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Implementation of Project-Based Learning on Alternative Energy Materials to Enhance Class X Students' Cognitive Learning Outcomes at SMA Negeri 1 Perhentian Raja

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Abstract
The purpose of this research is to characterize and ascertain how project-based learning improves cognitive learning outcomes for students. The quasi-experimental research design are employed. The X-grade children of SMA Negeri 1 Perhentian Raja made up the study's population, while the X2 and X5 classes, which included 33 and 32 students respectively, served as the study's samples. Primary and secondary data are the two types of data collection methodologies. Descriptive and inferential analysis are two methods of data analysis. The group that used project-based learning had an average score of 60.7, falling into the "fairly good" category, according to the statistics. In contrast, the group that used traditional learning had an average score of 51.0 in the category of fairly good. A sig value was obtained from the hypothesis testing findings using the Independent sample t-test. There is a statistically significant difference between project-based learning and standard learning classes (2-tailed) 0.002 <0.05). These findings suggest that project-based learning on alternative energy sources can enhance the cognitive learning outcomes of SMA Negeri 1 Perhentian Raja class X students.

INTRODUCTION

The 21st century, in which we currently live, is marked by ever-faster innovations in every sphere of human endeavor (Rosnaeni, 2021). The field of education has many difficulties and difficult tasks, one of which is to develop competent human resources with a minimum of four skills, or what is popularly referred to as the "4C": critical thinking, communication, creativity, and collaboration (Partono et al., 2021). Teachers can use creative learning and learning that develops 21st-century abilities to generate these human resources (Mashudi, 2021). Teachers might use instructional models that encourage student participation in the learning process (Handayani & Wulandari, 2021). The project-based learning paradigm is one setting in which these abilities are put to use (Karomatunnisa et al., 2022).

A project-based learning paradigm emphasizes learning activities linked to the creation, manufacture, analysis, and even presentation of products (Nirmayani & Dewi, 2021). A learning approach called project-based learning (PjBL) gives teachers the chance to employ project work as a means of carrying out instruction (Eliza et al., 2019). The stages of the model of project-based learning as described by (Anggraini & Wulandari, 2020). (1) identifying the fundamentals; (2) creating a project plan; (3) planning; (4) keeping an eye on the project's advancement; (5) analyzing the outcomes; and (6) assessing the experience. The benefits of the project-based learning approach include improved student talents and skills, improved group collaboration, and improved student capacity for deliberation to arrive at a consensus in the group (Guo et al., 2020).

Physics is one of the SMA/MA lessons that can be implemented with a project-based learning methodology. According to observations made at SMA Negeri 1 Perhentian Raja, physics is taught in a traditional manner where professors employ the lecture approach, which makes students disinterested and unmotivated to master the subject. As a result, the researcher sought to use project-based learning as a different approach to teaching in the classroom.

The behavioral changes that take place as a result of cognitive learning outcomes include the ability to recall, interpret, apply, analyze, evaluate, and create (Anderson et al., 2001).

These observations are in line with research conducted by (Nurhaniah et al., 2022) that because they view physics as a challenging subject that needs more thought to understand and since learning is done traditionally, students are less motivated to learn the subject. The application of learning media in conventional physics education is relatively uncommon. Everything that teachers use to communicate with students so they can fully understand the material is considered learning media (Puspita Sari & Setiawan, 2018). Given the media's significant role in the educational process, it is expected of teachers to select the appropriate medium to meet learning objectives. Students who have little interest in learning physics may find it difficult to meet learning objectives, which will negatively impact the learning process and result in poor learning results for the students (Astalini et al., 2018).

This means that to prevent students from becoming disinterested and thinking that physics classes are hard, it is important to adopt a variety of learning strategies. Promoting students' enthusiasm in learning is the first step in using the project-based learning paradigm to enhance their learning results. Students will engage in practical learning and create valuable goods by utilizing the project-based learning paradigm of alternative energy media. The "Implementation of Project-Based Learning on Alternative Energy Materials to Improve Cognitive Learning Outcomes of Class X Students of SMA Negeri 1 Perhentian Raja" study was therefore carried out by researchers.

METHOD

A quasi-experimental design using a non-equivalent posttest-only control group design was the study methodology employed. The research was carried out at SMA Negeri 1 Perhentian Raja in the province of Riau's Kampar Regency. The 198 students in X grade at SMA Negeri 1 Perhentian Raja comprised the study's population. Class X2, which consisted of 33 students, was the experimental class used in this research, whereas class X5, which consisted of 32 students, served as the control class.

The research instrument used in this study was a test of cognitive learning outcomes of class X SMA students on alternative energy material. Where this cognitive learning outcomes test consists of 25 multiple choice questions that cover the cognitive domain according to Bloom's Taxonomy which consists of C1 to C6.

Primary and secondary data were used in this research data collection process. While initial test scores provided secondary data, posttest results provided primary data. Both descriptive and inferential analysis were employed in the data analysis process. In this research, descriptive analysis is used to characterize the cognitive learning results of the students. A method for analyzing sample data and extrapolating the findings to the population is called inferential analysis (Sugiyono, 2019). The normalcy, homogeneity, and hypothesis tests are the inferential analyses that are employed.

RESULT AND DISCUSSION

The memory (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6) learning outcomes data were taken from the posttest results of students in the experimental and control classes on alternative energy material. These learning outcomes data were used in this research. Table 1 shows the results of the post-test.

Table 1. Average Score of Cognitive Learning Outcomes

Aspect	Experimental class		Control class	
	X̅	Category	X̅	Category
Remembering	72,7	Good	61,0	Good enough
Understanding	57,6	Good enough	59,0	Good enough
Applying	54,5	Good enough	56,3	Good enough
Analyzing	60,3	Good enough	48,0	Not good
Evaluating	70,7	Good	56,0	Good enough
Creating	53,5	Good enough	36,0	Not good
Average	**60,7**		**51,0**	
Category	**Good enough**		**Good enough**	

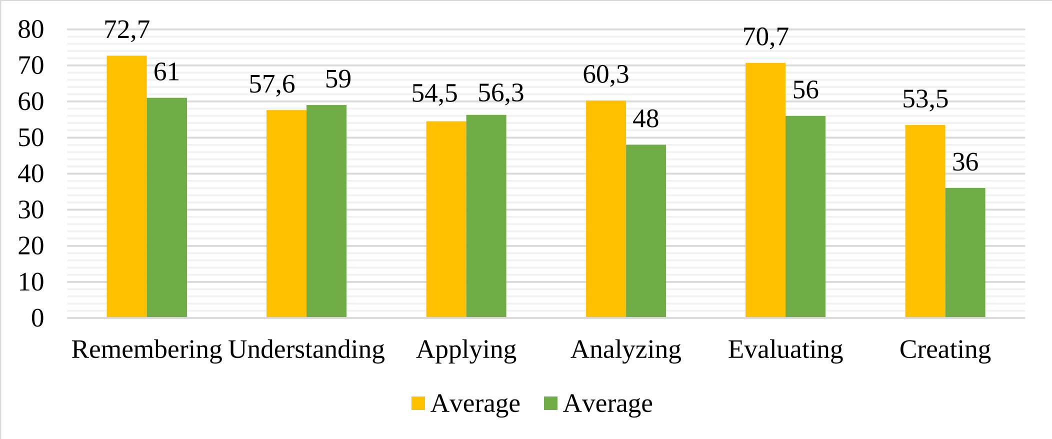

Figure 1. Graph of Average Score of Cognitive Learning Outcomes

The average score of the experimental class is higher than that of the control class in the cognitive domains of remembering (C1), analyzing (C4), evaluating (C5), and producing (C6), as shown by Table 1 and Figure 1. The control class performs better than the experimental class in the cognitive domains of comprehending (C2) and applying (C3).

Table 2. displays the inferential analysis in the form of a normality test using the Kolmogrov-Smirnov test. Table 2 indicates that the experimental class's significance value is 0.092, while the control class's is 0.200. This indicates that the sig value is less than 0.05, indicating that the data for the two classes is normally distributed.

Following the completion of the normalcy test, the homogeneity test is conducted, as shown in Table 3.

Table 2. Normality Test Results

		Kolmogorov-Smirnov[a]		
	Class	Statistic	df	Sig.
Posttest Score	X2 (Experimental)	.142	33	.092
	X5 (Control)	.099	32	.200*

Table 3. Homogeneity Test Results

Levene Statistic	df1	df2	Sig.
.041	1	63	.840

Table 3 provided the significance value of 0.840, indicating that the variance of the two classes is homogeneous and that the sig value is less than 0.05.

The data is homogeneous and normally distributed once the homogeneity and normality tests are completed, which satisfies the requirements for applying the Independent sample t-test for hypothesis testing. Table 4 below displays the results of the hypothesis test.

Table 4. Hypothesis Test Results

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Posttest Score	Equal variances assumed	.041	.840	3.174	63	.002	9.727	3.065
	Equal variances not assumed			3.176	62.996	.002	9.727	3.063

Table 4 indicates that there is a significant difference in students' cognitive learning outcomes between classes that apply project-based learning on alternative energy materials and classes that apply conventional learning on the same materials. The Sig. (2-tailed) value is 0.002 <0.05, which means that H_0 is rejected.

According to the study's findings, the experimental class's average score for indicators C1, C4, C5, and C6 is higher than that of the control class. The experimental class was inferior than the control class for indications C2 and C3. This is because, in contrast to the experimental class, which completes numerous projects, the control class's learning is teacher-centered, with the teacher explaining more content through power points. Nonetheless, the experimental class outperformed the control class in terms of overall average score. This is due to the fact that the experimental class completed numerous projects utilizing alternative energy KITs directed by LKPD during the learning process, including the Simple Windmill, Simple Waterwheel, and Simple Garden Lights LKPD. This is in line with what was said by (Aristiadi, Heldi; Putra, 2018) because the experimental class actively participated in the project's implementation using the project LKPD guide, the learning results of the experimental class that used the project LKPD were superior to the learning outcomes of the control class that did not use the project LKPD.

Project-based learning also teaches students how to build projects and find innovative solutions to issues (Chistyakov et al., 2023). One of the most important 21st-century skills is effective communication, which project-based learning may help with both (Rohmatin et al., 2023). Because students engage with the media directly through practical activities, project-based learning facilitates retention of the material. In line with research conducted by (Untari et al., 2020) that practical activities help 70% of students absorb the material more quickly, whereas hearing and seeing help 50%. Furthermore, as 83% of learners can recall information quickly when it is presented visually, learning is enhanced when media is used as a facilitator.

The experimental class outperformed the control class on the Higher Order Thinking Skills (HOTS) question in indications C4, C5, and C6. Project-based learning can therefore help students become more proficient at responding to HOTS questions (Hujjatusnaini et al., 2022). This is because the experimental class completed more projects using hands-on activities to assemble tools during the learning process. Through the completion of projects, students in experimental classes receive training to enhance their abilities in analysis, evaluation, and creation.

Students are more motivated to learn physics now that project-based learning is in place because they are actively participating in problem-solving through group projects and idea-sharing with friends and classmates through presentations. This is in line with what was said by (Alibraheim & El-Sayed, 2021) kids can improve their social and cognitive abilities as well as be motivated to learn since project-based learning gives them more chances to ask questions, make arguments, and draw conclusions from what they have learned. In line with what was said by (Santhosh et al., 2023) that project-based learning, as opposed to traditional learning, can enhance students' cognitive learning outcomes.

CONCLUSION

The study's findings and the subsequent discussion indicate that, when using project-based learning with alternative energy materials, class X students at SMA Negeri 1 Perhentian Raja achieved better cognitive learning outcomes than when using conventional learning methods. where project-based learning and traditional learning both produce cognitive learning results that fall within the "good enough" category. Nonetheless, project-based learning's cognitive learning outcomes outperform traditional learning when analyzed from the average score. The results of inferential analysis using hypothesis testing indicate that project-based learning and traditional learning differ significantly from one another. Thus, it can be said that project-based learning enhances the cognitive learning outcomes of students.

REFERENCES

Alibraheim, E. A., & El-Sayed, S. A. (2021). Exploring Female Undergraduate Education Students' Perceptions of Collaborative Online Project-Based Learning (COPBL). *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(8), 1–13. https://doi.org/10.29333/EJMSTE/11079

Anderson, L. W., Krathwohl Peter W Airasian, D. R., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *A Taxonomy for Learning, Teaching, and Assesing: A Revision of Bloom's Taxonomy of Educatioanl Objectives*. Addison Wesley Longman, Inc.

Anggraini, P. D., & Wulandari, S. S. (2020). Analysis of the Use of Project Based Learning Model in Increasing Student Activeness. *Jurnal Pendidikan Administrasi Perkantoran (JPAP)*, *9*(2), 292–299. https://doi.org/10.26740/jpap.v9n2.p292-299

Aristiadi, Heldi; Putra, R. R. (2018). The Effect of Using Project-Based Learner Worksheets (LKPD) on Student Learning Outcomes on the Concept of Global Warming. *Bioedusiana*, *3*(24). https://doi.org/https://doi.org/10.34289/277886

Astalini, A., Kurniawan, D. A., & Sumaryanti, S. (2018). Students' Attitudes Towards Physics Lessons at SMAN Batanghari Regency. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *3*(2), 59. https://doi.org/10.26737/jipf.v3i2.694

Chistyakov, A. A., Zhdanov, S. P., Avdeeva, E. L., Dyadichenko, E. A., Kunitsyna, M. L., & Yagudina, R. I. (2023). Exploring the characteristics and effectiveness of project-based learning for science and STEAM education. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(5). https://doi.org/10.29333/EJMSTE/13128

Eliza, F., Suriyadi, S., & Yanto, D. T. P. (2019). Improving Students' Psychomotor Competence Through Project Based Learning Model (PjBL) at SMKN 5 Padang. *INVOTEK: Jurnal Inovasi Vokasional Dan Teknologi*, *19*(2), 57–66. https://doi.org/10.24036/invotek.v19i2.427

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International Journal of Educational Research*, *102*(May), 101586. https://doi.org/10.1016/j.ijer.2020.101586

Handayani, R., & Wulandari, D. (2021). Modern Assessment for 21st Century Learning and Barriers in Developing Countries. *Jurnal Pendidikan Edutama*, *8*(1), 13. https://doi.org/10.30734/jpe.v8i1.1363

Hujjatusnaini, N., Corebima, A. D., Prawiro, S. R., & Gofur, A. (2022). the Effect of Blended Project-Based Learning Integrated With 21st-Century Skills on Pre-Service Biology Teachers' Higher-Order Thinking Skills. *Jurnal Pendidikan*

IPA Indonesia, *11*(1), 104–118. https://doi.org/10.15294/jpii.v11i1.27148

Karomatunnisa, A.-Z. A., Sholih, J. A. U., Hanifah, N., & Prihantini, P. (2022). Meta-Analysis of Project Based Learning Model in Improving 21st Century Skills Capability. *Jurnal Pendidikan Sosiologi Dan Humaniora*, *13*(2), 522. https://doi.org/10.26418/j-psh.v13i2.54755

Mashudi, M. (2021). Modern Learning: Equipping Learners with 21st Century Skills. *Al-Mudarris (Jurnal Ilmiah Pendidikan Islam)*, *4*(1), 93–114. https://doi.org/10.23971/mdr.v4i1.3187

Nirmayani, L. H., & Dewi, N. P. C. P. (2021). Project Based Learning Model in accordance with 21st Century Learning with Tri Kaya Parisudha. *Jurnal Pedagogi Dan Pembelajaran*, *4*(3), 378. https://doi.org/10.23887/jp2.v4i3.39891

Nurhaniah, A., Kaharuddin, K., & Ali, M. S. (2022). Diagnosis of Physics Material Difficulties in Xi Ipa Class Students of Sma Negeri 3 Barru. *Jurnal Sains Dan Pendidikan Fisika*, *18*(2), 161. https://doi.org/10.35580/jspf.v18i2.34491

Partono, P., Wardhani, H. N., Setyowati, N. I., Tsalitsa, A., & Putri, S. N. (2021). Strategies to Improve 4C Competencies (Critical Thinking, Creativity, Communication, and collaborative. *Jurnal Penelitian Ilmu Pendidikan*, *14*(1), 41–52. https://doi.org/10.21831/jpipfip.v14i1.35810

Puspita Sari, A., & Setiawan, A. (2018). The Development of Internet-Based Economic Learning Media using Moodle Approach. *International Journal of Active Learning*, *3*(2), 100–109. http://journal.unnes.ac.id/nju/index.php/ijal

Rohmatin, D. N., Masfingatin, T., & Widodo, C. W. (2023). Project-Based Learning: An Effort to Improve Communication Skills and Student Learning Outcomes. *Quantum: Jurnal Inovasi Pendidikan Sains*, *14*(2), 173. https://doi.org/10.20527/quantum.v14i2.16292

Rosnaeni, R. (2021). Characteristics and Assessment of 21st Century Learning. *Jurnal Basicedu*, *5*(5), 4341–4350. https://doi.org/10.31004/basicedu.v5i5.1548

Santhosh, M., Farooqi, H., Ammar, M., Siby, N., Bhadra, J., Al-Thani, N. J., Sellami, A., Fatima, N., & Ahmad, Z. (2023). A Meta-Analysis to Gauge the Effectiveness of STEM Informal Project-Based Learning: Investigating the Potential Moderator Variables. *Journal of Science Education and Technology*, *32*(5), 671–685. https://doi.org/10.1007/s10956-023-10063-y

Sugiyono. (2019). *Quantitative, Qualitative and R&D Research Methods*.

Untari, R. S., Kamdi, W., Dardiri, A., Hadi, S., & Nurhadi, D. (2020). The Development and Application of Interactive Multimedia in Project-Based Learning to Enhance Students' Achievement for 2D Animation Making. *International Journal of Emerging Technologies in Learning (IJET)*, *15*(16), 17. https://doi.org/10.3991/ijet.v15i16.16521