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Epistemological Obstacles Experienced by Indonesian Students in Answering Mathematics PISA Test on the Content Uncertainty and Data

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Abstract: The purpose of this research is trying to identify epistemological obstacles which were experienced by Indonesian students in answering PISA test for mathematics literacy content uncertainty and data. Epistemological obstacles was identified by giving a test to the respondent, students of grade 7th and 8th who have studied data representation in the class. Respondents' work analysed by qualitative method. The result showed that respondents have epistemological obstacles in reading the data, reading between the data, and reading beyond the data. To gain further understanding, some respondents chose to be interviewed.

Keyword: key Epistemological obstacles, ability of interpreting data, PISA test

1. Introduction

The PISA 2012 result in mathematics literacy for content **uncertainty and data**, says that 35.7% of Indonesian student participants are below level 1. Meanwhile, 36.1% of Indonesians participants are at level 1, and 27.2% above level 1 but none reached level 6. Students at level 1 understand and able to read information represented in graph [1]. It means that 35.7% Indonesian participants unable identify information represented in graph. Based on the age, Indonesian student should already got the material related with graphical data representation. This condition bears a natural conjecture that Indonesian participants had some epistemological obstacles in answering PISA test.

1.1. PISA

Program International Student Assessment abbreviated as PISA is a program which intent on observe level of students knowledge and capability at the age of 15 [1]. The knowledge and capability tested were mathematics, reading and science which are needed in modern society life.

Mathematics test assessed students capability to measure in formulate, employ and interpret mathematics in a variety contexts [1]. One of the content was **uncertainty and data**. This content measured students' capability to interpret information represented in graph. **Uncertainty** include making prediction scientifically, poll results, weather forecast, and economics model.

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1.2. Data on the Graph

In general, graph is an information transmitted by position, point, line or area on the surface of two-dimension plan [7]. Position, point, line or area on the surface of two-dimension plan called *specifier*. In bar graph, its *specifier* is a bar. Labels on graph give interpretation to the *specifier* [2].

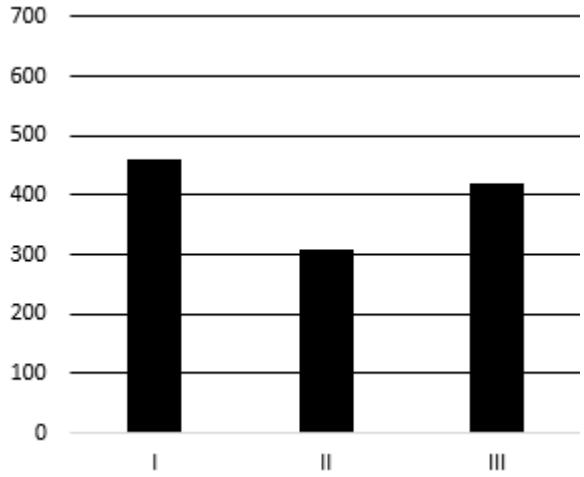

Figure 1. Example of *specifier*. Bar in a bar grap graph is an one of *specifier.*

1.3. Interpreting Graph

To interpret is to grasp the meaning of word (sentence etc.) not only textually but also implicit textually (by giving his/her own argumentation) [3]. So, to interpret data on the graph is to reveal meaning of data in graph both explicit and implicit.

In mathematic education, to interpret graph is an ability to derive meaning from graphs, creating by others or themselves [2]. There are three main component interpreting graphs: a) reading information directly from the graphs; b) manipulate information on the graph, students make comparison and calculation; c) generalize, predict, or identify trends [2]. Students have to know the relation between the information on the graph to the situation of the context [2]. This three component referring to terms used by Curcio that is reading the data, reading between the data, and reading beyond the data [8].

Gillan [8] developed a concept of information process modelling on the graph. It is called MA-P model. According to MA-P model, basicaly when comprehending graph, someone will apply some components.

3) Searching component for every indicator (*specifier*) asked in the question.
4) Encoding component following searching component for every indicator (*specifier*) asked in the identification question or arithmetic question.
5) Arithmetic component after found they have searched for and *encoded* the indicator value in question asking mean, summation, differences or ratio.
6) Spatial comparison component when asked which indicator has greater or less value.
7) Response component every produce openly numeric response.

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Gillan used context-free graph in his research which is different with contextual graph. In contextual graph there is one component must be added that is a component which translate the visual features into conceptual relations when interpreting title, labels, and scales and another keys or symbols that part of the display [9]. The graph reader must be able to relate the ability of interpreting graph and the context.

1.4. Epistemological obstacles

Epistemological obstacles is an obstacle caused by student's previous knowledge before entering learning situation [4]. Dorux in Brousseau [4] proposed some condition of epistemological obstacles:

8) Epistemological obstacle is a knowledge or concept.
9) This knowledge response properly on a certain context.
10) But general response made is wrong outside the context. A correct, universal response requires a notably different point of view.
11) This obstacle hold out on the contradiction and establishment condition of a better knowledge.
12) After inaccuracy recognized then new knowledge emerge, in a most certain way.
13) We can conclude that identifying epistemological obstacle is important to recognize error and replace it with the new one which is better.

Janvier says, synthesys from some authors, that epistemological obstacle is a needed "correct" pieces of knowledge that are "inappropriately" utilized [10]. Epistemological obstacle is defined by as a way of knowing that functions productively in some settings [11]. But it is not productive in other setting.

2. Experimental Method

This research used a qualitative method. Respondents were given several question related to data graph to 70 students' grade 7 and 8 without giving any treatment. The test was done at one of mid school in Purwakarta, Indonesia. Response of the respondents were analyzed to understand obstacles experienced by the students in answering PISA test, focused on mathematics content **uncertainty and data.** To gain further understanding, 5 respondents chose to be interviewed by the researcher.

The instrument consist 1 problem. The problem was build based on PISA's framework. The problem consist a data representation bar graph, and stimulus followed by 3 questions. Stimulus is a context situation related to the problem. The problem is attached in appendix.

The research also made some possibilities obstacle source to identify epistemological obstacle. The respondent's obstacle would be categorized referring these possibilities.

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Table 1. Possibilities obstacles source in answering PISA test content uncertainty and data

Possibilities obstacles source	Indicators	Number question
Reading the data	Unable to identify information represented in graph and recognize the relation to the context.	a
Reading between the data	Unable to compare the data value represented in graph and recognize the relation to the context.	b
Reading beyond the data	Unable to identify trends and make prediction relating to the context.	c

3. Result and Discussion

After the respondent answered the question. The response analyzed using qualitative method. The analyses focused on classifying obstacles into the category a) reading the data, c) reading between the data, and c) reading beyond the data.

3.1. Reading the data

Reading the data is a basic ability to interpret graph. In this ability, respondents only asked to identify one of *specifier* on the graph. The graph was different from graph usually found by the respondent in the class. The difference was the graph consist 4 variable whereas respondent usually found the graph consist a variable (see appendix).

Table 2. Percentage of respondent who have obstacle in *reading the data*.

Possibilities obstacles source	Indicators	Number question	
Unable to identify information represented in graph and recognize the relation to the context.	a	26	39,13

From the table we can see that the respondent who have obstacles identifying information represented in graph was 39, 13%. The Percentage of the respondent who have obstacle in *reading the graph* was more than the PISA 2012 result. In this question respondents was asked to choose appropriate *specifier* and estimate the value of the *specifier*. The estimation is important because the *specifier* didn't show value clearly. The following example reflect respondent who has obstacles in reading the data.

Interviewer : please read question a.
Yulindra : [read question a]
Interviewer : what was the question asked?
Yulindra : [silent]

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Interviewer : okay, what's your answer?
Yulindra : 1400
Interviewer : okay, how did you get the answer?
Yulindra : from this (point Terios specifier)
Interviewer : okay, thank you.

The obstacles that made Yulindra couldn't answer the question was she wasn't only choose the wrong *specifier* but also she couldn't estimate the value exactly because the *specifier* didn't show the value clearly.

3.2. Reading Between The Data

Ability of reading between the data, question b, focused on making comparison graph data values.

Table 3. Percentage of respondent who have obstacle in reading between the data.

Indicator	Item number	The numbers of respondents who comply the indicator	Percentage
Unable to compare the data value represented in graph and recognize the relation to the context.	b	8	13,04

The respondent who have obstacles in reading between the data was 13.04% (table 3). The interesting here was the Percentage less than in reading the data. The research infer question number b was easier than question number a. Because question number b only asked respondent to choose the *specifier* that should be compared and obtain which one was higher than other. The differences between two *specifier* could be seen more clearly than estimating the value of *specifier* in this problem. The following example reflect respondent who has obstacles in reading between the data.

Interviewer : please read question number b
Sika : when is the number of Sigara more than Senia?
Interviewer : what does the question mean?
Sika : because in 2011 Sigara is more than 2012.
Interviewer : (that's the answer) from the question right?
Sika : yes
Interviewer : what does the question mean?
Sika : because in 2012 Sigara is less than 2011..

The interview showed that Sika can't understand the question well. It could be seen that Sika understand the question as "in what year the number of Sigara were decrease". Sika has an obstacle obtaining which *specifier* should be compared. In this question, Sika should compare the number of Sigara and Senia and obtain when the number of Sigara is more than Senia.

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3.3. Reading Beyond The Data

Ability of reading beyond the data, question number c, focused on identifying trends and predict the next value beyond the data based on the identified trends. 78.26% of respondent experienced answering question number c (table 4).

Table 4. Percentage of respondent who have obstacle in reading beyond the data.

Indicator	Item number	The numbers of respondents who comply the indicator	Percentage
Unable to identify trends and make prediction relating to the context.	c	53	78,26

The following example reflect respondent who has obstacles in reading beyond the data.

Interviewer : please read question number c.
Wulan : [read question number c]
Interviewer : what did the question mean?
Wulan : counting all (the values)
Interviewer : what was your answer?
Wulan : 3900

Wulan was aksed to make a prediction the number of Sigara would be sold in 2016 by identifying positive trends on the graph. She decided to sum all the number Sigara from 2012 till 2015 then she got 3900. In this case, Wulan has an obstacle how to obtain data trends.

4. Conclusion

Obstacles experienced by students in reading the data were estimating the value of *specifier* and choose the *specifier*. Obstacles experienced by students in reading between the data was obtaining the *specifier* which is compared. And obstacles experienced by students in reading beyond the data was obtaining data trends.

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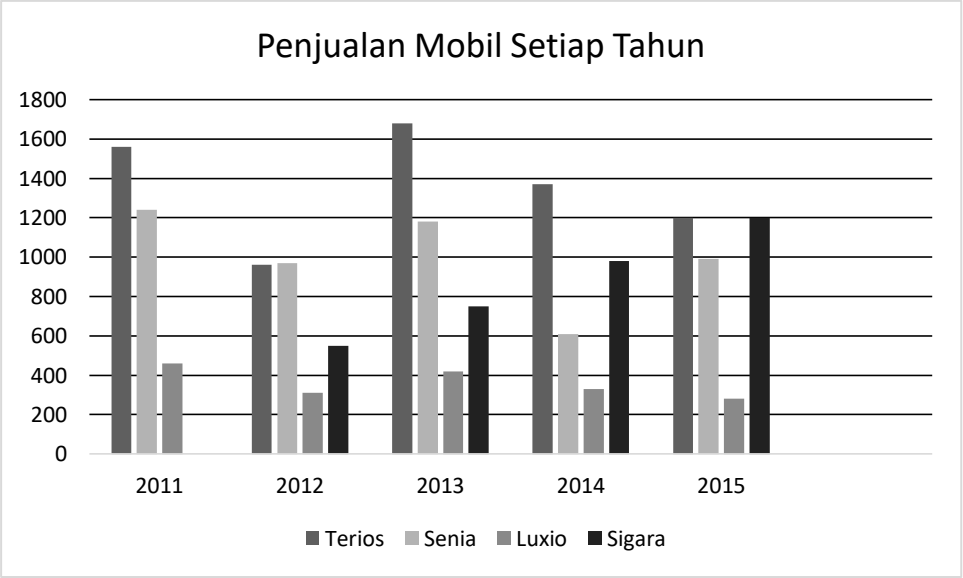
Appendix

Penjualan Mobil Setiap Tahun

Pada tahun 2011 mobil Terios, Senia, and Luxio sudah mulai dijual. Diikuti pada tahun 2012 Sigara kemudian dijual. Berikut ini adalah grafik penjualan keempat mobil dari tahun 2011 sampai 2015.



a) Berapa banyak mobil Luxio yang dijual pada tahun 2014?
b) Pada tahun berapa penjualan mobil Sigara melebihi mobil Senia?
c) Direktur perusahaan mobil optimis dengan jumlah penjualan mobil mereka yang terus meningkat dari tahun pertama keluar sampai dengan tahun 2015. Perkirakanlah jumlah penjualan mobil Sigara pada tahun 2016 seandainya trends positif (kenaikan) berlanjut. Tunjukkan hasil perhitunganmu.

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