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The Effect of Implementing Interactive Learning Media Based on Virtual Laboratory on Student Learning Outcomes in Force Topic

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Abstract: Learning media is a teaching aid that educators can use to convey lesson material, increase student creativity, and increase student attention during the learning process. This research examines the effect of implementing interactive learning media based on virtual laboratory on student learning outcomes in force topic at SMP Negeri 1 Gorontalo. This research uses an experimental method, and the research design used is a group pre-test and post-test design. The subjects of this research were 30 students in each class divided into three classes: experimental class, replication 1, and replication 2. The data analysis techniques used are normality, hypothesis, and n-gain tests. The results of the hypothesis testing criteria were T-count ≥ T-table with a level of $\propto = 0.05$ for the experimental class, replication 1, and replication 2; therefore, Ho is rejected, and Ha is accepted. This is also supported by the acquisition of the course average normalized gain for all sample classes, both experimental and replication classes, which fall into the high and medium categories in the experimental class (0.71), replication 1 (0.70), and replication 2 (0.66). Data analysis shows that the average post-test score for the experimental and replication classes is higher than the pre-test. This indicates that virtual laboratory media improves student learning outcomes in force topics. This research concludes that using interactive learning media based on virtual laboratories can be an effective alternative for improving the quality of science learning in schools.

Keywords: Force; Learning Media; Learning Outcomes; Virtual Laboratory.

Introduction

Learning outcomes are the abilities possessed by students after receiving learning experiences. Some of the experiences students gain include the cognitive, affective, and psychomotor domains [1]. The low quality of education can be seen in some students who get high grades but are less able to apply knowledge. Difficulties in understanding also cause low student learning outcomes, and students are less motivated to learn because their study habits are less effective and efficient [2].

The factors causing students' low or lack of understanding of concepts are the learning media used by teachers, for example, in learning oriented to a traditional approach, which places students in the teaching and learning process as listeners [3]. Another factor that causes low student learning outcomes is students' lack of interest in taking lessons. Therefore, using media in learning can generate new interests, increase motivation, stimulate learning activities, and even psychologically impact children [4]. Previous researchers also stated that learning that utilizes virtual media (websites) has proven less effective. A comparison of learning outcomes before and after implementing website-based learning shows that there has been no significant improvement. The number of students with low learning outcomes was 50% before using the website and increased to 60% after. Meanwhile, the percentage of students in the sufficient category before using the website was 7%, and after implementing the website, their learning outcomes increased slightly to 25%. For students classified as high, the percentage before using the website is 15%, and after using it, it rises to 40% [5].

According to [6], using media in learning can provide positive and significant benefits in facilitating students' learning process. Previous studies indicate that interactive multimedia can improve conceptual understanding, academic achievement, and critical thinking skills. The use of technology is essential in the learning process in the classroom, including in the application of learning media in science lessons. Science learning is one part that cannot be separated from the changes triggered by the profound advances in information and communication technology. Information and communication technology have become inseparable in the classroom learning system [7].

Quality education in Indonesia is increasingly needed to keep up with the rapidly developing times [8]. Previous studies show interactive media can increase concept mastery, critical thinking skills, and learning success. This is in line with the opinion of [9], which states that, in general, the function and benefits of teaching media are to improve communication skills between teachers and students so that the teaching and learning process can take place in optimal conditions for students. Learning media is a teaching aid that educators can use to convey lesson material, increase student creativity, and increase student attention during the learning process [10]. One form of progress in information technology in education is using simulation media based on information technology, which aims to attract students' attention during the learning process [11].

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Virtual Laboratory is a digital simulation that allows the essential functions of a real laboratory to be used on mobile phones, tablets, laptops, and computers [11-12]. Applications that can support virtual laboratories include Phet Simulation. PhET simulations are visual representations or moving animations created as games students can learn by exploring. This simulation focuses on the correspondence between computer simulations and actual events and presents them as physical concepts that are easy for students to understand [13]. This statement is also supported by previous research, which states that the learning method using PHET Simulation in experimental classes significantly impacts student activity and learning outcomes. Compared with the control class, which implemented conventional techniques, the experimental class showed a higher level of student participation, responded well to instructions, and better understood the material [14]. Apart from that, there are differences in the learning outcomes of students who use the virtual laboratory-based learning model and the learning outcomes of students who use the real experimental learning model, where the learning outcomes based on virtual laboratories are higher than the learning outcomes of students who use real experiment-based learning models [15].

This research uses the problem-based learning (PBL) model to apply interactive learning media based on a virtual laboratory. Using the PBL model will minimize student dependence on the teacher [16]. The PBL learning model aims to develop critical thinking patterns to solve problems and master learning material. With the PBL model, students can conduct analysis and trials, make references, and conclude by investigating the problems faced [17]. This research describes the effect of implementing interactive learning media based on virtual laboratories on student learning outcomes assisted by PhET simulations using problem-based learning tools. The background of this research is the researcher's observations with science teachers regarding student learning outcomes at SMP Negeri 1 Gorontalo. The science teacher stated, We have done many ways, including improving the learning system and learning facilities, but student learning outcomes have not improved. Based on the results of these observations, researchers are interested in conducting research through the application of digital-based interactive learning media, namely virtual laboratories, in the student learning system.

Based on information from the school interviewed, this school is digital-based. Therefore, the application of virtual lab-based interactive learning media is suitable for implementation because apart from researchers examining the effect of implementing virtual laboratory-based interactive learning media on student learning outcomes, researchers can also introduce to students the development of increasingly sophisticated technology that requires students to understand the use of digital and to increase students' knowledge that digital is not only about the world of play but digital can be used in the world of education, especially in practical science subjects.

Research Methods

This research uses an experimental method, and the research design used is a group pre-test and post-test design. The research flow chart in Figura 1. This research was carried out in class VII of SMP Negeri 1 Gorontalo in the 2024/2025 academic year. The subjects of this research were 30 students in each class divided into three classes: experimental class, replication 1, and replication 2. This research took samples using cluster random sampling techniques. The instrument used in this research was a written test covering 10 items given at the beginning of learning (pre-test) and the end of learning (post-test). The research instrument has been validated by two validators and is classified as very valid and reliable. The data analysis techniques used are normality, hypothesis, and n-gain tests. This research was also supported by implementation, student activities, and student questionnaires, which achieved very good criteria in experimental and replication 1 and good criteria in replication 2.

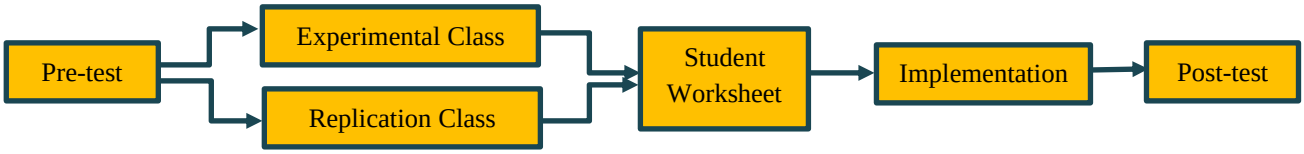

Figure 1. Research Flow Chart

Results and Discussion

Students' cognitive learning outcomes are obtained from test results or working on the questions given, which are arranged based on indicators. Students' cognitive abilities can be assessed based on C2 (Understanding), C3 (Applying) and C4 (Analysing). Then, the average presentation of cognitive domain achievements of students from the experimental class, replication 1, and replication 2 will be calculated in Table 1.

Table 1. Percentage of Cognitive Achievement

Class	C2 (%)		C3 (%)		C4 (%)	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Experimental	69	88	65	87	21	89
Replication 1	60	84	48	86	26	81
Replication 2	59	85	48	85	26	87

Based on Table 1, it can be seen in experimental class that the cognitive criteria C2 to C4 obtained from the pre-test percentage show that C2 has a percentage of 69%, C3 has a percentage of 65%, and C4 has a percentage of 21% based on the percentage of cognitive achievements in the experimental class. C2 has a higher percentage than C3. and C4; for the post-test scores in the experimental class, the percentage of C2 increased to 88%, C3 increased to 87%, and C4 increased to 89%. The cognitive criteria C2 to C4 in replication 1 obtained from the pre-test percentage show that C2 has a percentage of 60%, C3 has a percentage of 48%, and C4 has a percentage of 26% based on the percentage of cognitive achievement in the experimental class. C2 has a higher percentage compared to C3 and C4. The post-test value in the experimental class showed that the percentage of C2 increased to 84%, C3 increased to 86%, and C4 increased to 81%.

Cognitive criteria C2 to C4 in replication 2 obtained from the pre-test percentage show that C2 has a percentage of 59%, C3 has a percentage of 48%, and C4 has a percentage of 26% based on the percentage of cognitive achievement in the experimental class. C2 has a higher percentage than C3 and C4. For the post-test scores in the experimental class, the percentage of C2 and C3 increased to 85%, and C4 increased to 87%. The percentage of cognitive achievement for C2 is higher than C3 and C4 in the pre-test because, based on observation through question and answer, students have received force topic from elementary school. However, the application of the formula for Newton's law of 1 to 3 in practice has not been studied in elementary school, which causes C2's cognitive level to be higher than C3 and C4. However, after implementing virtual laboratory-based interactive learning media, the cognitive percentage of students' C2, C3, and C4 in the post-test became higher. This indicates that students can remember information and understand concepts, apply them in different situations, and analyze data critically. This aligns with research [18], which states that the cognitive domain includes mental (brain) activities. The aim of the cognitive aspect is oriented towards thinking abilities, which include the ability to solve problems that require students to connect and combine several ideas, notions, methods, or learned procedures to solve the problem. Researchers used the calculated average for each sample group to find out how distributed quantitative data was and to see whether there was an increase in learning outcomes after using virtual laboratory-based interactive learning media. The results of calculating pre-test and post-test scores in the experimental class, replication 1 and replication 2, were computed using the Excel application program as in Table 2.

Table 2. Average scores of Pre-test and Post-test

Class	Average	
	Pre-test	Post-test
Experimental	57.71	87.33
Replication 1	57.76	86.67
Replication 2	57.52	85.71

Based on Table 2, the average pre-test score for the experimental class was 57.71, while for replication 1, it was 57.76, and for replication 2 was 57.52. Meanwhile, the post-test score for the experimental class reached 87.33, replication 1 was 86.67, and replication 2 was 87.71. This shows an increase in the average student learning outcomes. Analysis of learning implementation data aims to examine and interpret data obtained from observations or evaluations of the implementation of teaching and learning activities in the classroom. Meanwhile, student activity analysis seeks to measure everything students do during the learning process to support the implementation of teaching and learning activities. Analysis of the results of learning implementation can be seen in Figure 2.

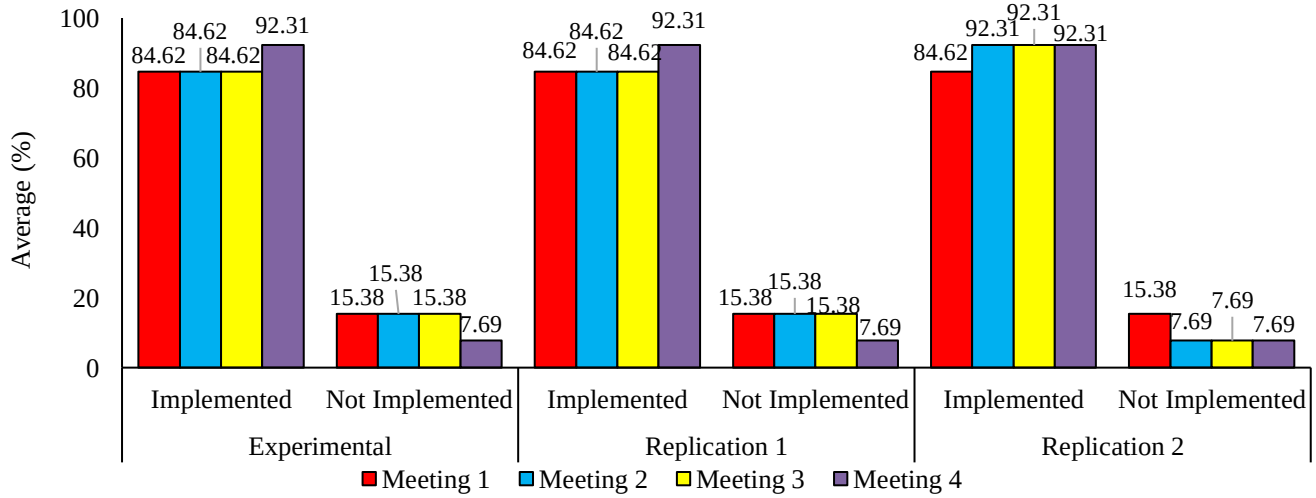

Figure 2. Analysis of Learning Implementation Results

This analysis aims to clearly show the extent to which the learning process has gone according to the plans and objectives set. Apart from measuring learning implementation data, this research also measures learning activity data. Based on Figure 2, the achievement level of success in student activities in the experimental class, replication 1, and replication 2 from the first to the fourth meeting was included in the high category. This research also measured student questionnaires regarding student responses to learning that implemented interactive learning media based on virtual laboratory. This questionnaire can collect information from respondents (students) in a

systematic and structured manner. By using a questionnaire, researchers can ask relevant and specific questions to obtain the required data, both in qualitative and quantitative form. Questionnaires can support collecting data and analysing student implementation and activities in class. The average achievement of the indicator student questionnaire in the experimental and replication 1 percentage range was very good. The percentage range in the replication 2 category was a good category.

This research uses descriptive statistical techniques and inferential statistical techniques. Descriptive statistical methods describe or provide an overview of an object to be studied through sample or population data as it is without carrying out analysis and making conclusions that apply to the general public. Inferential statistical techniques are often called probability statistics. The data obtained was then analyzed, including four tests: the normality test, homogeneity test, hypothesis test, and n-gain analysis.

Normality Test

In this research, the Smirnov colmogrof normality test formula was used using Microsoft Excel to test the normality of the data in the three classes: experiment, replication 1, and replication 2. The results of the data normality test are in Table 3.

Table 3. Data Normality Test Results

Class	Fi	K	Status
Experimental	0.48	0.24	Normally distributed
Replication 1	0.48	0.24	Normally distributed
Replication 2	0.48	0.24	Normally distributed

The results of data normality testing, based on Table 3, show that Fi ≥ K for the α = 0.05 level. This indicates that the research data for the experimental class, replication 1 and replication 2, are normally distributed. Normality test data shows that the experimental class, replication 1, and replication 2 have a Fi value of 0.48, while the K value for these three classes is 0.24. The results of data normality testing show that Fi ≥ K for the α = 0.05 level. Thus, it can be concluded that the research data for the experimental class, replication 1 and replication 2, are normally distributed. This normal distribution is important because it supports the validity of the statistical analysis that will be carried out next and provides confidence that the research results can be interpreted correctly in the applied learning context.

Hypothesis Testing

In this research, the Smirnov colmogrof hypothesis test formula was used using Microsoft Excel to test the data hypothesis in the three classes: experiment, replication 1, and replication 2. The data hypothesis test results are in Table 4.

Table 4. Data Hypothesis Test Results

Class	T-count	T-table	Status
Experimental	16.78	1.699	H_1 accepted
Replication 1	16.36	1.699	H_1 accepted
Replication 2	15.71	1.699	H_1 accepted

Based on Table 4, we get T-count ≥ T-table with a level of $\propto = 0.05$ for the experimental class, replication one, and replication 2. Therefore, Ho is rejected, and H1 is accepted. This shows that applying interactive learning media based on a virtual laboratory on a force topic influences student learning outcomes in the experimental class, replication 1 and 2. The effect of interactive learning media based on virtual laboratories can be seen from the cognitive results and the significant increase in post-graduate grades. Test students after carrying out the pre-test.

Hypothesis testing is carried out to determine whether significant differences exist between the groups tested. Based on Table 4, the calculated T-count for the experimental class (16.78), replication 1 (16.36), and replication 2 (15.71) are all greater than the T-table (1.699), which indicates that the alternative hypothesis (H1) is accepted for the three classes. This means there are significant differences in the results obtained from each class; the treatment given in the experimental class, replication 1, and replication 2 positively affect student learning outcomes. Thus, these results support the conclusion that implementing interactive learning media based on a virtual laboratory effectively improves students' abilities in all classes tested. The effect of implementing interactive learning media based on a virtual laboratory can be seen from the cognitive results and the significant increase in students' post-test scores after implementing the pre-test.

N-Gain Test

The n-gain test aims to increase student learning outcomes through pre-tests and post-tests. Table 5 shows the n-gain analysis of the test results using the course average normalized gain per class.

Table 5. N-Gain Test Results

Class	N-gain	Criteria
Experimental	0.71	High
Replication 1	0.70	High
Replication 2	0.66	Medium

Based on Table 5 shows the result in the experimental class (0.71), replication 1 (0.70), and replication 2 (0.66). The experimental and replication 1 is included in the high category, and the replication 2 is included in the medium category. This shows that learning

outcomes in force topic using interactive learning media based on virtual laboratory have increased. The n-gain analysis per indicator determines whether a student's conceptual understanding of each indicator in the force topic increases.

The application of interactive learning media based on virtual laboratories positively affects students' enthusiasm for learning and increases their self-confidence in the teaching and learning process. This media also encourages students to study force topics through the Phet Simulation application actively. Based on research results [11], virtual laboratories can attract students' attention to make them happier and more active in receiving lesson topics. This finding aligns with research conducted by [4], which shows that practicums using virtual laboratories provide students with comfort during the practicum process, making it easier to understand the topic and get a more profound impression. Thus, virtual laboratories can effectively assist teachers and instructors in implementing virtual-based practicums in schools.

Virtual laboratory can reduce time constraints if there is not enough time to teach students in the laboratory until they understand. It can also improve the quality of experiments because it allows them to be repeated to clarify doubts about measurements in the laboratory. This is in line with research conducted by [19], which states that virtual laboratory learning is more efficient because the management of learning with virtual laboratories is carried out more quickly compared to safe and cheap teaching and is very useful as a virtual laboratory medium. Students can carry out experiments safely if the actual experiment is dangerous. Also, using a virtual laboratory will feel very cheap compared to experiments that require a real laboratory. Research regarding the effect of implementing interactive learning media based on virtual laboratory on the learning outcomes of SMP Negeri 1 Gorontalo students is proven. By using virtual laboratory-based interactive learning media, the learning outcomes of junior high school students in science subjects, specifically the force topic, are higher.

Conclusion

Based on the research results, the application of interactive learning media based on virtual laboratory influences student learning outcomes in force topic at SMP Negeri 1 Gorontalo in the experimental and replication classes. This is shown by the results of the hypothesis testing criteria where T-count ≥ T-table with a level of $\propto$ = 0.05 for the experimental class, replication 1, replication 2; therefore, Ho is rejected, and Ha is accepted. This is also supported by the acquisition of the course average normalized gain for all sample classes, both experimental and replication classes, which fall into the high and medium categories in the experimental class (0.71), replication 1 (0.70), and replication 2 (0.66). This shows that interactive learning media based on virtual laboratory influences student learning outcomes in force topic at SMP Negeri 1 Gorontalo in the experimental and replication classes.

Author's Contributions

Nadrah Pratiwi Naki: Conceptualization, writing-original draft preparation, methodology; Tirtawaty Abdjul: Methodology; Nurhayati: Curation, writing-original draft preparation; Abdul Haris Odja: Writing-review and editing; Muhammad Yusuf: Formal analysis, methodology; Citron S. Payu: Validation.

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