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STUDENTS' ERROR IN STATISTICAL PROBLEMS SOLVING BASED ON THE ONTO-SEMIOTIC APPROACH

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Abstract:
Understanding is one of the aims of mathematics learning, though there are still many students who do not understand the material that they were studying. It indicates that there is a mistake they do in solving mathematics problems. Therefore, it is necessary to identify the types of errors made by students in solving mathematics problems in order to advance solutions. One of the approaches that can be used to identify the types of errors is the onto-semiotic, which is able to notice the meaning of mathematics object consists of language, concept, procedure, computation, proposition, and argument. The population in this study were students of STKIP PGRI Tulungagung, Indonesia. While the sample was students of the mathematic education study program. Data was collected through tasks and interviews. Data were analyzed by means of data reduction, data presentation, and conclusion drawing. The result showed that students' error in solving the statistics problem based on onto-semiotic include an aspect of language (incorrect use of terms), concept aspects (incorrectly defining terms, incorrect example), procedural aspect (incorrect use of strategy), computational aspect (incorrect grouping), the proposition aspect (making false statement), and the argument aspect (wrong explanation of each answer). The mistake starts with the misunderstanding of the problem given because of the dominant error in terms of the concept aspect. Researchers recommend that the onto-semiotic approach is a solution for teachers and practitioners to anticipate the types of errors and how to deal with these errors during learning.

Keywords: students' error, statistics problem, onto-semiotic approach, understanding

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1. Introduction

One of the aims of mathematics learning is students can solve the mathematics problem (NCTM, 2006). For this reason, a prospective teacher must be prepared to have good problem-solving skills, but in reality, there are still many students who have low mathematical problem-solving abilities. This condition was seen in the observation and the result of the final examination when mathematics students were given questions about statistics problem-solving. It showed that only 8 out of 34 students could solve the problem correctly, six students could solve some parts of the problems, 16 students solve the problem incorrectly, and 4 students did not write anything.

Mathematics students face difficulties in distinguishing symbols used in statistics concepts (Godino, Batanero, & Font, 2007). It shows that students have trouble in solving statistics problems which cause them to make mistakes. Based on the interview result, several students stated that most of them know the concept, but they are confused about using formula and mathematics symbols because they could not memorize and made mistakes in calculation due to inaccuracy.

The errors that students made must immediately be given a solution, so the aims of learning are achieved because the mistake is the one indicator that student doesn't understand the material that they have learned. One of the ways that can be done is to identify the type of mistakes that the students made. Error needs to be analyzed further in order to get an overview of students' weaknesses in solving the mathematics problem (Safaat & Sari, 2016).

One of the approaches that can be used to analyze student error is the onto-semiotic approach, which is one of the approaches that take into account the meaning of each mathematics object (Neto, 2012). Mathematics object in onto-semiotic approach according to previous research includes language, problem situation, concept, procedure, proposition, and an argument (Godino & Batanero, 2013; Godino et al., 2007; Godino, Batanero, & Rafael, 2015). While, according to Neto, (2012), mathematics object in onto-semiotic approach includes language, concept/property, procedure, and an argument. Mathematics objects in the onto-semiotic approach are problem, language, action, definition, and trait an argument (Godino et al., 2007; Roa, 2005).

An onto-semiotic approach is a tool that explains didactics aimed at effectiveness in the classroom (Godino et al., 2015). The onto-semiotic approach can contribute to mathematics instructional design (Font, Godino, & Gallardo, 2013; Godino et al., 2007). The onto-semiotic approach in this study is used to analyze students' error in solving statistic problems which include language aspect, concept, procedure, computing, proposition, and an argument.

Previously, some researchers had conducted research involving the onto-semiotic approach. One of them is from previous research who had examined the profile of students' ability to solve the mathematics problem (Afifah, 2016; De Zeeuw, Craig, & You, 2013). Her research only revealed the student's ability to solve the mathematics problem based on Polya's steps, but it had not revealed how the types of students' errors in solving mathematics problems base on the onto-semiotic approach. Previous research

uses the onto-semiotic approach to identify and analyze the meaning of mathematics in a multivariate context (Montiel, 2009). Another one research has not revealed how this type of error in problem-solving is based on the onto-semiotic approach (Afifah, 2016; Montiel, 2009).

The onto-semiotic approach can use as a tool to analyze the students' error solve a mathematical problem (Neto, 2012). So, the explanation of the onto semiotic approaches as troubleshooting analysis tools for students that used in this research are as follows: language, students can be said to be able to understand the language of mathematical objects, the definition of students understand the mathematical objects. Procedures, students understand the mathematical objects from the aspect of the procedure. Computation, students understand the computational aspects of mathematical objects. Proposition, the students understand the mathematical objects of the proposition. Arguments, students understand the mathematical objects from the aspect of the definition.

Therefore, the aim of this study is to analyze the student's error in solving the problem using an onto-semiotic approach. By using the onto-semiotic approach, it can be known the type of student error, so lecture can improve the planning in learning and choose the right strategy to improve understanding of students pedagogy (Alias, 2009; Almog & Ilany, 2012).

2. Materials and Methods

The type of research method used in this study is qualitative with a purposive sampling technique. The subjects of this study were mathematics education students of STKIP PGRI Tulungagung, Indonesia for the 6th semester. The main instrument is the researcher themselves and the supporting instrument are tasks and interviews. The tasks were used to find out the types of students' error in solving the problem, while interview was used to explore the obtained data. To test the data validity, time triangulation was applied. Data analysis included reduction, data presentation, and conclusion drawing. The statistical problem provided was an open problem.

3. Results and Discussion

The percentage of student's error based on an onto-semiotic approach in terms of language aspect is 8%, concept aspect is 18%, procedure aspect is 16%, computational aspect is 19%, proposition aspect is 22% and argument is 17%. The least error type is based on the language aspect, while the dominant error type is the proposition aspect. For other aspects, the concept, procedure, computation, and argument are in the same average. The description of the error types is presented in Table 1 below.

Table 1: Description of error types

The aspect of an Onto-Semiotic approach	Description
Language	1. Incorrect in using statistics terms 2. Incorrect in writing symbol 3. Incorrect in making a picture 4. Incorrect in presenting in table form statistics
Concept	1. Incorrect in defining 2. Incorrect in giving example and not an example
Procedure	Incorrect in using strategies or completion steps
Computation	1. Incorrect in using formula 2. Incorrect in writing the formula 3. Incorrect in counting the operation
Proposition	Incorrect in making a statement
Argument	Incorrect in giving the reason for the answer

Based on the interview result with a student, it was seen that student could not understand statistics concept. The concept is referred to data, mean, median, mode and data distribution. They are also not careful in calculating, forget the formula, and not prepared to study before a test.

This explains students answer in solving statistics problem. The student understands the problem given by writing the following:

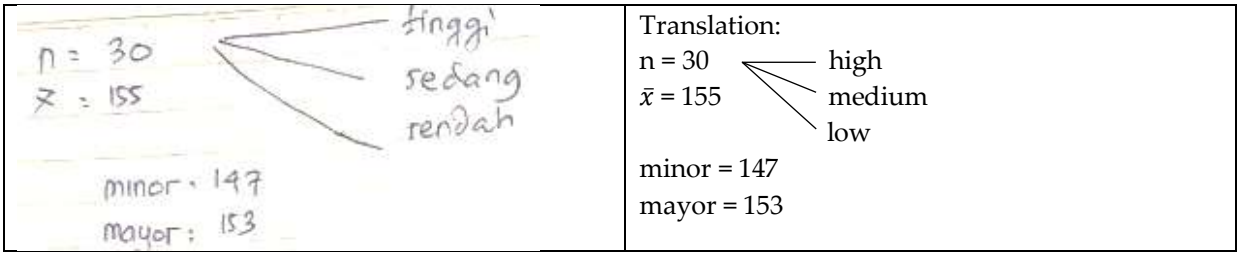
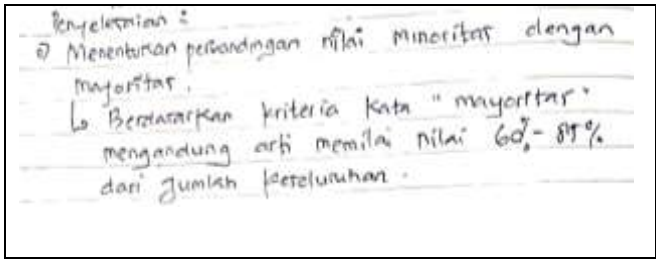


Figure 1: Students answer in understanding the problem

Students made mistakes in using the terms minor and major. The minor in question is the lowest value and the major is the highest value. Major should be the dominant value or the one that most often appears in the statistics are called mode. The use of minor and major words is based on the student's own intuition because it is not used in the problem.

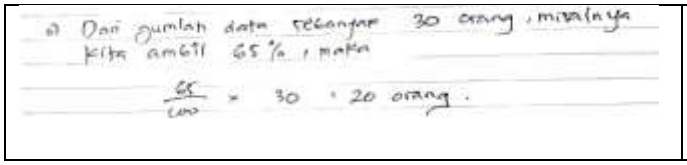
Based on Figure 1, the student made a mistake in understanding the statistics problem. This error type is based on the aspect of language which is wrong in using the terms minor and major. They also made mistake in defining "the majority of high", so that it includes the type of error based on the concept in statistics, the terms minor and major are not used.



Translation
Settlement:
- Determining the ratio of value to the majority
  - Based on the criteria the word "majority" implies a value of 60% -85% of the total.

Figure 2: First student step in solving the statistics problem

The first step that was used in solving the problem is to determine the comparison of minority value with the majority value. The majority value is interpreted to be more than 50% which is in the range of 65-85%. The student assumes that the scale used is 1-100 so the "majority" is more than 50%. In this case, the student made mistakes in defining the term majority which should be interpreted not to have more than 50%. After being given a data example, the student still defines the term majority use percentage. In this case, students understood using intuition on percentage concept, which is based on his experience.

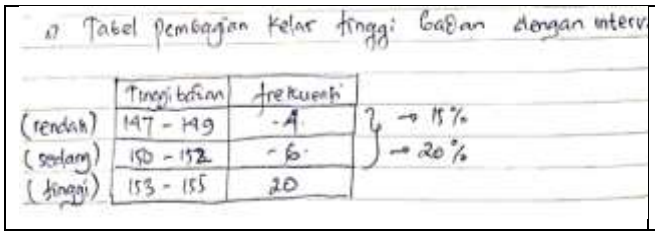


Translation:
- From the total data of 30 people, for example we take 65%, then

$\frac{65}{100} \times 30 = 20$ people

Figure 3: Second student steps in solving the problem

The second step is determining the number of students who have the majority the body by taking 65% of 30 students based on previous intuition to get 20 students. The steps taken are correct, but the concept used is wrong. The error concept is because the incorrectness in using the term in statistics.



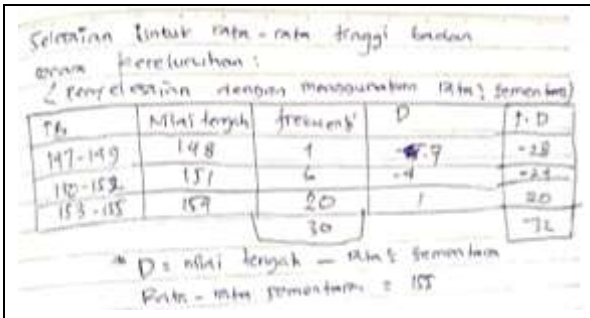
Translation

Table of height class division with intervals:

	Height	Frequency	
(low)	147-149	4	→15%
(medium)	150-152	6	→20%
(high)	153-155	20	

Figure 4: Third students step in solving the problem

The third step is to present the data by creating a group frequency table. From the figure, it can be seen that the student still uses percentage concept to determine the frequency or number of students. In addition, it is also divided into three classes, assuming high, medium and low. For the classes, the frequency is respectively 65% (high), 20% (medium), and 15% (low). From the table, it is proven that several errors are made, namely the average height is not equal to 155 and the mode is not 153. The error is a procedure error because the student did not use known data in making the table, which are average and mode.



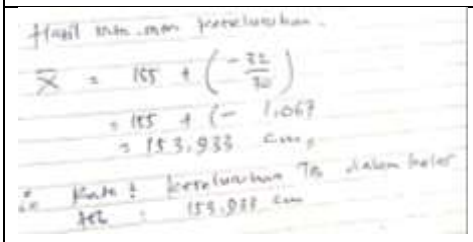
Translation

Complete for the average overall student height (solution using temporary mean)

Height	Median	Frequency	D	F.D
147-149	148	4	-7	-28
150-152	151	6	-4	-24
153-155	154	20	1	20
		30		-32

*D = median – temporary mean

Temporary mean = 155



Translation

Results of total mean

$\bar{X} = 155 + \left(\frac{-32}{30}\right)$

= 155 + (-1.067)

= 153.933 cm

Total mean height in class is 153.933 cm

Figure 5: Fourth student step in solving the problem

The fourth step is determining the high average of all student from the data presented in the frequency table. The formula used was a temporary average of 155 (known in the problem). The reason for determining the average is to get the average data of height in class. In this case, the student made mistakes in understanding what must be determined or find in the problem. Actually, what was asked in the problem is the data about student height and grouping into high, medium, low according to the known information in the problem, so there is a procedure error in this case.

The student did not understand what was meant by data, so that they could not give or show the requested data according to the problem. The information known in the problem is the amount of the data 30, the average, classification division, maximum data is 153 and the smallest data value is 147. Students made mistakes though the requested data had actually been presented in the group frequency table. In this case, including a misconception that is the concept of data (Üzel, 2018). The student is convinced of the answer, but cannot prove it. Besides, they could not give another answer. Based on the problem given and the answer obtained, the student could make only one statement which was made according to the initial intuition used in solving the problem, which was the statement about concept uses in categorizing high, medium and low height. In making a statement, there was an error, namely in the distribution of the percentage of high, medium, low groups. Because highest group should not have the most percentage, as well as the medium and lowest group (Sari, Sa'dijah, Nengah, & Rahardjo, 2019).

From the type of mistakes, they are always equipped with the error based on argument aspect, because the argument is an explanation or reason for each answer. The six aspects of the onto-semiotic approach are interrelated to one another so they cannot be separated. When there is a mistake in understanding the problem, the final answer will also be wrong. This result is similar to the result who found that students made

mistakes in understanding the problem (Amalia, 2017; Dewanti, 2013). In addition, stated that error in drawing conclusion is caused by an error in understanding the problem.

4. Recommendation

Researchers recommend that the onto-semiotic approach is a solution for teachers and practitioners to identify student mistakes while solving problems. This has implications for more anticipatory preparation for teachers to make lesson plans and teaching to anticipate the types of errors and how to deal with these mistakes during learning. In addition, the onto-semiotic approach can be used as material so that students have a better understanding of material from the aspect of language, concept, procedure, computation, proposition, and an argument, especially in statistical material. For further research, the researcher recommends students' misconceptions that occur in solving problems to be further investigated using the onto-semiotic approach. Through this follow-up research, it will be known the types and reasons why students make mistakes in solving problems.

5. Conclusion

Based on the analysis in the perspective of onto-semiotic approach, it could be said that the most dominant mistake made by students in solving statistics problem was their misunderstanding on the concept part. This misconception, then, caused other error types, such as language, procedure, computation, proposition, and argument. In understanding the statistics problem student could mention all the information known, but there were some errors in understanding the problem are students used the terms "major" and "minor" in understanding the problem given. The term should have not been used in the problem. In this case, this type of error was classified into language and argument error. The student defined the term majority as the highest value, but by interpretation the value was more than 50%. It was a mistake because the majority of what is meant in the problem appears in statistics is defined as "mode". In this case, it was included as an error in concept and argument. Students were given example by mentioning all the false information, so the final answer was also false. In this case, it was included in the error in concept and argument.

Other mistakes were also made by students in solving the problem, such as students created data by presenting it in the table, but the steps in making the data was false because the data was made without the correct information about average and mode. The students made mistakes in using data concept and steps to make the data because they only used reasoning and intuiting. It could be included in the mistakes in conception, procedure, computing, and argument. The students in determining high, medium and low group used the concept with a high percentage of 65%, medium 20% and 15% low, even though they should have used the data distribution concept, namely quartile 1, 2 and 3. In this case, it could be classified into error in concept, computation, and argument.

The final mistakes in concluding the final answer were the student made mistakes in mentioning and showing the data requested in the problem, even though the data had been presented in tables. Besides, they also made mistakes in categorizing the high, medium and low. In this case, it could be defined as error in procedure, and argument. Students made mistakes in making the statement because of the procedure involved in solving statistics problem. In this case, it was included in the type of error in proposition and argument

Based on the result and discussion, it can be concluded that the error of student in solving the statistics problem based on onto-semiotic includes aspect of language (wrong in use of the terms), aspect of the concept (incorrectness defining terms, incorrectness example), aspect of procedure (incorrectness in using settlement strategy), aspect computing (misclassifying), proposition aspect (misrepresenting statement) and argument aspect (incorrect in explain each answer). The initial problem that causes the mistakes is their misunderstanding in problem that is given which then, causing the dominant error in terms of the concept aspect.

Conflict of Interest Statement

The authors declare no conflict of interest.

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