Profile of Students' Statistical Reasoning Capabilities in Introductory Social Statistics Courses

A L R Jauhari, R L Ariany, F Fardillah and A Ayu

1 Universitas Pendidikan Indonesia, 229 Setiabudhi Street, Bandung, Indonesia
2 Universitas Pasundan, 68 Lengkong Besar Street, Bandung, Indonesia
3 UIN Sunan Gunung Djati Bandung, 105 A.H Nasution Street, Bandung, Indonesia
4 Universitas Muhammadiyah Tangerang, Tangerang, Indonesia

*afifahlatip@upi.edu

Abstract. Statistical Reasoning is the ability to understand information in daily life based on statistical data. This study aims to determine the ability of student statistical reasoning based on 5 levels of statistical reasoning models. The research subjects are two classes of first semester students majoring in Communication Sciences. The data collected is in the form of statistical reasoning test result. The data are categorized into five namely Level 1 (Idiosyncratic reasoning), level 2 (Verbal reasoning), level 3 (Transitional reasoning), level 4 (Procedural reasoning) and level 5 (Integrated process reasoning). Next, look at the percentage of student statistical reasoning included in the level 1, level 2, level 3, level 4 and level 5 categories. The results of data analysis showed that students level 3 with statistical reasoning were far more numerous than students' statistical reasoning abilities categorized as than on the other.

1. Introduction

Statistics is one of the courses that is always in every curriculum at university in Indonesia. In line with Watson's opinion which states that "statistics is one of the most important quantitative subjects in a university curriculum"[1]. Statistical reasoning is needed in all fields of work in the future[2], [3]. Statistics is a science of mathematics but not a branch of mathematics, and appear as a statistical discipline having the characteristics of a more basic way of thinking with a particular method[4]. Statistics is seen as knowledge that provides a means to be able to provide solutions to problems that occur in life, in the work environment and in science itself. But most students only use statistics as a tool to analyze it without understanding its contents, even though it can be said that statistics are very important. To support success in studying statistics, students must have good statistical reasoning ability. Because one of the goals of learning statistics is to build and improve the ability of statistical reasoning [5].

Statistical reasoning is the ability a statistical assessment of what a student can do with statistical content (considering, testing, and distinguishing between statistical concepts) and skills that discuss students in using statistical concepts in specific problem solving steps.[1] The Chervany et al. model depicts the statistical reasoning process in three stages: 1). Comprehension -the recognition of a specific problem or task as an instance of a more general category or prototype of methods for solving instances of the prototype. 2). Planning and execution -the application of these methods to the specific instance at
hand. Evaluation and interpretation - the evaluation of the validity of the outcome from this application against the initial problem or question [1].

Final year students have the obligation to conduct research as one of the requirements for graduating a bachelor's program. Statistical reasoning plays an important role in research practice, so detecting the initial ability of mathematical reasoning becomes a preventative step to avoid misinterpretation of data interpretation of research results. This study uses the theory of statistical reasoning models to categorize student statistical reasoning, the statistical reasoning model is shown in Table 1 [6].

| Level                          | Description                                                                 |
|-------------------------------|-----------------------------------------------------------------------------|
| 1. Idiosyncratic reasoning    | Students know the words and symbols related to correlation and linear regression, but do not understand the concept well, often incorrectly, and may scramble these words with unrelated information. |
| 2. Verbal reasoning           | Students understand the correlation and linear regression verbally, they can define but can't apply this knowledge to actual behaviour. |
| 3. Transitional reasoning     | Students can identify cases that use correlation or linear regression but have not been able to implement it to test different contexts or still allow errors in the tests conducted. |
| 4. Procedural reasoning       | The students is able to correctly identify the dimensions of the correlation but does not fully integrated them nor understand the process correlation and linear regression test. Students have not been able to make conclusions from the results of tests conducted or still allow misinterpretations to occur. |
| 5. Integrated process reasoning | The student has a complete understanding of the process of correlation and linear regression. The student can explain the process in her or his own words and makes correct predictions with confidence. |

The ability of statistical reasoning in social science students is also very necessary, determining the level of statistical reasoning ability of students aims to be a benchmark in the next statistical learning that will be applied in the field of student work in the future.

2. Method

The research method used was descriptive qualitative research. [7] The specific purpose of this study is to determine the profile of students' statistical reasoning abilities in introductory subjects in social statistics based on their level of statistical reasoning. This study involved students in the international relations study program semester one of the 2019/2020 school year consisting of 100 students selected from 2 existing classes. Data collection techniques using written tests, namely tests of statistical reasoning ability based on three indicators (Comprehension, Planning and execution, Evaluation and interpretation) and interviews. Test data analysis techniques as follows: 1). The statistical reasoning ability test is corrected, 2). Analyzing the mistakes that occur in student answers 3). Classifying student answers based on the type of error, 4). Determine the ability of statistical reasoning based on levels that have been determined, 5). Determine the percentage of grouping statistical reasoning skills 6). Interview analysis to strengthen the analysis of test results.
3. **Result and Discussion**

The data obtained in this study are written answers that were done by students during tests of statistical reasoning abilities and the results of interviews with several students. The data obtained were then analyzed to determine the ability of students' statistical reasoning by seeing students work on three questions of statistical reasoning ability. Based on the results of tests of students' statistical reasoning abilities in introductory subjects in social statics, students are categorized into 5 groups, namely level 1 to level 5.

![Percentage of students' Statistical Reasoning Abilities](image)

**Figure 1.** Percentage of students’ Statistical reasoning abilities

Based on diagram 1. Obtained as many as 48% of students with statistical reasoning ability who are at level 3. Level 3 of this ability is called the level of transitional reasoning, this shows that most students can identify problems using appropriate symbols or terms, can determine research hypotheses and know the concepts that will be used in solving problems but do not understand the use of concepts. Students with level 3 statistical reasoning abilities are the levels that students generally have. There is also still a statistical reasoning ability of students who are at level 1 that the student cannot identify the problem by using with symbols or terms only copying the problem contained in the problem or rewriting the problem. While on the other hand, there are students who are at level 5, that is, students can apply the concepts correctly to solve problems and can interpretation and associate with original problems. The percentage of students with statistical reasoning ability at level 1 and level 5 is equivalent. The percentage is 4%.

**Level 1 (Idiosyncratic Reasoning)**
Students at level 1 generally know that correlations are relationships, but this knowledge only covers the definition of correlations in general, student do not yet understand the context of correlation in statistics, when to use correlations tests, what is correlated in special cases. As well as linear regression, students are limited to knowing the term linear regression.

**Level 2 (Verbal Reasoning)**
Students can define for themselves what is correlation and linear regression, but but do not understand the use of linear regression or correlation, procedures, test requirements and their interpretation.

**Level 3 (Transitional Reasoning)**
The following is an example of one of the answer of student at level 3 statistical reasoning abilities.
At level 3, students can identify problems using appropriate symbols or terms, can determine research hypotheses and know the concepts that will be used in solving the problems presented, but students have not been able to use concepts on those problems.

Figure 2 shows that students have been able to identify problems by determining the variables of money needed in determining the regression equation. However, the student has not been able to deduce what the meaning of the number is and has not been able to conceptualize which will be used to solve the existing problem.

**Level 5 (Integrated Reasoning)**
The following is an example of one of the answer of student at level 5 statistical reasoning abilities.
It can be seen from Figure 3 that students at this level are able to apply concepts well in problem solving and are able to make conclusions in accordance with the problems presented correctly. Figure 3 shows that the ability of students at this level shows that students are able to apply the concept of correlation correctly with the right formula. Also students are also able to make precise conclusions about the relationships between existing variables. And able to see the significance of the correlation coefficient.

Based on the results of the interview, students claimed to rarely work on problems related to statistical reasoning, because their background was not from an exact study program. Students also find it difficult to express ideas, make connections or conclusions from the problems presented. This proves that it is important for students to improve their statistical reasoning abilities in order to achieve success in learning related to statistics, especially in the Introduction to Social Statistics course.

4. Conclusion

Based on the results of research and discussion obtained that the statistical reasoning ability of most students are still at level 3 (Transitional Reasoning) which shows that students can only identify problems using appropriate symbols or terms, can determine research hypotheses and know the concepts that will be used in solving a problem but don't understand the use of the concept. This can be seen in the grouping of students based on their level of statistical reasoning ability which shows the highest percentage. To increase the level of statistical reasoning students, especially in introductory courses in social statistics, students must make a habit of working on questions related to the ability of statistical reasoning.

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