the material he receives himself so that it is more analytical [19].
4. Conclusion

Based on the results of the study, it can be concluded about the process of mathematical literacy of students in the filed dependent and Field Independent cognitive style as follows:

In the formulating process, both FD students and FI students can identify important questions. FD students tend to use the language or sentences in the questions, while FI students tend to use their language. Both FD students and FI students can use verbal representations, symbols, and mathematically appropriate modeling. However, FD students are not proficient in understanding the meaning of the question because the element of distraction influences it. In the employment process, both FD students and FI students can design and implement various strategies to find mathematical solutions and use mathematical procedures and reasoning when looking for solutions. However, FD students were not precise in determining the problem solving, where FD students tended to understand the questions, not in-depth. In contrast, FI students can design and implement concise strategies to find mathematical solutions. Interpretation process, both FD and FI students, can interpret mathematical solutions contextually both those obtained in the steps of solving the problem, as well as the final solution that is asked of the questions, double-checking the mathematical solutions obtained by believing that the solutions obtained are correct and can double-check the solutions work backward and reexamine the problem-solving process, explaining why mathematical solutions make sense.

From the conclusion, it is suggested for teachers to pay more attention to students with FD cognitive style in solving questions because FD students tend to be less selective in absorbing information on questions and need scaffolding to maximize their abilities. And more often than not, questions related to open mathematical literacy are given, which have many solutions. Also, this research only reveals about students 'mathematical literacy on the PISA questions about the content of space and form, and it is suggested that in the future, it is advisable to examine more deeply the students' mathematical literacy, which contains the overall content contained in the PISA questions.

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