JURNAL PEMBELAJARAN FISIKA

http://jurnal.fkip.unila.ac.id/index.php/JPF

Vol 10 (1), 2022, 031-041 ISSN: 2302-0105 (p); 2684-9828 (e)

# PhET Simulation Software-Problem Based Learning to Improve Physics Concepts on Newton's Law

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*Received: June 7, 2022* *Accepted: June 12, 2022* *Published: June 13, 2022*

**Abstract:** The purpose of this action research is to improve students' understanding of basic physics concepts by using the Problem Based Learning model on Newton's law of motion and its application with PhET simulation media. This research is classroom action research with two cycles. Each cycle consists of four stages, namely planning, implementation, observation, and reflection. The subjects in this study were students of Science Education at the Global Nusantara Education Institute. Data collection techniques with observation and tests. Meanwhile, the data were analyzed using a combination method with a convergent parallel mixed method. Quantitative data analysis with descriptive analysis, data analysis used on qualitative data for data presentation, data presentation, and concluding. The results showed that the use of the Problem Based Learning model with PhET Simulation Media could improve students' understanding of basic physics concepts in Newton's law of motion and its application. The improvement in students' understanding of basic physics concepts is marked by an improvement in the average value of understanding basic physics concepts, namely the average value of students from 36.50 (0%) at the pre-action stage to 63.75 (55%) after the first cycle of action and again increasing after-action cycle 2 with an average value of 84.75 (90%). From these data, it can be seen that the use of the Problem Based Learning model with PhET Simulation Media can improve students' understanding of basic physics concepts.

**Keywords:** Understanding Physics Concepts; Problem Based Learning; PhET Simulation

**DOI:** http://dx.doi.org/10.23960/jpf.v10.n1.202204

## INTRODUCTION

The purpose of higher education is to prepare students to become members of the community who have professional academic abilities and can apply, develop and disseminate knowledge to improve people's lives and enrich national life. One of the universities in Lombok, namely the Global Nusantara Education Institute (IPNG), has a science education study program. The learning activities, it is prepared so that students have the ability and skills to apply the learning outcomes in everyday life.

Basic physics is a compulsory subject that must be taken by students in the science education study program. Each student is required to pass this course and is only allowed to take other physics courses in the following semester. However, the graduation of students in this course does not guarantee their high understanding of the concept of Physics, this happens to students of IPNG science education. Almost all students passed this course, but most of them complained about their lack of understanding of basic physics concepts which made it difficult for them to follow several other physics courses.

The results of the preliminary study indicate that the students' lack of understanding of basic physics concepts is caused by several factors, one of which is the way the lecturers teach still uses the old method, namely lectures and group discussions, and emphasizes problem-solving exercises. This model does not train students to understand basic physics concepts. The results of observations at IPNG also found that the science laboratory room was still used for classrooms. Laboratory equipment is still limited and rarely used so the teaching and learning process that requires students to do practicum does not run smoothly and affects the understanding of the concepts of the material taught to students. The lack of use of laboratory equipment in the learning process and the lack of practicum activities result in less active students during learning and increasingly boring so that the concepts taught are poorly understood (Athaillah et.al. 2017). Experiments in science learning, especially physics, are useful for constructing students' understanding in understanding natural phenomena, concepts, and principles of science (Yahya et.al. 2019). Experimental activities in the laboratory must be carried out in physics learning and require laboratory space (Tuhusula et al. 2020).

One solution to solving student problems is to use a Problem Based Learning (PBL) model which will be combined with PhET simulation media. The PBL model is a learning model that has student-centered characteristics in solving problems and the problems studied are contextual problems found in everyday life, activating the participation of students in learning experiences, and forming students into flexible thinkers in problem-solving (Jailani, 2017; Maryati, 2018). This can train students' understanding of basic physics concepts. This can train students' understanding of basic physics concepts. Several previous research results show the successful application of the PBL model in learning. The results of research conducted by (Rosyidi, 2018) show that the "Problem-based learning model can improve student learning outcomes". Research results (Aristawati et al. 2018) also showed that there were significant differences in conceptual understanding between students who studied with the problem-based learning model and students who studied with the direct learning model. The group of students who studied using the problem-based learning model showed a higher understanding of students' physics learning concepts than the group of students who used the direct learning model so the application of the problem-based learning

model made a positive contribution to students. Research conducted by (Tania et al. 2017) also shows that the problem-based learning model is student-centered learning to solve a problem through the stages of the scientific method, students can learn knowledge related to the problem.

Concepts can be interpreted as a basic unit of cognition that is formed through knowledge schemas that are used to group objects into a category (Churchill, 2017). Conceptual understanding is an understanding that is built and obtained from factual knowledge and events that produce principles, laws, and theories without the need for deep difficulties (Stern et al. 2018; Aulia et al. 2017). Concept understanding is defined as a very important thing that can be used by students to solve problems and is needed by students in mastering various fields of science (Radiusman, 2020). Understanding the concepts and principles of Physics is a requirement for successful learning of Physics and increasing student interest in Physics. The learning process is said to be successful if the acquisition of knowledge and skills of each student is as expected. Understanding of students' physics concepts can be seen in student learning outcomes. Activities that can be done to improve students' understanding of physics concepts are using learning media.

One of the means to realize aspects of increasing understanding of the concept of physics is with computer media. One of the computer-based media that can support the learning process is simulation. Simulation media must be by existing concepts and theories. One of the appropriate simulation media used in physics lessons in Physics Education Technology or commonly known as PhET. PhET interactive simulation is a fun and research-based interactive simulation media in the form of software and can be used to clarify physics concepts or phenomena that have been put into practice. Hasibuan (2020) said that the application of the PhET simulation learning media was effective in increasing the understanding of physics concepts for modern physics students. The results of other studies show that learning using PhET Simulation can improve students' understanding of physics concepts with the results of calculating the n-gain in the experimental class of 0.62 while for the control class it is 0.13 (Masita et al. 2020). The use of virtual PhET simulation laboratories as learning media can improve students' understanding of physics concepts by increasing student learning outcomes by obtaining high criteria with an n-gain score of 0.732 (Theasy et.al. 2021). In PhET there are theoretical and experimental simulations that actively involve the user. Users can manipulate activities related to experiments. So apart from being able to build concepts, PhET can also be used to develop science process skills (Wati et.al. 2015). PhET was developed to provide a virtual laboratory-based physics teaching and learning simulation that makes it easier for lecturers and students to learn in the classroom.

## METHOD

This research is action research with the research subject being Students of Natural Science Education (IPA) at the Global Nusantara Education Institute in semester 1. Data collection techniques are observation and tests. While the data analysis technique used is the data analysis technique using quantitative and qualitative data analysis, the combination method used is a type of convergent parallel mixed method, that is, the researcher collects quantitative and qualitative data at the same time,

analyzes the data separately, and compares the results to determine whether the findings are complementary or not (Sugiyono, 2015). Type convergent parallel mixed methods can be described as follows:

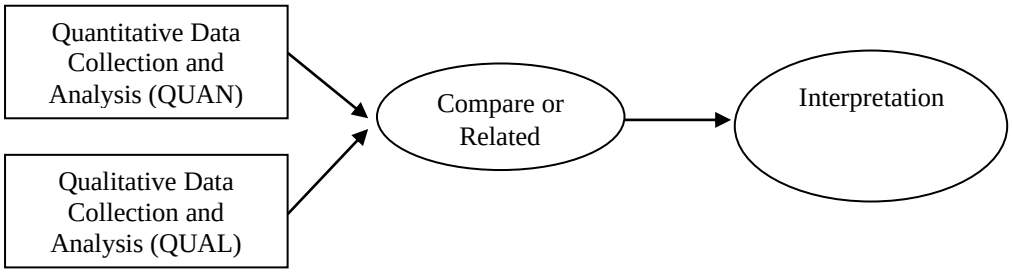


Figure 1. Convergent Parallel Mixed Methods (Sugiyono, 2015)

Based on Figure 1, both qualitative and quantitative research methods are used together at the same time. Researchers collect quantitative and qualitative data and analyze it. The results of the quantitative and qualitative analysis were then compared and interpreted. Quantitative data were analyzed by themselves using descriptive statistics with average calculations, while qualitative data were analyzed using the qualitative method of the Miles and Huberman model (Sugiyono, 2015) using the following steps:

a. Data reduction

Reducing data means summarizing, choosing the main things, and focusing on the important things. Thus the data that has been reduced will provide a clearer picture of the data obtained so that researchers can make conclusions that can be accounted for.

b. Data presentation

After being reduced, the next step is to present the data, so that the data can be organized, and arranged in a pattern of relationships to make it easier to understand.

c. Conclusion

The final step is to provide conclusions and verification. The initial conclusions put forward are still temporary, and will change if no strong evidence is found to support the next stage of data collection, but if the conclusions raised at an early stage are supported by valid and consistent evidence when the researcher returns to the field. collect data, then the conclusions put forward are credible because they have been verified.

Quantitative data in this study is the result of a test of understanding the concept of physics, then qualitative data is the result of observing student activities. Students' abilities are assessed during the learning process using observation sheets and assessed from the results of the tests given. The indicator of success in this action research is if students can achieve (KKM). Learning outcomes are said to improve if: there is an improvement in the average score obtained by students, there is an improvement in the number of students who get a standard score of 65%, and an improvement in classical power of 85% (Trianto, 2010).

The action research procedure will be carried out in several cycles, each cycle having stages, namely:

1) Action planning

The planning includes: making lesson plans and preparing instruments to measure understanding of the basic physics concepts of Newton's law of motion and its application.

2) Action implementation

The plan that has been prepared is then implemented, namely the implementation of basic physics learning with a problem-based learning model combined with PhET Simulation media.

3) Observing

During the action (learning process), the researcher observes and interprets the learning conditions.

4) Reflection.

At this stage, the researcher analyzes and reflects on what has been done and the results achieved. Is the implementation of the plan, whether the results achieved are by the objectives. If the goal has not been achieved in cycle 1, namely increasing students' understanding of basic physics concepts, the cause will be sought. After the errors were corrected, it was continued with the second cycle, to prove whether the improvements made were effective or not. If the goal has been achieved then the learning is stopped until cycle 2.

The stages of action research carried out are as follows:

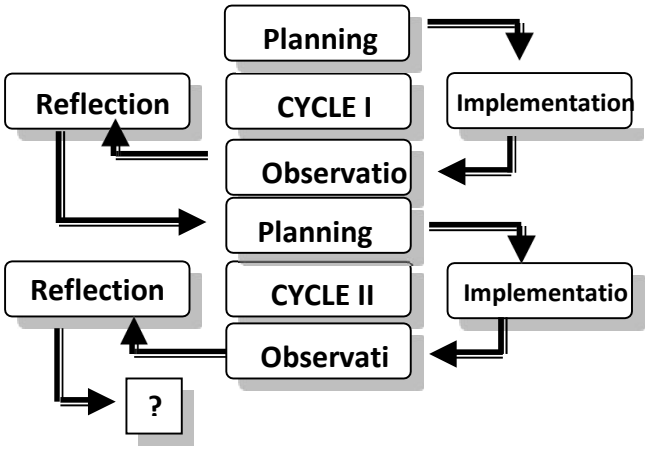


Figure 2. Classroom Action Research Cycle Model Kemmis and Mc. Taggrat (Arikunto, 2010)

## RESULT AND DISCUSSION

The study discusses matters relating to data processing and discussion based on the data obtained by the data collection techniques and procedures in this study. The data processing referred to here includes the level of understanding of physics concepts and the activities of students and lecturers towards learning basic physics courses using

a problem-based learning model of PhET Simulation learning media. Data obtained from observations made through direct observations during the learning process and giving students understanding tests of basic physics concepts at the pre-action stage, cycle 1 action stage, and cycle 2 action stage.

Improved Understanding of Physics Concepts

The improvement of students' understanding of physics concepts is seen based on the results of the student's conceptual understanding test, totaling 20 people, at the pre-action stage, the action stage of cycle 1, and the action stage of cycle 2. This research was carried out through several cycles, where the next cycle was an improvement from the previous cycle. If in the next cycle the data obtained is by the expectations of the researcher, the research can be stopped. The increase in the results of the students' understanding of basic physics concepts from the pre-action stage, the action stage of cycle 1, and the action stage of cycle 2 can be seen in Table 1 below:

Table 1. Improved Understanding of Physics Concepts

| No | Initials | Concept Understanding Test | | | Information |
|---|---|---|---|---|---|
| | | Pre-action | Cycle 1 | Cycle 2 | |
| 1 | ZU | 20 | 50 | 75 | Improve |
| 2 | AH | 35 | 50 | 80 | Improve |
| 3 | WF | 30 | 75 | 90 | Improve |
| 4 | AFS | 30 | 50 | 85 | Improve |
| 5 | PS | 20 | 45 | 80 | Improve |
| 6 | SI | 25 | 85 | 95 | Improve |
| 7 | ES | 40 | 40 | 75 | Improve |
| 8 | IA | 45 | 70 | 85 | Improve |
| 9 | SNV | 60 | 80 | 90 | Improve |
| 10 | KAA | 50 | 65 | 90 | Improve |
| 11 | LS | 35 | 55 | 80 | Improve |
| 12 | MA | 45 | 70 | 90 | Improve |
| 13 | MAA | 40 | 75 | 85 | Improve |
| 14 | DI | 50 | 80 | 95 | Improve |
| 15 | PA | 50 | 75 | 90 | Improve |
| 16 | SA | 55 | 70 | 85 | Improve |
| 17 | SIW | 35 | 65 | 80 | Improve |
| 18 | FP | 20 | 60 | 80 | Improve |
| 19 | TH | 25 | 55 | 80 | Improve |
| 20 | RE | 20 | 60 | 85 | Improve |
| Total | | 730 | 1275 | 1695 | |
| Average | | 36,50 | 63,75 | 84,75 | Improve |
| Percentage Graduation | | 0% | 55% | 90% | |

Based on table 1, it is known that there is an increase in students' understanding of basic physics concepts as indicated by an increase in the average value of students' understanding of basic physics concepts, which is 36.50 before receiving the action to 63.75 after receiving the first cycle of action and again increasing to 84.75 after receiving the action. received cycle 2 action with a success percentage of 90% of students succeeded in increasing their understanding of basic physics concepts. More clearly the increase in the success of understanding students' basic physics concepts can be seen in the diagram below:

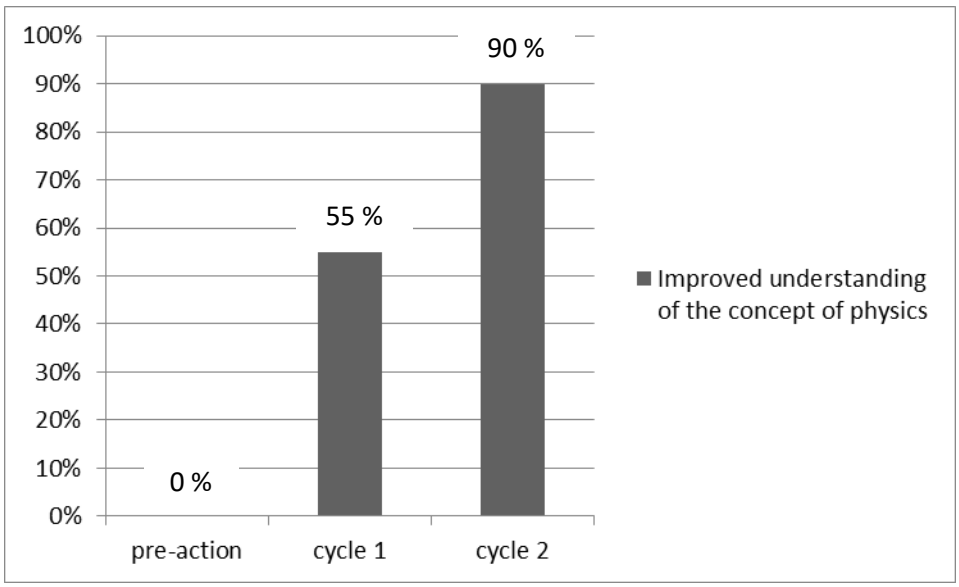


Figure 3. Diagram of increasing understanding of physics concepts

Based on the diagram in Figure 3, it can be seen that in general students' understanding of basic physics concepts in pre-action is still relatively low, it can be seen that the percentage of student success is 0% with a class average of 36.50. After the action stage of cycle 1 was carried out, the success rate was 55% with a class average of 63.75 but it was not said to have experienced success because classical completeness had not yet reached 85%. After the action stage of cycle 2 experienced significant success, it can be seen that the class average was 84.75 with a success rate of 90%. This shows that the application of problem-based learning models with PhET Simulation media can improve students' understanding of basic physics concepts from pre-action, cycle 1 to cycle 2. This is in line with research conducted (Yanti et al. 2019) that there is an effect of the Problem Based Learning (PBL) learning model through PhET simulation on increasing students' understanding of concepts.

Observation of Student and Lecturer Activities

Observational data is carried out through direct observation during the learning process. The pre-action stage is the stage before the action is given. The results of observing the activities of lecturers/researchers and students at the pre-action stage are as follows:

a. The basic physics learning process still uses the lecture method and group discussion and only emphasizes problem-solving exercises.
b. Basic physics practicum is rarely done due to limited laboratory equipment.
c. Students are still passive in learning.
d. Students feel bored learning basic physics.
e. Lack of understanding of students' basic physics concepts.
f. The questions asked by students are often outside the context of the learning material
g. Students want to learn basic physics with more practice than theory.

Problems found in the pre-action stage were solved in the action stage of cycle 1. To overcome the above problems, the researcher applied a problem-based learning model using Physics Education Technology (PhET) media. The material that will be discussed is Newton's law of motion and its application. The actions that will be taken in the first cycle are: preparing a learning implementation plan (RPP) that contains the steps of learning activities using a problem-based learning model assisted by PhET simulation media, preparing the media needed in learning activities in the form of (in focus, student worksheets, and PhET simulation) explains to students the steps of learning activities using PhET simulation and prepares observation sheets for student learning activities and the learning process of problem-based learning assisted by PhET simulation media.

The results of the observation of the activities of lecturers/researchers and students at the action stage of cycle 1 are as follows:

*a.* The basic physics learning process is carried out with a problem-based learning model through 5 phases, namely the stage of orienting students to problems, organizing students to study, assisting in independent and group investigations, and students developing and presenting their work in front of the class, and helping students analyze and evaluate the problem-solving process. which has been done.
b. Students are starting to be active in learning, but there are still some students who do not dare to express their opinions and are less serious in responding to learning.
c. Students enjoy learning basic physics.
d. With the PhET simulation media, virtual laboratory-based physics teaching and learning simulations can be carried out which makes it easier for lecturers and students to learn in the classroom. However, students are still too relaxed watching the PhET animation so they don't have time.
e. The questions asked by students are by the material being studied.
f. The ability of students to work on the LKM is still not careful.
g. Students begin to understand basic physics, but there are still indicators that have not been achieved, seen from the level of mastery of learning and student mastery both classically and individually.

The deficiencies found in cycle I was then resolved in cycle 2. The improvements made in cycle 2 were making planning in cycle 2. The plans carried out

were; Researchers improve several steps in the implementation of the lesson plan by applying the Problem Based Learning learning model, researchers provide opportunities for all students to provide answers, and researchers are more careful in explaining important concepts that must be understood by students, researchers remind participants to be more careful in observing animations PhET and researchers remind time so they are more serious and less relaxed.

The results of observing the activities of lecturers/researchers and students at the action stage of cycle 2 are as follows:

a. The basic physics learning process is carried out with a problem-based learning model through 5 phases, namely the stage of orienting students to problems, organizing students to study, assisting in independent and group investigations, and students developing and presenting their work in front of the class, and helping students analyze and evaluate the problem-solving process. which has been done.
b. Students are active during the learning process, actively asking and answering questions.
c. Students enjoy learning basic physics.
d. With PhET simulation media, virtual laboratory-based physics teaching and learning simulations can be carried out which makes it easier for lecturers and students to learn in the classroom.
e. Students begin to understand basic physics.

The results showed that in learning students were very active and made a big contribution during learning, which was different from before, which made the lecturer the center of learning, and students contributed very little. Likewise, student responses to the use of problem-based learning models with PhET Simulation media are very good and feel happy with the categories from the aspect of ease and assistance in the learning process so that student activities increase by using problem-based learning models assisted by PhET Simulation media. This is to what was said by (Agusmin et al. 2018) namely the application of the Problem Based Learning model assisted by PhET simulation can improve learning activities, learning motivation, and student learning outcomes.

## CONCLUSION

Based on the results of data analysis and discussion, it can be concluded that the use of the Problem Based Learning model with PhET simulation media can improve students' understanding of basic physics concepts in Newton's law of motion and its application with PhET Simulation media. The increase in students' understanding of the basic physics concepts of students is indicated by an increase in the average value of understanding students' basic physics concepts, which is 36.50 before receiving the action to 63.75 after receiving the first cycle of action and again increasing to 84.75 after receiving the second cycle of action with a percentage 90% of students succeed in increasing their understanding of basic physics concepts.

**ACKNOWLEDGEMENTS (OPTIONAL)**

This writing gets a lot of help for the author. Therefore, thank you, especially: first to Mr. Dr. A Talib as Chancellor of the Global Nusantara Institute of Education. Second, the entire academic community of the Global Nusantara Education Institute.

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