

ARTICLE

# Implementing STAD cooperative learning model integrated interactive PhET simulation to enhance high school students' learning outcomes: a case of momentum-impulse concepts

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## Abstract

This study aims to determine the effectiveness of STAD with the help of PhET interactive simulations in increasing student activity and learning outcomes and to find out the difference in improving student learning outcomes before and after the implementation of Student Team Achievement Division (STAD) cooperative learning with the help of PhET interactive simulations about momentum and impulse. This research was conducted because there are still many students who get unsatisfactory learning outcomes in physics subjects, because students think that physics subjects are difficult to understand. One of the reasons is that learning is dominated by the teacher so that students do not have the opportunity to exchange ideas. In addition, students need tools to get an overview of the material presented by the teacher. So that STAD learning with the help of interactive PhET simulation can help students to improve student learning outcomes. The research method used is a quasi-experimental design with a non-equivalent control group. Based on the Wilcoxon test, the Z value was obtained ( $Z=-2.532$ ;  $p=0.11 < 0.05$ ), the hypothesis was that there was a difference in the improvement of student learning outcomes between those using STAD learning with the help of PhET interactive simulation and conventional learning methods.

**Keywords:** STAD model, cooperative learning model, students' learning outcomes, momentum-impulse concepts

## 1. Introduction

Physics subjects are materials that are correlated with our lives. Thus, the teacher must be able to explain various concepts in a tangible form. According to Government Regulation Number 19 of 2005 in Article 19 Paragraph 1, learning is carried out interactively, inspiring, fun, challenging, motivating students to increase creativity and independence of students according to interests, psychological development, and physical development of students. However, in learning physics there is a lot of material that is not understood by students so that many students become lazy to learn physics because of the many formulas in its application. If only using the explanation method

will only make students bored, there must be other methods used by teachers to change students' mindsets.

Learning strategies are particularly important. Something new is easily learned by children. Features that have meaning from new knowledge can be noted by a child, not just given by the teacher (Aqib *et al.* 2013). Therefore, a teacher must make a learning strategy (plan) for students so that the learning process becomes more effective (effective). Lack of communication in learning is caused by teachers who are more dominant in providing knowledge. In learning and the instruments used are only power points and video clips in which students have no interaction with the media. So that it causes the learning process to be more passive and makes students' understanding less (Wahidah 2014).

To help smooth learning, it is necessary to use technology by presenting virtual practicums. One of the reasons for the increase in learning in schools is the development of current educational technology. Virtual laboratories are an example of such technological advancements, PhET (Physics Environment Technologies) is one of them. The unpreparedness of a real laboratory can be anticipated using a virtual laboratory, a virtual lab is an interactive tool of science assisted by software on a device such as a mobile phone, laptop, and computer in the form of replicating science experiments. Virtual labs can be used to help simplify the learning process by increasing students' understanding of material concepts. PhET is an application that provides various kinds of physics simulations that will help students to learn physics materials.

The solution is to apply the STAD learning model with the help of PhET interactive simulations because STAD is one of the many lessons that are easy to adapt and have been widely researched. This small group requires students to pay attention to the diversity between members to be used as a forum for students to work in groups and solve problems by interacting with their members so that this can give students time to think about and study certain material well and students can be a source of learning for other students.

In addition, the subject of physics is one of the many materials whose material is not liked by many students, this is due to the lack of media or tools used in learning for complex material. The instruments used are only whiteboards and markers, this is what makes students less understanding of physics material, especially about Momentum and Impulse, most students cannot imagine what things can affect Momentum and Impulse so that teachers need more effective media such as PhET simulations. With the STAD and PhET Simulation, students will work in groups with their respective groups to understand lessons about momentum and impulses accompanied by the help of interactive PhET simulations. understand the material in question.

## **2. Literature Framework**

### **2.1 Cooperative learning model**

Cooperative learning is a way of learning in which students actively interact in group activities and facilitate the exchange of ideas as they learn. This encourages students to interact actively, in line with the philosophy of constructivism, and allows them to exchange ideas in a comfortable atmosphere (Yusuf, Jusoh, and Yusuf 2019). Therefore, education must be able to coordinate and encourage the development of the potential and creativity of students optimally to ensure dynamism during educational and learning activities. Cooperative Learning Model, namely learning carried out in groups aimed at constructing concepts and solving problems together (Lee *et al.* 2021).

### **2.2 Student Team Achievement Division (STAD) cooperative learning**

The STAD learning model was originally developed by Slavin. This learning can be adapted in various ways for elementary school and college students (Yusuf, Jusoh, and Yusuf 2019). STAD can consist of 4-5 people with various abilities. A teacher will give must ensure that in the group students can master the lesson. Furthermore, students fill out individual quizzes about the material that has

been described by a teacher, students are not allowed to work with their friends during the quiz, then they will get prizes based on how much value they get and how much comparison with the previous value. These scores will be accumulated to produce a score for the group, if the group reaches the criteria, the group will receive an award from the teacher such as a certificate or other prize.

In this learning, students can ask for help to exchange answers, discuss differences in learning, and help each other moreover ask the teacher if they face difficulties in the learning process (Septian, Agustina, and Maghfirah 2020). This is the main thing because it can arouse students' creativity in solving problems in learning (Sharifov and MacIsaac 2021). Students will be given time by the teacher to work together on group discussions. However, it is not allowed to cheat on friends or discuss in individual quizzes because students are required to master the material which is the responsibility of an individual. STAD is a generic method of class rules but not class rules with easy-to-accept teaching methods on certain subjects, so teachers make lessons and materials that teachers make themselves (Ridia and Afriansyah 2019). The teacher provides students with worksheets and quizzes. Worksheets and quizzes for students are provided in most school subjects.

### 2.3 *Physics Environment Technology (PhET)*

PhET is software that includes interactive simulations of research and is licensed for free (As 2021). The purpose in making this software is to help students conceptualize in real terms and ensure effective Education and ensure the usefulness of Education for the future. In this case, it offers virtual lab-based physics lessons and learning simulations that make it easy for teachers and students to use them for classroom learning. Even students or teachers who do not understand technology will be able to use it. Simulations are scripted in Java and Flash and can be processed using standard browsers such as google chrome, safari, opera and so on as long as Flash and Java plugins are downloaded (Kurniawan, Rifa'i, and Fajar 2020). Which means, the interactive PhET simulation is an easy-to-use simulation. This simulation is free and can be downloaded from <http://phet.colorado.edu/>. PhET software can be installed on operating systems such as Windows, Linux, and macOS. You can also use it online and run the simulation. The simulation is also remarkably interesting and easy to process, making it easier for students to understand.

### 2.4 *Physics Environment Technology (PhET)*

Learning outcomes are the skills of students based on the learning outcomes achieved. Learning outcomes are achieved academically by students through exams or assignments by responding and proactively answering questions that support the acquisition of these learning outcomes (Sudibjo 2019). Learning outcomes are the results of student performance and the realization of changes and the formation of individual student behavior. If the teacher has his own opinion, then the learning process is successful (Abidin 2020). However, for general awareness raising, at this point those with very mature curricula must be declared as successful teaching materials in the learning process if subject-specific ability goals are to be achieved.

Here are 2 factors that can affect learning outcomes (Marlina and Sholehun 2021), namely physiological and psychological factors. Some physiological factors are health conditions and physical conditions. Meanwhile, psychological factors include attention, interest, talent, and readiness. Attention, students are required to pay attention to the material they are learning so that the optimal value, when being a student boredom usually appears, so students feel lazy to learn. Interest is an ongoing desire to listen and remember an activity. Talent is the ability to learn, and once learned or practiced, translates into tangible skills. Readiness is the availability of students to answer or react. The readiness of students in learning means that their knowledge at the first time is learning so that they can participate in learning activities. In this study, students' learning outcomes were evaluated by using the instruments that follow Blooms' cognitive dimension. The instruments were divided into four categories such as remembering, comprehending, applying, and analyzing. Then, it was

adopted to every learning indicator that aims to achieve in the learning process by using STAD cooperative learning model.

### **3. Research Method**

#### **3.1 Research design**

This research uses Quasi Experiment method with Nonequivalent Control Group design. This design uses pretest and posttest. this can be calculated by comparing the posttest and pretest final scores in which the experimental and control groups were not randomly selected (Fagin and Merkle 2002). There are two groups of research subjects, namely the experimental and control groups. Both will be given pretest before treatment and posttest after treatment. The difference between the two is in the treatment that will be applied. The control group will be given material using a conventional learning model, while the experimental group will be given the STAD learning method with the help of PhET interactive simulation. The treatment was carried out to identify whether there was differentiation in the two classes. This differentiation makes it easy to identify which learning is most effective. If the posttest value is greater, it means that the treatment has a positive effect.

#### **3.2 Population and sample**

The population is an individual unit or region at the time to be studied (14). Population is a general domain consisting of objects or subjects that allows researchers to determine the number and characteristics for research and completion. The population does not only include the number of objects and subjects, but all the properties and characteristics they have (Fagin and Merkle 2002). The population in this study is the tenth-grade science class students in one of the cities in Indonesia who have received an A (excellent) accreditation. This school was chosen based on the consideration of researchers because the school has students and teachers who have qualified abilities in using learning simulation applications.

While the samples in this study were two classes, namely the tenth-grade students of Mathematics and Natural Sciences who were selected by purposive sampling technique. Purposive sampling technique was used in this study because this technique was carried out with certain considerations (Fagin and Merkle 2002). The experimental and control classes consisted of 35 students. The consideration in selecting this sample is the character of the students in each class and the students' ability to operate mobile phones, computers, or laptops.

#### **3.3 Instruments**

The research instrument is a measuring instrument used to assess various kinds of social phenomena and phenomena to be monitored (Fagin and Merkle 2002). The tests used in the study were in the form of objective tests and non-tests in the form of questionnaires and interviews. The test was applied to find out the difference in learning outcomes at the pretest and posttest. In this study, a multiple-choice test was conducted with several 20 items with 5 choice answers and only 1 correct answer. Before carrying out the objective test, in collecting data, questions will be distributed to students who are outside the sample.

Validity is defined as a benchmark to find out how accurately a test can perform its measurement function. So, for the test to be declared valid, it must be measured carefully (Taherdoost 2016). Processing the validity test was carried out with Anates. Anates is an application that is free to download besides that the application can be accessed easily; the result of this validity showed that the instruments used were valid in which all validity scores were above 0.57. Reliability test is a reliable data collection instrument because of its superior tools. Reliability will show the level of reliability of something where reliable itself means (trustworthy) can be trusted and can be relied on (Taherdoost 2016). In this present study, the reliability score was 0.75 that means the instrument has good consistency.

**3.4 Data analysis**

Based on the instruments used, some analyses were conducted to evaluate the data scores of learning outcome and interview data. First, the Wilcoxon test was used to test significant difference of mean between experimental and control group. Level of significance used was 0.05. Second, normalized gain (N-gain) (Hake 2002) was used to distinguish effectiveness of learning process in the experimental and control group. Lastly, the narration of the interview was presented to support how students perceived the use of STAD cooperative learning model in improving students' learning outcomes.

**4. Result of the research**

**4.1 Effect of the STAD cooperative learning model on Student Learning Outcomes**

The summary of the results of the pretest and posttest of improving learning outcomes on the topic of momentum and impulse achieved by the experimental and control class students is as follows:

**Table 1.** The result of the pretest and post-test

Group	Pretest				Post-test			
	Max	Min	Mean	SD	Max	Min	Mean	SD
Experiment	60	10	36.57	13.71	100	50	76.29	13.30
Control	50	10	29.71	13.39	60	10	35.43	14.0-

Referring to the data in table 4.1 for the experimental class, the students' pretest mean score is 36.57 and the students' posttest mean is 76.29 with a standard deviation of 13.71 for the pretest and 13.30 for the posttest. Meanwhile for the control class, the mean score for the pretest was 29.71 and the mean score for the posttest was 35.43 with a standard deviation of 14.00 for the pretest and 11.67 for the posttest. Therefore, it can be concluded that the achievement of the average value of the experimental class is higher than the control class.

Based on the calculation results of the Wilcoxon Signed Rank Test on the pretest data of the control class and the experimental class, the value of  $Z = -2,054$  with p value (Asymp. Sig 2 tailed) =  $0.040 < 0.05$ , which means the initial abilities of the two groups are different. While the control and experimental class posttest data obtained a value of  $Z = -5,172$  p value (Asymp. Sig 2 tailed) =  $0.000 < 0.05$  (less) which means if  $Z < 0.05$  then  $H_a$  is accepted. So, the hypothesis decision is to accept  $H_a$  or it means that there are differences in student learning outcomes between those using STAD learning with the help of PhET interactive simulation and conventional learning methods.

**4.1.1 Effectiveness of the STAD cooperative learning model**

Based on table 2, the results of the N-Gain score test calculations show that the average N-Gain score for the experimental class is 63.87 percent, which means that it is included in the quite effective category with a minimum N-Gain score of 40 percent and a maximum of 100 percent. Meanwhile, the average N-Gain score for the control class is 4.43 percent, which means that it is included in the ineffective category with a minimum N-Gain score of -60 percent and a maximum of 56 percent. It can be concluded that the use of the STAD Learning Model with the help of PhET Interactive Simulation is effective in improving student learning outcomes.

**5. Discussion**

STAD Learning Model with the help of PhET interactive simulation will equip students with active learning, students feel this learning model is something new and can increase motivation in learning. Students not only understand the material and are motivated in learning, but they also learn to solve

**Table 2.** Normalized gain (N-Gain) of pretest and post-test

Value	N-Gain	
	Pretest	Posttest
Mean	0.64	0.04
Maximum	0.40	-0.6
Minimum	1.00	0.56

problems. The basic concepts in learning can be understood easily. Because students are not only instructed to understand the basic concepts but they will see tactics with the help of interactive PhET simulations so that students can learn and apply them in their daily lives considering that physics lessons are learning that is considered saturated and boring by students.

Based on the results of the study, the average pretest of the experimental class was 36.57 and the posttest was 76.29. The mean pretest of the control group was 29.71 and the mean of posttest was 35.43. It can be seen that students who learn to use the STAD type cooperative learning model with the help of PhET interactive simulations show higher learning outcomes than students who learn to use conventional learning methods.

Based on the results of the Wilcoxon Signed Rank Test analysis on the pretest of the experimental and control classes, a Z-score of -2.054 was obtained, while the posttest of the control and experimental classes obtained a Z-score of -5172 with a p-value (Asymp. Sig 2-tailed) below the critical operating limit. 0.05, which is the assumption made that Ha's decision is accepted or implies that there are differences in student learning outcomes between the experimental and control groups.

Based on the calculation results of the N-Gain test, it shows that the N-Gain Score for the experimental class is in the quite effective category, while the N-Gain Score for the control class is in the ineffective category. It can be concluded that the use of the Student Teams Achievement Division (STAD) Cooperative Learning Model with the help of PhET Interactive Simulation can effectively improve student learning outcomes (Sharifov and MacIsaac 2021).

The positivity on students' conceptual skills shows that the PhET interactive simulation-assisted learning model in the experimental class can expand students' conceptual skills than the conventional learning model in the control class. With this learning model students can play an active role in working together and supporting each other when group members face difficulties in learning (Sharifov and MacIsaac 2021). In addition, student activities carried out by teachers in group learning emphasize how to lead and the obligations of students individually or in groups, that's why the responsibility is not only carried out by group leaders but group members must also be responsible, therefore value is the goal to be achieved. achieved by all students. Therefore, all students have the same (equal) rights and obligations.

The results of a survey of students using the PhET interactive simulation-assisted learning model have a positive influence on student learning outcomes. About Indicators The average student response for each indicator assessed is positive. From this it can be concluded that there is a positive response from students in the learning model that is carried out. Interviews were conducted with 3 students to verify the survey results. Most students feel interested and happy to learn the STAD type cooperative learning model with PhET interactive simulation because the learning is not boring and easy to understand (Aqib *et al.* 2013). PhET simulations make the material easier for some to understand and master. However, some students feel that the STAD interactive simulation cooperative learning model with the help of PhET interactive simulation is not suitable for everyday learning because sometimes a cooperative learning model is needed to make it easier for students to understand the lesson better. According to students, when the material is explained in a shorter and easier to understand manner, the learning process becomes fun and understandable.

## 6. Conclusion

The STAD type cooperative learning model with the help of PhET interactive simulation can improve student learning outcomes in cognitive aspects when compared to the use of conventional learning. In the concept of learning, students who learn using PhET interactive simulations have higher learning outcomes than students who use conventional learning. After using the Wilcoxon test, it was concluded that in the experimental class there was an increase between the results of the pretest and posttest because the Z value  $< 0.05$ , which means there was an increase in student learning outcomes after the implementation of STAD type cooperative learning with the help of PhET interactive simulation.

The STAD type cooperative learning model with the help of interactive PhET simulation is effective in improving student learning outcomes in the cognitive aspect because it is obtained from the results of the N-gain score calculation showing that the average N-gain score for the experimental class is 63.87 percent, which means it is included in the sufficient category. effective. Meanwhile, the control class is 4.43 percent, which means it is in the ineffective category. In addition, some students feel enthusiastic, motivated and their enthusiasm for learning increases with this PhET interactive simulation, both individually and in groups. Students feel that STAD type cooperative learning with the help of PhET interactive simulation is more effective than conventional learning models which are dominated by teachers because it makes students not bored and not boring in learning. PhET interactive simulation makes it easier for students to understand.

In conclusion, it can be stated that in this study students who were taught using the STAD learning model with the help of PhET interactive simulations obtained higher learning outcomes than students who learned using conventional methods, especially on the subject of momentum and impulse. Teachers can use the STAD type learning model with the help of this PhET interactive simulation as an alternative learning model for physics subjects.

Students can operate learning media using PhET interactive simulation which is used as a learning tool easily. The choice of learning model will be a major factor in planning learning. The use of learning methods will be better if students are active in developing their skills and mindset, especially in physics subjects. The application of a good learning model not only requires students to be active but teachers are also required to be active in order to develop optimal learning and develop potential so that students are more enthusiastic in learning.

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