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The Influence of the Project Based Learning Model Assisted by PhET Simulations on Students' Generic Science Skills in Energy Source Materials

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Abstract: This research aims to determine the effect of the Project Based Learning model assisted by PhET simulations on students' generic science skills in energy sources. The type of research used in this research is quasi-experimental with a pre-test post-test control group design. The population in this study was all class The research sample was taken using purposive sampling, so that 28 class X1 students were selected as the experimental class and 22 class X2 students as the control class. The independent variable in this research is the Project Based Learning model assisted by PhET simulations which is used in the experimental class, while generic science skills are the dependent variable. The instrument used to measure generic science skills is a test instrument in the form of a multiple choices test with 10 questions. The results of pre-test data analysis showed that students' initial knowledge was almost the same, but after being given treatment the average post-test score for the experimental class was 80.00 and the control class was 71.67. The results of the t test using the Independent Sample T-test in the post-test showed a significance (2 tailed) of 0.018 < 0.050, so it can be concluded that the Project Based Learning model assisted by PhET simulations has an effect on students' generic science skills in energy sources.

Keywords: Energy sources; Generic science skills; PhET Simulations; Project based learning

Introduction

Education is a very important aspect for the future of the nation because education can increase knowledge for students and the next generation which will have a positive impact on the progress of a nation. In essence, education is a learning and development process that aims to prepare individuals to become knowledgeable, skilled and responsible members of society. In its development, education is faced with the challenges of changing times and the character of the generation living today, namely generation Z (Hendrastomo & Januarti, 2023). Education in the 21st century era is required to teach students to develop 21st century skills. Skills that must be developed in the 21st century include critical thinking, creativity, collaboration and communication (Parmini et al., 2023).

Science learning can be done by experimentation and observation. Science is developed through natural observations, laboratory experiments and theoretical studies, so that science learning follows the characteristics of science (Khery et al., 2020). Science is a scientific subject studied to understand nature comprehensively (García-Carmona, 2021). In science, scientific concepts and theories are obtained based on experimental activities carried out on the basis of the scientific process (Susilawati et al., 2023). Therefore, science learning is delivered not only orally and in

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writing in class but also involves activities in the laboratory and observations of the natural surroundings. Teachers as a component in the learning process must be skilled in using appropriate learning models and media. Without using clear models and media, the learning process becomes undirected so that students become bored and do not produce optimal results. It is hoped that the learning models and media used by teachers will make it easier for teachers to convey the material and relate the material to everyday life so that students can easily master the concepts well and remember the material provided easily.

Some physics concepts are abstract concepts. The characteristics of several abstract concepts in physics cause difficulties in visualizing and conveying them to students (Hidayat et al., 2022). Understanding abstract physics concepts is often a challenge for teachers in communicating material to students, so that students have not reached their optimal potential in understanding the concepts being taught. This situation certainly has an impact on students' interest in learning physics, which in the end can hinder the development of students' science generic skills. Generic science skills are basic abilities that can be developed through learning. Generic science skills have the advantage that they can be applied to learning concepts and solving problems (Doyan et al., 2022). Generic science skills are important to master so that students have good mastery of science concepts, scientific attitudes and science process skills (Ratnasari et al., 2023).

In general, there are nine generic scientific abilities that can be developed through teaching physics, which include: direct observation, indirect observation, awareness of magnitude scales, symbolic language, logical framework, logical inference, cause and effect laws, mathematical modeling, and building concepts. In the learning process, generic scientific abilities must be trained in students so that they can have basic abilities that are very useful for continuing their education and career success. Based on the results of observations with the physics subject teacher at SMAN 1 Kayangan, students still experience many difficulties in understanding the physics concepts being studied. The learning used uses little discussion and question and answer methods, therefore learning is still teacher-centred.

The use of learning media such as PhET simulations has never been used so that the learning carried out is still not optimal (Endrayani et al., 2022; Juandi et al., 2024). This can be seen from the lack of enthusiasm of students in asking questions or submitting opinions during learning. Students tend to be passive, only taking notes on the material and formulas of the concepts presented and then doing exercises focused on the formulas, based on the limitations of practical equipment and abstract material, this means that generic science skills are still not optimal. In addressing this problem, researchers offer a Project Based Learning model assisted by PhET simulations which can improve students' generic science skills. Project based learning is innovative learning that is student centered and places the teacher as a motivator and facilitator, where students are given the opportunity to work autonomously to construct their learning (Keiler, 2018).

The Project Based Learning model directs students to create a project in learning activities (Rahman et al., 2023) which states that project-based teaching makes a fundamental change from being teacher-focused to student-centered. According to Li et al. (2024) Project Based Learning is an innovative model that involves project work where students work independently in constructing learning. Of course, project work carried out by students will make students indirectly active and trained to act and think creatively. Through this project work, students will also discover for themselves the concepts they are studying so that learning will become more meaningful.

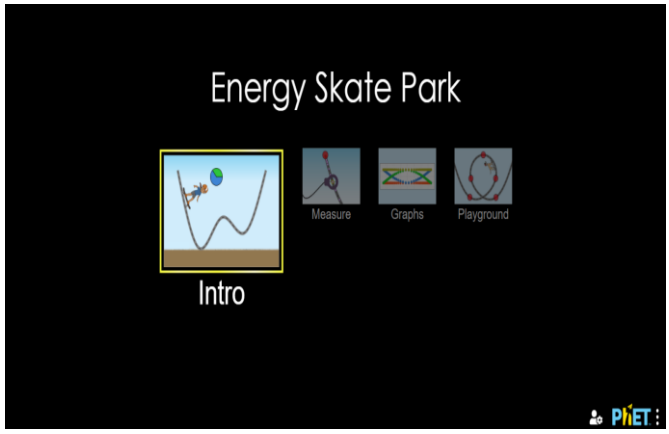

Figure 1. PhET simulations experiments on energy materials

Project based learning has a number of advantages including increasing students' motivation to learn in order to improve their ability to complete important tasks; increasing students' abilities in solving complex problems; produce work that is ready to use and can be used (Zulyusri et al., 2023). The Project Based Learning model in the classroom can be optimized using learning media. The use of learning media such as PhET Simulations media can increase students' motivation to learn and really help the effectiveness of the learning process which can improve students' generic science skills. The forms of learning media are very diverse, one of the learning media is the PhET simulation (Inayah & Masruroh, 2021). PhET simulation is a media developed by experts to improve education through media that has been created with the aim of increasing understanding. Learning to use PhET simulation does not require a lot

of money because it only requires a computer to run it (Ismalia et al., 2022). Virtual media or PhET Simulation media is computer-based media.

PhET Simulations is a simulation that is easy to use and can be applied in the classroom (Mahtari et al., 2020). The advantage of using PhET Simulations is that it can carry out physics experiments ideally, where not everything can be done using real tools. The hope is that with Using PhET simulations in physics material can help students better understand and master the material because by using PhET simulations media it can create active, creative, effective and fun learning. Using PhET simulations in the Project Based learning model, students can combine theoretical knowledge with direct experience by PhET simulation It encourages exploration, engagement, and better understanding of scientific concepts, and prepares students to apply their knowledge in real-world contexts. Research conducted by Sumo et al. (2024) and Alina et al. (2019) states that the Project Based Learning model influences students' generic science skills. Another research conducted by Amsikan (2022) on the Application of the Project Based Learning Model to Improve Students' Physics Learning Outcomes and Science Process Skills students' science process skills.

Method

This research was carried out at SMAN 1 Kayangan for the 2023/2024 academic year. The type of research used is quasi-experimental research or quasi-experiment, quasi-experiments have a control group but cannot fully function to control external variables that influence the implementation of the experiment. This research was used because in reality it was difficult to get a control group to use for research (Busetto et al., 2020). The research design used was a pre-test post-test control group design. This research requires two classes, namely the experimental class and the control class. The experimental class was given treatment, namely learning using a Project Based Learning model assisted by PhET simulations, while the control class used conventional learning. The following is a research design table according to Thahir et al. (2020).

Table 1. Pre-test Post-test Control Group Design

Class	Pre-test	Treatment	Post-test
Control	O_1	X_1	O_2
Experiment	O_3	X_2	O_4

Information:

O_1 = Giving a pre-test to the experimental class before being given treatment.

O_2 = Giving a post-test to the experimental class after being given treatment.

O_3 = Giving a pre-test to the control class before being given treatment.

O_4 = Giving a post-test to the control class after being given treatment.

X_1 = Treatment in the form of a Project Based Learning model assisted by PhET simulation.

X_2 = Treatment in the form of a conventional learning model.

The population in this study were 6 classes of class The sample in this study was taken using a purposive sampling technique, namely a technique for determining samples with certain considerations. In this study, the sample chosen was students in class X1 as the experimental class and X2 as the control class. The instrument used in this research is a multiple-choice test with 10 questions to measure generic science skills according to indicators including: direct observation, indirect observation, awareness of magnitude scales, symbolic language, logical framework, logical inference, cause and effect law, modeling mathematics, and building concepts.

Before the instrument is used in research, its suitability is first tested with a validity test to find out whether the instrument is valid or not. Reliability test to determine the extent to which the instrument can be trusted. Difficulty level test to find out whether a question item is included in the question group as difficult, medium or easy to do. The higher the index value obtained, the easier the question item. The discrimination test is the ability of a question to differentiate between students who are intelligent capable and students who are less capable. After the test instrument has been tested on a class that has received previous material that meets the criteria, the test instrument can be used as pre-test and post-test questions.

Test questions were given to the experimental class and control class during the pre-test (before being given treatment) and post-test (after being given treatment). The data obtained was then analyzed using the normality test and homogeneity test as a requirement for conducting hypothesis testing. The normality test is carried out to determine whether the data obtained is normally distributed or not. The normality test in this study used the Shapiro-Wilk test with the help of SPSS 21 software. The homogeneity test was used to explain the variance of the research data. Test the homogeneity of the data using the Levene test with the help of SPSS 21 software.

The post-test data is then tested for the hypothesis to determine the influence between the independent variables and the dependent variable. Hypothesis

testing is a Decision making method based on data analysis this test uses parameteric statistics where if the data is homogeneous and normally distributed then parameteric statistics are used (Palupi et al., 2021). In this research, an independent sample t-test was used to determine the effect of the Project Based Learning model assisted by PhET simulations on students' generic science skills in energy sources.

Result and Discussion

The results of data analysis include validity tests, reliability tests, question differentiation and question difficulty levels can be seen in Table 2.

Table 2. Instrument Test Results

Question Items	r_{table}	r_{xy}	r_{11}	Tk	Dp	Information
X1	0.43	0.59	0.74	0.81	0.47	Accepted
X2	0.43	0.47	0.74	0.71	0.30	Accepted
X3	0.43	0.62	0.74	0.90	0.54	Accepted
X4	0.43	0.59	0,74	0.67	0.52	Accepted
X5	0.43	0.55	0.74	0.62	0.46	Accepted
X6	0.43	0.50	0.74	0.81	0.36	Accepted
X7	0.43	0.61	0.74	0.76	0.58	Accepted
X8	0.43	0.55	0.74	0.67	0.37	Accepted
X9	0.43	0.75	0.74	0.67	0.62	Accepted
X10	0.43	0.43	0.74	0,71	0.34	Accepted

Based on the instrument test results table, it can be seen that all question items are valid (accepted) so they can be used in research. The r_table is 0.43, obtained using the formula df = n-2 (Monariska et al., 2024). All items have a high degree of reliability, namely 0.74. Based on the results of the analysis of the difficulty level of the questions, it is known that 6 question items fall into the easy category, and 4 questions fall into the medium category. 6 question items have differentiating power which is in the good category, and 3 questions are in the sufficient category. Before being given treatment to both classes, a post-test was first given and then a normality test and homogeneity test were carried out with the aim of finding out whether the students' initial abilities had the same abilities.

Table 3. Generic Science Skills Pre-test Data

		Pre-test
Information	Experiment	Control
The highest score	70	70
Lowest Value	10	10
Average	46.07	41.67
Normality test	Normal	Normal
Homogeneity Test	Homogeneous	Homogeneous

Based on the normality test and homogeneity test, it is known that both classes have the same initial abilities, meaning that the data is normally distributed and comes from a homogeneous sample (Asrizal et al., 2023). A comparison of the results of the pre-test data science generic skills between the two classes can be seen in Figure 2.

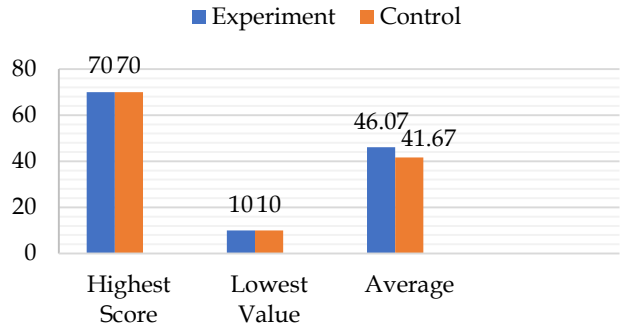

Figure 2. Comparison of the results of generic science skills for the experimental class and the control class with pre-test data

After giving an initial test (pre-test) in the experimental class and control class, it was continued by providing treatment with a Project Based Learning model assisted by PhET Simulation in the experimental class and a conventional learning model in the control class. After both classes were given treatment, the researcher gave a post-test to both classes to determine the effect of the treatment given. The students' post-test data has been tested for normality and homogeneity which is presented in Table 4.

Table 4. Generic Science Skills Post-test Data

		Post-test
Information	Experiment	Control
The highest score	100	90
Lowest Value	50	50
Average	80.00	71.67
Normality test	Normal	Normal
Homogeneity Test	Homogeneous	Homogeneous

Based on the table above, the experimental class and control class experienced an increase in generic science skills, but the experimental class experienced a higher increase than the control class.

Figure 3 shows an increase in generic science skill scores in the experimental class and control class after being given treatment. The use of the Project Based Learning model assisted by PhET simulations has a great influence on students' generic science skills (Rianti et al., 2024; Hasanah et al., 2023), this can be seen directly based on the results obtained by students where the highest score before being given treatment using the Project Based Learning model assisted by PhET simulations was 70 while after being given treatment it

increased became 100. The lowest score before being given treatment was 10, while after being given treatment, it increased to 50. The average score also increased from 46.07 to 80.00.

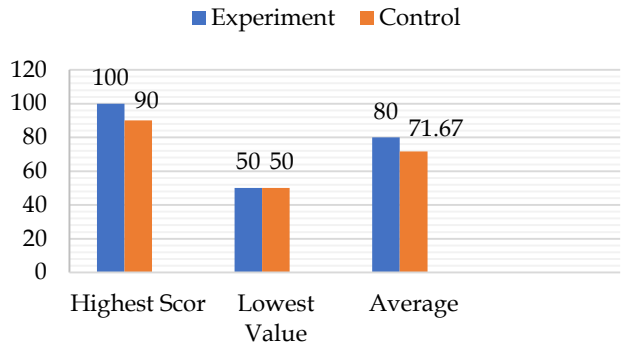

Figure 3. Comparison of the results of generic science skills for the experimental class and control class post-test data

The value of generic science skills in the control class with conventional learning model treatment has increased (Harefa & Suyanti, 2019; Khabibah et al., 2017; Darling-Hammond et al., 2020; Petropoulos et al., 2022). The highest score before being given the treatment was 70, then after being given the treatment, it became 90, the lowest score before being given the treatment was 10, after being given the treatment, it increased to 50. The average score before being given the treatment was 41.67 and after being given the treatment increased to 71.67 where the average increase in the experimental class was higher than the control class.

Then a normality test and homogeneity test are carried out as a condition for conducting hypothesis testing. The normality test in this study used the Shapiro-Wilk test with the help of SPSS 21 software to obtain post-test scores with a normal distribution. Testing the homogeneity of the data using the Levene test with the help of SPSS 21 software found that the samples came from a homogeneous population (Husnizar et al., 2022). The data for both samples were declared normal and homogeneous so the independent sample t-test assisted by SPSS 21 was used. Based on the calculation results, a significance figure of 0.018 is obtained, which is smaller than 0.050.

This shows that H_a is accepted and H_0 is rejected, which means that there is an influence of the Project Based Learning model assisted by PhET simulations on students' generic science skills in energy sources. The results show that the class treated with the Project Based Learning model assisted by PhET simulations obtained higher generic science skill scores compared to the class with the conventional learning model. This is in line with research conducted by Rahayu et al. (2020) concluding that the Project Based Learning model has an effect on students' generic science skills.

The application of PhET simulation media in learning has been proven to increase student activity in the classroom (Liswar et al., 2023; Sari et al., 2021; Aprida & Mayarni, 2023). By using PhET simulation in the Project Based Learning model, students can combine theoretical knowledge with direct experience generated by PhET simulation (Rayan et al., 2023; Sismawarni et al., 2020; Sukarso et al., 2023). This is in line with research by Rizaldi et al. (2023) who concluded that the combination of the PJBL model with PhET simulation is very suitable, this is because in the PJBL model the teacher is the facilitator while the students participate in conducting research, this causes the students to have more experience and trains them to work together in groups.

Using PhET simulation in the PJBL Model also allows greater accessibility to experiments and simulations that are difficult or expensive to carry out in real environments. The PJBL model assisted by PhET simulation provides students with an active, interactive and in-depth learning experience. It encourages exploration, engagement, and better understanding of scientific concepts, as well as preparing students to apply their knowledge in real-world contexts and can improve students' generic science skills.

Conclusion

Based on the research that has been conducted, it can be concluded that there is an influence of the Project Based Learning model assisted by PhET simulations on students' generic science skills in energy sources.

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Author Contributions
Conceptualization; D. L.; methodology.; A. D.; validation; M. T.; formal analysis; S. R.; investigation.; D. L; resources; A. D.; data curation: M. T.; writing—original draft preparation. S. R.; writing—review and editing: D. L.; visualization: A. D. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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