

Analysis of statistical misconception in terms of statistical reasoning

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Abstract. Reasoning skill is needed for everyone to face globalization era, because every person have to be able to manage and use information from all over the world which can be obtained easily. Statistical reasoning skill is the ability to collect, group, process, interpret, and draw conclusion of information. Developing this skill can be done through various levels of education. However, the skill is low because many people assume that statistics is just the ability to count and using formulas and so do students. Students still have negative attitude toward course which is related to research. The purpose of this research is analyzing students' misconception in descriptive statistic course toward the statistical reasoning skill. The observation was done by analyzing the misconception test result and statistical reasoning skill test; observing the students' misconception effect toward statistical reasoning skill. The sample of this research was 32 students of math education department who had taken descriptive statistic course. The mean value of misconception test was 49,7 and standard deviation was 10,6 whereas the mean value of statistical reasoning skill test was 51,8 and standard deviation was 8,5. If the minimal value is 65 to state the standard achievement of a course competence, students' mean value is lower than the standard competence. The result of students' misconception study emphasized on which sub discussion that should be considered. Based on the assessment result, it was found that students' misconception happen on this: 1) writing mathematical sentence and symbol well, 2) understanding basic definitions, 3) determining concept that will be used in solving problem. In statistical reasoning skill, the assessment was done to measure reasoning from: 1) data, 2) representation, 3) statistic format, 4) probability, 5) sample, and 6) association.

1. Introduction

1.1. Background of the Study

Along with the development of science and technology, reasoning skill becomes one of skills that must be owned by everyone, so that people can sort, group, and draw conclusion after receiving information. Statistical reasoning is one way to understand and find ideas based on statistic content. According to Ben-Zvi and Garfield (2015)[1], statistical reasoning involves decision interpretation based on set of data, data representation, or summary of statistical data. In Lovett (2001)[2] research, understanding and improving students' statistical reasoning can be done by integrating three



approaches: theoretical study approach, empirical studies, and class-based research. Lovett suggests an environment learning model to help students develop their statistical reasoning appropriately that will be evaluated in the future. However, statistical reasoning skill is not considered as an important skill in society. A lot of students assume negatively toward a course which involves statistical concepts, including descriptive statistics course.

As an effort to improve statistical reasoning skill, researchers consider this as an important thing to analyze students' misconception of descriptive statistics concepts. Based on the questionnaire result of learning evaluation from students who had taken descriptive statistics course, it could be illustrated that students' misconception of descriptive statistics concept happened in: 1) Recognizing and categorizing data, 2) Understanding how to collect sample that represent population, 3) Modifying graphic to represent a data, 4) Understanding measure of central tendency, positioning measure, measure of data dispersion, 5) Understanding random ideas, opportunity and probability, 6) Understanding the relation of sample and population, 7) Interpreting relation between two variables. By analyzing the students' misconception, statistical reasoning which is meant in this paper is the ability of students in using statistical ideas from statistical information which is logical and analytical.

A relevant research that is done by Karman, L. (2015)[3] states that achievement of statistical reasoning skill (KPS) of students who take ICT project-based learning (ICT-assisted PBP) are higher than students who take conventional learning (PK). The higher achievement is occurred in every class level or in entire class. Ulpah, M.(2013)[4] concludes that statistical reasoning ability of Madrasah Aliyah students who use contextual learning model is higher than students who use conventional learning model. The lack of statistical reasoning skill is not only happen in students, but also happen to teachers; this is in line with the research of Martadiputra (2010 [5] which suggests that high school teachers' average ability of statistical reasoning is in the medium category. Regnier Kutnezova (2013), [6] states that an underlying problem is that middle-grade students generally do not see 'five feet' as a value of the variable 'height', but as a personal characteristic of, say, Katie. While Johnson, et al [7] shows that statistical reasoning can be developed in every concept of statistics learning.

The formulation of the problem in this research are: a) What is the description of students' misconception in descriptive statistics course?, b) Is there any positive influence between students' misconception in descriptive statistics course toward statistical reasoning skill?. At the same time, the purpose of this research are: a) Analyzing students' misconception in descriptive statistics course, b) Finding the influence of students' misconception in descriptive statistics course toward statistical reasoning skills.

1.2. Theoretical Study

1.2.1. Misconception, Misconception can be defined as a definition that is not accurate toward a concept, using wrong concept, classifying wrong concept, and relation of incorrect concepts. The form of misconception are concept error, incorrect relation between concepts and intuitive ideas or wrong point of view. (Sastradi, 2013) [8], delivering unclear and incomplete information to the students in learning process can be the reason of misconception. Furthermore, the use of learning model is not quite appropriate, so it interferes students' thinking process and students get difficulty in understanding the concept learned.

Students' misconception can be detected by: a) giving structured assignments; b) giving diagnostic test in the early lectures; c) Asking open questions to students verbally; d) Asking inverted questions; e) Providing correction to the students for the taken steps in solving problem; and f) Holding interview.

1.2.2. Statistical Reasoning Skills, According to Delmas (2002) [9], statistical reasoning is a way of thinking in producing statistical information. This includes ability in interpreting a group of data, graph and a number of statistical information. Other definition mentions that statistical reasoning is students' ability in working on statistical calculations and reasoning toward statistical

concept. Statistical ability are understanding statistical concept, graph representation, data and opportunity interpretation. This ability is called statistical reasoning (Garfield, 2002)[10]. Related to statistical reasoning ability, Dasari, D (2009)[11] suggests that statistical reasoning ability is an ability to draw conclusion and give explanation based on data orientation by paying attention on structured procedure, unstructured procedure and statistical concept, also making critical comment toward statistical process and result.

Based on the mentioned definitions, statistical reasoning skill can be defined as someone's skill of thinking to produce statistical information based on statistical facts in order to draw conclusion for evaluation as a foundation to make a policy.

2. Methods

2.1. Research Data

Research data were obtained from 32 students of third semester in academic year 2016/2017 from mathematic education department of STKIP Garut. In order to get information of students' misconception in descriptive statistics course, misconception test and statistical reasoning skills were held. As a supporting data, students were given questionnaire to get information about students' difficulties in learning descriptive statistics.

Moreover, before working on the misconception test and statistical reasoning skills test, researchers interviewed students to get broader information about their difficulty in learning descriptive statistics.

2.2. Data Analysis

Collected observation data from students' questionnaire, misconception test, and statistical reasoning skill test were analyzed through the following steps:

- 1) Working on data tabulation about learning difficulties that were faced by students in descriptive statistics course.
- 2) Classifying students' misconceptions including concept, sub discussion or material that were not understood, and problem solving steps.
- 3) Classifying the statistical reasoning skills such as reasoning about data, data representation, statistical measure, opportunity, sample, and association.
- 4) Presenting misconception test and statistical reasoning test along with its correlation by descriptive statistics way.

3. Results and Discussion

3.1. Introduction of Analysis

Introduction of Analysis related to the observation result from questionnaire and interview towards students of Mathematics Education Department who took Descriptive Statistic course in regard to their difficulties in the learning process:

- 1) They found difficulties in acknowledging and classifying types of data; whether it was qualitative or quantitative, discrete or continue, and how to present it in a table or graph.
- 2) They were lack in understanding how to do sampling that represents a population and to modify graph that represent a data.
- 3) They were confused in understanding measurements of central tendency, layout and data dispersion; and in describing the differences of a data.
- 4) They were lack in understanding the random ideas, opportunity, and probability for making decision of an event.
- 5) They were lack in knowing the correlation between sample and population as well as how to draw conclusion from the sample.
- 6) They lacked in knowing how to asses and interpret correlation between two variables.

This analysis result of Students' needs would be used as the measurements of guidelines in constructing learning material and in choosing the appropriate learning model as the characteristics of descriptive statistic course material based on the students' difficulties in learning process so that their Statistical reasoning skills could be improved.

3.2. Classification of Students' Misconception

In order to classifying types of students' misconception in Descriptive Statistic course, a misconception test was done which included various types of questions about descriptive statistic. Those questions are below:

- 1) Find the median and the modus of this data: 8,10,9,7,6,8,8,7,5,9,6,8,9,8,7!
- 2) A student can take X course or Y course but cannot take both. The probability of taking X course is 0,06 and for Y course is 0,15. Based on the condition that the student take X course or Y course, how many probability for the student to take the X course?
- 3) A student scores 90 on an exam with an average of grade 70 and standard deviation is 10. In another test, he earns 600 with an average of grade 560 and standard deviation. In the first case he scores 20 above the average and in the second case he scores 40 above the average. Which case which shows that the student does better?
- 4) The average number is 140, the modus is 140 and the standard deviation is 35. Find the slope based on Pearson! Give your comment!
- 5) Out of 10 students who take descriptive statistic exam (I) and basic math introduction (II) the scores got are:

Table 1. The Score from 10 students who take descriptive statistic exam (I) and basic math introduction (II)

Student	1	2	3	4	5	6	7	8	9	10
Course I	46	52	77	83	63	56	65	75	65	78
Course II	54	55	75	75	56	65	56	68	67	72

How is the correlation between the two courses?

From the types of the questions constructed in the misconception test, based on the scores of 32 students as the sample of this research, there were misconceptions in 1) writing mathematic sentence and symbol well, 2) understanding basic definitions, 3) deciding the concept that will be used to solve the problems.

3.3. Classification of students' statistical reasoning skills

In order to classify Student Statistical reasoning Skills in Descriptive Statistic course, the students were given statistical reasoning skills test by the questions below:

- 1) Based on a data, the scores obtained from 15 students who take the test were 56, 45,25, 65, 76, 85, 63,72,85,90, 55, 46, 76, 45, and 58. What is the average, median and the mode of the data?
- 2) In the election for chairman and vice chairman of an organization, there are four candidates A, B, C, and D. How many election options can be done?
- 3) A set of data consists of 4 numbers (1,2, 6, and 9). Calculate the standard deviation of the data, if all data multiplied by 2 and added 2!
- 4) Given $\bar{x} = 80$, $s = 20,95$ and $N = 303$. What is the area of point $x = 55$ and what is the expected frequency?
- 5) Based on the result of mathematic skills comprehension test (I) and problem solving (II) from 10 students, the data scores obtained are:

Table 2. The Score from 10 students which Based on the result of mathematic skills comprehension test (I) and problem solving (II)

Students		1	2	3	4	5	6	7	8	9	10
Mathematic	I	46	52	77	83	63	56	65	75	65	78
Skills	II	54	55	75	75	56	65	56	68	67	72

How is the correlation between the two courses?

From those types of question in Statistical reasoning Skills test, based on the scores of 32 students as the sample of this research, there were Statistical reasoning Skills in: 1) data, 2) representation, 3) statistical measurement, 4) probability, 5) sample, and 6) association.

3.4. Analysis of Students' misconception in descriptive statistic course

The summary of observational data of students from mathematics education program for the variable of misconception test score and students' statistical reasoning skills could be described in table as follows:

Table 3. Scores of Student misconception and Statistical reasoning Skills

Variabel	N	Minimum	maximum	Average	Standard Deviation
Misconception	32	25	90	49,7	10,6
Statistical reasoning Skills	32	28	95	51,8	8,5

Scores of misconception and statistical reasoning skills test have very wide range between the lowest and the highest. The range is 65, the average is 49, 7 and the standard deviation is 10, 6. Meanwhile, the misconception score is 67 and the statistical reasoning skills' average was 8,5. It means that both of misconception test and statistical reasoning skills test is various. Several students may understand well so that they get good scores, but some of them may don't, so that their scores is far below from the average score.

When using a standard score of 65 as the minimum value of the standard achievement of descriptive statistics course, it would appear that the mean scores of both misconception and statistical reasoning skills tests were below the minimum competency standards. This score provided information that there was still a very high misconception and low statistical reasoning skills of students who follow descriptive statistics lectures.

The linear correlation between students' misconception score and the test score of students' statistical reasoning skills was 0.57, which indicated that there was a significant relationship between the two variables. Students' understanding of the concepts in descriptive statistics influenced the score of statistical reasoning skills. Students with a better misconception score would have a better score in statistical reasoning skills.

3.5. Analysis of Students' Statistical Reasoning Skills

In order to determine the students' statistical reasoning skills, the research used a modified description of A Comprehensive Assessment of Outcomes in Statistical (CAOS) developed by delmas, Robert.C et.al (1999) [12]. The test to measure students' statistical reasoning skills consisted of five essays questions as presented in the classification section of the students' statistical reasoning skills. The result of data processing of statistical reasoning skills is shown in the following table:

Table 4. Results of Data Processing of Students' Statistical Reasoning Skills

No	Material	Measured Statistical Reasoning Skills	Percentage (%)	
			Wrong Answer	Right Answer
1.	Central tendency	Categorizing Data	64	36
2.	Measure of Data Dispersion	Understanding representation of the data	45	55
3.	Layout Measurement	Understanding statistical measurement	37	63
4.	Data Distribution	Understanding the opportunity/ probability	52	48
5.	Data Presentation	Understanding Sample and association	28	72

Based on the table above, it can be seen that the statistical reasoning skills in categorizing the data with the material of the central tendency consists of 64% students answered it correctly and 36% wrongly answer. The Statistical Reasoning related to data representation is the ability to understand sampling which represent the population and to modify the graph of data representation in the material of measurement of Data dispersion in which 45% students are correctly answer and 55% are wrongly answer. In regard to statistical reasoning skills related to the understanding of statistical and layout measurement, there are 37% students correctly answer and 63% wrongly answer. In the data distribution to measure statistical reasoning skills regarding opportunity reasoning or probability, there are 52% student correctly answer and 48% wrongly answer. For measuring students' statistical reasoning skills in sampling and association in data presentation, there are 28% student correctly answer and 72% wrongly answer.

4. Conclusion

The description of students' misconception in descriptive statistics course based on observation result, the percentage were below standard of competency. As for the correlation between misconception with the statistical reasoning skills, there was a positive correlation which meant that the better the score of misconception tests the better the score of statistical reasoning skills test.

Even though the results of this study could not be used as a tool to generalize the students' statistical reasoning skills but the authors thought that it could be used as a reference in determining policies in general education, and in particular setting learning methods that would be applied to minimize students' misconceptions and to improve students' statistical reasoning skills.

5. References

- [1] Ben-Zvi D and Garfield J B 2004 *The challenge of developing statistical literacy, reasoning and thinking* (The Netherlands: Kluwer academic publishers).
- [2] Lovett M C 2001 A collaborative convergence on studying reasoning processes: A case study in statistics *Cognition and instruction: Twenty-five years of progress* 347-384
- [3] Nani K L 2015 *Kemampuan Penalaran Statistis, Komunikasi Statistis, dan Academic Help-Seeking Mahasiswa Melalui Pembelajaran Berbasis Proyek Berbantuan ICT* (Doctoral dissertation, Universitas Pendidikan Indonesia)
- [4] Ulpah M 2013 *Peningkatan Kemampuan Penalaran Statistis dan Self-Efficacy Siswa Madrasah Aliyah Melalui Pembelajaran Kontekstual* (Doctoral dissertation, Universitas Pendidikan Indonesia)
- [5] Martadiputra B A P 2010 *Kajian Tentang Kemampuan Melek Statistis (statistical Literacy), Penalaran Statistis (statistical Reasoning), Dan Berpikir Statistis (statistical Thinking) Guru Smp saung-guru* 83
- [6] Régnier J C and Kuznetsova E 2014 Teaching of Statistics: Formation of Statistical Reasoning *Procedia-Social and Behavioral Sciences* **154** 99-103.
- [7] Johnson R and Thomas S 2013 *Statistical Reasoning in the Middle School*
- [8] Sastradi T 2013 *Pengertian Prakonsepsi dan Miskonsepsi* <http://mediafunia.blogspot.com/>

- [9] DelMas R C 2002 Statistical literacy, reasoning, and learning: A commentary *Journal of Statistics Education* **10** 3
- [10] Garfield J 2002 The challenge of developing statistical reasoning *Journal of Statistics Education* **10** 3
- [11] Dasari D 2009 *Meningkatkan Kemampuan Penalaran Statistis Mahasiswa Melalui Pembelajaran Model PACE* (Disertasi SPS UPI)
- [12] Chance B, Garfield J and delMas B 1999 *A model of classroom research in action: Developing simulation activities to improve students' statistical reasoning* (Finland: International Statistical Institute).

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