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PhET Simulation Media Part Time Using a Problem Based Learning Model Improves Student Learning Outcomes

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Abstract: Quantum physics is the science that deals with objects that are so small that they cannot be seen with the naked eye. Quantum physics is the study of the behavior of matter and energy related to the molecular, atomic, nuclear, microscopic levels, also in terms of security levels. Therefore, relevant media are needed to convey material about the half-life of an atom according to the independent curriculum through a scientific approach. One of the media related to this article is PhET simulation. This study used the Classroom Action Research (PTK) research method which was carried out in Class XII IPA1 to overcome the problems faced in class. This study uses observation, tests and documentation. In the examination results based on each cycle, it can be seen that the results of Cycle I and Cycle II showed a significant increase. After studying and analyzing the results, in the first cycle, the average student achievement data was 70.18, while in the second cycle, the average student achievement in the second cycle was 77.03. Learning related to management also increased from 55.56% in cycle I to 85.18% in cycle II. The completion rate increased from 55.56% in Cycle I to 85.18% in Cycle II. The results showed that the Problem Based Learning Model assisted by the Phet virtual laboratory could improve student learning outcomes on part-time material at MAN 1 Bungo.

Keywords: Problem Based Learning Model, PhET Virtual Laboratory, Student Learning Outcomes.

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INTRODUCTION

Physics is a natural science that observes matter, activity in the dimensions of time and place, packaged in the concepts of force and energy. basic science to understand the universe created by God Almighty, one of the goals of understanding physics is how we realize the majesty of this natural order. Yuningsi et al (2021) Physics is learning that shows students' activeness in exploring learning so that student learning activities can be seen, also from problem solving, students get an understanding of concepts so that they can be applied in everyday life.

The subject matter covered in modern physics is special relativity, particle properties of waves, atomic structure, quantum mechanics, atomic theory. Quantum physics is a branch of modern physics and is an abstract material. Sinaga (2016) states

that decay is the conversion of an unstable nucleus into another nucleus, or the conversion of one radioactive element into another. Modern physics studies are designed to train students to observe and experiment. It is based on the objective of physics, ie. observation, understanding and use of the natural phenomena of matter and energy. This observation and experimentation ability is emphasized to train experimental thinking, including experimental management, through the introduction of measuring instruments both in the laboratory and in human life. Suparjo, (2014)

Quantum physics is still considered difficult by students because it deals with small things, as small as electrons, especially in the decay of radioactive substances which are viewed from their safety level. So that relevant media is needed to teach material about the process of radioactive decay to students according to the independent curriculum with a scientific approach. This is in accordance with what was conveyed by Ariyani (2018) that introductory learning of quantum physics with phet simulation media can increase student interest and understanding of concepts. Concepts and material in learning physics materials should use the media and tools used for practicum so that students get results with direct observation, not just theory and sentences.

One of the learning models suggested in the independent curriculum is the Problem Based Learning Model. The problem-based learning model involves posing questions or problems, focusing on interdisciplinary relationships, authentic research, collaboration, and the creation of works and demonstrations. Problem-based learning is not designed to help teachers provide as much information as possible to students. Ibrahim (cited in Hosnan, 2014) Problem-based learning is a learning model that emphasizes solving real-world problems. This learning model encourages students to learn and work together in groups to solve the problems they face. Riani Ayu Utami and Sri Giarti (2020). From the above opinion, it can be seen that problem-based learning is an educational innovation, it can be seen that students' thinking abilities can be maximized by group learning processes that find problems, organize, conduct tests so that they can develop problem-solving skills well.

The 2013 curriculum is an innovative idea for planning and implementing learning as well as assessing learning outcomes in a comprehensive manner by involving three domains of learning assessment, namely the assessment of attitudes, knowledge and skills. The scientific approach is a learning approach that requires the management of learning to be carried out through a scientific process. The scientific process carried out in accordance with the stages of the scientific method is able to provide a vehicle for the development of scientific skills and scientific attitudes, both of which are basic elements of achieving national education goals, namely to develop the potential of students to become human beings who believe and fear God Almighty, have noble character, healthy, knowledgeable, capable, creative, independent, and become a democratic and responsible citizen Subagia (2013).

Based on the results of observations and interviews with physics teachers at MAN 1 Bungo Plus Skills, quantum physics is still considered difficult for some students. Physics learning in class is still centered on the teacher. Teachers still use the traditional learning model with the lecture method. The average daily test results of 50% of quantum physics do not meet the KKM that has been determined, namely 75, this can be seen from 15 students out of 30 students who are below the KKM. To overcome this problem, it is necessary to find a solution so that the learning of quantum physics, especially the law of shifting half-lives, becomes more meaningful so that it can have a positive influence on improving student learning outcomes for class XII IPA1 at MAN 1 Bungo Plus Skills.

When observations were made when the teacher was teaching, it was found that in the learning process the teacher provided more information in a less attractive way, namely the lecture method. The problem that is often found in the field is the teacher's low understanding of the characteristics of Active, Creative, Effective and Enjoyable Learning (PAKEM), also seen the lack of use of learning media that is relevant to the material

provided. Because the use of relevant learning media in accordance with the subject matter provided is considered the expected solution.

Problem Based Learning research using the Phet Virtual Laboratory for part-time practicum, will not be separated from previous research studies. The results of Marpaung's research (2021) state that experiments using Phet Simulation show a high level of accuracy so that it can be used as a half-life practicum solution, Masfaratna (2022) Quantum physics studies matter at the microscopic level and from its safety level, relevant media is needed, namely using the Phet Simulation medium. Pamungkas (2016) numerical simulation of the mass decay of the core of the radioactive element Uranium-238 using the matrix algebra method. Also, research by Ridanmi (2017) The effect of voltage and time on the treatment of radioactive uranium and thorium waste using the electrocoagulation process. And Safitrianaz's research (2019) entitled Analogy of Radioactive Half-Life and Decay Constants (Disintegration).

The results of previous research explain the use of Phet Simulation media and other media as a half-life practicum solution. However, this research is a Classroom Action Research using the Phet virtual laboratory as a learning medium using the Problem Based Learning model to improve student learning outcomes.

Media Phet Interactive Simulations is a University of Colorado project developing simulation tools focused on learning physics, but Phet also offers several simulations for studying chemistry, biology, math, and other sciences. This is in accordance with Sinulingga (2016) that learning physics with Phet simulation media can improve student learning outcomes. So, in the opinion of the author, one of the relevant media uses is Phet simulation media to teach material on part-time material. This is in line with what was conveyed by Muzana (2021) that students enjoy the learning process more because it can be used for independent learning and is also easier to understand in each stage of the simulation.

The advantage of a virtual lab using a PhET simulator is that it can explain abstract concepts that cannot be explained verbally. Virtual laboratories can be a place to conduct experiments that cannot be done in traditional laboratories. This is in line with what was stated by Riantoni (2019) which states that PhET simulations can be collaborated with real experiments or as a substitute for real laboratories. So, using PhET simulation can help explain abstract physics concepts that cannot be explained with the naked eye and do not require a lot of time to use. So, in the author's opinion the use of PhET simulation media is a relevant medium for teaching part-time material.

After this research is completed, it is hoped that it will provide the following uses or benefits: For researchers, it is expected to increase teachers' understanding of learning management and delivery of quantum physics topics, and researchers' knowledge of quantum physics. phet use. -Media as related learning tools for part time learning. Students are expected to be able to explain or define and apply modern physics concepts to the development of new technological advances, namely nanotechnology. For schools, it can be used as teaching material in planning and developing educational media for madrasas.

Radioactivity is a physics concept that studies an unstable element. The half-life is defined as the period during which the number of nuclei of the radioactive parent atom is half of the original number in line with Tomo (2021).

$$N_t = N_0\, e^{-\lambda t}$$

That $N_t = \frac{1}{2}\, N_o$ and $t = T\frac{1}{2}$

So, obtained:

$$\lambda = \frac{0{,}693}{T\frac{1}{2}}$$

$$N_t = \left(\frac{1}{2}\right)^n \text{No}$$

Information

t = decay time, $T\frac{1}{2}$ = half time,

Nt = residual core, No= core first, λ = decay constant.

The experimental procedure is to prepare a laptop or computer device that is connected to the internet. Then enter the following link https://phet.colorado.edu/sims/cheerpj/nuclear-physics/latest/nuclear-physics.html?simulation=radioactive-dating-game&locale=in then select the "Decay Rate" submenu. Select the type of isotope to be reviewed (carbon-14 and Uranium-238). For the first experiment using carbon-14 and the second experiment using the isotope aursnium-238). Returns all kernels currently in the container. Use all atomic nuclei (1000 nuclei) to facilitate the observation process. At this time, observe the number of atomic nuclei 14C and 14N reaching the half-lives of the 1st, 2nd, and 3rd repeated three times. Record the observations in the observation table. Repeat the steps up to three times to review the isotope 238U to 238Pb. The number of nuclei remaining was then analyzed to determine the relationship between the half-life and the number of nuclei remaining to decay.

Media comes from the word "medium", which comes from the Latin word "medius" which means "intermediary" or introduction. According to Mustofa (2020) The learning components are curriculum, teachers, students, methods, materials, tools (media) and learning assessment. Synchronization between these components makes the learning process run well and achieve the expected learning objectives. One important part of the learning process is learning (media). Along with the development of the world of education, the availability of learning environments is also growing. The presence of educational media has increased in the world of education since the implementation of the 2013 curriculum. Where it is explained that learning media is integrated with information and communication technology (ICT).

Learning media is a container for connecting or mediating information, whether in the form of materials, tools, or techniques that can be used to encourage students to understand learning. Based on this, there is a relationship between teachers, media and students in the learning process.

The advantage of virtual labs with PhET simulation tools is that they can explain abstract concepts that cannot be explained verbally. Virtual laboratories can be a place to conduct experiments that are not possible in traditional laboratories. This is in line with what was stated by Riantoni (2019) which states that PhET simulations can be collaborated with real experiments or as a substitute for real laboratories. So using PhET simulation can help explain abstract physics concepts that cannot be explained with the naked eye and do not require a lot of time to use.

Assessment is an integral part of a lesson. In each lesson, assessment serves to measure the extent to which students can achieve the learning objectives that have been set. Assessment in learning assists teachers in evaluating the effectiveness of the curriculum, teaching strategies and learning activities that include knowledge competence, attitudes and skills of students. According to Arifin (2021), assessment is a process or activity that is systematic and continuous to collect information about student learning processes and outcomes in order to make decisions based on certain criteria and considerations. Assessment is not only limited to grades, but through assessment the teacher can describe achievements and support students in facing learning challenges.

One of the priorities of the 2013 curriculum is authentic assessment. According to Sani (2022) states that assessment is a process of collecting various data that provides an overview of student development after students undergo learning. Authentic Assessment is a student assessment activity that highlights assessment and processes and results using various assessment instruments that are tailored to the competency requirements of Qualification Standards (SK) or Core Competencies (KI) and Core Competencies (CD) this is according to what was conveyed by Kunandar (2013).

In the 2013 Curriculum, assessment of student learning outcomes is emphasized on authentic assessments that consider all interests, abilities, and overall student performance. Evaluation is also carried out systematically and continuously to describe the skills of the students being evaluated. It is very important to involve students in the assessment so that students can consciously see their learning progress.

Student learning outcomes are not only learning achievement figures, but in the form of descriptions of students' competencies in words. Innovative learning management that involves students actively by planning fun learning using digital learning so that scientific skills and scientific attitudes are realized which are national education goals. Develop the potential of students to become human beings who believe in and fear God Almighty, knowledgeable, intelligent, independent and creative towards God Almighty, have noble character, are healthy and responsible.

METHODS

This type of research is Classroom Action Research (PTK) which is carried out collaboratively so that researchers do not conduct their own research but work together with physics and research teachers who are directly involved in the implementation step by step. This research was carried out in the classroom with the aim of improving student learning outcomes in the part-time material.

Observations were made by teachers and observers by observing and recording aspects of the components of the implementation of learning in the classroom during the learning process without disturbing the course of learning activities. The observer uses the observation sheet that has been prepared. Observations will be used to obtain data on the implementation of the virtual lab as a part-time learning medium using a problem-based learning model to improve student learning outcomes.

The research subjects were students of class XII IPA 1 MAN 1 Bungo plus skills for the 2022/2023 academic year. The number of students was 32 students and consisted of 10 male students & 22 female students. This research was conducted in class XII IPA1 MAN 1 Bungo Plus Odd Semester Skills for the 2022/2023 academic year on part-time material. This research is a Classroom action research carried out using two cycles, with each cycle being held in 2 meetings.

Observations were made by teachers and observers by observing and recording aspects of the components of the implementation of learning in the classroom during the learning process without disturbing the course of learning activities. Observe using the observation sheet that has been prepared. Observations will be used to obtain data on the implementation of the virtual lab as a part-time learning medium using a problem-based learning model to improve student learning outcomes. Documentation is used as enrichment for data obtained during observation activities. The documents used in this study were baseline values, data on the number of students, student records, curriculum, and lesson plans test scores.

The learning achievement test is used to collect data on student learning outcomes in part-time material to find out the increase in student learning outcomes after implementing a problem-based learning model using the Phet virtual laboratory learning media. The test used in this research is a written test. Student learning outcomes are measured against a minimum mastery standard of 75 in physics subjects that students must achieve individually, while classic indicators of success are when students achieve a minimum score of 85% of students in class XII IPA1 who have completed their studies.

RESULTS

Cycle 1

Observation results were obtained from teacher observations by other researchers who filled out observation forms about teacher and student activities to record the course of learning. Based on the observations made, students did not understand the features in the PhET simulation in determining the radioactive age with the decay rate sub-theme. How to run simulation and fetch data during 1st half time, 2nd half time and 3rd half time. For the isotope C14 it becomes N14, as well as for the isotope uranium. Teachers are less active in observing students' difficulties when collecting data. Students lack literacy about what quantities will be observed when the virtual lab is run. Teachers have not optimally guided and motivated students to follow the steps in carrying out Phet simulation virtual experiment activities. So that the data obtained is still not maximal.

The six aspects of assessing student learning motivation are: Student attention when participating in learning activities where students do not yet understand the features in the Radioactive Phet simulation with the decay rate sub-theme; Student participation in group work during practicum activities; Student participation in group discussions; Involvement of students in data collection results of practicum; Student participation in presenting observational data. Students' attention during the presentation of the experimental results. Based on the results of observations of students' learning motivation at meeting 1 and meeting 2 cycle I. Based on the results of observations of student activities after the analysis was carried out, the following information was obtained:

Table 1. Observations of Student Activities in Cycle I

Learning meeting	The total score shown						Σ Activity Score	Average	Category
	1	2	3	4	5	6			
First meeting	2	2	2,7	2,7	2,3	1,7	13,4	2,23	Less Active
Second meeting	2,3	2,3	2,7	2,7	2,7	2	14,7	2,45	Less Active

The table above shows that the student learning outcomes were 2.23 in the less active class in Cycle I Session 1 and 2.45 in the less active class in Session 2. The student achievement was relatively low. Therefore, student performance must be further improved in the next cycle.

Complete data on student learning outcomes in Cycle 1 can be seen in Appendices 1 and 2. Based on the post-analytic evaluation results in Cycle 1, the following data were obtained: Table 2. Results of Evaluation of Student Learning in Cycle I.

Table 2. Student Learning Test Results for Class XII Cycle I

No	Aspect	Score
1	Average value	70,18
2	Lowest value	45
3	Highest score	90
4.	Classical completeness percentage	55, 56 %

From the table above it can be seen that students achieved a learning completeness level of 55.56% with an average score of 70.18, with a maximum score of 90 and a minimum score of 45. These results have not reached classical learning mastery, so learning is continued in the next cycle. Information on student learning outcomes in cycle I can be described in the histogram below.

Figure 1. Learning Outcomes of Cycle I

Based on the analysis of the results of Cycle I, the student completeness rate remained at 55.56, meaning that it was still below the minimum threshold of 85%. These results did not give the expected results, so the researchers continued to the next cycle. Cycle I has several deficiencies that must be corrected and improved in Cycle II activities: So that more attention is paid to motivation and perceptions in the first cycle.

The lack of motivation and literacy of students makes students a little confused in receiving material or the subject of quantum physics at decay level material to determine the half-life of radioactive substances with the help of the PhET Virtual laboratory. so that in the first cycle giving motivation and apperception more attention.

Student orientation to the problem: The teacher shows a short video discussing half-life. Organizing students for learning: The teacher gives some questions to the students what magnitudes are reviewed in the half-time and the relationship between these quantities, gathering information from books and relevant sources. Guiding individual and group investigations: The teacher gives worksheets to each group and then asks students to prepare laptops and internet connections to carry out virtual experimental activities through Phet simulation. Developing and presenting results: The teacher guides students to work on LKPD to prove half-life. Analyzing data: The teacher guides students to analyze the data that has been obtained from the practicum results in accordance with the directions available in the LKPD to prove the law of half-life. Analyzing and evaluating the problem-solving process: The teacher instructs representatives from each group to convey the conclusions of the results of the experiments that have been carried out.

Cycle 2

Observation results were obtained from teacher observations by filling out forms observing teacher-student activity and observing learning performance. The improvement was seen in the second phase of learning, and the analysis of Cycle II student observations showed that students were more active in each meeting. This can be seen in the table of student performance scores which have increased from the first session to the second session, as shown in the table below.

Table 3. Observation Results of Student Activities in Cycle II

Learning meeting	The total score shown						Σ Activity Score	Average	Category
	1	2	3	4	5	6			
First meeting	3	2,7	3	2,7	3,3	2,7	17,4	2,9	Moderately Active
Second meeting	3,6	3	3,3	3,3	3,3	3,3	19,8	3,3	Moderately Active

From the table above it can be seen that the student activity in Cycle II at Meeting 1 was 2.9 and at Meeting 2 was 3.3. Based on the classification of student learning activities,

the second cycle of student activity is very active. Complete data on Cycle II student performance can be seen in Table 4.

Tabel 4. Hasil Tes Belajar Siswa Kelas XII IPA1 Siklus II

No	Aspect	Score
1	Average value	77,03
2	Lowest value	65
3	Highest score	95
4.	Classical completeness percentage	85,18 %

The evaluation results achieved in Cycle II reached a level of 85.18% with an average value of 77.03, a satisfactory score. Therefore, it is no longer necessary to carry out learning in the next cycle because learning mastery has been achieved. Thus the implementation of the virtual laboratory as a medium for part-time learning using the Problem Based Learning model can improve student learning outcomes for class XII IPA1 in part-time material.

Table 5. Comparison of Student Test Results for Class XII Cycle I and Cycle II

NO	Aspect	Score		Enhancement
		Cycle I	Cycle II	
1	Average value	70,18	77.03	6,85
2	Lowest value	45	65	20
3	Highest score	90	95	5

Based on the results of the first cycle test and the second cycle learning outcomes test can be presented in the following histogram.

Figure 2. Learning Outcomes of Cycle 1 and Cycle 2

From the results of observations of student activity in Cycle II, learning went well, and the results of observations of student activity in each lesson were considered quite active and teacher activity was considered quite active. The results of the analysis of the evaluation results showed an increase in the average classical class and the graduation rate reached 85.18%, that is, more than 85% of students achieved learning outcomes according to the KKM or exceeded the KKM determined by the madrasa. Therefore, this research was stopped and until cycle II went according to plan.

DISCUSSION

This Classroom Action Research was carried out as an effort to improve student learning outcomes on half-life material in class XII IPA1 students by carrying out learning using the Problem Based Learning Model at MAN 1 Bungo Plus Skills for the 2022/2023 Academic Year.

Low student activity affects student learning outcomes, so action is needed in Cycle II. In cycle II, there was a significant increase in scores that could be associated with an increase in student learning activities. The average student activity was 2.23 (less active) for the first meeting and 2.45 (less active) for the second meeting in cycle I and increased student activity 2.9 (quite active) for the first meeting and 3.3 (active) for the second meeting in cycle II. Learning is no longer the focus of the teacher, but students are directly involved in acquiring knowledge. Student attention to participation in learning develops because learning methods are interesting and involve students in learning. Student participation in group discussions, group assignments, individual assignments and group work increased satisfactorily.

Based on the results of data analysis in each cycle, it appears that the results from cycle I to cycle II have increased. In the implementation of learning and the results of data analysis in cycle I, for student activity an average value of 70.18 was obtained and student activity in cycle II obtained an average class value of 77.03. After looking at the two tables of evaluation results from cycles I and II where the scores they obtained had reached the level of learning completeness. And exceeds the level of classical learning mastery, namely 85%. Based on the test results of Cycle I and Cycle II, several improvements were obtained. The magnitude of the increase in the average value is 6.85. The minimum increment is 20 and the maximum increment is 5.

This is in line with Alfiah (2022) The application of PhET laboratory-assisted PBL to increase student Hots. Also, in line with Hastuti's research (2016) entitled Effects of Virtual Media Assisted PBL Models on Physics Problem Solving Ability. Also, according to Hawa's research (2021) entitled The Effectiveness of Developing Learning Devices for the PBL Model Assisted by Phet Simulations on Thermodynamic Materials to Improve Students' Critical Thinking Ability.

This classroom action research was carried out as an effort to increase the activity and learning outcomes of class XII IPA 1 students in part-time material through the Problem Based Learning Model. Where this research was conducted in two cycles based on the coverage of half-life material.

CONCLUSION

Based on the results of data analysis in each cycle, it appears that the results from cycle I to cycle II have increased. In the implementation of learning and the results of data analysis in cycle I, for student activity an average value of 70.18 was obtained and student activity in cycle II obtained an average class value of 77.03. After seeing the results of the evaluation of cycles I and II where the grades they obtained had reached the level of learning completeness. And exceeds the level of classical learning mastery, namely 85%. From the results of the research and discussion above, we can conclude that the Problem Based Learning Model can improve the learning outcomes of class XII IPA1 students at MAN 1 Bungo Plus Skills in the mid-term material for the 2022/2023 school year.

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