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THE EFFECT OF THE PROJECT BASED LEARNING MODEL ON THE LEARNING OUTCOMES OF HIGH SCHOOL STUDENTS IN PASCAL'S LEGAL MATERIAL

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Abstract: This study aims to analyze the influence of the Project-Based Learning (PjBL) model on the learning outcomes of high school students in Pascal's Law material. The background of this research is the low level of students' understanding of Pascal's Law, which is often taught theoretically, so it is less contextual and can be applied. This study uses a quantitative approach with quasi-experimental methods and Pretest-Posttest Design of Control Groups. The research subjects were 11th grade students of SMA Negeri 1 Sei Bamban for the 2024/2025 academic year, with a total sample of 60 students, consisting of 30 students in the experimental class and 30 students in the control class, selected using purposive sampling. The research instrument consisted of a multiple-choice learning outcome test with 20 validated items and an observation sheet of student activities. The results showed that the average pretest scores of the two classes were relatively equivalent (experimental = 45.33; control = 45.17) with a significance value of 0.960 (>0.05), indicating no significant difference in initial ability. After treatment, the average post-experimental class score increased to 78.67, while the control class only reached 66.33. The t-test reveals a significant difference between the two classes (Sig. <0.05). Student activity in the experimental class was also recorded high, with an average of 79.97% in the active category. It can be concluded that the application of the Project-Based Learning model has a significant influence on improving student learning outcomes in Pascal's Law compared to conventional learning. These findings reinforce previous literature on the effectiveness of PjBL as an innovative learning strategy that is able to connect abstract concepts with students' real-life experiences.
Keywords: Project-Based Learning, Learning Outcomes, High School Students, Pascal's Law

1. INTRODUCTION

21st century education demands a fundamental transformation in the learning process (Silaban et al., 2025), where students are no longer positioned only as passive recipients of information, but also as active subjects in building knowledge (Alexander et al., 2024). Science education, especially physics, has an important role in shaping students' critical, logical, and creative thinking skills (Silaban et al., 2024). Physics is not just a collection of formulas or theories, but is a science that explains natural phenomena and their application in daily life (Sinaga et al., 2024). However, in practice, learning physics is often still theoretical, abstract (Sirait et al., 2021), and less involving real learning experiences that can enhance students' conceptual understanding (Sirait et al., 2025). This condition has implications for the low interest and learning outcomes of students in the field of physics (Sitinjak et al., 2024), including on the topic of Pascal's Law, which should be very contextual as it relates directly to various fluid pressure-based technologies (Sirait et al., 2024).

In recent decades, various learning model innovations have been introduced to overcome the weaknesses of conventional learning (Silaban et al., 2020). One of them is Project Based Learning (PjBL) (Pardede et al., 2024). PjBL is a student-centered learning model with an emphasis on learning activities through real projects (Ramadhan et al., 2025). This model not only requires students to understand concepts, but also to design, create, and present works as solutions to given problems (Pasaribu et al., 2024). Several studies report that the application of PjBL contributes positively to students' critical thinking skills, collaboration, and cognitive learning outcomes (Alexander et al., 2023). Thus, PjBL is believed to be relevant applied in physics learning which requires students to connect theory with everyday reality (Anwar et al., 2021).

Research on PjBL in science learning has been conducted by a number of researchers. For example (Safitri et al., 2025) showed that there was a significant influence of the Quipper School-assisted Project Based Learning (PjBL) learning model on students' cognitive learning achievement in sociology. Other research by (Ahmad et al., 2025) revealed that there was a significant increase in students' collaboration skills and creativity after the implementation of the PjBL learning model. In the field of physics, several studies stated that PjBL can increase student involvement in experimentation and concept understanding (Ramadhan et al., 2025). However, most research is still focused on the topic of electricity or mechanics (Siahaan et al, 2023), while studies that specifically highlight Pascal's Law and fluid pressure are still limited. In fact, this material has great potential to be taught through PjBL because it is very closely related to simple technological devices that students can make, such as mini hydraulic jacks, simple pumps, or hydraulic brake systems (Sirait, Aleksander, & Silaban, 2023). Based on this study, it can be identified that the gap can be identified that previous research has mostly discussed the effectiveness of PjBL in the fields of biology, chemistry, or physics on certain topics, but it is still rare to research the application of PjBL in depth to Pascal's Law material (Sirait., 2025). In addition, most of Pascal's Law learning in the classroom still uses the conventional approach in the form of lectures and practice questions, which lack applicative experience for students (Safitri et al., 2025). As a result, students can memorize the law, but are less able to explain its practical application in real life. This gap is the basis for the importance of this research (Alexander et al., 2024).

The main problem in this study is how to improve the learning outcomes of high school students in Pascal's Law material through a more contextual learning model, applicative, and innovative. Based on this, the hypothesis of this study is: *"There is a significant influence of*

the application of the Project Based Learning model on the learning outcomes of high school students in Pascal's Law material compared to conventional learning." To answer these problems, this study implements the Project Based Learning model in Pascal's Law learning. With this approach, students not only learn theoretical concepts, but also design and create simple projects based on the principles of Pascal's Law (Silaban et al., 2021). For example, the creation of miniature hydraulic jacks, which allow students to see firsthand the application of the law while practicing creative thinking, problem-solving, and group collaboration skills.

Specifically, this study aims to:

a. Describe the process of applying the Project Based Learning model in Pascal's Law learning in high school.
b. Analyzing the effect of the application of Project Based Learning on students' cognitive learning outcomes on Pascal's Law material.
c. Provide alternative innovative learning strategies that are applicable to improve the quality of physics learning in secondary schools.

Through this study, it is hoped that it can make an empirical contribution to the development of a more effective physics learning model, as well as enrich the literature on the application of PjBL in the context of fluid pressure materials, especially Pascal's Law.

2. RESEARCH METHODS

This study uses a quantitative approach with the *Quasi-Experiment* and design *Pretest Design–Post-Control Group* (Silaban et al., 2025). This design involves two groups, namely the experimental class and the control class. The experimental class received treatment using the Project Based Learning (PjBL) model, while the control class was taught using the conventional learning model. Before the treatment was given, both groups first underwent a pretest to determine the student's initial ability, and after the learning process was completed, a posttest was given to measure the improvement in learning outcomes after the treatment.

This research was carried out at SMA Negeri 1 Sei Bamban, which is located in Gempolan Village, Sei Bamban District, Serdang Bedagai Regency, in the 2024/2025 school year. The research population is all grade XI students of SMA Negeri 1 Sei Bamban which totals 150 students from five classes. From this population, class XI-1 was designated as an experimental class and class XI-3 as a control class, each amounting to 30 students. The determination of the sample was carried out using the purposive sampling technique, which is

the selection of samples based on certain considerations that are in accordance with the purpose of the research.

The variables used in this study consist of two types, namely independent variables (X) and bound variables (Y). The independent variable is the Project Based Learning (PjBL) model, while the bound variable is the learning outcomes of students in the cognitive realm of Pascal's Law material. The material taught is Pascal's Law which is formulated as:

$$P = \frac{F}{A}$$

Description:P = pressure (N/m²),
F = force (N),
A = cross-sectional area (m²).

The principle of application of Pascal's Law to hydraulic systems is stated:

$$\frac{F1}{A1} = \frac{F2}{A2}$$

Description:F1= force on a small cross-section (N),
A1 = small cross-sectional area (m²),
F2 = force on a large cross-section (N),
A2 = large cross-sectional area (m²).

Research instruments consist of several types. First, the learning outcome test is in the form of 20 multiple-choice questions used for both pretest and posttest. These questions have gone through a validation process, reliability test, and difficulty level analysis to ensure the quality of the instruments. Second, student activity observation sheets are used to record student involvement and activeness during the PjBL-based learning process in experimental classes. The data collection technique is carried out through three main stages, namely pretest, posttest, and observation. The pretest is given before the implementation of learning to find out the initial ability of the students, while the posttest is given after all learning activities are completed to see the improvement in learning outcomes. Observation was carried out in conjunction with the learning process in the experimental classroom to monitor student activities in the application of the PjBL model.

The data obtained was analyzed through several stages. First, a normality test was carried out using the Kolmogorov–Smirnov test at a significance level of 5% ($\alpha = 0.05$) to ensure normal data distribution. Second, a homogeneity test was carried out using the Levene

Test to find out the similarity of variance between groups. After these two prerequisites are met, a hypothesis test is carried out using the Independent Sample t-test. The decision-making criteria are: if the significance value (Sig.) > 0.05 then H_0 is accepted, which means that there is no significant influence between the two learning models on student learning outcomes; on the other hand, if Sig. < 0.05 then H_0 is rejected and H_1 is accepted, which indicates a significant influence of the PjBL model on student learning outcomes (Alexander et al., 2025).

3. RESULTS AND DISCUSSION

This study aims to determine the influence of the Project Based Learning (PjBL) model on the learning outcomes of grade XI students of SMA Negeri 1 Sei Bamban on Pascal's Law material. The data from the research results were obtained through learning outcome tests (pretest and posttest) as well as observation of student activities during the learning process. The average results of pretest and posttest student learning outcomes can be seen in Table 1.

Table 1. Average Pretest and Posttest of Student Learning Outcomes

Class	Average prates	Posttest Average	Increased
Experiment	45,33	78,67	+33,34
Control	45,17	66,33	+21,16

Based on the results of the pretest, it was obtained that the initial ability of students in the experimental class and the control class was relatively equivalent. The average pretest score of the experimental class was 45.33 with a standard deviation of 13.58, while the control class had an average of 45.17 with a standard deviation of 11.71. The t-test showed a significance value of 0.960 (> 0.05), meaning there was no significant difference in initial ability between the two groups. This is important because it ensures initial equality before treatment is given. After being given different treatments, the posttest results showed an increase in learning outcomes in both groups, but a more significant improvement occurred in the experimental class. The average posttest score of the experimental class reached 78.67 (good category), while the control class was only 66.33 (fair category). The standard deviation of the experimental class was 8.40 and the control class was 9.46. The results of the observation also showed that student activities during the implementation of the PjBL model were in the active category, with an average score of 79.97%. Students are intensively involved in project design, group discussions, and presentation of project results in the form of simple hydraulic jacks.

The results of this study show that the application of the Project Based Learning model has a significant influence on improving student learning outcomes. This is shown by the higher posttest value of the experimental class than that of the control class. These findings support the research hypothesis that there is a significant influence of the application of PjBL on student learning outcomes in Pascal's Law material. Theoretically, these findings are in line with the principles of constructivism, where students build their knowledge through hands-on experience, collaboration, and real-world problem-solving. Pascal's Law material that is abstract becomes more meaningful when students practice it through a simple hydraulic tool making project (Sirait et al., 2023). The results of this study are also in line with the findings of the (Ahmad et al., 2025) which shows that PjBL is able to improve students' collaboration skills and creativity in biology materials. The active involvement of students in real projects encourages them to work together, think critically, and produce concrete products. Similarly (Safitri et al., 2025) proving that the implementation of PjBL assisted by Quipper School's digital media increases students' cognitive learning achievement in sociology subjects. The two studies reinforce this finding, that PjBL is effective in improving cognitive learning outcomes, high-level thinking skills, and learning motivation.

4. CONCLUSIONS AND SUGGESTIONS

CONCLUSION

The application of the Project Based Learning (PjBL) model has a significant effect on the learning outcomes of grade XI students of SMA Negeri 1 Sei Bamban on Pascal's Law material. Students who study with the PjBL model show improved learning outcomes and better activities compared to conventional learning. These findings prove the effectiveness of PjBL in improving physics learning outcomes and helping students relate concepts to real experiences.

SUGGESTION

Based on the results of the research, it is recommended that physics teachers use the Project Based Learning (PjBL) model as an alternative learning strategy, especially in abstract and applicative materials such as Pascal's Law.

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BIBLIOGRAPHY

Ahmad, J., Usman, N.F., Dama, L., & Pagalla, D.B. (2025). *The Effect of Project Based Learning Model on Students' Collaboration Skills and Creativity on Plant Network Structure and Function Material in Class Xi State High School 1 Kabila (The Effect of the Project Basic Learning Model on Students ' C*. *11*, 430–443.

Alexander, I. J., Sinurat, H., Sirait, G., Siahaan, M. M., Silaban, R., & Nainggolan, J. R. (2024). Language and Technology Literacy Education in Early Childhood at the I See You Foundation (AME) Medan. *JOURNAL of Community Service: Journal Related to Community Service Activities, Especially in the Fields of Technology, Entrepreneurship and Social Society*, *6*(2).

Alexander, I. J., Sinurat, H., Nainggolan, J. R., & Sirait, G. (2024). Education on the Problem of Hoaxes and Cyberbullying in Adolescents of the Indonesian Pentecostal Church (GPI) Paya Kapar Congregation of Tebingtinggi City. *Journal of Community Service of the Archipelago (JPkMN), 5*(2), 2379–2383.

Alexander, I. J., Sirait, G., Sibarani, I. S., & Sitorus, L. (2023). Digital Literacy Education in Countering the Spread of Hoaxes in the Community. *Research Development of Indonesian* Journals, *1*(4), 1–5.

Alexander, I. J., Siregar, S. S., Sitorus, G. N., & Zalogo, W. K. (2025). *Control of cyberbulllying and hoaxes through guided training at SMK Negeri 2 Tebing Tinggi*. *2*(1), 49–56.

Anwar, Y., Fadillah, A., & Syam, M. (2021). The Effect of the Project Based Learning Model on the Learning Outcomes of Class X Students at SMA Negeri 11 Samarinda. *Journal of Education*, *30*(3), 399–408. https://doi.org/10.32585/jp.v30i3.1753

Cahaya Ramadhan, U., Jamaluddin, Rasmi, D. A. C., & Kusmiyati. (2025). The Effect of Project Based Learning Model-Based LKPD on Biology Learning Outcomes and Critical Thinking Tendencies of SMA Negeri 2 Mataram Students. *Journal of Classroom Action Research*, *7*(2), 673–682. http://jppipa.unram.ac.id/index.php/jcar/index_____

Gloria Sirait. (2025). Analysis of the quality of biobriquettes from salak bark with starch adhesives. *EduMatScience: Journal of Education, Mathematics and Science*, *9*(2), 232–243.

Pardede, D.L., Pardede, L., Siahaan, M., Alexander, J.I., & Sirait, G. (2024). THE IMPLEMENTATION OF A PROBLEM-BASED LEARNING MODEL ON STUDENTS' PKN LEARNING OUTCOMES IN THE MATERIAL ON THE EQUALITY OF CITIZENS' POSITION. *Journal of Mental Health*, *32*(6), 426–430.

Pasaribu, K., Pardede, L., Alexander, J.I., & Pardede, D. (2024). ACTIVE LEARNING APPROACH WITH THE CARD SORT METHOD TO IMPROVE STUDENT LEARNING ACHIEVEMENT. *Darma Agung Journal*, *32*(5).

Safitri, V., Sukardi, S., Nursaptini, N., & Suryanti, N. M. N. (2025). The Influence of the Quipper School Media-Assisted Project Based Learning Model on the Cognitive Learning Achievement of Sociology Grade XI Students of SMAN 1 Jonggat. *Scientific Journal of the Education Profession*, *10*(2), 1875–1880. https://doi.org/10.29303/jipp.v10i2.3258

Siahaan, RDR, & Sirait, G. (2023). The Importance of Digital Literacy in the Era of Society 5.0. *Journal of Indo-Mathematical Intellectuals*, *4*(3), 1734–1742.

https://doi.org/10.54373/imeij.v4i3.417

Silaban, R., Panggabean, F. T., Panggabean, M. V., Sianturi, P. A., & Alexander, I. J. (2021). Development of Android-based learning media for chemical balance materials 121-131. *Indonesian Journal of Education*, *9*(3), 121–131.

Silaban, R., Panggabean, F. T. M., Hutapea, F. M., Hutahaean, E., & Alexander, I. J. (2020). The implementation of problem-based-learning (PBL) and a scientific approach using card media to improve students' learning outcomes about teaching chemical bonds. *Indonesian Journal of Education*, *8*(2).

Silaban, B., Surbakti, M.B., Josafat, I., & Silaban, A. (2024). *Lens: Journal of Physics Education Identification of Misconceptions of High School Students Through a Four-Tier Diagnostic Test on Newton's Law Identification of Senior High Learner's Misconceptions Through A Four-Tier Diagnostic Test on Newton's Law PENDAHUL*. *12*(2), 260–274.

Silaban, R., Riris, D. I., Sitorus, M., Tambunan, Y. A., Alexander, I. J., & Sirait, G. (2025). *Development of an innovative e-module based on Project Based Learning (PJBL) Integrated Mendel Eating Local Wishdom (Man Belo or Marsukil) from North Sumatra on Teaching Stoichiometric Chemistry using Anyflip*. *10*, 932–945.

Silaban, R., Sijabat, C. Y., & Nasution, H. A. (2025). *DEVELOPMENT OF E-MODULES BASED ON SAVI. 10* (July), 76–87.

Sinaga, G. H. D., Halawa, A., Prasetyo, R. A., Silaban, I. J. A., & Sinaga, M. P. (2024). Changes in Coulomb stress in the 2004 Aceh earthquake on Mount Sibualbuali and Mount Lubukraya. *Journal of Physics and Technology Education*, *10*(2), 264–273.

Sirait, G., Tobing, P. U. A. L., & Djulia, E. (2021). Biology Teacher's Understanding of Nature Science (NOS). *Journal of Mathematics and Natural Sciences*, *1*(2).

Sirait, G., Alexander, I. J., & Mahulae, S. H. R. (2023). Socialization of the cultivation of the noble values of Pancasila. *Research Development of Indonesian Journal of Service (P3JI), 1*(3), 104–108.

Sirait, G., Alexander, I. J., & Silaban, R. (2023). *Analysis of the Utilization of Hydroponic Media on Welsh Onions (Allium fistulosum L .) Cultivation*. *6*(2), 147–157.

Sirait, G., Alexander, J.I., & Soripada, T.A. (2024). *Digital Entrepreneurship Training for the Indonesian Pentecostal Church Congregation Paya Kapar Tebingtinggi*. *6*, 397–403.

Sirait, G., Alexander, I. J., Uli, M., Purba, M., Lestari, K., & Miranda, X. S. (2025). *Plastic waste in college*. *10*(1), 309–324.

Sitinjak, E. K., Marbun, J., Alexander, I. J., Sagala, I., & Statis, F. (2024). *Development of static fluid E-LKPD based on the 7E learning cycle model using the Canva application*. 897–910. https://doi.org/10.47709/educendikia.v4i03.4856