The process of formulating in mathematical literacy in solving Pisa-like problems viewed from cognitive style

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Abstract. This research aims to describe the process of formulating in mathematical literacy in solving the PISA-like problem viewed from cognitive style. In this research, two subjects were selected based on the math ability test, GEFT test, and the same sex. The results showed that in solving the PISA-like mathematics problems in the process of formulating, students with a cognitive field-dependent style were able to identify the information needed to solve the problem by mentioning information that was known and asked about the problem and tending to use the sentence in the question. Students are able to represent a problem mathematically using verbal representations, symbols, images, variables, formulas, diagrams and mathematical models that are appropriate, but not capable of visually representing a 3-D model into a 2-D model. While students in the cognitive field independent style in solving the PISA model problem in the process of formulating, students are able to identify the information needed to solve the problem by mentioning information that is known and asked about the problem and tends to use their own language. Students are able to represent a problem mathematically using verbal representations, symbols, images, variables, formulas/formulas, diagrams, and appropriate modeling, and are capable of visually representing 3-D models into 2-D models.

1. Introduction

The mathematical literacy is one of the main problems examined in the PISA (Program for International Student Assessment). In OECD, it was explained that "Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety context. It includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and makes it well-founded judgments and decisions needed by constructive, engaged and reflective citizens [1].

PISA is an international scale assessment program that is used as a reference to see the quality of education of a country. The purpose of PISA is to test the academic achievements of 15-year-old school children. PISA in its study used the term “literacy” to refer to the assessment not only of knowledge as a domain, but also the ability to apply that knowledge [2]. The domain of mathematics in the PISA survey covers process, content and context aspects. The process aspect refers to the definition of mathematical literacy, namely a person's ability to formulate, employ and interpret mathematical forms [3]. This is in line with the results of Edo, Hartono, & Putri's research concluded...
that students have difficulty in formulating mathematical problems in daily life which are presented in the form of mathematical models [4]. This shows that students have difficulties in the initial step of the process of formulating and not yet arrived at the stage of mathematical procedures when solving contextual problems.

The word “formulate” in the definition of mathematical literacy refers to individuals being able to recognize and identify opportunities to use mathematics and then provide mathematical structure to a problem presented in some contextual form [1]. In the process of formulating problems mathematically, someone determines where they can take the mathematical ideas needed to analyze, start and solve problems. They translate from real-world problems into mathematical language and provide mathematical structures, representations, and specificities to real-world problems. They reason and understand the obstacles and assumptions of the problem [1].

Specifically, the process of formulating is explained by the following indicators. (a) Identifying mathematical aspects of a problem found in the real world context and identifying important variables; (b) Recognizing mathematical structures (which include order, relationship, and pattern) in problems or situations; (c) Simplifying problems to make them easily accepted by mathematical analysis; (d) Identifying the obstacles and assumptions behind mathematical modeling and simplification obtained from the context; (e) Represent a problem mathematically by using variables, symbols, diagrams and appropriate modeling; (f) Represent problems in different ways, including organizing them based on mathematical concepts and making appropriate assumptions [1].

In the process of formulating problems mathematically, students need the ability to plan mathematical problem-solving strategies. This involves a set of critical control processes that guide a person to effectively process, formulate, and solve problems. A person's ability to process, formulate, solve problems can be influenced by cognitive style. Cognitive style is a typical way for students to learn, both related to how information is received and processed, attitudes toward information, and habits related to learning ability. This results in students being different in responding to a problem.

The cognitive style that is the focus of the discussion in this study, namely field dependent and field independent. Witkin, et al. suggested that field-dependent people tend to see things as a whole pattern and find it difficult to separate all patterns into parts "field-dependent students tend to see things as a whole pattern and find it difficult to separate a whole pattern into parts "[5]. A field-dependent has a tendency to be easily disturbed and easily confused so that he lacks the ability to solve problems. This means that a field-dependent is easily affected by deceptive elements. On the other hand, explained by Witkin that a field independent easily gets part of the whole pattern of "student can easily separate parts from the whole pattern" [5]. Morgan states that when faced with something that is not clearly organized, a field dependent tends to accept as it is, while an independent field will implement their own structure [6].

2. Methods
The purpose of this research was to describe the process of formulating in mathematical literacy in solving PISA-like problem viewed from cognitive style. The criteria for taking subjects were based on tests of mathematical abilities, gender, and GEFT tests. The GEFT test used in this research was adopted from GEFT Rahayu from the standard instruments developed by Witkin [7]. This criterion was proposed so that the differences in processes of formulating on mathematical literacy of students were not likely to be influenced by mathematical abilities and gender but were only influenced by cognitive field dependent and field independent styles. Selected subjects can communicate well when expressing ideas verbally or in writing. The selected subjects were given Mathematical Literacy Tasks (MLT) consisting of four questions in the form of descriptions that were adapted from PISA questions and conducted interviews to obtain data on the process of formulating on students' mathematical literacy to explore data that was not revealed from written results. To test the credibility of the data, researchers used time-type data source triangulation, which was triangulated data obtained from MLT 1, MLT 2 and interviews. Researchers take data from the same research subject at different times. While data analysis includes the phase of data reduction, data presentation in the form of formulating process descriptions, and conclusions.
3. Results and discussion
To describe the process of formulating on mathematical literacy in solving PISA-like mathematics problems requires indicators to facilitate analysis. The indicators used to analyze the process of formulating on student mathematical literacy were adapted from several indicator components in the mathematical process proposed by the OECD and adapted to the definition of each mathematical process.

The indicator of formulating on mathematical literacy in solving PISA-like mathematical problems based on the mathematical process used in this study is as follows.

Table 1. The Indicators of Formulating on Mathematical Literacy in Solving PISA-like Mathematical Problems

| Mathematical Processes | Indicators                                           |
|------------------------|------------------------------------------------------|
| Formulating            | Identify the information needed to solve problems.   |
|                        | Represent a problem mathematically using variables,  |
|                        | symbols, diagrams, and appropriate modeling.         |

The Mathematical Literacy Task (MLT) in this research is an instrument used to describe the process of formulating in students' mathematical literacy in solving PISA-like mathematical problems. This instrument consists of four questions in the form of essay that are adapted from PISA questions.

The MLT instruments given to both subjects are shown as follows.

1. DICE MODEL
The picture on the side is a model that is made using nine dice that are identical to the surface of the eye dice numbered 1 to 6. When this model is seen from above, there are only 5 dice visible. What is the number of points that appear when this model is viewed from above?

2. RECIPE CHOCOLATE MILKSHAKE
Mrs. Melati has a milkshake business in her front shop. Here is a recipe for 2 cups of chocolate milkshake

| Pure milk          | 500 cc |
|--------------------|--------|
| Chocolate ice cream| 3 scoop|
| Syrup              | 25 cc  |

How much syrup is needed if Bau Melati wants to make 5 glasses of chocolate milkshake?
(Note: 1 cc = 1 cm³)

3. GROUP OF EXPENDITURE PER CAPITA IN MONTH
Faizar got a mathematical assignment looking for data and presented it in the form of a diagram with the help of an application chart in MS Word or MS Excel. Faizar found 2016 national census data from The Central Bureau of Statistics (BPS) on the percentage of expenditure per capita population in a month in East Java province according to districts/cities as shown in the following table.
Table 2. Percentage of per capita population expenditure data in a month in east java according to District / City in 2016

| Districts / Cities | Percentage of Per Capita Expenditure Group for A Month |
|--------------------|------------------------------------------------------|
|                    | 100.00-299.999 | 300.000-999.999 | 1.000.000 or above |
| Tulungagung        | 9.07          | 65.71           | 25.21             |
| Jember             | 12.52         | 77.78           | 9.7               |
| Sidoarjo           | 1.05          | 42.91           | 56.03             |
| Kota               | 0.82          | 28.08           | 71.1              |
| Surabaya           | 3.36          | 63.45           | 33.19             |

Source: jatim.bps.go.id

Next faizar made a diagram based on the data. If you get the same task as Faizar, make a diagram to present data on the percentage of expenditure per capita population in a month in East Java in 2016! In your opinion, which diagram is more appropriate to present the data and give your reasons?

4. THE FERRIS WHEEL

A Ferris wheel has an outer diameter of 140 meters and the highest point is at an altitude of 150 meters above the river surface. This Ferris wheel has 20 seats and rotates at a fixed speed in the direction indicated by the arrow in the picture above. One full round was passed in exactly 40 minutes. If the light starts to spin at 18:45, determine which seat occupies the number 1 seat at 19.01!

3.1. The process of formulating in mathematical literacy of students with cognitive field dependent style in solving PISA-like mathematical problems

Task 1
Based on written results and interviews, FD students are able to represent the dice model when viewed right from above by describing it, even though its representation is still inaccurate. The subject uses 3-D visual representation for the dice model when viewed from the top side so that the resulting representation is still not a suitable 2-D representation.

Task 2

![Dice Model Diagram]

**Translation:**

*Known: 2 glasses = 25 cc syrup*
*Asked: 5 glasses = . . . syrup*

**Figure 6.** Formulating the known information from the milkshake problem

This is also done when representing 5 glasses of chocolate milkshakes into the addition of 2 cups + 2 cups + 1 glass. Based on written results and interviews, students keep writing 2 cups as information that has been known from the problem when describing the 5 glasses of milkshakes that were asked. This shows what was stated by Candiasa[8], that the characteristics of someone who has a field-dependent cognitive style tend to accept an existing structure.

Task 3

**Table 3.** The interview result of filed dependent student for the third problem

|   | What was asked in the question? |
|---|---------------------------------|
| SD | Eeee…. Make a diagram then determine which diagram is more appropriate to present the data and give your reasons. |

|   | In your opinion, what diagram is appropriate to present data from this problem? |
|---|----------------------------------------------------------------------------|
| SD | Bar chart. |

|   | Why choose a bar chart? |
|---|------------------------|
| SD | Because there will be 100 thousand units later, there are 300, there are 1 million and above, so it's easier to bar charts. |

|   | Why aren't line diagrams or anything else? |
|---|------------------------------------------|
| SD | If the line diagram might be difficult to be guaranteed later. Yes, there are many statements, there are also several cities. |

|   | Why not a pie chart? |
|---|---------------------|
| SD | For this circle diagram, there are many percentages. So, later make a lot of it too. It can be possible, but it is more difficult to determine the price of the 100 one so much ... |

Students choose to use bar charts to represent data in the table presented in the diagram making problem because there are more than two information on the problem, namely several districts or cities with several categories of expenditure per capita so that it will be easier if made with bar charts compared to line diagrams or with pie charts. Students argue that if the data in the table on the question is made in a line diagram then there will be a lot of information so that the diagram will be difficult to understand, whereas if you use a pie chart because the percentages and categories are many then more than one pie chart is needed.
Task 4

Figure 7. Formulating the time interval

Based on students' written results and interviews, in determining the time interval, students represent in the hour number reduction model then solve it by representing the model in the clock image to calculate the number of minutes passed. Here, students state the difficulty in using the hour number reduction procedure with borrowing techniques so that it represents it to the clock image shape.

The results showed that in the process of formulating, field-dependent students were able to identify the information needed to solve the problem by mentioning the information needed and asked in the question namely in determining the many dice that appeared on a dice model when viewed from above, determining the number syrup is needed to make 5 glasses of chocolate milkshake, in determining and making the right diagram to present a data on the table, determine which seat occupies the number one seat position on the Ferris wheel at a certain time, and in determining the time at the latest Naufal must start climb so you can return at 8:00 p.m. When students mention the information needed and information asked on the question, students tend to use the sentence in the question. This is in accordance with Morgan's statement that when faced with something that is not clearly organized, a field dependent tends to accept it as it is [6].

3.2. The process of formulating in mathematical literacy of students with cognitive field independent style in solving PISA-like mathematical problems.

Task 1

Figure 8. Representing the dice model when viewed from the top
Figure 9. Formulating the known information from the dice model problem

In the dice model problem, students are able to provide a visual internal representation of a 3-D dice model when viewed right from above by describing it using the appropriate 2-D visual representation. In this case, the representation is in the form of a surface image of 5 dice that appear from above with their chest eyes. Students can explain why they describe it because if seen from above, only the top ones appear.

Task 2

Figure 10. Formulating the known information from the milkshake problem

Based on written results and subject interviews. The subject identified the information needed to solve the problem, namely the composition of the recipe printed on the question and information that the recipe was used for 2 cups of chocolate milkshake and the information asked about the question was a lot of syrup used for 5 cups chocolate milkshakes and the subject represented known information and asked on the question by writing it in the form of verbal representation.

Task 3

Table 4. The interview result of field-independent student for the third problem

|   |   |
|---|---|
| P | What was asked in the question? |
| SI | What is asked is which diagram is suitable for the data and told to make a diagram too. |
| P | What do you think the diagram is suitable for presenting the data? |
| SI | When this fits, use a bar chart. |
| P | Why are bar charts suitable? |
| SI | Because yes ... If you use a pie chart, for example, make this mean 3. Make use of bar charts. |
| P | If it is a line or rod diagram, what kind of data does it display are the same or different? |
| SI | Different. |
| P | What is the difference? |
| SI | If that line is like a change from year to year. If the stem is usually from different cities. |
| P | Try to make a trunk diagram on the settlement |

Translation:
Known: to make 2 cups of milkshake it takes 25 cc syrup
Asked: how much syrup is needed for 5 glasses of chocolate milkshake?
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In the problem of making a diagram, students represent known information and information asked by writing it into verbal representations. In the problem of making diagrams, students choose to use bar charts to represent data in the table by reason of making it easier to draw than using line diagrams or pie charts. Students argue that the type of data displayed on the line diagram is like a change from year to year, whereas in bar charts it is usually from different cities.

Task 4

![Diagram](image)

**Figure 11.** Formulating the known information from the ferris wheel problem

The same is done when students use an hourly number reduction model to represent the time interval from when the Ferris wheel starts to spin at 18.45 until 19.01. Likewise in the problem when students use the hour number reduction model to represent time 13.5 hours before 20:00. Students are also able to use the addition number hour model to represent the amount of time needed to go and go home.

In the process of formulating, independent field students can identify the information needed to solve the problem by mentioning the information needed and asked questions such as in determining the number of dice asked from 5 dice that appear when the dice model is seen from above, determine the place Which seat in the Ferris wheel will occupy the number one seat position at 19.01 after turning since 18:45. When students mention the information needed and information asked on the question, students tend to use their own language. This is in accordance with Morgan's statement that when faced with something that is not clearly organized, a field independent will implement their own structure [6].

4. Conclusion

Based on the results of the discussion, it can be concluded that the process of formulating on students' mathematical literacy in solving PISA-like problem can be summarized as follows: student FD in formulating, can identify the information needed to solve the problem by mentioning the information needed and asked questions and tend to use existing sentences in the problem. FD students are able to represent a problem mathematically using verbal representations, symbols, images, variables, formulas, diagrams and appropriate modeling. However, inadequate FD students in visually representing 3-D models into 2-D models. While FI students in formulating (formulate), can identify the information needed to solve the problem by mentioning the information needed and asked questions and tend to use their own language. FI students can represent a problem mathematically using verbal representations, symbols, images, variables, formulas/formulas, diagrams, and appropriate modeling. FI students are also capable of visually representing 3-D models into 2-D models. In choosing a diagram that is suitable for the data presented in the level 3 problem table, FI students can provide the right reasons both in terms of ease of manufacture and the characteristics of bar charts.

From this conclusion it is recommended for teachers to give more questions about mathematical literacy and open ended questions that have many solutions and choices in problem solving, and pay
more attention to the cognitive style of students in carrying out learning activities so that they can use strategies or suitable approaches.

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