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Analysis of PhET Virtual Laboratory in Nuclear Physics Course at Physics Education

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Abstract

In the introductory physics course, conducting experiments and learning topics that seem abstract using a PhET virtual laboratory is necessary. With several previous research results showing that PhET has benefits in learning activities, this study aims to find out Physics Education students related to the usefulness of the PhET virtual laboratory in the introductory alpha decay Nuclear physics course. This research is a quantitative descriptive technique with the research variable of the Colorado PhET virtual laboratory in the Introduction to Nuclear Physics course on alpha decay material. The data collection technique is through a questionnaire method using a Likert scale of five answer choices marked by giving a negative to positive score. The population of the survey is all students of physical education, which is 79 people. However, only 71 people filled out the questionnaire. Characteristics of students who are 21 years old on average with computer/laptop skills on average 81%, interest in introductory physics courses as much as 77%, interest in practicum as much as 86%, and interest in learning topics as much as 61% it can be said that the laboratory virtual PhET is helpful in the learning process of the introductory alpha decay Nuclear physics course with a proportion of 86% of PhET virtual laboratories can help the learning process, 81% of PhET virtual laboratories are the preferred learning method, 80% of PhET virtual laboratories are engaging learning, 81% virtual laboratories PhET can be done independently, and 79.99% use of the virtual laboratory application is easy to use.

INTRODUCTION

Physics is one of the Natural Sciences (IPA) branches that study non-living natural phenomena in space and time and the interactions accompanying them. The purpose of reviewing these phenomena is to obtain products (concepts, laws, and theories) of physics that are distinctive and can explain these phenomena, both as a scientific process and the development of a scientific attitude. Physics involves the product dimension in the form of a collection of theories whose truth has been tested and the product dimension in the form of a series of activities that must be taken to obtain knowledge of natural phenomena called the scientific method. The scientific method in question is constructing knowledge from existing natural wonders.

In the introductory course in Nuclear physics, students must understand all fundamental physics knowledge about various microscopic physics concepts. In addition to requiring theoretical skills, students also need psychomotor skills for experiments.

Experimental activities are one of the supporting factors for the success of achieving physics learning goals. In learning physics, it is necessary to familiarize yourself with practical exercises. Experimental activities are essential because they make it easier for students to absorb, elaborate, and build concepts [1]. An experiment can be defined as a planned program to test a hypothesis by providing empirical evidence to a group of subjects. This activity in search of truth involves a series

of scientific methods, one of which is experimentation. So that experiments are beneficial because they provide a direct experience so that they can develop an attitude of scientific thinking.

Learning materials in the introductory Nuclear physics course include discussing the composition of the nucleus, nuclear properties, radioactivity, radioactive equilibrium, alpha decay, beta decay, gamma decay, atomic reactions, core forces, nuclear models, fission and fusion reactions, elementary particles, and nuclear radiation detectors. This topic still seems abstract for students because natural experiments in the concept are also rarely found in everyday life, so students cannot hone their psychomotor skills.

Currently, technology in the field of education is developing very rapidly, which certainly has an impact on the development of the process of learning activities in Indonesia. Can be seen in the efforts to update the use of technology in the learning process by lecturers and teachers. The trend of experimental activities began to change and develop with the existence of virtual laboratories. Experiments that are difficult to do in natural laboratories can be done using virtual computer laboratories.

A virtual laboratory is one of the ICT-based learning processes that can be used as an alternative solution for learning with experimental methods. Students can do practicum using virtual labs with the advantage of displaying microstructures in learning [2]. In addition, the virtual lab has flexibility in terms of practicality, so it is effective for saving time and has high practical safety when compared to practicum using a real lab [3]. This virtual laboratory can potentially provide significant improvements and a more real learning experience. Virtual laboratories can be a solution to learning problems experienced by students in overcoming physics learning topics that seem abstract because they are difficult to collaborate on in everyday life.

One application of virtual laboratories is the simulation of Physics Education Technology (PhET). PhET is a site that provides various learning simulations in physics, chemistry, biology, and mathematics, offered free of charge by the University of Colorado to benefit classroom or individual learning. This simulation is interactive so that users have real experience from using it directly.

Some research results show that using PhET in learning activities include: 1) Prihatiningtyas et al. (2013) stated that using PhET Simulation could help students understand physics concepts for abstract physics topics. PhET simulation is more practical and fun compared to the use of laboratory KIT [4]. The study aims to implement PhET simulation in learning activities, while the author seeks to determine the usefulness of PhET; 2) Nur (2013) revealed that learning that utilizes PhET simulation obtained better student learning outcomes than students without using PhET simulation [5]. The research aims to develop learning tools with PhET virtual laboratory, while in this case, the author seeks to find out the benefits of PhET.

Based on the explanation above, the preliminary study conducted in the Physics Education study program of Siliwangi University showed the use of learning media in the Introduction to Nuclear Physics course, namely with PhET. That means as educators, namely lecturers, facilities can meet the needs of students' psychomotor abilities to carry out experiments on learning topics that seem abstract with the use of PhET virtual laboratories. With several previous research results showing that PhET has benefits in learning activities, this study aims to get an overview of the response of Physics Education students of Siliwangi University related to the usefulness of the PhET virtual laboratory in the introductory Nuclear physics course on alpha decay material.

RESEARCH METHODS

The study used quantitative descriptive techniques with research variables on the usefulness of using the Colorado PhET application in the introductory course of Nuclear physics on alpha decay material. The respondents in this study were Physics Education students actively participating in lectures in the even semester of the 2021/2022 academic year and were taking Nuclear physics preliminary courses, a total of 79 students. The questionnaire (questionnaire) for students consists of 13 questions covering the learning process, aspects of interest, aspects of ease of application, aspects of learning independence, and aspects of application use. The survey was conducted online through Google Forms and completed from May 27, 2022, to June 6, 2022, or counted for ten days.

The data collection technique used in this study is the questionnaire method (questionnaire) using a Likert scale of five answer choices on perception questionnaires adapted and modified from research conducted by Edward Chi et al. [3]. in his thesis entitled "High School Students' Perceptions about the Helpfulness of PhET Simulations for Learning Physics." The level of determining student perceptions of the usefulness of the Colorado PhET application in the Introduction to Nuclear Physics of Alpha Decay material can be seen in Table 1.

Table 1. Likert Scale on Student Perception Level of Colorado PhET Usefulness

Score Interval	Student Perception Level
5	Very agreeable
4	Agree
3	Quite Agree
2	Disagree Less
1	Strongly Disagree

Table 1 shows the level of student perception of the usefulness of PhET Colorado in the introductory course in the Nuclear physics of alpha decay material which can be categorized from strongly disagree to strongly agree, according to the resulting score interval in Table 2 below.

Table 2. Assessment Results Interval

Assessment Interval	Results
0% - 19,99%	Strongly Disagree
20% - 39,99%	Disagree Less
40% - 59,99%	Quite Agree
60% - 79,99%	Agree
80% - 100%	Very agreeable

RESULTS AND DISCUSSION

Practicum for the physics introduction course on alpha decay virtually using the PhET virtual laboratory has been carried out by students of the physics education study program at Siliwangi University. Based on questionnaires (questionnaires) conducted from May 27, 2022, to June 6, 2022, to physics education students of Siliwangi University, several data were obtained regarding student characteristics and the usefulness of the PhET virtual laboratory in Nuclear physics preliminary learning.

The survey population is all active students carrying out the lecture process, which is 79 people. However, in the field, only 71 people filled out the questionnaire. In implementing virtual practicum, students are given practicum guidelines where the experimental procedures have been adjusted to the practicum design using a virtual laboratory. The survey population is all active students carrying out the lecture process, which is 79 people. However, in the field, only 71 people filled out the questionnaire. In implementing virtual practicum, students are given practicum guidelines where the experimental procedures have been adjusted to the practicum design using a virtual laboratory.

Based on data, it was found that the characteristics of students aged 21 years with the skills to use computers/laptops on average amounted to 81%, it was found that interest in learning Nuclear physics introductory courses was 77%, interest in practicum as much as 86%, and interest in teaching topics, namely alpha decay as much as 61% which is shown in Table 3.

Table 3. Student Characteristics

Characteristic	Final Calculation	Category
Computer/laptop skills	81%	Very Agreeable
Interest in Nuclear physics introductory courses	77%	Agree
Interest in practicum	81%	Very Agreeable
Understanding of alpha decay material	61%	Agree

Based on the next questionnaire item, data were obtained regarding the usefulness of the PhET virtual laboratory in learning the introductory course of Nuclear physics on alpha decay, shown in Table 4.

Table 4. Student Perception of the Benefits of PhET Virtual Laboratory

Indicators	Index Indicators	Category
Aids learning	86%	Very Agreeable
Preferred learning method	81%	Very Agreeable
Engaging learning	80%	Very Agreeable
Learning can be done alone (independently)	81%	Very Agreeable
Application usage	79,99%	Agree

Retna Wuryaningsih and Suharno revealed that by using a technology-based physics learning model using PhET simulation media, students enjoy the learning process more, and the results show that there is a considerable improvement because students find it helpful to understand concepts visually [1]. Following Table 4 of the first indicator, data obtained that the PhET virtual laboratory helps the learning process with a percentage of 86%. That means students strongly agree that the PhET virtual laboratory is very helpful in visualizing the concept of alpha decay, which is abstract and helps students better understand the physics concepts of alpha decay material.

The second indicator regarding the learning method students prefer in the learning process is 81%. That shows the use of the PhET virtual laboratory is interesting to follow and can raise enthusiasm following the Nuclear physics preliminary learning activities. PhET simulation has an uncomplicated menu and suitable colors to attract interest in learning [7].

The third indicator related to the learning process used interestingly gets a percentage of 80%. That means practicum using virtual laboratory PhET is easier to understand than practicum without using PhET simulations. In addition, PhET simulation visualization is easier to understand than animation or learning videos. Students also think that a virtual laboratory internship is easier and more practical than a practicum in a laboratory because using PhET practically does not require as much time as a practicum in the laboratory.

The next indicator, learning using virtual laboratory PhET, can be done independently, earning 81%. Students stated that using the PhET virtual laboratory can increase independence and be carried out independently, not necessarily in groups. This PhET virtual laboratory is used with procedures and guidelines that course lecturers have prepared. Students can be independent and think creatively in digging for their information to be obtained with indirect direction from lecturers who teach alpha decay material.

The last indicator, which is related to the aspect of application usage, gets a percentage of 79.99%. As many as 79.99% of students revealed that PhET's virtual laboratory is easy to access and use. They are also supported by the skills to use computers/laptops owned by physics education students of Siliwangi University, with a percentage of 81%.

Learning in the Nuclear physics introduction course cannot be separated from the practicum process; the practicum in this course is carried out to prove an abstract concept to be understood just by reading. Alpha decay material is a complex teaching material, which must have a good focus on its understanding. The practicum in the Nuclear physics introduction course can facilitate students in the process of receiving the information being studied.

Based on the data obtained, using the PhET virtual laboratory can facilitate and benefit students in understanding the alpha decay process. PhET provides research-based math and science simulations that are fun, interactive, and effective for use in education [8].

CONCLUSION

Based on the results of the analysis of the research that has been carried out, it can be concluded that the PhET virtual laboratory is helpful in the learning process of the Introduction to Nuclear Physics Course of alpha decay material with a percentage of 86% for PhET virtual laboratory indicators can help the learning process, 81% for virtual laboratory indicators PhET is the preferred learning method, 80% for learning indicators using virtual laboratory PhET is engaging learning, 81% for hands

of learning implementation using virtual laboratory PhET can be done independently, and 79.99% for indicators of using virtual laboratory applications.

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