

**THE COMPARATION STUDY OF LABORATORY EXPERIMENT AND
COMPUTER SIMULATION METHODS IN INCREASING STUDENTS'
COGNITIVE ACHIEVEMENT AND SCIENCE PROCESS SKILLS ON THE
TOPIC OF LINEAR MOTION**

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Abstract

This research aims to compare the effectiveness of laboratory experiment and computer simulation methods in the teaching-learning of physics. It can done by testting the difference of cognitive achievement and science process skills for students who learn physics, on the topic of linear motion, by using laboratory experiment and computer simulation methods. This topic includes motions along a straight line with a constant velocity and a constant acceleration.

The research method was a quasi-experiment with *pretest-posttest experimental group design*. It was conducted in SMAN 2 Wates. The population was all students in this school and the sample was the X-grade students. The sampling technique was the cluster random sampling. After drawing lots, the X-A-grade student was the experiment group using simulation and the X-C-grade student was the experiment group using experiment laboratory. Data were collected by using pretest and posttest, based on students' cognitive achievement and science process skills. Data analysis method to test hypothesis was Manova (Multivariate Analysis of Variance). Before hypothesis testing, the pre-requisite analysis was done, that is the normality of data distribution and variance homogeneity.

This research shows that (1) there were the increasing differences of cognitive achievement and science process skills between students who learn physics on the topic of linear motion by using laboratory experiment and computer simulation methods; (2) the laboratory experiment method was more effective than the computer simulation.

Key words: *laboratory experiment, computer simulation, students' cognitive achievement, science process skills.*

INTRODUCTION

In conformity with the characteristic of physics, the teaching-learning of physics should involve the concepts of physics that can be studied through students' observation and experiment. In studying the concepts of physics students should also do scientific activities. They should possess science process skills that they can get from their learning process.

Laboratory work is a unique type of instruction that be an integral part of science teaching. This type of activity involves students in first hand experiences that permit them to participate in science as a way of thinking and as a way of investigating. Laboratory work provides students with concrete exemplars of science concepts and principles (Collette and Chiappetta, 1994: 197).

Computer as an integral part of contemporary science. The use of computer in physics can be divided into five categories: numerical analysis, symbolic manipulation, simulation, collection analysis of data, visualization. In simulation mode, the essential elements of the model are included with a minimum of analysis. Computer simulations are sometimes referred as computer experiments because they share much in common with laboratory experiments. We can obtain essentially exact results by simulating an idealized models that has no laboratory counterpart. Simulation can be done on realistic model in order to make a more direct comparison with laboratory experiment (Gold and Tobochnick, 1996: 2-3).

The similarity of simulations with laboratory works can be seen from some points of view. Samples in laboratory work are identic with models in computer simulation. Physical apparatus are similar to computer program. Calibration in laboratory works similar to computer program in computer simulation. There is data analysis in both laboratory works and computer simulation. Therefore, it is interesting to make a research concerning with laboratory experiment and computer simulation in teaching-learning physics.

There are three domains of objectives for science teaching, that are cognitive, affective and psychomotor domain. The cognitive domains are: knowing, comprehending, applying, analyzing, synthesizing, and evaluating (Trowbridge, Bybee and Powell, 2004: 94). Physics is a part of science, so its objectives in physics teaching with the same with the objectives in science teaching.

The science process skills includes observing, communicating, classifying, measuring metrically, inferring, predicting, identifying variables, constructing a table of data, constructing a graph, describing relationship between variables, acquiring and processing your own data, analyzing investigations, constructing hypothesis, defining variables operationally, designing experiments, and experimenting (Rezba et al, 2007: iii; Padilla, 1990: 1; Chiapetta & Koballa, 2010: 131-132).

Laboratory experiments have been done in many schools, especially teaching-learning science, physics included. Similarly, many schools are interested in computer simulations in teaching-learning science.

This research was conducted to compare the effectiveness of laboratory experiment and computer simulation methods in the teaching-learning of physics. It can done by testing the difference of cognitive achievement and science process skills for students who learn physics, on the topic of linear motion, by using laboratory experiment and computer simulation methods. This topic includes motions along a straight line with a constant velocity and a constant acceleration.

The problems of research can be formulated as follow:

1. Were there the increasing differences of cognitive achievement and their science process skills between students who learn physics, on the topic of linear motion, by using laboratory experiment and computer simulation methods?
2. Which method was more effective in the teaching-learning of physics on the topic of linear motion above?

The dependent variables of this research were students' cognitive achievement and their science process skills. This variables are limited to the following components:

1. The students' cognitive achievements were limited to knowing, comprehending, applying, analyzing, synthesizing.
2. The students' science process skills were limited to identifying variables, constructing a table of data, constructing a graph, acquiring and processing data.

In accordance with the problem formulation, the goals of research were:

1. Knowing the increasing differences of cognitive achievement and their science process skills between students who learn physics, on the topic of linear motion, by using laboratory experiment and computer simulation methods.
2. Knowing which method was more effective in the teaching-learning of physics on the topic of linear motion above.

The benefits of the research project were:

1. Theoretically benefit
This research can give positive contribution to the teaching-learning of physics, especially it related to the laboratory experiment and computer simulation methods
2. Practically benefit
 - a. For teachers
 - 1) This research can give insight of them, especially in selecting methods in their teaching-learning of physics.
 - 2) It can also motivate teachers to increase the ability of students to do laboratory experiment and computer simulation.
 - b. For students
 - 1) This research can support students in comprehending physics concepts through laboratory experiment and computer simulation.
 - 2) It can increase the students' science process skills through laboratory experiment and computer simulation.

RESEARCH METHOD

This research was a quasi-experiment by *pretest-posttest experimental group design*, as shown in Table 1.

Table 1. Experimental design

Groups	Pretest	Treatment	Posttest
Experiment 1	T_1	X_1	T_2
Experiment 2	T_1	X_2	T_2

Pretest (T_1) was given to the two groups of experiment. Then, they were given two different treatments. The group experiment 1 was given the laboratory experiment method (X_1). The group experiment 2 was given the computer simulation method (X_2). After treatment they were given posttest (T_2).

This research was conducted in SMAN 2 Wates. The population was all students in this school and the sample was the X-grade students. The sampling technique was the cluster random sampling. After drawing lots, the X-A-grade student was the experiment group using simulation and the X-C-grade student was the experiment group using experiment laboratory.

The variables of research as follow:

1. Independent variables were laboratory experiment and computer simulation.
2. Dependent variables were students' cognitive achievement and their science process skills.
3. Control variables were content of subject, teacher, and time allocation.

There were two kinds of instrument, i.e. the teaching-learning instruments and the data collecting instruments. The teaching-learning instruments include syllabus, lesson plan, the sets of teaching learning materials covers laboratory tools and computer simulation software. The data collecting instruments were student's worksheet and test.

The model of teaching was 5E model developed by constructivism expert. This model includes five stages, i.e. engagement, exploration, explanation, elaboration dan evaluation. This model emphasize that the teaching-learning process do not give information to the students, but it creates the situation in order they can interpret information by their own (Ansberry & Morgan, 2005: 29-30; Llewellyn, 2005: 46-48). This model was implemented in the teaching-learning process of this research.

The instruments of this research were validated by learning media expert and physicist. The validity and reliability of test were tested and there are 25 valid items. The test reliability shows that the coefficient alpha was 0.875. It means that the test was reliable to apply in this research.

Data were collected by using pretest and posttest, based on students' cognitive achievement and their science process skills. Data analysis method to test hypothesis was Manova (Multivariate Analysis of Variance). Before hypothesis testing, the pre-requisite analysis was done, that is the normality of data distribution and variance homogeneity. The The significant level of statistical test in this research was $\alpha = 0.05$.

The null hypotheses (H_0) can be expressed that there was no difference between the means of students' cognitive achieve and science process skills in the two experiment groups ($\mu_1 = \mu_2$). The alternative hypotheses (H_a) can be expressed that there was a difference between the means of students' cognitive achieve and science process skills in the two experiment groups ($\mu_1 \neq \mu_2$).

The criterion of hypotheses acceptance based on the significant level (α) of 0.05 or 5%. If the probability (Sig.) of solution was $p > 0,05$, then H_0 was accepted and H_a was rejected. If the probability (Sig.) of solution was $p < 0,05$, then H_0 was rejected and H_a was accepted.

RESULT AND DISCUSSION

The data of this research were scores of pretest and posttest. They included the scores of of students' cognitive achieve and science process skills in the two experiment groups. Based on the scores of each student, it can be find its absolute gain, that is the posttest score minus the pretest score. The absolute gain of cognitive achieve and science process skills were tested by statistical parametrical statistics.

The pre-requisite analysis shows that The absolute gains of cognitive achieve and science process skills come from the normal distribution population. Their variance of absolute gains come from the homogen variance of population.

The statistical analysis of Manova can be explained as follow. Table 2 shows the descriptive statistics of absolute gain. It consists of mean, standard deviation, and number of students (N).

Table 2
Descriptive Statistics

	Methods	Mean	Std. Deviation	N
Process_Skills	Comp_Simulation	23.1875	7.64299	32
	Lab_Experiment	43.8750	12.90849	32
	Total	33.5313	14.81309	64
Cognitive_Achivement	Comp_Simulation	4.4688	2.87351	32
	Lab_Experiment	11.7500	3.47340	32
	Total	8.1094	4.84397	64

In Table 2 it can be seen that the mean of gain of science process skills using laboratory experiment method (43.8750) was higher than the mean of gain of science process skills using computer simulation method (23.1875). Similarly, the mean of gain of cognitive achievement using laboratory experiment method (11.7500) was higher than the mean of gain of cognitive achievement using computer simulation method (4.4688).

Table 3
Multivariate Tests^b

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.955	6.541E2 ^a	2.000	61.000	.000
	Wilks' Lambda	.045	6.541E2 ^a	2.000	61.000	.000
	Hotelling's Trace	21.447	6.541E2 ^a	2.000	61.000	.000
	Roy's Largest Root	21.447	6.541E2 ^a	2.000	61.000	.000
Methods	Pillai's Trace	.746	89.772 ^a	2.000	61.000	.000
	Wilks' Lambda	.254	89.772 ^a	2.000	61.000	.000
	Hotelling's Trace	2.943	89.772 ^a	2.000	61.000	.000
	Roy's Largest Root	2.943	89.772 ^a	2.000	61.000	.000

a. Exact statistic

b. Design: Intercept + Methods

Table 4
Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Process_Skills	6847.562 ^a	1	6847.562	60.855	.000
	Cognitive_Achivement	848.266 ^b	1	848.266	83.484	.000
Intercept	Process_Skills	71958.062	1	71958.062	639.501	.000
	Cognitive_Achivement	4208.766	1	4208.766	414.217	.000

Methods	Process_Skills	6847.562	1	6847.562	60.855	.000
	Cognitive_Achivement	848.266	1	848.266	83.484	.000
Error	Process_Skills	6976.375	62	112.522		
	Cognitive_Achivement	629.969	62	10.161		
Total	Process_Skills	85782.000	64			
	Cognitive_Achivement	5687.000	64			
Corrected Total	Process_Skills	13823.938	63			
	Cognitive_Achivement	1478.234	63			

a. R Squared = .495 (Adjusted R Squared = .487)

b. R Squared = .574 (Adjusted R Squared = .567)

Table 3 shows the Multivariate Test. In this table it can be seen that the probability Sig. (p) = 0.000 (was less than $\alpha = 0.05$) in all effect. It means that there were the increasing differences of cognitive achievement and science process skills between students who learn physics by using laboratory experiment and computer simulation methods.

Table 4 shows Tests of Between-Subjects Effects. In this table it can be seen that all probability Sig. (p) = 0.000 (was less than $\alpha = 0.05$). It means that there were the increasing differences of cognitive achievement. Similarly, there were the increasing differences of students' science process skills.

Based on explanations above, it can be said that there were significant effect differences between the laboratory experement method and computer simulation method to the students' cognitive achievement and science process skills. Because the mean of gain of cognitive achievement and science process skills using laboratory experiment method was higher than those of computer methods, it can be conclude that the laboratory experiment method was more effective than the computer simulation method.

Why the laboratory experiment method was more effective than the computer simulation method? Laboratory work involves students in scientific inquiry that places them in the position of asking question, proposing solutions, making prediction, taking observations, organizing data, explaining pattern, and so on. This type of work permits students to plan and to participate in investigations or to take part in activities that will help them improve their technical laboratory skills (Collette and Chiapetta, 1994: 198). But the cooperative learning using computer simulation is effective to overcome misconception in physics for students in senior high school (Sahrul Saehana Haeruddin, 2010: 289). These activities were parts of science process skills, so students would be accustom to improve and to increase science process skills.

Laboratory experiment use real things, tools, and measuring instruments, so it is also referred as the real experiment. Computer simulation is sometimes referred as a virtual experiment. It is suitable to simulate the microscopy process and dangerous real experiment. It is not substitute for thinking, but it is tool that we can use to understand complex phenomena. Therefore, the cognitive domain of objective is easier to attain by laboratory experiment than computer simulation.

CONCLUSION AND SUGGESTION

A. Conclusion

Based on analyses and discussion above it can be concluded as follow:

1. there were the increasing differences of cognitive achievement and science process skills between students who learn physics by using laboratory experiment and computer simulation method
2. the laboratory experiment method was more effective than the computer simulation method.

B. Suggestion

Some suggestions are proposed as follow:

1. The teachers of physics should make a priority to choose the laboratory experiment method first before using the other methods.
2. They can use computer simulation to explain the dangerous physical phenomena or microscopy process.

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