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Review Article

The Effect of Learning Cycle 7E Model Assisted by PhET Simulation on Collaboration Skills and Physics Learning Outcomes of Vocational Students

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Abstract: Low student collaboration skills are often found in learning activities at school. This will certainly impact the low level of student learning outcomes. This study aims to examine the effect of the Learning Cycle 7E model assisted by PhET Simulation on students' collaboration skills and physics learning outcomes. This research is a true experimental study using a posttest-only control group design. The population in this study was class X students of SMK Negeri 2 Jember, while the research sample was determined using the cluster random sampling technique. Data collection methods included observation, interviews, tests, and documentation. The data obtained were analyzed using a normality test, followed by statistical tests using the Independent Sample T-test for collaboration skills and the Mann Whitney U-Test for physics learning outcomes. The results showed that the analysis of collaboration skills data using the Independent Sample T-test obtained a Sig. (2-tailed) of 0.000 ≤ 0.05, indicating a significant difference between the experimental and control groups. Meanwhile, the analysis of physics learning outcomes using the Mann Whitney U-Test obtained a Sig. (2-tailed) of 0.000 ≤ 0.05, also indicating a significant difference. Therefore, it can be concluded that the application of the Learning Cycle 7E model assisted by PhET Simulation has a significant positive effect on improving students' collaboration skills and physics learning outcomes.

Keywords: Collaboration Skills, Learning Cycle, Learning Outcomes,PhET Simulation

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1. Introduction

Part of the science family applied in secondary schools, one of which is physics. Physics subjects have the potential to develop student's cognitive capacity, especially in the aspects of knowledge, conceptual understanding, and analytical skills relevant to natural phenomena or the environment (Anjelina et al., 2023). Physics tends to be less attractive to the majority of students, because they think that physics must memorize formulas and it is difficult to understand the concepts contained therein. The application of suboptimal learning models, particularly teacher-centered approaches, has been identified as a significant factor contributing to students' low motivation in physics (Peranginangin et al., 2020). This condition results in passive student engagement during the learning process, subsequently impeding the cultivation of collaborative abilities (Palennari, 2021). Therefore, the innovation of more student-centered learning models is necessary.

21st century learning emphasizes students to have skills that are relevant to aspects of life in the 21st century as it is today, namely The Four C Skills (Sari et al., 2022). Where the 4C skills are important for students to develop, one of which is collaboration skills. Collaboration skills are skills to work together between group members who help each other and understand each other's tasks to achieve common goals (Apriliyani and Masrurotullaily,

2023). The teacher-centered learning approach has proven unable to develop students' collaboration skills. This is because teachers do not train students to solve problems independently (Sari et al., 2022). Based on interviews with physics teachers at SMK Negeri 2 Jember, student's collaboration skills are still relatively low. Students are less active in discussing and exchanging ideas with peers, because they only receive explanations from the teacher and do not try to explore. When there is a group assignment, only active students are dominant in the group. Meanwhile, other group members only join and do not contribute to the group. This led to the low collaboration skills of students.

Student's ability in physics subjects is still relatively low (Peranginangin et al., 2020). The majority of students who only listen to explanations from teachers, results in a significant deficit in conceptual understanding of the subject matter. Student understanding of subject matter is often associated with student learning outcomes (Nurbaity et al., 2020). Learning outcomes are academic achievements achieved through the learning process based on predetermined criteria (Pratiwi et al., 2023). The results of interviews with physics teachers at SMK Negeri 2 Jember revealed that student learning outcomes in physics courses was still below the expected standard, only about 40% of which met the minimum criteria standards. A principal factor that contribute to low learning outcomes is learning practices that tend to be monotonous and the selection of inappropriate learning models (Peranginangin et al., 2020).

There is a need for a learning model that can be used as an alternative solution that can optimize the development of collaboration skills and student learning outcomes. Researchers chose the Learning Cycle 7E model in this study because of its student-centered characteristics. The Learning Cycle 7E model has the potential to build student's initial knowledge and conceptual understanding of the subject matter, through the formation of concepts which are then connected and applied in a real context. The Learning Cycle 7E model facilitates students to collaborate in exchanging ideas, work with peers, interact actively with the teacher, and recall related concepts that have been learned (Apriliyani and Masrurotullaily, 2023). Research researched by Sari et al. (2022) provides evidence that the Learning Cycle 7E model has a significant effect on collaboration skills and student's critical thinking skills. Thus, the Learning Cycle 7E model is considered effective by researchers to be applied in learning to determine the level of collaboration skills and student's learning outcomes.

The effectiveness of learning activities can be achieved if the implementation of the learning model is accompanied by media to support learning activities. Physics concepts become easy to understand when assisted by learning media related to these physics concepts (Saputra et al., 2020). With the help of learning media, students can explore using these media to understand the subject matter. Therefore, physics learning in schools is usually supported by laboratory practical activities. However, there are still many schools whose laboratory facilities are inadequate. Based on an interview with a physics teacher at SMK Negeri 2 Jember, the physics laboratory at the school was no longer functioning. So during physics learning, they never did practical work in the laboratory. The use of virtual laboratories has also never been done during physics learning at the school. One of the easy-to-operate virtual laboratory platforms that can be used to carry out physics practicals is PhET Simulation. PhET simulation media is a learning media that has interesting and interactive characteristics, so that it can facilitate students to explore learning materials (Rais et al., 2020). PhET Simulation can explain abstract physics concepts, one of which is on energy and its changes. The advantage of PhET Simulation is that it can conduct experiments ideally without having to require real materials and tools (Saputra et al., 2020). The 7E Learning Cycle Model can be integrated with PhET Simulation media in its implementation (Palennari et al., 2021). At the explore stage, students can conduct investigations through practical activities in PhET Simulation. So that students become more interested in participating in learning activities, discussing, and exchanging ideas with their group members. Students also understand physics concepts better and are able to explain them at the explain stage. This can improve collaboration skills and student learning outcomes.

Based on the analysis of the problems that have been described related to the low collaboration skills and physics learning outcomes of students and the inaccurate use of learning models, researchers are interested in providing alternative solutions by implementing the Learning Cycle 7E model integrated with PhET simulation in learning. The difference between this study and previous studies is in the variables tested. Where in this study, the variables tested are student's collaboration skills. Other differences also lie in the levels and materials presented, where in this study the researchers applied the Learning Cycle 7E model

assisted by PhET Simulation for vocational high school students on the material of energy and its changes. So the researchers conducted a study entitled "The Effect of Learning Cycle 7E Model Assisted by PhET Simulation on Collaboration Skills and Physics Learning Outcomes of Vocational Students".

2. Method

This research is classified as a quantitative research. The research methodology applied is an experimental method, with a True Experimental research design involving Posttest-only Control Group Design. The population in this study were grade X students at SMK Negeri 2 Jember. While the sample was taken from two classes that were considered representative of the entire population, and then grouped into experimental and control groups. The process of determining the sample involved a homogeneity test as an initial step. If the test results show homogeneity, then the sampling is carried out randomly. If the test results show non-homogeneity, then two classes were taken with the most minimal difference in average values, and then randomly selected through a lottery to be determined as the experimental class and the control class.

3. Results

The results of the research described are data on the effect of Learning Cycle 7E model assisted by PhET Simulation on collaboration skills and physics learning outcomes of vocational students. The research for two weeks, including submission of research permits, determination of population and samples, learning activities, and collection of posttest data.

Homogeneity Test of Research Samples

The population in this study were grade X students, while the sample was determined through a homogeneity test first obtained from the daily test scores of the science subjects in the previous material. The homogeneity test of variance was carried out using the Levene Statistic using IBM SPSS 25 software. The results of the homogeneity test can be seen in Table 1 below.

Table 1. Results of the Homogeneity Test.

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
NILAI	Based on Mean	,900	4	174	,465
	Based on Median	,850	4	174	,495
	Based on Median and with adjusted df	,850	4	172,181	,495
	Based on trimmed mean	,902	4	174	,464

Based on the analysis results in Table 1, a significance value of 0.465 was obtained. This value exceeds the significance limit of 0.05 (Sig. ≥ 0.05), so it can be concluded that the data variance is homogeneous. After the homogeneity test, sampling was carried out. The sampling process was carried out using a cluster random sampling technique through a lottery because the data was homogeneous. So that class X DKV as the experimental class and X TKP as the control class. The research schedule was adjusted to the hours of the IPAS subject in both classes for two weeks with three meetings. Two meetings for delivering material accompanied by seven observers, and one meeting to posttest.

Data Analysis of Collaboration Skills of Vocational Students

Data on student's collaboration skills were obtained from observations in both classes. Observations were conducted by seven observers during the learning activities, where one observer observed one group. Data on collaboration skills for each indicator are presented in Table 2 below.

Table 2. Summary of Data on Student's Collaboration Skills for Each Indicator

Indicator	Experimental Class			Control Class		
	Meeting 1	Meeting 2	Average	Meeting 1	Meeting 2	Average
Responsibility in completing work	84.29	86.67	85.48	61.11	54.63	57.87

Compromising	90	91.9	90.95	56.94	58.8	57.87
Working productively	88.1	90	89.05	60.19	54.17	57.18
Adapting to various roles or activities	89.05	72.38	80.72	59.26	51.85	55.56

Based on the data presented in Table 2, the average value of student's collaboration skills on each indicator showed higher in the experimental class than in the control class. The highest score was in the compromise indicator in both classes. While the indicator of adapting in various roles or activities showed the lowest score in both classes. Furthermore, the data from the research on the collaboration skills of vocational high school students are briefly presented in Table 3 below.

Table 3. Summary of Student Collaboration Skills Data

Class	Total Students	Highest Score	Lowest Score	Average
Experimental	35	97.92	68.75	86.55
Control	36	79.17	33.34	57.12

The data in Table 3 clearly indicates that students in the experimental class have a higher level of collaboration skills than students in the control class. In the experimental class, the highest score was 97.92 and the lowest score was 68.75 with an average of 86.55. Meanwhile, the highest score in the control class was 79.17 and the lowest score was 33.34 with an average of 57.12. Based on these data, of course, it still cannot answer the research objectives. Therefore, the next step is to conduct statistical tests with the help of IBM SPSS 25 software.

The normality test of collaboration skills of vocational students was conducted through the Kolmogorov-Smirnov test using SPSS 25. The normality test aims to ensure that the data is normally distributed or not. The results of the normality test can be seen in Table 4 below.

Table 4. Normality Test of Student Collaboration Skills

One-Sample Kolmogorov-Smirnov Test

		EKSPERIMEN	KONTROL
N		35	36
Normal Parameters[a,b]	Mean	86,5506	57,1203
	Std. Deviation	7,11637	14,92689
Most Extreme Differences	Absolute	,135	,108
	Positive	,076	,108
	Negative	-,135	-,104
Test Statistic		,135	,108
Asymp. Sig. (2-tailed)		,103[c]	,200[c,d]

Table 4 shows that the collaboration skills of students in the experimental class obtained a Sig. (2-tailed) value of 0.103 and in the control class of 0.200, both of which are greater than 0.05. In the decision-making framework, it states that the Sig. (2-tailed) value ≥ 0.05 means that the data is normally distributed. Based on the significance value obtained, it can be concluded that the data on student collaboration skills in both classes are normally distributed.

Based on the results of the normality test which show that the data has a normal distribution, the next step is to conduct a hypothesis test using the Independent Sample T-Test. The results of the Independent Sample T-Test can be seen in Table 5 below.

Table 5. Independent Sample T-Test Collaboration Skills

Independent Samples Test

	Levene's Test for Equality of Variances	t-test for Equality of Means

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
NILAI	Equal variances assumed	26,519	,000	10,555	69	,000	29,43029	2,78833	23,86773	34,99286
	Equal variances not assumed			10,650	50,440	,000	29,43029	2,76336	23,88112	34,97947

Theorem-type environ meIn Table 5, the Sig. (2-tailed) value is 0.000, which indicates that the value is less than 0.05. Referring to the basis for decision making, Ho is rejected and Ha is accepted. This indicates that the average value of the collaboration skills of students in the experimental class is not the same as the average value of the collaboration skills of students in the control class, meaning there is a difference. This difference indicates that there is a significant influence of the Learning Cycle 7E model assisted by PhET Simulation on the collaboration skills of vocational students.

Data Analysis of Physics Learning Outcomes of Vocational Students

Data on student's physics learning outcomes were obtained through a posttest conducted after carrying out the learning process for two meetings in each class. The posttest was conducted after learning with the Learning Cycle 7E model assisted by PhET Simulation in the experimental class, and learning with the model usually applied in schools in the control class. The posttest given was in the form of 10 multiple-choice questions arranged based on cognitive domain learning outcome indicators with levels C4, C5, and C6. A summary of student's physics learning outcome data is presented in Table 6 below.

Table 6. Summary of Student's Physics Learning Outcome Data

Class	Total Students	Highest Score	Lowest Score	Average
Experimental	35	100	70	87.43
Control	36	90	40	71.67

Based on Table 6, it can be seen that the physics learning outcomes of students in the experimental class are higher than those in the control class. The highest score in the experimental class is 100 and the lowest score is 70 with an average of 87.43. While the highest score in the control class is 90 and the lowest score is 40 with an average of 71.67. Based on these data, of course, it still cannot answer the research objectives. Therefore, the next step is to statistical tests using SPSS 25.

The normality test of physics learning outcomes of vocational high school students was carried out through the Kolmogorov-Smirnov test using IBM SPSS 25 software which can be seen in Table 7 below.

Table 7. Normality Test of Physics Learning Outcomes of Students

One-Sample Kolmogorov-Smirnov Test

		EKSPERIMEN	KONTROL
N		35	36
Normal Parameters[a,b]	Mean	87,43	71,67
	Std. Deviation	8,521	14,041
Most Extreme Differences	Absolute	,219	,175
	Positive	,208	,105
	Negative	-,219	-,175

Test Statistic	,219	,175
Asymp. Sig. (2-tailed)	,000[c]	,007[c]

Table 7 shows the results of the normality test of physics learning outcomes of students in the experimental class obtained a Sig. (2-tailed) value of 0.000 and in the control class of 0.007, both of which are less than 0.05. In the decision-making framework, it states that the Sig. (2-tailed) value < 0.05 means that the data is not normally distributed. Based on the significance value obtained, it can be concluded that the physics learning outcome data of students in the two classes are not normally distributed.

The results of the normality test show that the data is not normally distributed, so the next step is to analyze the data with a nonparametric statistical test through the Mann Whitney U-test. The results of the Mann Whitney U-test can be seen in Table 8 below.

Table 8. Results of the Mann Whitney U-test Data Learning Outcomes

Test Statistics[a]

	NILAI
Mann-Whitney U	229,000
Wilcoxon W	895,000
Z	-4,751
Asymp. Sig. (2-tailed)	,000

The results of the statistical test in Table 8 obtained a Sig. (2-tailed) value of 0.000, which means the Sig. (2-tailed) value ≤ 0.05. Referring to the basis for decision making, Ho is rejected and Ha is accepted. This indicates that the average value of the physics learning outcomes of students in the experimental class is different from the average value of the physics learning outcomes of students in the control class. This difference indicates that there is a significant influence of the Learning Cycle 7E model assisted by PhET Simulation on the physics learning outcomes of vocational students.

4. Discussion

This research was conducted at SMK Negeri 2 Jember in the odd semester of the 2024/2025 academic year involving two classes, namely class X DKV as the experimental class and class X TKP as the control class. In class X DKV, learning was carried out by implementing the Learning Cycle 7E model assisted by PhET Simulation, while class X TKP used a model that is usually applied by physics teachers in schools. Learning activities in the experimental class were supported by the use of PhET Simulation as a learning medium. PhET Simulation is used by students in the learning process at the explore stage. Through PhET Simulation, students can carry out simulations so that they are able to understand physics concepts more deeply. In addition, students can also discuss with their respective groups to collect data, so that they can answer the problems given in the LKPD.

The Effect of Learning Cycle 7E Model Assisted by PhET Simulation on Collaboration Skills of Vocational Students

The first objective of this study examines the significant effect of Learning Cycle 7E model assisted by PhET Simulation on collaboration skills of vocational high school students. Student's collaboration skills were studied by conducting observations in each class during two meetings which showed superiority in the experimental class. This is due to the implementation factor of the Learning Cycle 7E model integrated with PhET Simulation. This study uses the reference indicator of collaboration skills according to Greenstein (2012) which was modified by Sarifah and Nurita (2023), including responsibility in completing work, compromising, working productively, and adapting to various roles or activities. The average final score obtained by students in the experimental class was 86.55. While in the control class it was 57.12. Based on these results, it can be said that the level of collaboration skills of students in the experimental class is higher than in the control class.

The highest score in the experimental class is in the compromise indicator of 90.95. This is evident when students discuss in groups. Students are able to exchange opinions in a group to solve problems in the LKPD. Students also provide assistance to group members who are experiencing difficulties, so that difficulties in solving a problem can be resolved properly and

the right solution can be found. The majority of students are able to fulfill every aspect of the compromise indicator very well. This is what makes the compromise indicator have the highest score in the experimental class. The results of this study are in line with research conducted by Sarifah and Nurita (2023) which shows that students compromise neutrally with their groups in solving problems in the LKPD, students are also able to respect the opinions of other groups and provide assistance to group members who are experiencing difficulties. The more often students help group members who are experiencing difficulties, the more skilled they are in collaborating with their teams. While the lowest score in the experimental class was in the indicator of adapting in various roles or activities of 80.72. This was caused by some students who paid less attention when other groups were presenting. Some students did not listen to the presentation, and did not provide feedback to the group that was presenting. The majority of students fulfilled every aspect contained in the indicator of adapting in various roles or activities poorly. This is what makes this indicator have the lowest score in the experimental class. The results of this study are in line with the results of research found by Sarifah and Nurita (2023) which showed that the aspect of adapting in various roles had the lowest percentage because students were busy preparing their respective group presentations, so students were less focused on listening to other groups who were presenting and were less able to provide feedback.

The level of collaboration skills of students in the experimental class was significantly different from the control class. This difference was caused by the implementation of the Learning Cycle 7E model integrated with PhET Simulation in the experimental class. Meanwhile, the control class implemented a learning model that is usually implemented by physics teachers at SMK Negeri 2 Jember, and only used the lecture method without the help of interactive media. All indicators of collaboration skills according to Greenstein (2012) were applied in the stages of the Learning Cycle 7E model assisted by PhET Simulation during learning activities in the experimental class. The compromise indicator was applied at the explore stage. The indicator of adapting in various roles or activities was applied at the explain stage, namely when making presentations. The indicator of working productively was applied at the elaborate stage. The indicator of responsibility in completing work was applied at the elaborate and extend stages. According to Sari et al. (2022), the stages of the Learning Cycle 7E model that were effectively able to improve students' collaboration skills include the explore, explain, and elaborate stages. This was evident during the learning process in the experimental class. At the explore stage, students were able to explore and discuss to solve problems through the application of concepts that had been obtained in the previous stage. At the explain stage, students had the opportunity to convey their findings and learn to respect the opinions of other students. Meanwhile, at the elaborate stage, students are able to discuss to connect concepts with relevant examples in everyday life. The 7E Learning Cycle Model can create active student responses at every stage of learning, because this model is student-centered and adheres to the theory of constructivism. Where students must construct their own knowledge through interaction with the environment in the learning process (Maulani, 2022:1). This is what makes student's collaboration skills in the experimental class better than the control class.

The positive influence of the implementation of the Learning Cycle 7E model assisted by PhET Simulation on collaboration skills was seen during learning activities in the experimental class. Students became more interested in participating in learning activities because the simulations in PhET Simulation were easy to apply and physics concepts became easier to understand. Students can utilize PhET Simulation media in group discussions to collect data contained in the LKPD. So that students are more active in discussing and exchanging opinions with groups in completing LKPD by simulating PhET Simulation. This is what causes students' collaboration skills in the experimental class to be better than in the control class. So it can be said that there is a significant influence of the Learning Cycle 7E model assisted by PhET Simulation on students' collaboration skills. The results of this study are relevant to the research conducted by Apriliyani and Masrurotullaily (2023) and Sari et al. (2022) which proves that the Learning Cycle 7E model has a significant effect on students' collaboration skills. Therefore, it can be said that the implementation of the Learning Cycle 7E model supported by PhET Simulation can be used as an alternative to improve student's collaboration skills.

The Effect of Learning Cycle 7E Model Assisted by PhET Simulation on Physics Learning Outcomes of Vocational Students

The second objective of this study examines the effect of the Learning Cycle 7E model assisted by PhET Simulation on physics learning outcomes of vocational high school students. Students' physics learning outcomes were examined by conducting a posttest after carrying out the learning process for two meetings. The posttest consisted of 10 multiple-choice questions arranged based on learning outcome indicators in the cognitive domain with levels C4, C5, and C6. The average physics learning outcomes of students in the experimental class were 87.43. While the average physics learning outcomes of students in the control class were 71.67. This average indicates that the physics learning outcomes of students in the experimental class were higher than those in the control class. This is due to the treatment of implementing the Learning Cycle 7E model assisted by PhET Simulation as a supporting medium for learning in the experimental class.

The implementation of the Learning Cycle 7E model assisted by PhET Simulation has a significant influence on student's physics learning outcomes through habituation in solving the given problems. The Learning Cycle 7E model is able to train students to form their own knowledge. Students are also trained to be able to think more deeply, explore, find concepts, and describe applications of the concepts learned in completing LKPD and posttest questions. The use of PhET Simulation can make it easier for students to understand physics concepts in depth. PhET Simulation makes abstract phenomena appear real so that students find it easier to understand physical concepts. This is known when the learning process takes place in the experimental class, students can easily operate PhET Simulation via their respective smartphones in completing LKPD so that the physics concepts learned can be understood by students well. Thus, completing the posttest becomes easier because students have understood the physics concepts from the material being studied. This is evident in the results of the student's posttest, where students in the experimental class have a higher average learning outcome than the control class. So it can be concluded that the implementation of the Learning Cycle 7E model integrated with PhET Simulation has a significant positive influence on student's physics learning outcomes. This is in line with research conducted by Mubarokhah (2023) and Sari (2023) which proves that the Learning Cycle 7E learning model accompanied by PhET Simulation has a significant effect on student's physics learning outcomes.

The implementation of learning activities in the experimental class was also strengthened by the observation sheet of learning implementation, which was observed by the observer at each meeting. At the first meeting, learning activities with the Learning Cycle 7E model assisted by PhET Simulation were implemented 93.75%. While at the second meeting it was 98.44%. So overall, the average implementation of learning activities using the Learning Cycle 7E model assisted by PhET Simulation was 96%, which means that all stages of learning were implemented very well.

The learning process with the Learning Cycle 7E model assisted by PhET Simulation in the experimental class has obstacles in its implementation. Students are using PhET Simulation as a learning medium for the first time, so they are still unfamiliar and confused in operating PhET Simulation. This certainly hinders the learning process in the next stages. The solution implemented is to explain the procedure for using PhET Simulation directly through a projector before the discussion activity takes place. So that students can see directly and know how it works, then practice it during group discussions. Thus, the allocation of learning time can be managed properly, so that all stages can be carried out optimally. Another obstacle is that there are several students who use smartphones for other activities outside of practicum activities. This is because the practicum is carried out on the smartphones of each group member. The solution implemented is to supervise each group more with the help of observers, and to divide clear tasks to each group member so that they can be responsible and focus on their duties according to their respective job descriptions.

5. Conclusions

Based on the results of the research and discussion explained, it is concluded that there is a significant influence of the Learning Cycle 7E model assisted by PhET Simulation on the collaboration skills of vocational students with a Sig. (2-tailed) value of 0.000. In addition, there is also a significant influence of the Learning Cycle 7E model assisted by PhET Simulation on the physics learning outcomes of vocational students with a Sig. (2-tailed) value of 0.000.

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