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The Effect of the Project-Based Learning Model with the STEAM Approach on Learning Outcomes of High School Students the Subject of Material Elasticity

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Abstract: Applying the right learning model is very much needed in learning physics, because there is still a lot of physics learning that is applied using classical methods, such as lectures and direct instruction, so that it affects student learning outcomes. The material elasticity of materials is not only dominated by theory but also real practice (practicum). This requires a more effective learning model so as to improve student learning outcomes. Learning outcomes are achievements achieved by students academically through exams or tests. Current developments have brought progress in education, one of which is project-based learning (PjBL) and learning that collaborates multi-disciplines, namely science, technology, arts, engineering, and mathematics (STEAM). The purpose of this study was to investigate the impact of using the project based learning model with the STEAM approach on high school student learning outcomes on the subject of material elasticity. The type of research used is true experiment with the Pretest-Posttest Control Group Design. The research subjects were 2 classes at XI MIPA at SMAN 3 Bondowoso. Research data on learning outcomes were obtained from students' pretest and posttest scores. The data obtained was processed using the SPSS 23.0 program. The PjBL model with the STEAM approach stated that there was a significant influence on the learning outcomes of high school students on the subject of material elasticity.

Keywords: Learning outcomes; Material elasticity; PjBL-STEAM

Introduction

This research is motivated by the method of learning physics in the classroom which is still dominated by the classical method, namely lectures and questions and answers, resulting in learning physics in the classroom which is still teacher-centered. This makes learning in class less meaningful, so that students' motivation and achievement in learning physics is not optimal (Mulyadi, 2015; Saefullah, 2021). The purpose of this research is to investigate how the project based learning model with the STEAM approach affects high school student learning outcomes in the material elasticity material.

Physics is a part of natural science that concentrates on abstract properties. The concepts of physics material are not only obtained by listening, reading, and demonstrating but also must be done through direct experience so that these concepts are more firmly embedded in students' memories. The process of understanding physics concepts teaches students to think constructively so that students' understanding of physics is intact, both as a process or as a product (Jagantara et al., 2014; Rismawati. & Saputro, 2019).

The industrial revolution 4.0 and the rapid evolution of technology have had an impact on the implementation of 21st century education. Education requires 4C abilities, namely critical thinking and problem solving, collaboration, creativity and

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innovation, as well as communication skills that prepare human resources (HR) to compete globally (Sinurat et al., 2022; Yennita et al., 2021). Based on the 2013 curriculum, it requires learning that can develop students' mindsets to find solutions to every problem with a scientific process. One way is to change the learning model in the classroom with the PjBL model (Tamba & Turnip, 2017).

Project based learning (PjBL) is a learning model that uses a project as its goal. Through this project learning physics in class is no longer teacher centered because it focuses on student activity. Project-based learning (PjBL) can be applied as a learning model to develop students' planning, communication, problem-solving and decision-making skills (Nurfitriyanti, 2016; Nurhadiyati et al., 2021).

The PjBL model is more efficient for students when learning is related to everyday life, such as science and technology. The PjBL model can be balanced with an approach that facilitates students' understanding of concepts, problem solving, perfecting creativity, utilizing technology, and can instill character in students, namely the Science, Technology, Engineering, Art and Mathematics (STEAM) approach.

One form of educational reform can be carried out using a learning approach that can assist teachers in creating experts, namely the STEAM approach is an adaptation of STEM, which highlights the relationship of two or more content areas to guide instruction through observation, investigation and problem solving (Wahyuni et al., 2020).

STEAM is an educational approach that utilizes the five sciences, namely science, technology, engineering, art and mathematics. The STEAM approach teaches a number of skills to students, namely problem solving skills, critical thinking and cooperation skills (Atmojo et al., 2020). STEAM learning involves students actively in practicum activities and facing real situations.

Students' curiosity and motivation towards higher-order thinking skills, such as problem solving, collaboration, independent learning, project-based learning, challenge-based learning, and research, are stimulated when learning with the STEAM approach (Apriliana et al., 2018). The application of learning with the STEAM approach (Science, Technology, Engineering, Arts and Mathematics) is very important and has many benefits for students, because a curriculum that emphasizes collaboration, creativity, verbal and nonverbal communication, research, problem solving, and critical thinking is included in the STEAM approach . Through this learning approach, students are taught not only to be smart in academic aspects but also in social and emotional aspects (Tabi'in, 2019).

PjBL-STEAM is a project-based learning model and a combination of STEAM approaches. Classroom learning using the STEAM approach is very suitable if implementing a project-based learning model (PjBL). This is because the STEAM approach can show positive results in students' scientific knowledge. So that learning with the PJBL-STEAM model can make the class more active, students can think at a higher level, solve problems, be active in practical activities (practicum) and students are directed to real situations, which makes the learning being taught more meaningful for students. Apart from that, learning is no longer teacher-centered but students play an active role in it and students can achieve 21st century skills. The application of the PjBL-STEAM model enables students to build skills in the real world, such as working together, making decisions, initiatives, communication, problem solving and self-management so as to improve students' critical thinking skills and emotional intelligence (Diana & Saputri, 2021).

Learning using the model (PjBL-STEAM) is not used haphazardly. There are several steps (syntax) in the PjBL learning model with the STEAM approach according to The George Lucas Education Foundation (in Kemendikbud, 2014) as follows Table 1.

Tabel 1. Sintaks pembelajaran PjBL-STEAM

PjBL syntax	STEAM features	STEAM aspect
Phase 1: Determination of fundamental questions (start with essential question)	Learning must contain STEAM, namely Science, Technology, Engineering, Art, and Mathematics.	In faes 1 students begin with essential questions, namely questions that can assign students to carry out an activity related to the material to be studied by loading science.
Phase 2: Develop a project plan (design project)		In phase 2, students design a project that contains elements of science, engineering, art and mathematics.
Phase 3: Arrange a schedule (create a schedule)		In phase 3, the students and the teacher make an agreement on a project schedule to complete the project.
Phase 4: Monitoring students and project progress (monitoring the		In phase 4, the teacher monitors or monitors project-making activities by paying attention to STEAM elements and conducting virtual practicums using PhET Simulation.

PjBL syntax	STEAM features	STEAM aspect
students and progress of the project)		
Phase 5: Outcome assessment (assess the outcome)		In phase 5, the teacher evaluates the results of projects that have been made by students by taking into account STEAM elements and other assessment criteria.
Phase 6: Evaluation of the experience (evaluation of the experience)		In phase 6, students and teachers reflect (evaluate) the activities and results of projects that have been carried out by looking at STEAM elements.

Student learning outcomes are student academic achievements through tests and assignments, performance in asking and answering questions that support the achievement of these learning outcomes (Dakhi, 2020). Learning outcomes are the final results achieved by students after learning procedures, which are shown on the class scale with letters or symbols or numbers. And often used as a benchmark for the success or failure of students in learning the material.

According to Rohman & Ishafit (2021), the results of his research after implementing the PjBL-STEAM showed significant results on students' creative thinking skills. According to Fitriyah & Ramadani (2021) in their research results after using the STEAM-based PjBL model, the results of the posttest and pretest scores reached being able to think creatively and think critically in the good category. Based on the results of research from these sources, it shows that the implementation of PjBL-STEAM can increase the effectiveness of students' understanding of concepts in the cognitive domain.

Based on the results of observations at one of the Bondowoso State Senior High Schools and interviews with physics teachers in January 2022, the researchers obtained information that learning physics is still teacher centered, because when teaching physics teachers often use lecture and direct instruction learning models. Limited facilities and infrastructure in technology so that students have never tried to do physics practicum using a virtual lab. Therefore, teachers need to regenerate learning activities in class using learning models and learning approaches that are more fun, meaningful and able to motivate students in learning activities.

This research was conducted to improve student academic achievement by applying the PjBL model with the STEAM approach. The purpose of this study was to examine the effect of implementing the PjBL-STEAM model on high school student learning outcomes. The benefits of this research are to obtain cognitive content of science and to provide alternative choices of learning processes in the classroom as well as references for conducting further research.

Method

This type of research is a true experiment using the Pretest-Posttest Control Group Design research which involves two classes, namely the experimental class and the control class. Determination of these two class samples uses a homogeneity test on the entire population of class XI MIPA in SMA.

The experimental class is the class that is given treatment by applying the PjBL model with the STEAM approach, while the control class is without treatment. The mechanisms for the two classes are described in the following table:

Table 2. Pretest-posttest control group design

Class	Pretest	Treatment	Posttest
Experiment	E_1	X	E_2
Control	K_1		K_2

(Sugiyono, 2013:113)

Note:

E_1 : Initial test (Pretest) given to the experimental class

E_2 : The final test (posttest) was given to the experimental class

X : The treatment of the experimental class uses the PjBL-STEAM learning model

K_1 : Initial test (Pretest) given to the control class

K_2 : The final test (Posttest) was given to the control class

Preparation, data collection, data processing, data analysis, discussion, and drawing conclusions are the steps taken in this study. This preparatory stage is the first step carried out in the research in the form of initial observations, problem formulation, and determination of samples for the experimental class and the control class. The next stage of data collection is giving pretest to both classes. Learning with the STEAM approach was then applied to the experimental class, and conventional learning was applied to the control class. After learning is done then do the posttest. Furthermore, typing the data that has been obtained is done data processing then the results of the processed data are carried out data analysis. The analysis of the data obtained was then discussed and conclusions were drawn. The following steps in this study are presented in Figure 1.

This research data collection methods include observation, interviews, and tests. After applying the PjBL-STEAM model to learning in the experimental class, while the control class used conventional learning, the data on students' pretest and posttest scores from the final test were used in the technique of analyzing student learning outcomes data. Then using the SPSS 23.0 program for descriptive analysis, normality test and the Mann Whitney u-test.

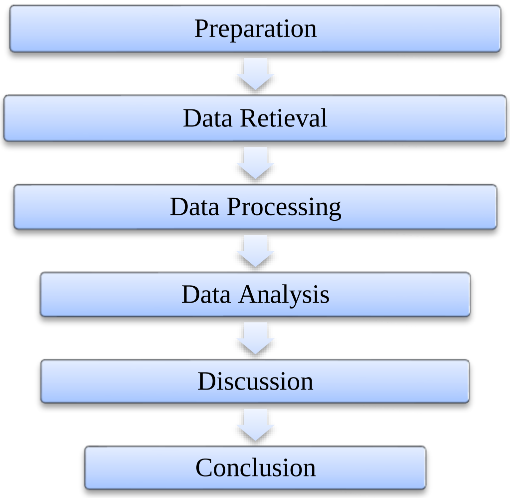

Figure 1. Research steps

Result and Discussion

The experimental class was treated with the project-based learning model (PjBL) and the STEAM approach in this study, while the control class was treated with the conventional model. The elasticity of the material in chapter 2 of class XI MIPA SMA is used as learning material. The selected high school in this study was Bondowoso 3 Public High School with a purposive sampling area method, namely a sampling technique that was deliberately chosen based on certain considerations, one of which was the availability of facilities and infrastructure needed during the study. This research was conducted in the odd semester of the 2022/2023 academic year.

In SMA Negeri 3 Bondowoso, where there were three XI MIPA classes with 26 students each, a homogeneity test was used to determine the sample for the experimental class and the control class. This homogeneity test utilizes daily test scores on previous physics teacher material. The following is presented Table 2.

Table 2. Homogenity test result

		Levene Statistic	df1	df2	Sig.
students' physics learning outcomes	Based on Mean	2.681	2	75	0.075
	Based on Median	1.647	2	75	0.200
	Based on Median and with adjusted df	1.647	2	28.190	0.211
	Based on trimmed mean	1.780	2	75	0.176

Based on the homogeneity test output in Table 2, the Based on Mean significance value is 0.075. This is in accordance with the basis for decision making, if the Based on Mean significance value obtained is > 0.05, the data is said to be homogeneous (same). Based on the homogeneity test results obtained in this study, it is said that the data is homogeneous because the Based on Mean significance is 0.075 > 0.05. Then the sample can be determined by simple random sampling method. The simple random sampling method was carried out by randomizing class XI MIPA by taking two class samples, namely the control class and the experimental class. The results determined that class XI MIPA 2 as a control and class XI MIPA 1 as an experiment. Six face-to-face meetings were held in the experimental class and five in the control class for this study. Since students are required to make projects in the experimental class, this is a direct difference between the control class and the experimental class.

In accordance with the project-based learning model (PjBL), where students are required to create a project. The making of this project was only carried out in the experimental class because only the experimental class received treatment in physics learning using the project based learning model with the STEAM approach. The project made or done by students in this experimental class is in the form of making simple practicum tools and posters that are in accordance with the material elasticity of materials.

The results of this study were obtained by giving five descriptive questions related to the taxonomy of blooming aspects C1 to C4 on the tests given both to the experimental group and the control group. SPSS 23.0 analysis of student learning outcomes test data is needed to interpret the results of pretest and posttest data taken by students of the experimental class and control class. Following are the results of data analysis of student learning outcomes in this study:

Descriptive Analysis of Student Learning Outcomes.

The purpose of this descriptive analysis is to get a complete picture of the data studied, which will be shown in Table 3 as the following amount of data, maximum, average, and maximum values:

Table 3. Study result of students

	N	Min	Max	Mean	Std. Deviation
Pretest Experiment	26	0	66	18.73	14.734
Posttest Experiment	26	20	96	78.58	17.655
Pretest Control	26	33	85	48.46	17.060
Posttest Control	26	32	78	53.58	11.920
Valid N (listwise)	26				

Based on the results of the descriptive analysis in Table 3. above shows the total data of 26 students in both the experimental and control groups. Students in the experimental class had an average pretest score of 18.73 with a maximum score of 66 and a minimum score of 0. Meanwhile, the average pretest score for control class students was 48.46 with a maximum score of 33 and a minimum of 85. The posttest scores of students in the experimental class ranged between 20 to 96, with an average value of 78.58. While the control class obtained an average posttest score of 53.58, with a maximum value of 78 and a minimum of 32. This shows that the average result between the two classes is that the experimental class has a higher average value than the control class (78, 58 > 53.58).

Normality Test of Student Learning Outcomes

As a prerequisite for continuing data analysis, this normality test aims to determine whether the data on student learning outcomes is normally distributed or not. Because the number of data samples for each class was less than fifty and the significance level was less than 0.05, the ShapiroWilk normality test was used in this study. Figure 4 illustrates the results of the normality test output as Table 4.

Table 4. Normality test of study result

		Kolmogorov-Smirnov			Shapiro-Wilk		
	Class	Statistic	df	Sig.	Statistic	df	Sig.
students' physics learning outcomes	Pretest Experiment	0,292	26	0,000	0,743	26	0,000
	Posttest Experiment	0,224	26	0,002	0,808	26	0,000
	Pretest Control	0,356	26	0,000	0,697	26	0,000
	Posttest Control	0,205	26	0,006	0,917	26	0,039

It is known from the results of the Shapiro-Wilk normality test in Table 4 that the pretest and posttest significance values for the experimental and control classes are less than 0.05, this indicates that the research data is not normally distributed. because the significance results obtained are less than or equal to 0.05. Where is the sig value in the posttest experimental class 0.000 less than 0.05, and the sig value in the control class is 0.039 < 0.05. While sig shows that the research data is normally distributed when > 0.05. Therefore, for additional data analysis the Mann-Whitney U-test.

Because the posttest results of the students in the two classes were not normally distributed, the Mann Whitney U-Test was used. The Mann Whitney U-Test is used to determine whether there is an influence of the STEAM approach and the PjBL model on student learning outcomes in elasticity material. The Mann Whitney U-Test test is said to be accepted if the Asymp.Sig value is < than 0.05. Vice versa, if the value of Asymp.Sig > than 0.05 then it is said to be rejected. The output results of the Mann Whitney U-Test are presented in Table 5.

Based on Figure 5. in the results of the Mann Whitney u-test it can be explained that the value of Asymp.Sig. (2-tailed) is 0.000. Based on the results obtained, the Asymp.Sig (2-tailed) value is <0.05, which means that the hypothesis is accepted. This shows that the average value of student learning outcomes in the experimental class is significantly higher than the control class. It can be said that the STEAM approach and the project-based learning model have an effect on student learning outcomes in terms of material elasticity due to significant differences.

Table 5. Output of the Mann Whitney u-test of student learning outcomes

	students' physics learning outcomes
Mann-Whitney U	89.500
Wilcoxon W	440.500
Z	-4.564
Asymp. Sig. (2-tailed)	0.000

The models and methods used in the learning process differentiate the results obtained by the experimental class and the control class. Project-based instruction encourages students' active participation in problem solving, decision making, research, presentation, and product creation, and awakens their interest in real-world physics topics.

Through this project-based learning activity it is also able to shape student creativity and self-knowledge so that the knowledge students have will be more meaningful. This causes the knowledge to be remembered longer by students because students themselves find their own understanding. In addition, the PjBL model is able to increase collaboration between fellow students and scientific communication between fellow students or students and teachers which causes scientific activity, making students more active in class.

Integrated with the STEAM approach which is an approach that combines five multi-disciplines, namely Science, Technology, Engineering, Art, and Mathematics in its application. The aspect of science is learning with science, its application is that students not only learn what is in the book but what is in the surrounding environment as well. The Technology aspect is learning that utilizes technology according to current developments, its application is that students are given the freedom to seek other sources of knowledge besides what is in the student textbook. The Engineering aspect is a combination of science and technology, the application of which is that students can use smartphones, laptops, to find other sources of knowledge. The Art aspect is student art or creativity, the application is for students to make projects in the form of simple practicum tools and posters. The mathematics aspect is the analysis of calculations that use quantities and numbers, the application is for students to process data from the results of the practicum that has been done. By implementing the STEAM approach, students become more familiar with broader knowledge and hone students' creative skills in expressing their ideas in the projects they create.

The success of the learning process applying the project based learning model with the STEAM approach is not only the result of the efforts of the teacher but also the active participation and hard work of students in learning. So it can be concluded that based on the results of the Mann Whitney u-test, learning that applies the project based learning model with the STEAM approach to high school student learning outcomes in material elasticity has a significant effect. Compared to the control class, where learning is applied only conventional learning with lecture methods, practice questions and assignment of questions.

Based on the results obtained by researchers in this study, in accordance with the results of research from Badriah et al (2020), which stated that the average value of classes that apply the PjBL learning model with the STEAM approach is better than classes that do not use the PjBL model with the STEAM approach. STEAM. And also in accordance with the results of research from Firmansyah (2019), which states that the implementation of PjBL-STEAM can improve student learning outcomes.

Conclusion

Learning that applies the project based learning model with the STEAM approach is one of the efforts implemented to improve high school student learning outcomes in material elasticity. This can be proven by the significant results from the results of the Mann Whitney u-test posttest. It can be explained that the value of Asymp.Sig. (2-tailed) is 0.000 < 0.05, which means the hypothesis is accepted. Therefore, it can be concluded that the STEAM approach combined with the project-based learning model has a significant influence on student learning outcomes at SMA Negeri 3 Bondowoso in terms of material elasticity.

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