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Generative learning models assisted by virtual laboratory to improve mastery of student physics concept

Generative learning models assisted by virtual laboratory to improve mastery of student physics concept

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Abstract. Teaching abstract concepts in experimental activities is one of the problems in the physics learning process, thus causing low levels of participation and mastery of students' physics concepts. Generative learning assisted by a virtual laboratory can be an alternative to solve this problem. The purpose of this study was to examine the effectiveness of generative models assisted by virtual laboratories for mastering students' physics concepts. The research and development used is based on the 4-D model. Test the effectiveness of learning devices through quasi-experiments conducted at one of the high schools in Mataram, which consists of experimental and control groups. The model testing phase used a pre-test post-test non-equivalent control group design. There are differences in mastery of student concept of experimental and control groups that were analysed using the independent sample t-test. Increased mastery of student concepts is measured using the N-gain test. The results of mastery of concepts were higher in the experimental group compared to the control group. Improvement is analysed based on improvement at each cognitive level, as well as an increase in each sub-material. This research has proven that generative learning assisted by virtual laboratories effectively increases mastery of students' physics concepts.

1. Introduction

Physics consists of simple, complex, and abstract concepts. These concepts are interconnected. Linking concepts to one another requires understanding and mastering the correct concepts. Mastery of concepts in a subject matter is essential for students who have experienced the learning process [1]. Students must be able to develop their abilities so that they can master the concept. Mastery of concepts in physics learning is very important. If students do not understand the concept well, they will have difficulty solving more complex problems with the same concept.

One of the efforts made to hone the mastery of students' concepts is through generative learning with the steps used are preparation, focusing, challenges, and applications. The stages of the generative model are expected to guide students to discover new concepts of learning activities. Generative models with context-based learning approaches have a positive impact on learning [2]. Generative models have a better impact on increasing mastery of physics concepts [3]. Generative models emphasize the role of the teacher in guiding students in expressing conception, which is accompanied by arguments and can argue with other students. The use of generative models fosters positive attitudes of students in interacting with each other during the learning process [4]. This will familiarize students with respect to other people's conceptions and get used to expressing opinions so that they can develop creative ideas in solving problems in a particular subject matter.

Problems arise when the teacher teaches the material with abstract physics concepts and difficult to visualize for real. This condition has an impact on the low mastery of students' concepts [5]. The cause of the low mastery of students' concepts is that the teacher lacks an understanding of the demands of concept evaluation [6].

The development of computer technology is one of the solutions in physics learning, namely by using virtual laboratory media, so that concepts can be conveyed according to the demands of the learning objectives. This is based on basic competency skills that require students to carry out scientific experiments. Computer simulations such as virtual laboratories, interactive e-book, and animation media can be used in physics learning to help students observe abstract scientific phenomena [7-9]. The study by Tawil & Dahlan [10] concluded that computer simulation-based learning could improve students' mastery of concepts.

One way to improve students' thinking skills is through experimental activities in the laboratory [11]. However, the material in this study is abstract and difficult to discuss with real laboratory equipment. Learning with generative models will be effectively accepted by virtual laboratories, so abstract concepts can be appropriately conveyed. Virtual laboratories are not to replace real laboratories but as an alternative to conducting experiments virtually, which are difficult to do with real laboratories [12]. Generative models assisted by virtual laboratories have been proven to be able to increase students' creativity in physics [13].

The purpose of this study was to examine the effectiveness of generative models assisted by virtual laboratory to improve mastery of students' physics concepts. Hermansyah et al. [14] have conducted research with virtual laboratories and different learning models on improving mastery of concepts. In this study, mastery of concepts was analysed based on cognitive and sub-material levels.

2. Methods

This type of research is Research and Development (R & D) referring to the 4-D model, which consists of four stages of development, namely define, design, develop, and disseminate. This research has passed define, design, and develop stages by testing the validity and practicality of generative learning devices assisted by a virtual laboratory. Furthermore, the effectiveness test of the device was developed on the mastery of students' concepts using quasi-experiments. Model testing using pre-test post-test non-equivalent control group design and using purposive sampling. The study was conducted on group X, which consisted of experimental and control groups at one of the high schools in Mataram. The respondents were 68 students consisting of 33 male and 35 female students. Before being given the learning treatment, the two groups were given initial tests with six cognitive levels from mastery of concepts namely remembering (C1), understanding (C2), applying (C3), analysing (4), evaluating (C5) and creating (C6), on the material of Newton's law of gravity. After that, students are given a final test. Hypothesis testing uses the independent sample t-test which is carried out if the data are homogeneous and normally distributed. Test homogeneity with Levene and normality test with Shapiro-Wilk. Increased mastery of student concepts is determined by the N-gain test using equation (1):

$$\mathrm{N-gain} = \frac{S_{post} - S_{pre}}{S_{\max} - S_{pre}} \times 100\% \quad (1)$$

Criteria for high N-gain score if > 70%, medium if 30% ≤ 70% and <30% low. S_{pre}, S_{post}, and S_{max} are the average initial test scores, final tests and maximum tests [15]. Data were analyzed using statistical software, namely Version 21 of the Statistical Package for the Social Science (SPSS).

3. Result and Discussion

This study aims to examine the effectiveness of generative learning assisted by the virtual laboratory on mastery of student concepts. Data mastery of students' concepts was obtained through the provision of initial and final tests. Before analysing the hypothesis test of mastery of students' concepts, a homogeneity test was used to determine the variance of the data from both groups which are homogeneous or heterogeneous. The homogeneity test used the Levene test with a significant level of 0.05.

Table 1. Homogeneity Data Final Test Experiment and Control Groups

Criteria	Result
Calculation results	0.39
Significant Level	0.05
Degree of Freedom	66
Varians	Homogeneous

Table 1 show that the data of the two groups are homogeneous with a significant calculation of 0.20. The calculation results of 0.39 > 0.05 can be stated that the final test data of the two groups have the same variance.

Furthermore, a normality test was conducted to find out whether the data in both groups were normally distributed or not by using the Shapiro-Wilk test, which can be seen in Table 2.

Table 2. Normality Test Results

Group	Shapiro-Wilk		
	Statistic	Degree of Freedom	Significant Level
Experimental	0.94	36	0.09
Control	0.94	32	0.11

Table 2 shows that the results of the calculation of the experimental group normality test are 0.09 and the control group is 0.11, the results of both groups are > 0.05, it can be concluded that the final test data of both groups are normally distributed. Then tested the hypothesis that the test was independent sample t-test to determine the differences in the mastery of students' physics concepts taught with generative models assisted by virtual laboratories and conventional learning models.

Table 3. Test of Experimental and Control Group t-test Independence Sample

Group	N	Independent Sample T-test		
		T	Degree of Freedom	p
Experimental and Control	68	7.25	66	0.00

The results of hypothesis testing showed that there were differences in the mastery of students' concepts taught with generative models assisted by virtual laboratories and students taught with conventional models as shown in Table 3 that p values< 0.05. The results of this study are reinforced by Sugiana et al. [16] which state that the increase in mastery of physics concepts of students in the experimental group with generative models assisted by virtual laboratories is higher than the control group. These findings are in line with the results of research by Dewi et al. [17] that the use of virtual simulations affects the mastery of students' physics concepts. The virtual lab is an alternative to solve the problem and increase the student's ability in applying the concept correctly [14].

In addition to testing the differences in the mastery of students' concepts in the experimental and control group, testing was also conducted on improving mastery of concepts analysed based on each cognitive level C1 to C6. The experimental group has a higher improve, as shown in Figure 1.

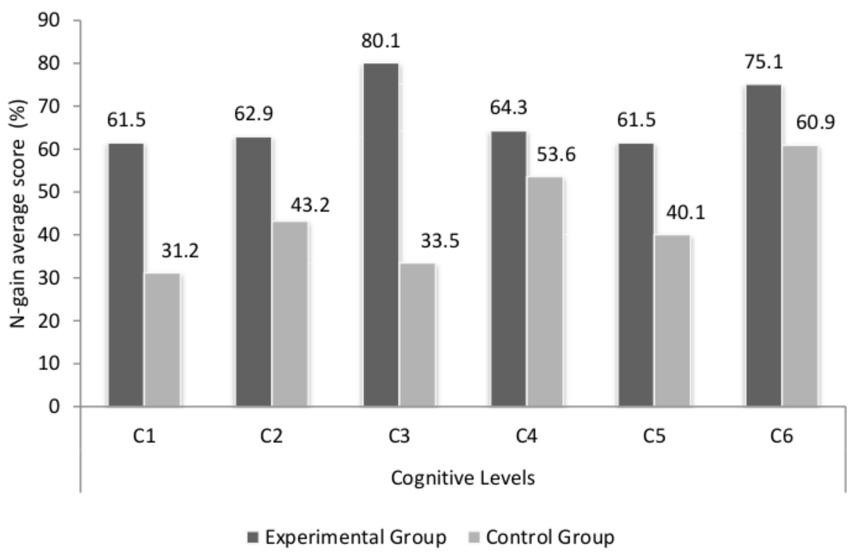

Figure 1. Comparison of Increased Every Cognitive Level

Figure 1 shows that overall the experimental group obtained a higher final test score for each cognitive level C1 to C6. C3 and C6 Levels are in the high criteria, besides that in the medium criteria. While in the control group the cognitive levels improved on average in the medium criteria. Improvement with high and medium criteria is caused by students being actively involved during group discussions, and through guidance, the teacher can master the concept well. In line with the research of Sugiana et al. [16] showed that the use of generative models assisted by virtual laboratories could improve mastery of students' concepts on cognitive levels C3, C4, C5, and C6. This is because students are trained to be able to think higher during a virtual experiment by following all stages of generative learning. Students can remember the concepts they learn well. The findings of researchers that during the learning activities students participate directly in discovering and connecting new concepts through generative learning models assisted by virtual laboratories.

In contrast to the research of Dewi et al. [17] which showed that C6 cognitive levels had an increase in low criteria. Research by Prima and Kaniawati [18] also stated that C5 cognitive levels experienced the same increase between the experimental group and the control group. This means that the learning applied with generative models to the experimental group is effective towards improving mastery of students' physics concepts. Also, student enthusiasm is very good during learning using a virtual laboratory. Generative learning assisted by virtual laboratory provides opportunities for students to build their knowledge and ideas. Students must be familiar with features in a virtual laboratory so that it is easy to solve various problems according to the concepts that have been studied [5, 19]. Students with a more active and creative learning process show better mastery of concepts, seen from the acquisition of student final test results [3].

Besides being seen from every cognitive level, the researcher also analysed the increase in mastery of students' concepts from each sub-material of Newton's gravitational law, as shown in Figure 2 below.

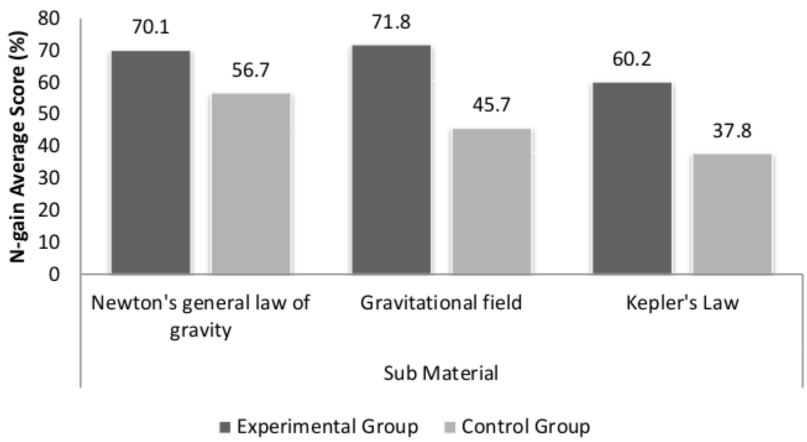

Figure 2. Increased Comparison of Each Sub Material

The results are shown in Figure 2 explain that there is an increase with high criteria in the sub-material of Newton's general gravitation law and gravitational field in the experimental group, while the control group is in the medium criteria. Improved results in the experimental group because students have succeeded in rearranging the formula of the relationship between object forces and distances, as well as determining the centripetal forces on a planet based on their learning experiences with generative models. This is inseparable from the use of virtual laboratories during experimental activities. The lowest increase occurred in sub-material of Kepler's law even though it was still in the medium criteria for both groups. This is because the test instruments in sub-material of Kepler's law covers all cognitive levels from C1 to C6. The acquisition of low scores on sub-material with high cognitive levels was caused by the higher level of difficulty of the questions, but students can analyse and master the concepts to solve the problems given by the teacher.

Based on the data obtained, students in the experimental group were able to master each cognitive levels from C1 to C6 and all sub-material well based on the results of the final test and observation during the learning process. The results obtained relate to the implementation of all the generative stages of preparation, focusing on problems, challenges to conducting virtual experiments in solving physics problems and their application, including problem training. The increase in mastery of student concepts is an influence during the learning process [16]. These results support some of the results of previous studies which found that the use of virtual laboratories in various learning models proved to be able to improve mastery of students' physics concepts [19]. The use of virtual labs in well-designed learning models can also improve students' ability to hypothesize and communicate ideas to others [20], and make appropriate judgments about concepts [8].

4. Conclusion

The application of generative models assisted by virtual laboratory effectively improve mastery of students' physics concepts. The experimental group is higher than the control group at each cognitive level from C1, C2, C3, C4, C5, and C6. Mastery of the concept of experimental group students also experienced a higher improve in each sub-material compared to the control group.

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