Minimizing student’s faults in determining the design of experiment through inquiry-based learning

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Abstract. The purpose of this study were to describe the used of inquiry method in an effort to minimize student’s fault in designing an experiment and to determine the effectiveness of the implementation of the inquiry method in minimizing student’s faults in designing experiments on subjects experimental design. This type of research is action research participants, with a model of action research design. The data source were students of the fifth semester who took a subject of experimental design at Mathematics Department, Faculty of Mathematics and Natural Sciences, Udayana University. Data was collected through tests, interviews, and observations. The hypothesis was tested by t-test. The result showed that the implementation of inquiry methods to minimize of students fault in designing experiments, analyzing experimental data, and interpret them in cycle 1 students can reduce fault by an average of 10.5%. While implementation in Cycle 2, students managed to reduce fault by an average of 8.78%. Based on t-test results can be concluded that the inquiry method effectively used to minimize of student’s fault in designing experiments, analyzing experimental data, and interpreting them. The nature of the teaching materials on subject of Experimental Design that demand the ability of students to think in a systematic, logical, and critical in analyzing the data and interpret the test cases makes the implementation of this inquiry become the proper method. In addition, utilization learning tool, in this case the teaching materials and the students worksheet is one of the factors that makes this inquiry method effectively minimizes of student’s fault when designing experiments.

1. Introduction
The demands for the quality of graduates and competition between institutions in improving graduate GPA sometimes into competition, however, as an educational institution should not be stuck in an increase GPA with a high value without going through a learning process that focuses on the gradual periodic competency.

The real conditions in the Mathematics Department of Udayana University, shows that the achievement of student learning outcomes for the course of Experimental Design in the last three years shows that the student grades is not increased. In addition, based on the results of the evaluation of the learning process is done by Quality Assurance Team of the Department and lecturer of the courses, found that the low of student grades on the course of Experimental Design, which are caused due to: (1) mistake in determining the appropriate design for the given case; (2) difficulty distinguishing between repetition and groups; (3) difficulty distinguishing between the treatment and groups; (4) difficulties in manual counting; (5) the limited laboratory facilities to support the practicum.
In spite of conditions mentioned above, the determination of appropriate learning methods is very important to be done in an effort to improve student results on this subject in particular, and to improve the quality and GPA of graduates in general quality of the learning process. One method that can be applied to minimize student’s faults in the designing of the experiment is a method of inquiry-based learning.

The purpose of this study were to describe the used of inquiry method in an effort to minimize student’s faults in designing an experiment and to determine the effectiveness of the implementation of the inquiry method in minimizing student’s faults in designing experiments on subjects experimental design.

Inquiry learning is rooted in constructivist view. [1] explains that the inquiry-based classroom as:

recognizes the diverse needs of students and employs the research-based strategies that help to keep all students engaged in learning. It is a community of inquiry where students and teachers share responsibility for learning, and where they collaborate on constructing new knowledge.

The statement above encourage teachers to develop learning inquiry on subjects where students are actively involved with mathematical concepts. [2], applying Inquiry-based learning to explore how researchers in this case are a teacher, can use Inquiry based learning encourages higher order thinking among students.

Five steps to be taken in carrying out the inquiry or discovery approach by [3, p.155], namely: (a) the formulation of the problem to be solved by students; (b) set a temporary answer, or better known as hypothesis; (c) students to find information, data, facts needed to answer the problems or hypothetical; (d) deduce the answer; and (e) apply the conclusions/ generalizations in new situations.

2. Research method
This type of research is action research participants, with a model of actionresearch design. The data source were students of the fifth semester who took a course of Experimental Design at Mathematics Department, Faculty of Mathematics and Natural Sciences, Udayana University.

Implementation of the overall study carried out for six months, while the implementation of the provision of treatment carried out over four months. Data was collected through tests, interviews, and observations. The data obtained from the test results were analyzed using statistical techniques t test, to test scores of students before and after the action learning groups. Hypothesis proposed in this study are: Inquiry method effective used in an effort to minimize the student’s faults in designing experiments on courses of Experimental Design at the Mathematics Department, Faculty of Mathematics and Natural Sciences, Udayana University.

Action procedures designed in two cycles, in each cycle was conducted for two months. The subject matter is given on the implementation of the action cycles 1 and 2 for this course of Experimental Design are: Complete Random Design in cycle 1 and Randomized Block Design in cycle 2. At the end of the cycle of actions carried out subsequent monitoring and evaluation of the results of the evaluation reflected for planning their next action. The observations were made using the observation, interviews, and learning achievement test.

3. Results and discussion
The result showed that the implementation of inquiry methods to minimize the student’s faults in designing experiments, analyzing experimental data, and interpret them in cycle 1 students can reduce faults by an average of 10.5%. While implementation in Cycle 2, students managed to reduce faults by an average of 8.78%.
The faults made by the students in designing experiments verified by observation, interview and assessment test results of students work in resolving cases of existing experiments in the Student Worksheet. There are some types of fault made by students in designing experiments, include: (1) mistake in determining the right environmental design in a case of experiment; (2) mistake in writing and explain precise linear model of an experiment; and (3) mistake in interpreting the results of data analysis in a case of experiment.

The effectiveness of methods of Inquiry in minimizing student’s faults in experimental design, are tested using the $t$ test. Results of testing the normality of the data as shown in Figure 1.

![Figure 1. Plot of normality test data difference cycle 1 to cycle 2.](image)

Anderson Darling test results get the value of 0.540 with $P$ value = 0.155, if the value of $P$ is compared with the value of $\alpha$ = 0.05, $P$ value is greater than the value of $\alpha$ = 0.05, this means that $H_0$ is accepted, indicate that data normal spread.

Results of testing the assumption of homogeneity of variance seen in the MINITAB output in Table 1, showing that the value of $P$ is equal to 0.571 greater than the value of $\alpha$ = 0.05, which means that $H_0$ is accepted. This indicates that the data are homogeneous.

| Test Method       | DF1 | DF2 | Statistic | P-Value |
|-------------------|-----|-----|-----------|---------|
| Levene’s Test     | 1   | 70  | 0.32      | 0.571   |

Since both assumptions are met, the test can be performed with the $t$ test, the results are presented in Table 2. The hypothesis tested is: $H_0 : \mu_1 = \mu_2$ (The mean of student learning outcomes with the implementation of inquiry method in cycle 1 and cycle 2 are the same) $H_1 : \mu_1 < \mu_2$ (The mean of student learning outcomes with the implementation of inquiry the method cycle 1 is smaller than the cycle 2).

The $t$ test results are presented in Table 2. The results of the $t$ test obtained $t$ value = 9.85 with $P$ value of 0.000 which is smaller than the value $\alpha$ = 0.05, this means that $H_0$
refused and accept $H_1$. The decision to reject $H_0$ implies that the action of implementation of inquiry method managed to increase the average score of the students, this means that the Inquiry method effectively improve the student learning outcomes in working on experiment cases given, also means reducing the students’ mistakes in analyzing the data and interpretation of experiment one factor in Experimental Design courses. Based on explanations above can be concluded that the inquiry method effectively used to minimize of student’s faults in designing experiments, analyzing experimental data, and interpreting them.

| Cycle     | N  | Mean | StDev | SE Mean |
|-----------|----|------|-------|---------|
| Cycle 1   | 36 | 65.36| 7.27  | 1.21    |
| Cycle 2   | 36 | 74.22| 6.66  | 1.11    |

95% CI for mean difference: $(7.034; 10.688)$

T-Test of mean difference = 0 (vs not = 0):

$T$-Value = 9.85 $P$-Value = 0.000

The nature of the teaching materials on subject of Experimental Design that demand the ability of students to think in a systematic, logical, and critical in analyzing the data and interpret the test cases makes the implementation of this inquiry become the proper method. This is supported by [4] about the purpose of the inquiry learning is to develop the ability to think in a systematic, logical, critical, or develop intellectual abilities as part of the mental process. Further explained that in the inquiry learning students are not only required to master the subject matter, but how they can use their potential. Man who just learned the lesson is not necessarily able to develop the ability to think optimally. Instead, students will be able to develop the capacity to think when he can master the subject matter.

The ability of students to think in a systematic, logical, and critical as required in the course of this experiment design, making the inquiry method proper applied to minimize student’s faults in designing experiments. This is supported by [2], applying the inquiry based learning to explore how researchers in this case are a teacher, can use inquiry-based learning encourages higher order thinking among students.

In addition, utilization learning tool, in this case the teaching materials and the students worksheet is one of the factors Based on t test results can be concluded that that makes this inquiry method effectively minimizes of student’s faults when designing experiments.

4. Conclusion
The implementation of inquiry method to minimize student’s faults in designing experiments, analyzing experimental data, and interpret it in Cycle 1 students can reduce faults by an average of 10.5%. While implementation in Cycle 2 students managed to reduce faults by an average of 8.78%. The faults can be minimized are (1) mistake in determining the right environmental design in a case of experiment; (2) mistake in writing and explain precise linear model of an experiment; and (3) mistake in interpreting the results of data analysis in a case of experiment.

The inquiry method effectively used to minimize of student’s faults in designing experiments, analyzing experimental data, and interpreting them on subject Complete Random Design and Randomized Block Design of Experimental Design course in the Department of Mathematics, University of Udayana.
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