Developing Statistical Reasoning Ability of Industrial Engineering Students Through Experiential Learning

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Abstract. Education is one way to develop thinking skills. The aim of implementing education is to produce quality human resources. So that the development of science and technology can develop in a better direction as technology advances. Quality learning will encourage students to have better cognitive abilities. Experiential learning implementation is a learning process that prioritizes experience during the learning process. The purpose of this study was to determine the effects of experiential learning on students' statistical reasoning abilities. The design of this study was one sample group with purposive sampling technique. The subjects of this study were students who contracted industrial statistics courses. Statistical test results prove that experiential learning provides a positive contribution to students' statistical reasoning abilities.

1. Introduction
Fundamental factors in the development of scientific and technological advances are findings from research results. Findings from research results are the basis for finding new knowledge. In the slightest progress research will be recorded, which will later be used as supporting data from a study. The data aims to support the findings that occurred during the research process. The data can be used as a strong excuse by a researcher in making decisions about the results of his research.

The importance of statistics in the advancement of science and technology is inversely proportional to the reality that occurs in the world of education. Where in the world of education the low ability in statistical reasoning is still a problem that is naturally given a solution in overcoming these problems. Facts that occur in the field of students, have negative suggestions for statistics. Similar opinion was also expressed by Snee (Martadiputra, 2010) who summarized the latest issues among American statisticians.

“…highlight the growing feeling that statistical education is in serious trouble and that changes must be made. These changes are necessary because, in general, people don’t understand statistical thinking and as a result don’t value its use. People can’t value what they don’t understand”.

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Boediono and Koster (2004) argued that Japan's success in developing statistical abilities starting from high school to higher education, especially in the matter of probability (opportunities) had a very positive impact. This has been proven in designing and marketing its products, such as cars, motorbikes and some electronic goods manufactured by Japan, Japan often uses statistical science in industrial life and business. If we examine in depth, that statistics especially the ability of statistical reasoning bring many benefits in the daily lives of various fields.

The right learning develops positive cognitive abilities, compared to learning that only prioritizes the delivery of material from one direction. Kolb and Kolb (2008) develop experiential learning models which are described as follows:

![Experiential Learning Diagram](image)

**Figure 1. Experiential Learning**

Based on Figure 2.1 shows that experiential learning has four stages, namely: 1. Experience, 2. Observation and reflection, 3. Formation of abstract concepts, 4. Active experimentation in new situations. So that students are not only fixated on the lecturer as a source of knowledge, but students form their concepts and knowledge actively and conduct several experiments on problems found everyday. Garfield (2002) states that the way to give reasons by using statistical ideas and giving meaning to that information is statistical reasoning.

Mathematical reasoning is an abstract mindset, to explain it a good conjecture is needed from the analogy that has been made. Sumarmo (Kusnandi, 2012) there are several indicators of ability referred to in mathematical reasoning abilities, namely as follows: 1. Making analogies and generalizations, 2. Providing explanations using models, 3. Using patterns and relationships to analyze mathematical situations, 4. Developing and test the conjecture, 5. Check the avalidity of arguments, 6. Arrange indirect proofs, 7. Provide examples of denial, 8. Follow the rules of referencing.

1.1. Scope Of Analysis

Based on the background that has been in the background, the formulation of the problem in this study is "Is there any increasing in the ability of students to perform statistic learning through experiential learning?"

1.2. Research Purpose

The purpose of this study is based on the background and formulation of the problem, so the purpose of this study is to examine the effects of experiential learning on students' statistical reasoning abilities.
1.3. Significance Research
This research is expected to provide positive benefits, namely:
1. Learning experiential learning can be used as an alternative learning in developing students' statistical reasoning abilities.
2. The data obtained will be supporting information in developing statistical reasoning abilities

2. Research Methods
The study used one sample group design with purposive sampling technique. With the research design as follows:

Group: O \( \chi \) O

Information:
O: Initial score and final score
\( \chi \): Experiential learning

2.1. Research Instrument
A description of mathematical statistical reasoning skills is used to collect data. The ability of statistical reasoning is measured as follows: (a) The ability to provide statistical explanations includes explanations and statistical meaning (generalization), (b) the ability to present statistical data, (c) the ability to interpret statistical data, (d) the ability of statistical data representation.

2.2. Results And Discussion
Research data analysis was carried out descriptively and inferentially. Scores of initial ability and final ability of students are measured by a description of statistical reasoning ability. After the data is obtained, the first step is to describe the students' statistical reasoning abilities using descriptive statistics. Descriptive results of student reasoning abilities are described in Table 1.

| Table 1. Description of Statistic Reasoning Ability |
|-----------------------------------------------|
| Score            | \( \bar{x} \) | SD |
|------------------|---------------|
| Initial ability  | 5.03          | 1.42 |
| Final ability    | 10.90         | 2.55 |

Table 1.1 shows that the average student's initial statistical reasoning ability is 5.03 and the average student's final statistical reasoning ability after experiential learning is 10.90. To see more clearly the difference is illustrated by the bar diagram as follows.

![Figure 2. The Difference is Illustrated by The Bar](image-url)
When looking at the bar diagram, the difference is very clear that experiential learning provides a positive contribution to increasing statistical ability, but to see whether this increase significantly increases the average difference test of the research hypothesis.

Prerequisite before conducting a statistical test is to test the average normality of the two. The results of testing normality with the help of statistical software are summarized in the following table.

| Test          | Statistic | Df | Sig. | Conclusion                     |
|---------------|-----------|----|------|--------------------------------|
| Initial score | .184      | 31 | .009 | Data is not normally distributed |
| Final score   | .131      | 31 | .189 | Data are normally distributed   |

The results of normality testing indicate that the data is not normally distributed. So that it will be continued with non-parametric statistical tests to test hypotheses with Wilcoxon test. The results of testing hypotheses are summarized in Table 3:

| Test          | Initial S. – final S. | Asymp. Sig. (2-tailed) |
|---------------|-----------------------|------------------------|
| Z             | -4.791                | .000                   |

Based on the results of statistical testing with Wilcoxon test, p-value is obtained or Sig. (2-tailed) that is equal to 0,000 < $\alpha$ = 0,05. So that the results of these tests indicate that H0 is rejected, this means that there is an increase in students’ statistical ability to learn through experiential learning.

After the data was analyzed descriptively and inferentially, we can draw the conclusion that the effects of experiential learning can improve students' statistical reasoning abilities. From the results of the analysis, it was also found that the improvement of students' statistical reasoning abilities increased based on several factors in the process of learning syntax that could improve reasoning ability. In experiential learning there are stages in which students actively experiment in new situations, at this stage students not only accept problems that lead them in the development of statistical reasoning. Students are also required to experiment with the problems they have and observe, the aim is with these problems their statistical reasoning abilities will develop well.

Students who through experiential learning are also required to make observations and reflections from the results of the experiences they have gained. So that the stages in this learning are able to improve students' statistical reasoning abilities. Dewey (Trianto, 2009) explains that when educators transfer knowledge to students must use reflective methods in solving problems, namely a process of thinking actively, carefully and based on the process of thinking towards a definitive conclusion. So that knowledge moves in two directions that start with the problem, suspect to prove to get a conclusion. Then the right learning begins with the student experience that ends in the conclusion of the subject matter obtained.

The Zone Proximal Development (ZPD) theory initiated by Vygotsky also strengthens, that in developing cognitive abilities there are stages that must be passed. During the learning process takes place Scaffolding is very necessary, because every individual who is learning in searching for new knowledge needs help, both peer assistance and assistance from tutors who are experienced in their fields.

This study is in accordance with the research of Fenyves, Koskima and Lavicz (2014), Weinberg, Basile, Albright (2011) and Chesimet, Githua, Ng’eno (2016). In these three studies using experiential
learning, the results of these three studies, that learning through experiential learning has a positive impact on students' cognitive abilities.

3. Conclusion and Suggestions
After the problem formulation is submitted, then the results are obtained followed by an analysis and discussion of the results obtained. Then the conclusion of the results of this study is as follows:

3.1. Conclusions
There is an increase in students' statistical reasoning abilities through experiential learning.

3.2. Suggestions
Based on the conclusions of the results of the study, several suggestions in this study are as follows:
1. Learning through experiential learning has a positive effect on students' statistical reasoning abilities.
2. Learning will be more effective when, before the start of learning, students have initial knowledge regarding the material to be studied. This aims to facilitate the process of assimilation and accommodation of students' cognitive abilities.

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