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THE EFFECT OF USING STEM PjBL-BASED SCIENCE LEARNING MODULES ON STUDENTS' PARTICIPATION IN THE MATERIALS OF WORK, ENERGY, AND SIMPLE MACHINES

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Abstract

Science learning approaches that are less interactive cause low student participation in education. Therefore, this study investigates an interactive approach, namely the STEM PjBL based science learning module. This study aims to determine the effect of STEM Project-Based Learning (PjBL)-based science learning modules on learner participation in the material of effort, energy, and simple machines. A quasi-experimental quantitative research design was conducted with 61 students divided into experimental groups and control groups, selected through a purposive sampling technique. Data were collected using questionnaires and participant observation sheets that had been tested for validity. Findings showed a significant increase in student participation in the experimental group (80%) compared to the control group (60%). Statistical analysis, including t-test with sig. 0.000 and Pearson's value correlation test of 0.539 with sig. 0.002, showed a significant difference between the two groups, supporting the effectiveness of the STEM PjBL module. However, this study highlights the limited role of the teacher as a facilitator and the project guidelines in the module are less specific so there are groups that make projects outside the topic. Overall, this study concluded that the use of STEM PjBL-based modules positively influenced students' participation in science learning.

Keywords: Participation, Learning module, STEM, Project-Based Learning, Science

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INTRODUCTION

Education in Indonesia is currently undergoing a significant transformation with the establishment of the Merdeka Curriculum (Qadafi et al., 2022). Permendikbudristek Number 53 of 2022 and Number 60 of 2022 provide wider space for an educational institution to create a curriculum according to the characteristics of students and regional needs. According to Alfaeni et al (2023) Curriculum flexibility allows the application of more innovative learning approaches, such as STEM (Science, Technology, Engineering, and Mathematics) which can accommodate the interests and talents of students more optimally.

The challenges of the 21st century require schools to provide a basic knowledge of skills in the 21st century for students. Learning that must be done by teachers to equip students based on the characteristics and principles of 21st century learning, namely: 1) Learning with a learner focused approach. 2) Learners are taught the ability to collaborate. 3) Problems encountered in daily life are used as learning materials and learning must make learners able to relate to their daily lives. 4) In preparing students to become responsible citizens, schools must be able to provide facilities for their integration into the social environment (Tanjung et al., 2022). Science learning in schools is often considered a subject that has topics that are difficult to learn and feel boring (Febrianti et al., 2021). This causes low interest in learning and participation from students in the learning process. As a result, the learning objectives of science in developing critical thinking, creativity, and problem solving skills are not optimally achieved.

Researchers have conducted interviews with science subject teachers and observations conducted for approximately one semester at SMP Negeri 23 Banjarmasin school, it was found that student participation in science learning was low, seen directly in learning activities, only some students were enthusiastic about arguing and responding to teacher questions. This happens because it is caused by various interrelated factors in achieving optimal learning, one of which is the learning tools used are only manuals that make learning boring. Individual learner problems, such as learning motivation, interest in science, and the level of difficulty in understanding concepts, are also influenced by factors of readiness and absorption of different learners, as well as the need for innovation in accordance with current developments so that students are motivated to participate in learning activities.

Science learning can be effective with the support of adequate learning tools such as using the STEM approach because with this alternative, students can understand the material better through a concrete learning process. One of the learning tools that can support effective learning is using STEM modules that can help students develop their creativity and ability to solve problems. One of the learning models that has the characteristics of improving the ability to solve problems is the STEM PjBL learning model. According to Ma'wa et al (2022) the PjBL model has characteristics that begin with a real-life problem and encourage students to solve it by producing a product or work.

The STEM approach integrates the four disciplines in a learning project that is relevant in everyday life. Thus, learning becomes more contextual, interesting and challenging for students. Although the potential of the STEM approach in increasing learner participation has been widely researched before, further research still needs to be done to find out the extent of the effect of using STEM-based science learning modules on learner participation. Science learning, especially the material of effort, energy, and simple machines, is often still centered on theory and tends to involve less active students in real practicum activities. This can cause students to have difficulty in understanding abstract concepts related to the material. STEM-based learning is considered capable of improving skills in the 21st century, especially in the ability of 4Cs, namely, Communication, Collaboration, Critical Thinking and Creativity because the STEM approach integrates these four subjects in solving real-life problems(Tanjung et al., 2022).

In addition to enhancing students' cognitive comprehension, scientific instruction in the twenty-first century is supposed to promote higher-order thinking abilities, self-efficacy, motivation, and active engagement. The incorporation of STEM (science, technology, engineering, and mathematics) into project-based learning (PjBL) is one strategy that has demonstrated potential in accomplishing these objectives. In order to connect theoretical knowledge with practical problem-solving, STEM-PjBL blends the interdisciplinary nature of STEM with the experiential, inquiry-driven nature of project-based learning (Guo et al., 2020;Samsudin et al., 2020). But even with its increasing use, there are still a number of significant implementation and assessment gaps.

Prior research has shown that the PjBL-STEM approach may successfully foster students' scientific creativity, especially when it comes to alternative energy subjects (Syamra, 2024). Nevertheless, the study mostly focused on the cognitive domain, ignoring the affective components such student enthusiasm, engagement, and classroom participation. Similar to this, Takndare et al.'s research from 2024 found that PjBL improved students' cognitive learning results, but it did not specifically target students' critical or creative thinking abilities or their active participation in the learning process, nor did it incorporate STEM (Takndare et al., 2024).

Globally, research on affective growth and learner agency is still lacking, despite the fact that STEM-PjBL can enhance students' self-efficacy and collaborative abilities in physics instruction, according to Samsudin et al., (2020). While many nations have effectively adopted STEM education,Trichkova-Kashamova et al., (2024)also underlined that teacher preparedness and contextual adaptability continue to be problems. Furthermore, Gao et al., (2020) noted that few assessments in interdisciplinary STEM education look at integrated skills, learner affect, or process-based engagement; instead, they frequently concentrate on disciplinary topic knowledge. These problems are a result of a general misalignment between the evaluation tools and the desired transdisciplinary learning outcomes.

Our knowledge of STEM-PjBL's efficacy is limited by the paucity of controlled studies contrasting it with conventional approaches, especially when it comes to lower secondary scientific subjects like work, energy, and simple machines. The majority of earlier research frequently used one-group designs and prioritizes learning outcomes above procedures. In order to fill that vacuum, this study uses a quasi-experimental approach to investigate whether giving students creative flexibility and autonomy in STEM-PjBL activities improves learning outcomes and involvement. The results are intended to facilitate assessments of multidisciplinary STEM education that are more affectively inclusive, contextual, and process-oriented.

According to the context of developing a more comprehensive learning model, it is important to evaluate not only the end result of learning, but also the extent to which students are actively involved in the learning process. Therefore, this study aims to fill the gap by examining the effect of using STEM PjBL-based science learning modules on learner participation in the material of effort, energy, and simple machines. This study was designed using two classes with different approaches which were divided into experimental and control classes. The difference in approach is intended to examine more deeply whether freedom in creativity can encourage higher participation. Thus, the use of STEM-based science learning teaching modules with team-based STEM project or PjBL models on the material of effort, energy, and simple machines as an effort to bring more active and contextual learning.

Based on the description of the background, a problem formulation can be made from this research, namely: Is there an effect of using STEM PjBL-based science learning modules on the participation of students in energy, effort and simple machines? The purpose of this study is to determine the effect of the use of STEM PjBL-based science learning modules on the participation of students in energy, effort and simple machines. This research is expected to provide new information about the use of STEM PjBL-based science learning modules on student participation as an alternative solution for learning for junior high school students in grade VIII on energy, effort and simple machines. The results of this study can provide options for educators to use tools in the form of learning modules that can support the effectiveness of learning in order to increase student participation as well as cognitive and psychomotor learning outcomes of students on energy, effort and simple machines material. This research can be used as an additional reference in innovating with the use of alternative learning tools in teaching and learning activities and improving the quality of school education. Based on the research objectives, the hypotheses of this study are formulated as follows:

H_0: There is no significant effect of using the STEM PjBL-based science learning module on students' participation in learning work, energy, and simple machines.

H_1: There is a significant effect of using the STEM PjBL-based science learning module on students' participation in learning work, energy, and simple machines.

METHOD

This study uses a Quasi-experimental design with a Non-equivalent control group design that uses questionnaire instruments and observation sheets as tools to obtain data. With this design, there are two classes, namely the experimental class that uses the STEM PjBL-based science learning module and the control class that uses conventional learning methods, namely PjBL activities without STEM. Both classes will be given observations to the observers of both classes as a tool to determine the level of student participation in the learning process of several meetings on the material of effort, energy and simple machines.

This research involves several types of variables that support the implementation and analysis of data systematically. The independent variable in this study is the use of STEM-based science learning modules with a Project Based Learning (PjBL) approach, which is expected to have an influence on other variables. The dependent variable is the participation of students in learning the material of effort, energy, and simple machines, which is an indicator of the success of the application of the module. To maintain consistency and avoid external influences that can interfere with the results of the study, control variables are used which include teachers, classroom conditions, learning duration, and material presented, so that the focus of observation can be on the effect of learning modules on student participation.

Research Design

Based on the learning process, data from the two research classes were obtained, then the results of observations in the two classes were compared to determine whether there were significant differences in learning with one of them being treated using the STEM PjBL-based science learning module. Furthermore, the experimental class was given a questionnaire sheet for students' responses to STEM learning to find out the correlation between the STEM PjBL module and students in learning the material of effort, energy and simple machines. According to Sugiyono (2023) the non-equivalent control group design scheme can be seen in the Table 1.

Table 1. Non-equivalent control group design

Experimental class	O_1	x	O_3
Control class	O_2	--	O_4

Description:
O_1 = initial learning of experimental group
O_2 = initial learning of the control group
O_3 = final learning of experimental group
O_4 = final learning of the control group
x = treatment using STEM PjBL-based module
-- = without using the module

Research Objectives

Population is the entire subject that will be used as an area in collecting data to be studied (Table 2). In this study, the population used is all VIII grade students at SMPN 23 Banjarmasin in the first semester (odd) of the 2024/2025 Academic Year.

Table 2. Number of students in each class

Class	Number (people)
VIII A	32
VIII B	30
VIII C	31
VIII D	30
VIII E	30
VIII F	30
VIII G	30
Totally VIII A - G	**213**

The sample is part of what is used in this study, part of the number and characteristics of the population. Sampling was done by purposive sampling technique which was selected based on equal cognitive level. Researchers were given two classes by the school as research samples because they had the same teacher so that it would be easier to coordinate and advice from the teacher who was seen from an academic point of view and the characteristics of the students. In this study, the samples used were two VIII classes at SMPN 23 Banjarmasin, namely VIII B as the control class and VIII C as the experimental class.

Research Instruments

Instrument is a data collection tool in research that aims to facilitate researchers in collecting and processing data. In this study, the instrument used was a questionnaire instrument for students' responses in the experimental class and an observation sheet instrument for students' participation.

a. Learning Devices

This study uses learning devices in the form of STEM PjBL-based modules accompanied by LKPD as learning resources used during learning for the experimental class.

b. Questionnaires

The questionnaire instrument contains several indicators of module practicality consisting of ease of understanding, content relevance, and student involvement in STEM PjBL-based science learning. This questionnaire is useful for measuring students' responses regarding the use of modules in learning (Table 3). The questionnaire in this study uses a Likert scale with a 1-4 scale labeled as strongly agree (SS), agree (S), disagree (TS), and strongly disagree (STS).

Table 3. The guidelines of the learner response questionnaire instrument

Aspect observed	Category	Question Number
Readability and Comprehension	Material is easy to understand, clear language, organized content	1,2,3,4,5
PjBL and STEM	Project teaching, STEM integration, creativity	6,7,8,9,10
Problem Solving	Finding solutions, confident, skillful.	11,12,13,14

c. Observation Sheet

The observation sheet consists of several items that measure various aspects of learner participation, such as activities in discussions, asking questions, working together in groups, and completing tasks and interactions with others in learning activities. The observation sheet instrument consists of several items that measure various aspects of learner participation, such as activities in discussions, asking questions, cooperating in groups, and completing tasks and interactions with others in learning activities (Table 4).

Table 4. The guidelines of the learner participation observation sheet instrument

Aspect observed	Category	Question Number
Active Participation	Verbal, Social	1,2,3,4 5
Engagement in the Learning Process	Non-verbal, cognitive	6,7 8,9
Creativity and Innovation	Cognitive, Non-verbal	10,12 11
Collaboration skills	Social	13,14.15

Data Collection Technique

The data collection techniques used by researchers in this study to obtain data are as follows.

a. Questionnaires

Data collection using questionnaires aims to measure the response of students related to the use of STEM PjBL-based science learning modules. The questionnaire is prepared based on indicators of module practicality, namely ease of understanding, content relevance, and student involvement in STEM PjBL-based science learning on the material of effort, energy and simple machines. This questionnaire was distributed to the experimental class totaling 31 people as a class that received treatment.

b. Observation

Data collection by observation is using an observation sheet to directly observe the participation of students during the learning process. In this study, observations were made when learning took place from beginning to end. Observers used in this study were three observers including two science teachers from SMPN 23 Banjarmasin and one FKIP student of Science Education. Observation was carried out for three meetings in learning with learner participation categories described in Table 5.

Table 5. Category of learner participation

Percentage	Category
0% - 20%	Very less
21% - 40%	Less
41% - 60%	Fair
61% - 80%	Good
81% - 100%	Very Good

(Wijarna & Sumandya, 2023)

Data Analysis Technique

The data that has been collected in the research will then be processed and analyzed to prove the extent to which the use of STEM PjBL-based science learning modules can increase the participation of students in learning the material of effort, energy and simple machines. Before testing the hypothesis, the data will first be tested for normality and homogeneity to ensure that the statistical analysis used is in accordance with the prerequisites for hypothesis testing using SPSS 21. Data analysis in this study used an independent T-test to compare the average participation of students between the experimental and control groups. In addition, conducting a correlation test to measure the strength and direction of the relationship between participation and other variables.

a. Normality Test

The normality test in this study used the Kolmogorov-Smirnov test. According to Kadir (2020) the decision making in this test is, if the Asymp. Sig. or significance ≤ 0.05 then the data is not normally distributed. If the Asymp. Sig. or significance > 0.05 then the data is normally distributed.

b. Homogeneity Test

The homogeneity test in this study used the Levene's test of Equality of Error Variances. According to Kadir (2020)the decision making in this test is, If the Sig. ≤ 0.05, then the variance of the data population is declared inhomogeneous. If the Sig value. > 0.05, then the variance of the data population is declared homogeneous.

c. T-Test

This test is conducted to compare two different samples. In principle, the t-test is used to compare the means between two groups of samples that have no relationship with each other. The T-test used in this study is the Independent Sample T-Test. According to Kadir (2020), the decision making for this test is if the Sig value. <0.05, then H_0 is rejected and H_1 is accepted, which means that there is an effect of learning using the learning module. If the value of Sig. > 0.05, then H_0 is accepted and H_1 is rejected, which means that there is no effect of learning using the learning module.

d. Correlation Test

The decision-making guidelines for the Pearson moment correlation test in this study are If the Sig. or significance value <0.05, then H_0 is rejected or there is a significant correlation between the variables being connected. If the Sig. value or significance> 0.05, then H_0 is accepted or there is no significant correlation between the variables being connected (Table 6).

Table 6. Criteria for the interpretation of the correlation coefficient r value

Coefficient Interval	Category
0,80 – 1,00	Very Strong
0,60 – 0,79	Strong
0,40 – 0,59	Medium
0,20 – 0,39	Low
0,00 – 0,19	Very Low

(Jabnabillah & Margina, 2021)

RESULTS AND DISCUSSION

The results of the study were obtained from several data collection processes by conducting three learning meetings at school. The research was conducted at the last three meetings of the material with the condition that students had received teaching from schoolteachers regarding the material of effort, energy and simple machines using two classes as samples, namely class VIII C as the experimental class and VIII B as the control class, located at SMP Negeri 23 Banjarmasin. Experiment and control mean that the experiment is a class that is given learning treatment based on the STEM PjBL-based science learning module. While the control is a class that is given learning according to the approach used by the school. In the learning of the two classes, of course, there are variables that are controlled in the form of teaching teachers, learning duration, and learning materials. This is done to minimize the influence of other factors that might interfere with the results of the study, so that it is more accurate that the differences in results found in the study are indeed caused by differences in treatment between classes during learning.

The learning outcomes in this study have differences between the experimental class and the control class, especially seen in the tools produced. In the experimental class, there is freedom to submit ideas and be creative in making tools so that students between groups in this class produce different tools including windmills, transport cars and water filtration. While in the control class, students are not given the freedom to submit ideas for making the tools produced so that all groups produce the same tools. The concept of this control class is only limited to helping students understand the concept of material through projects, different from the experimental class which emphasizes the development of problem-solving skills, creativity and collaboration from students through problems found around the living environment.

The statistical results of the experimental class students' response to learning science material on effort, energy and simple machines with the STEM PjBL module are shown in Table 7.

Table 7. Statistics of the experimental class students response

Statistics		
N	Valid	31
	Missing	0
Mean		.8529
Median		.8390
Mode		.82
Std. Deviation		.04310
Minimum		.79
Maximum		.96

As shown in Table 7, students in the experimental class gave consistently positive responses to the module, with an average score of 0.85. Several aspects of the learning module used by the experimental class received a positive response from students and the average results of the indicators had approximately the same value. the average response of students per-indicator in the STEM PjBL module is depicted in diagram form in Figure 1.

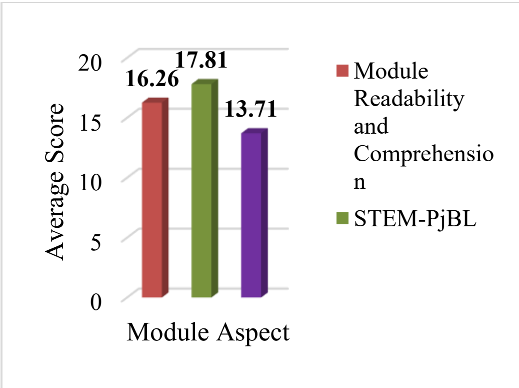

Figure 1. Average questionnaire response scores for each aspect of the STEM-PjBL learning module.

The values represent the average scores based on a four-point Likert scale (1 = Strongly Disagree, 4 = Strongly Agree). Figure 1 shows that the STEM-PjBL component in the questionnaire scored the highest, indicating that students valued the combination of the project and the STEM component the most. There are several indicators listed in the STEM PjBL aspect which can be calculated on average from the results of the learner response questionnaire shown in Figure 2.

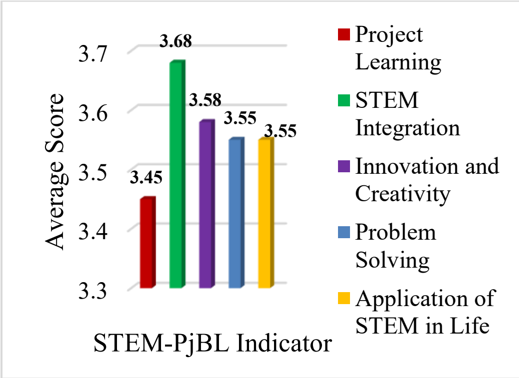

Figure 2. Average student response scores for each STEM-PjBL indicator.

The values represent the mean scores based on a four-point Likert scale (1 = Strongly Disagree, 4 = Strongly Agree). Higher scores indicate stronger agreement and more positive perceptions of each indicator. The STEM PjBL-based learning module used in this research is designed to facilitate learning to be more structured, but still flexible in the project model. With clear learning activities in the module, students can follow the learning stages systematically, starting from exploration of surrounding problems, project discussions to project completion. Based on the results of the research, learning effort, energy and simple machines is an ideal topic in applying the STEM PjBL approach. The concepts contained in the topic are easily connected to everyday life, such as the use of simple tools as examples of levers, pulleys, and inclined planes in activities. The use of real projects in learning allows students to see the direct relationship between the theory that students have learned and practice, thus encouraging students to be more actively involved in learning.

The participation of students between the experimental class and the control class in the observation results produced differences. The results of detailed observations can be seen in Table 8.

Table 8. Statistics of the observation results

Statistics Students Participation		Experiment Class	Control Class
N	Valid	31	30
	Missing	0	0
Mean		.8048	.5980
Median		.8000	.6000
Mode		.79	.60
Std. Deviation		.03595	.03527
Minimum		.75	.51
Maximum		.89	.67

As shown in Table 8, students in the experimental class demonstrated higher levels of participation (Good' category) compared to the control class ('Fair' category). The difference in the participation of the two classes looks significant, which can be illustrated in Figure 3.

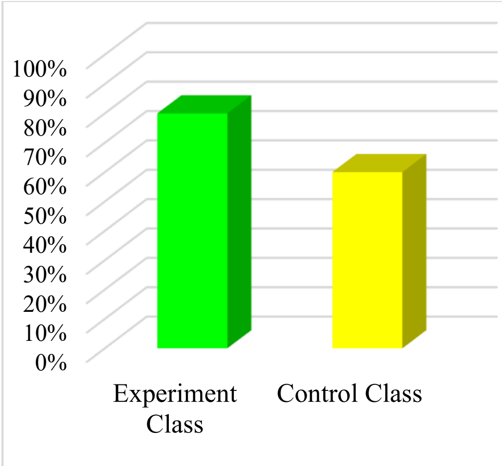

Figure 3. Comparison of average learner participation

Figure 3 representation indicates that the experimental and control groups' levels of engagement differ. The average degree of student participation in the two classrooms differs significantly, according to the comparison. The diagram shows that students in the experimental class who are allowed to use their imagination and creativity when selecting materials for projects are more likely to be actively involved in the process than students in the control class when using preset equipment. Additionally, this study shows that traditional teaching approaches continue to be less successful in raising student engagement. This is because of the teacher-centered approach, which makes students take on a more passive role.

In this study, the experimental and control classes were both divided into groups. The two classes differ in their originality; the experimental class is split into two groups according to the materials they utilize, specifically paper and plastic. This encourages students to take part more actively in group discussions and evaluations by giving them a place to exchange ideas and compare project outcomes amongst groups. Because all groups produce the same tools, group conversations in the control class tend to be less diversified because students are restricted to uniform tasks. Specific differences in student participation are shown in Figure 4.

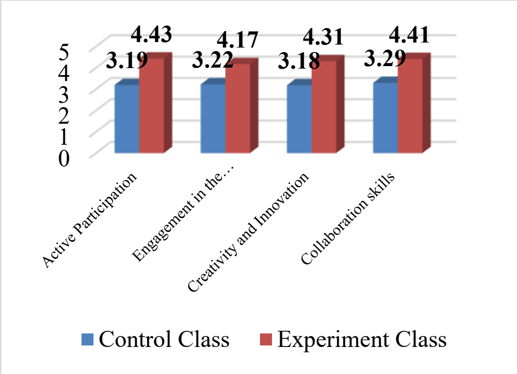

Figure 4. Comparison of average learner observation results participation aspect

The experimental class had increased levels of active engagement, teamwork, creativity, and learning involvement across the board Figure 4, demonstrating the beneficial effects of STEM PjBL. The Active Participation component shows how deeply students engage in tasks including posing questions, providing answers, discussion, and presenting the outcomes of group projects.

Through various dimensions, the STEM PjBL module provides opportunities for students to actively participate in the learning process. Students demonstrate a high level of engagement in the learning process by actively participating in data analysis, experimentation, and observation, as illustrated in Figure 4. As students are encouraged to come up with unique concepts and creative designs, the project-based learning method also encourages creativity. Students demonstrate a high level of teamwork by successfully dividing tasks, communicating within the group and completing tasks collaboratively.

On the other hand, the control class's observation data revealed an average contribution score of about 3, suggesting that while student participation was reasonably active, it was not as high as it was in the experimental class. Significant student involvement is hampered by conventional learning's lack of encouragement for critical thinking, teamwork, and problem-solving. Sari's research (2023), which claims that the PjBL technique greatly enhances students' collaboration skills, supports this conclusion. In the second cycle of her study, the collaboration score rose from 54% in the first to 74%. This demonstrates how PjBL can foster creativity, critical thinking abilities, and improved teamwork.

The experimental class employs a STEM PjBL-based science module, whereas the control class uses a traditional PjBL module. This is the main way that experimental and control classes differ from one another. Due to the parametric nature of the data, the Independent Sample T-Test was employed to test the hypothesis. The data is normally distributed, as indicated by the significance values of 0.542 (experimental class) and 0.562 (control class), both > 0.05, obtained from the One-Sample Kolmogorov-Smirnov Test. With a significant value of 0.544, the homogeneity test using Levene's Test revealed homogeneous variance between groups. As a result, the data are suitable for parametric t-test analysis. Table 9 displays the findings of homogeneity and normality tests.

Table 9. Normality test

One-Sample Kolmogorov-Smirnov Test				
		Response Questionnaire for the Use of Science Learning Module Based on STEM PjBL	Participation of Students Experiment Class	Participation of Students Control Class
N		31	31	30
Normal Parameters[a,b]	Mean	.8529	.8048	.5980
	Std. Deviation	.04310	.03595	.03527
Kolmogorov-Smirnov Z		.957	.802	.789
Asymp. Sig. (2-tailed)		.319	.542	.562

a. Test distribution is Normal.
b. Calculated from data.

Table 10. Homogeneity test

Levene's Test of Equality of Error Variances[a]			
F	df1	df2	Sig.
.373	1	59	.544

The One-Sample Kolmogorov-Smirnov Test results are consistent with the normality test significance provisions, which state that the data is normally distributed if the significance obtained is greater than 0.05. This is in accordance with Syamra's research (2024), which states that data with a sig value greater than 0.05 is considered normally distributed. Additionally, the homogeneity test is another prerequisite test to determine whether or not the variance distribution is homogeneous. According to the homogeneity test table that uses Levene's Test of Equality of Error Variances, the significance value is 0.544, indicating that the variance distribution is homogeneous. As a result, the data has met the prerequisite test when using parametric hypothesis testing.

Table 11. Independent sample t-test

Independent Sample T-Test		*T-test for Equality of Means*			
		t	df	*Sig. (2-tailed)*	*Mean Difference*
Participation	Equal variances assumed	22.674	59	.000	.20684
	Equal variances not assumed	22.681	58.988	.000	.20684

According to the t-test results table, under equal variance conditions, the statistical significance value (sig.) is 0.000. The value of the significant finding is less than the widely accepted significance level (α = 0.05). The sig. value indicates that the involvement of students in the experimental and control classes differs statistically significantly. This is consistent with research by (Kholifah et al., 2018) which found that the study's results had a sig. value of 0.02, or Sig. (2-tailed) <0.05, indicating a significant difference between the experimental and control classes in terms of student participation in science learning. According to Nurfaijah et al., (2021),students are more engaged in learning activities when utilizing the PjBL learning model with a STEM approach than when using traditional learning models. This study supports that finding. When learning activities are conducted in the control group, students focus more on the instructor. Conversely, students in the experimental class were urged to actively engage in educational activities that integrated the PjBL model with the STEM approach.

The findings of this study demonstrate that using the STEM PjBL approach to instruction can greatly boost student engagement. Because it is contextual and interactive, the project learning model (PjBL) can boost student engagement. This assertion is consistent with a number of earlier studies that show the PjBL model can foster an enjoyable learning environment by requiring students to actively participate in project creation, which raises their level of learning attention (Rachma et al., 2024)

In addition to using the PjBL approach, this study incorporates STEM components that can help to structure learning and reinforce students' improved engagement through their activities. This is in line with study by Pakpahan et al., (2023), which claims that using the STEM paradigm to teach science can boost students' engagement and collaboration. This is a result of the STEM model's active engagement of students in the educational process. In addition to hearing teacher explanations, students work on projects, solve problems, and do experiments. Thus, experimentation and project-based learning enable students to learn collaboratively and actively. This STEM PjBL learning can enhance students' communication, problem-solving, and teamwork skills. Additionally, students are encouraged to analyze observations and data, which calls for critical thinking abilities.

These results are reinforced by correlation test statistical data which produces a sig value <0.05, namely with a significance value of 0.02, which means that there is a correlation between the use of STEM PjBL-based science learning modules on student participation in the material of effort, energy and simple machines.

Table 12. Correlations test

Correlations		**Response Questionnaire for the Use of Science Learning Module Based on STEM PjBL**	**Participation of Students Experiment Class**
Response Questionnaire for the Use of Science Learning Module Based on STEM PjBL	Pearson Correlation	1	.539**
	Sig. (2-tailed)		.002
	N	31	31
Participation of Students Experiment Class	Pearson Correlation	.539**	1
	Sig. (2-tailed)	.002	
	N	31	31

Learner participation and the STEM PjBL module have a substantial positive link, as indicated by the Pearson correlation value of 0.539 with a significance level of 0.002. This positive association suggests that students' degree of participation in learning activities increases with their favorable response to the learning module.

The correlation results support previous findings that STEM education improves students' motivation, engagement, and academic performance. Khaira (2018) found high motivation in science learning with STEM, supported by (Hani & Rahma Suwarma, 2018), who noted increased enthusiasm through STEM-based instruction. Combined with the PjBL approach, STEM also enhances creativity. A higher N-gain and improved practical skill scores show that PjBL-STEM learning boosts both cognitive and psychomotor outcomes (Furi et al., 2018).

The findings align with Israwaty & Syam, (2021), who found that the STEM-PjBL approach enhances students' curiosity and motivation through problem-solving in groups or individually. Similarly, Sumaya et al., (2021) highlight several benefits of STEM-PjBL, including fostering scientific inquiry, critical thinking, creativity, interdisciplinary understanding, collaboration, independent learning, and the practical application of knowledge.

According to the study's findings, the hypothesis H_1, according to which there is an influence on student involvement, is accepted. However, H_0, which claims that using STEM PjBL-based science learning modules has no effect on student involvement, is disproved. The results of the independent sample t-test, which indicate a significant influence, are strengthened by the correlation significance value of 0.02 (<0.05), which indicates a positive influence. These findings corroborate the statistically significant link between student engagement and the variables of STEM PjBL-based science learning module utilization.

This study aligns with previous research, such as Sa'adhah et al., (2019), who found that the STEM approach improves students' cognitive, psychomotor outcomes, and engagement. Similarly, Putri & Rusijono, (2022) showed that PjBL enhances student activity, with a t-count of 2.281. However, this study showed a higher t-count of 22.674 for student participation, indicating a stronger impact likely due to the integration of STEM. As a collaborative approach combining science, technology, engineering, and math, STEM supports 21st-century skills like higher-order thinking, crucial for facing global challenges.

Four of these STEM components are required at the STEM and PjBL can be combined to create an engaging, integrated learning approach. STEM emphasizes the engineering design process, encouraging students to refine their work, while PjBL enhances understanding through product creation. The integration of STEM positively influences science and technology learning, contributing to a higher t-value in related research. Overall, STEM PjBL modules show greater impact on student engagement compared to using PjBL alone.

Based on these findings, several considerations emerge for broader implementation. The teacher's limited ability to assist students in matching projects to learning objectives was a major obstacle during the study. Some groups focused on work, energy, and basic machinery, but instead produced unrelated items (such as water filters). STEM-PjBL increases engagement, but its efficacy hinges on teachers maintaining alignment between projects and learning goals. Learning focus was further hampered by excessive project independence and minimal instructional guidance. To guarantee successful implementation, improvements such as clearer instructions, concept-validation forms, and teacher training in facilitating PjBL are required.

CONCLUSION AND SUGGESTION

Conclusion

The employment of STEM PjBL-based science learning modules has a favorable impact on student participation in learning, according to the description of the research findings. Tshe STEM PjBL-based science learning module has been successful in raising student engagement and enthusiasm in learning, which can lead to more active learning, according to the Pearson correlation value of 0.539 with a significance level of 0.002. A sig. value of 0.000 indicates a significant difference in student involvement between the experimental and control classes, with 80% of students in the experimental class and 60% in the control class. This demonstrates the acceptance of the study's H_1 hypothesis, which claims that the use of STEM PjBL-based science learning modules affects students' engagement with the content of work, energy, and simple machines.

Suggestion

Research results show that the STEM PjBL approach can be applied more widely to other science learning materials by involving more schools from different backgrounds to measure its effectiveness in general.

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