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The effectiveness of the laboratory work model based on senior high school students' learning outcomes and cooperative attitudes

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Abstract

This research aimed to determine the differences in learning physics using laboratory work and conventional learning models in learning outcomes and students' cooperative attitudes and determine the more effective model of those two models. This research was quasi-experimental research using two classes, consisting of an experimental class that was given a learning model of laboratory work, and a control class that was given learning as usual in schools. Additionally, the research instruments included tests, questionnaires, and observation sheets. This research used MANOVA analysis, effect size, and Generalized Linear Mixed Model analysis design to test the research hypothesis. The results showed that there were no differences in student physics learning outcomes between laboratory work and conventional learning models. Hence, laboratory work models were not more effective than conventional learning models, there were differences in cooperative attitudes between students who used the laboratory work model and the others who used the conventional learning model with effect size in the high category, and the laboratory work model was more effective than the conventional learning model in terms of student attitudes.

Keywords: cooperative attitudes; Laboratory work model; learning outcomes;.

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1. INTRODUCTION

Education is one of the necessities of life. It is stated so because education is used as one of the benchmarks for the human welfare level. It is assumed that a human's welfare is influenced by the quality of education they get at school (Kurniawan et al., 2018). In other words, the quality of the learning process has indirect implications for the human welfare level, including the quality of the implementation of the physics learning process. Students as social beings are required to be able to overcome all problems that arise as a result of interaction with the social environment (Omeri, 2015; Song & Cai 2024). Students must also be able to present themselves under applicable norms or rules. Therefore, students are required to master their social skills. These skills are usually considered psychosocial aspects (Astalini et al., 2019).

Social skills and adaptability become increasingly important as children enter adolescence. At that time, individuals had entered a more comprehensive social world. Thus, the influence of friends and their social environment would be decisive. Adolescents' failure to master social skills will make it difficult to adjust to their surroundings (Mujayanah & Fadilah, 2019; Rocha et al., 2024). It can lead to low self-esteem, being ostracized from the association, and behaving less normatively. A more extreme development can lead to mental disorders, juvenile delinquency, criminal acts, and even acts of violence. One of the personality developments that adolescents must master in their development phase is to have social skills to be able to adapt to daily life. These social skills include the skills to communicate, establish relationships with others, respect oneself and others, listen to opinions or complaints from others, give or receive criticism, act according to norms and rules, and cooperate (Islam, 2017; Hank & Huber 2024; Reith-Hall, 2022).

Educational institutions have an essential role in helping adolescents develop social skills. Therefore, the education curriculum must be comprehensive, responsive to social dynamics, relevant, and able to accommodate the diversity of needs and technological advances (Wulandari & Kristiawan, 2017). At the micro level, it is necessary to find effective classroom learning strategies that further empower students' potential. In terms of a practical learning approach, teachers must be creative in preparing and presenting the material. Meanwhile, students should be encouraged to be more active in the teaching and learning process to seek and find answers to what they are learning and solve their problems (Mardikarini & Suwarjo, 2016; Tsai, 2024; Fuchs & Sahmbi 2024).

Research showed that learning would be more productive and enjoyable if students felt a sense of belonging and that a class functioned as a caring community (Rakmawati et al., 2020). Therefore, teachers should choose methods that can generate interest, creativity, and students' reasoning abilities according to the character and potential of each student. Suastra et al., (2017) claim that students with high cognitive abilities tend to have a relatively lower cooperative attitude than those with average or below-average cognitive abilities.

The teaching process will be livelier and collaborative among students (Widita & Nurihsan, 2020). Therefore, the conventional learning process must be changed with various innovations that can increase students' creativity in thinking (Prasetyo et al., 2019). The direction of more complex learning is not only one way so that the teaching and learning process will be able to increase cooperation between students and teachers, students and students; thus, students who are less will be assisted by more intelligent students. Hence, the learning process is livelier, and the results are better (Surahman & Believers, 2017).

One learning model often used to improve students' cooperative attitudes is the laboratory work model (Sulistiyono et al., 2019). The implementation of laboratory work helps students to find facts, principles, and phenomena by observing students strengthen their knowledge and form new knowledge (McQuiggan et al., 2015). It was following the results of research conducted by Wardani et al., (2019).

Facts were an objective condition of objects or phenomena that would be the basis for the formation of knowledge. Therefore, the main challenge in learning physics is how to present and process facts from an object or phenomenon into knowledge or improve students' competence. The fact-finding process is a series of scientific activities in which the process of developing scientific abilities occurs, such as formulating problems, proposing hypotheses, designing experiments, collecting data, interpreting data, predicting, and drawing conclusions (Eren et al., 2015).

Practicum, also called laboratory work, is a learning experience that allows students to interact with the material to observe phenomena (Andersson & Enghag, 2017). Laboratory activities can be carried out by students individually or in small groups, and this definition does not include large group demonstrations or field activities (Suparno, 2013). Students in groups carry out practical activities in the laboratory. Each group ideally consists of three participants who will carry out one practicum topic (Nixon et al., 2016; Wilcox & Lewandowski, 2017). Using practical instructions, they will arrange or assemble the tools according to the instructions so that the tools can function (Holmes & Wieman, 2016).

Furthermore, the preparation of this tool is carried out jointly (*cooperation*). One member helps another and then collects data by measuring and reading carefully. Hence, the data obtained is valid and can be analyzed (Hadiati et al., 2019). In physics practicum, the observation of a physical phenomenon in the practicum is carried out at least three times. It is why members of the group consist of three people. Each member takes measurements without being affected by each other's results. The data obtained are then analyzed together by conducting detailed discussions that will be used to compile reports (Suastra et al., 2017). If, after being analyzed and based on the discussion results, the results do not follow their goals, they will retake the data until the results are under the practical objectives of the topic (Ekawati, 2017).

1.1. Purpose of study

This research aimed to determine the differences in learning physics using laboratory work and conventional learning models in learning outcomes and students' cooperative attitudes and determine the more effective model of those two models.

2. Method

The research design was a *quasi-experimental* type of *nonrandomized control group pre-test-post-test design* (Sugiyono, 2014). This research used two classes as research objects, namely one experimental class and one control class. The experimental class was treated using a laboratory work model. Meanwhile, the control class was treated with a conventional learning model. The research design was experimental, as shown in Table 1.

Table 1

Nonrandomized Control Group, Pretest–Posttest Design

Group	Pre-test	Independent Variable	Post-test
Experimental	Y_1	X	Y_2
Control	Y_1	–	Y_2

Description:
E = Experimental Class
C = Control Class
Y_1 = Mastery of students' initial material
X = Treatment with the laboratory work model
Y_2 = Mastery of students' final material

2.1. Data collection tool

The implementation of the research began by making research hypotheses and then determining the research variables consisting of independent and dependent variables. The next stage was to give a *pre-test* to measure the students' initial ability to master the material and an initial questionnaire to measure the initial ability of students' cooperative attitudes. After that, the researchers gave treatment to the classes under research and observed the process, then gave a *post-test* and final questionnaire to measure the dependent variable due to the treatment. Moreover, the research data were analyzed to test the hypothesis that had been compiled.

2.2. Participants

The population in this research consisted of all students of eleventh-grade students from Mathematics and Natural Science (MIPA) majors at State Senior High School Megang Sakti in the 2021/2022 academic year. The research sample was students of classes XI MIPA 2 and XI MIPA 3, with 30 students in each class. The classes were chosen based on discussions with the physics subject teacher, considering those two classes tended to be homogeneous and had the same characteristics. Then, class XI MIPA 2 as the experimental class and class XI MIPA 3 as the control class were determined using the cluster random sampling technique. The instrument used for data collection was a test question to collect data on student material mastery before and after learning. The questions used for the *pre-test* and *post-test* were the same for the experimental and control classes. A questionnaire was used to collect data on students' cooperative attitudes, and observation sheets were used to collect data on cooperative attitudes and learning implementation.

2.3. Data analysis

The data analysis technique was divided into two stages. The first stage was the requirements analysis test to determine the type of analysis to test the research hypothesis. Meanwhile, the second stage was testing the hypothesis that had been proposed. The requirement analysis testing included the *Normality Test*, which aimed to determine the normality of the data distribution to meet the statistical testing requirements for the hypothesis and was carried out on the *pre-test* score and the initial questionnaire data on students' cooperative attitudes. The normality test was performed using the *Kolmogorov-Smirnov* test. The data requirements were normal if the probability or $p > 0.05$ in the *Kolmogorov-Smirnov* normality test. The homogeneity test aimed to ensure that the compared groups were groups whose homogeneous variance. The *homogeneity test* was conducted by analyzing the *Test of Homogeneity Variance* through the SPSS 24.0 program. In the homogeneity test with the *Test of Homogeneity Variance*, it can be said that the data analyzed was homogeneous if the probability (Sig) > 0.05.

In this research, there were two hypothesis tests, namely testing differences in students' learning outcomes and testing the effectiveness of the laboratory work model in the experimental class compared to the control class. Hypothesis tests regarding differences in students' learning outcomes were carried out twice. The first test tested differences in students' learning outcomes and cooperative attitudes using the *Multivariate Analysis of Variance* (MANOVA) test. Finding out how big or strong the difference for each model used *effect size* analysis. It attempted to determine the laboratory work model's effectiveness in learning outcomes and students' cooperative attitudes compared to conventional learning models. The effect size calculation was carried out if the result of the T-Test calculation (*p*-value) was 0.05. The following equation could calculate *effect size (d)*:

$$d = \frac{M_1 - M_2}{\sigma_{pooled}}$$

$$\sigma_{pooled} = \sqrt{\frac{(\sigma_1^2 + \sigma_2^2)}{2}}$$

Description:
d = Effect size
M = Group average
σ = Deviation

The effect *size* criteria according to Widoyoko (2013) are shown in Table 2:

Table 2
Effect Size (*d*) Cohen's Criteria

No	Category	*Effect size*
1	Weak	0.2
2	Medium	0.5
3	Strong	0.8

The effectiveness of learning was the success level in achieving learning objectives. Therefore, to determine whether the laboratory work model was more effective than the conventional learning model. It was necessary to know the difference in the improvement experienced by the experimental and control classes. The *Generalized Linear Mixed Models* (GLMMs) analysis method was used in this regard. GLMMs analysis, also known as mixed analysis of variance (*mixed-design ANOVA*), was a test of the mean difference between two or more independent groups by measuring where the participants' observed scores were measured repeatedly. GLMMs used two sub-analyses, namely the *Within-Subjects Test* and the *Between-Subjects Test*. *Within-subjects test* was a test of differences in scores in one group (*pre-test* and *post-test*), and the *between-subjects test* was a test of differences in scores between groups (experimental and control). The rule was significant at $p \leq 0.05$ (Widita & Nurihsan 2020).

3. RESULTS

The results of the MANOVA test showed a difference between one independent variable and another if the significance of the *F*-test was less than 0.05.

Table 3
Multivariate test results on the MANOVA test

Multivariate Tests[b]							
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Learning_Model	Pillai's Trace	.156	3.437[a]	3.000	56.000	.023	.156
	Wilks' Lambda	.844	3.437[a]	3.000	56.000	.023	.156
	Hotelling's Trace	.184	3.437[a]	3.000	56.000	.023	.156
	Roy's Largest Root	.184	3.437[a]	3.000	56.000	.023	.156
a. Exact statistic							

The output of the MANOVA test using SPSS in Table 3 was the output for the multivariate test. Furthermore, the independent variable was the laboratory work model and the conventional model, while the dependent variable was the results of learning physics and students' cooperative attitudes. Based on the multivariate test, a significance value of 0.023 was obtained. The significance value was less than 0.05, so the H_0 was accepted. In other words, there was a joint difference between learning that used a laboratory work model and learning that used conventional learning in terms of the results of learning physics and students' cooperative attitudes.

Table 4

Results of tests of between-subjects effects on the MANOVA test

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Learning_Model	Cooperative_Attitudes	274.134	1	274.134	9.805	.003	.145
	Mastery_Material	.817	1	.817	.010	.922	.000

In Table 4, different tests were shown for each dependent variable. The table shows that the significance for learning outcomes was 0.922, which was more than 0.05. Furthermore, the cooperative attitude was 0.003, which was less than 0.05. Based on these data, it was concluded that learning physics using a laboratory work model and conventional learning had no difference in students' learning outcomes. However, there were differences in students' cooperative attitudes.

Hypothesis testing using *Effect size* was carried out to determine the effect of differences in learning using laboratory work models and conventional learning. Therefore, the test was only carried out on the dependent variable where there was a difference between the two models based on the MANOVA test, i.e., cooperative attitudes.

Table 5

Effect Size of Student Cooperative Attitudes

Learning Outcomes	*Effect Size*	Category
Cooperative attitudes	0.808	Strong

General *Linear Mixed Model* (GLMMs) *design* analysis was conducted to determine whether the physics laboratory work model was more effective than conventional learning models in learning outcomes and students' cooperative attitudes. The determination of the effectiveness of the laboratory work model referred to the *Pairwise Comparison* table *and the profile plot: Estimated Marginal Means of Measure*.

Based on Table 6, the analysis results showed that the students in the control class had a mean difference between the *pre-test* and *post-test* scores of -42.2 with a significance of 0.00 (p<0.05). In contrast, students in the experimental class had a mean difference of -47.4 with sig = 0.00 (p<0.05). This value indicated that students in both the control and experimental classes experienced a significant increase in the *pre-test-post-test* scores, which can be seen more clearly in a graph in Figure 1. It indicated that H_0 was accepted, i.e., the physics laboratory work model was not more effective than conventional learning models in terms of students' physics learning outcomes.

Table 6

Differences in the students' learning outcomes improvement

Pairwise Comparisons

Group	(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
Experimental	1	2	-47.400*	2.841	.000	-53.088	-41.712
	2	1	47.400*	2.841	.000	41.712	53.088
Control	1	2	-42.200*	2.841	.000	-47.888	-36.512
	2	1	42.200*	2.841	.000	36.512	47.888

Figure 1

A graph of students' learning outcome improvement

The results of hypothesis testing using MANOVA on the *between-subjects effect test* showed no significant difference in the physics learning outcomes of students who studied using a laboratory work model with conventional learning models. It was also supported by the data in Table 4, which showed that the two classes experienced a significant increase but only had a less different mean in the *pre-test-post-test*.

The lack of a significant difference in the *post-test* between the control and experimental classes was also possible because students still found it difficult to change their learning habits and adopted new learning models in a reasonably short period. The researcher obtained it when students collected impressions from the teacher at the last meeting. Some students in the experimental class stated that they felt bored if they continued to study in groups.

In Table 7, the analysis showed that the students in the control class had a mean difference between the initial and final questionnaire scores of students' cooperative attitudes of -1.097 with a significance of 0.240 ($p < 0.05$). Furthermore, in the experimental class, it was -3.337 with sig = 0.001 ($p < 0.05$). The significance value showed that the cooperative attitude of students in the experimental class had increased significantly. Meanwhile, in the control class, it increased but was not significant or tended to be stable (explained by a graph in Figure 2). It showed that H_0 was rejected. The laboratory work model was more effective than the conventional learning model regarding the student's cooperative attitude.

Table 7

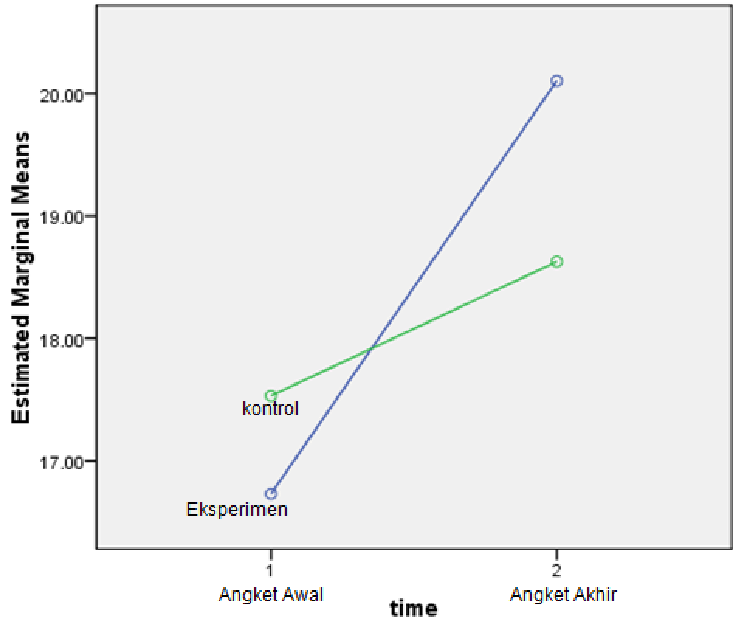
Differences in students' cooperative attitude improvement

Pairwise Comparisons

Group	(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
Experimental	1	2	-3.377*	.925	.001	-5.228	-1.526
	2	1	3.377*	.925	.001	1.526	5.228
Control	1	2	-1.097	.925	.240	-2.948	.754
	2	1	1.097	.925	.240	-.754	2.948

Figure 2

A graph of students' cooperative attitude improvement



Based on Table 7, it was shown that the results of the initial self-assessment questionnaire analysis of cooperative attitudes obtained by the experimental class students were lower than the control class. However, the assessment results on the peer assessment questionnaire, the final self-assessment questionnaire, and the observation results showed that the assessment of the cooperative attitude of the experimental class students was higher than the control class.

The results of hypothesis testing using MANOVA in the *between-subjects effect test* in Table 4 showed a significant difference in the cooperative attitude of students who learned with the laboratory work model and the conventional learning model. This difference was indicated by the *effect size* value of 0.808, which was included in the strong category in Table 5. Based on these differences, it was examined which learning model was more effective, using GMMLs design analysis. The analysis showed that the experimental class's cooperative attitude had increased significantly, while the control class had increased but not significantly. Therefore, the laboratory work model was more effective than the conventional learning model regarding students' cooperative attitudes.

4. DISCUSSION

The use of laboratories allows students to choose activities related to scientific investigations. Students' abstract understanding of physics is transformed into relevant students' understanding through scientific evidence in the laboratory. The effectiveness of the use of the laboratory helps students develop a positive attitude to meet their needs in a laboratory environment. Students are not only directed to have sufficient knowledge, but students can develop process skills (Hadiati et al., 2018; Dounas-Frazer & Lewandowski 2017).

Voronchenko et al., (2015) found that project-based learning with laboratory experiments produced professional competence and a tolerant culture that demanded cooperative strategies, respected differences of opinion, and encouraged students to understand differences in social phenomena.

According to Eren et al., (2015), science experiments can develop curiosity, a positive attitude, and an interest in science. Valeriu (2015) suggests that attitudes formed through learning science determine an individual's success. It indicates that learning science, including physics, through laboratory work can improve scientific attitudes.

Laboratory work and conventional learning models can affect students' cooperative attitudes differently. Students who use laboratory work models appear to be more active in learning than students in classes that use conventional learning models (Sabaryati & Darmayanti, 2018). During group discussions, students cooperate by expressing opinions or ideas and confirming and complementing the opinions of other students. Then, during group presentations, students are challenged to communicate the information that is their responsibility, so students who are usually only passive in learning inevitably have to participate in group discussions to master the material well. A quiz that will be given at the end of the lesson can increase students' enthusiasm to work together to exchange information, explain to group members who are still unclear, and ask other group members when they feel unclear.

Implementing laboratory work is beneficial for students to find facts, principles, and phenomena by observing students strengthen their knowledge and form new knowledge (Winanto & Makahube, 2016). It is under the results of research conducted by Wardani (2019). The fact was an objective condition of objects or phenomena that would be the basis for the formation of knowledge, so the main challenge in learning physics was how to present and process facts from an object or phenomenon into knowledge or to improve the competence of students.

Unlike the experimental class, students in the control class seemed passive. Although the learning activities were still held in pairs and groups in the practicum, students did not show a good attitude of cooperation, such as the absence of a good division of task responsibilities in groups. Hence, some students were still silent and depended on other group members. In the control class, students were used to being guided by the teacher. Therefore, when a discussion session was held, they tended to ask the teacher without discussing it with their group mates or working alone. In addition, group members were not enthusiastic about ensuring other group members understood the questions and the discussed practicum results.

Based on the GLMMs, it can be said that laboratory work was more effective than conventional learning models in terms of students' cooperative attitudes. However, the laboratory work learning model was not more effective than the conventional learning model in students' learning outcomes.

5. CONCLUSION

This research aimed to determine the differences in learning physics using laboratory work and conventional learning models in learning outcomes and students' cooperative attitudes and determine the more effective model of those two models. Based on the results of research and discussion, it could be concluded that there was no difference in the results of learning physics for students who took part in learning with laboratory work and conventional learning models. The laboratory work model was less effective than the conventional learning model regarding student physics learning outcomes.

There were differences in students' cooperative attitudes toward the laboratory work and conventional learning models. The laboratory work model was more effective than the conventional learning model regarding the student's cooperative attitude.

Conflict of Interest: The authors declare no conflict of interest.

Ethical Approval: The study adheres to the ethical guidelines for conducting research.

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