

THE EFFECT OF PROBLEM-BASED LEARNING ASSISTED BY THE PHET SIMULATION APPLICATION ON STUDENTS' LEARNING OUTCOMES ON THE TEMPERATURE AND HEAT MATERIAL

Nissi WF Manalu¹, Bajongga Silaban², Juliper Nainggolan³

^{1,2,3}Pendidikan Fisika, Fakultas Keguruan dan Ilmu Pendidikan, Universitas HKBP Nommensen, Indonesia
Corresponden E-mail; nissiwf.manalu@student.uhn.ac.id

Abstract

This study aims to determine the effect of the problem-based learning model assisted by the PhET Simulation application on student learning outcomes in the material of temperature and heat in class XI of GKPI Padang Bulan Medan Private High School. The research method used is a pre-experiment with a population of all class XI students of GKPI Padang Bulan Medan Private High School totaling 81 people. The sampling technique used is purposive sampling, and the sample is class XI IPA totaling 26 people. The instrument used is a multiple-choice learning outcome test consisting of 20 items. Before being given treatment to students, a prerequisite test was first carried out that the instrument used was indeed appropriate. Next, a pretest was given to students without any learning with an average score obtained of 24.42. After the pretest was given treatment, then continued with giving a posttest and the average score obtained was 83.65. To see the difference in pretest and posttest results, a one-tailed t-test was carried out with $\alpha = 0.05$. From the results of data analysis with N-Gain, it was finally concluded that there was an influence of problem-based learning assisted by the PhET simulation application on the learning outcomes of class XI IPA students at GKPI Padang Bulan Medan Private High School on the material of temperature and heat.

Keywords: Problem-based learning; PhET simulation; Learning outcomes

Abstrak

Penelitian ini bertujuan untuk menentukan pengaruh model pembelajaran berbasis masalah yang dibantu oleh aplikasi simulasi PhET terhadap hasil belajar siswa pada materi suhu dan panas di kelas XI SMA Swasta GKPI Padang Bulan Medan. Metode penelitian yang digunakan adalah pre-eksperimen dengan populasi seluruh siswa kelas XI SMA Swasta GKPI Padang Bulan Medan sebanyak 81 orang. Teknik sampling yang digunakan adalah purposive sampling, dan sampelnya adalah kelas XI IPA sebanyak 26 orang. Instrumen yang digunakan adalah tes hasil belajar pilihan ganda yang terdiri dari 20 item. Sebelum memberikan perlakuan kepada siswa, terlebih dahulu dilakukan tes prasyarat untuk memastikan bahwa instrumen yang digunakan memang sesuai. Selanjutnya, diberikan pretest kepada siswa tanpa pembelajaran, dengan rata-rata skor yang diperoleh sebesar 24,42. Setelah pretest, diberikan perlakuan, diikuti dengan posttest, dengan rata-rata skor yang diperoleh sebesar 83,65. Untuk melihat perbedaan hasil pretest dan posttest, dilakukan uji t satu ekor dengan $\alpha = 0,05$. Dari hasil analisis data dengan N-Gain, akhirnya disimpulkan bahwa terdapat pengaruh pembelajaran berbasis masalah yang dibantu oleh aplikasi simulasi PhET terhadap hasil belajar siswa kelas XI IPA di Sekolah Menengah Atas Swasta GKPI Padang Bulan Medan pada materi suhu dan panas.

Kata kunci: Pembelajaran berbasis masalah, simulasi PhET, hasil belajar

INTRODUCTION

Education is a very important process in human life that aims to shape a person or group of people to have good attitudes and behaviors as well as be responsible and mature in responding to various problems, through the process of training and teaching that is carried out during the education period. Law No. 20 of 2003 (SHELEMO, 2023) concerning the national education system states that: "Education functions to develop individual abilities and shape character or thought patterns that are able to enlighten the life of the nation, aiming to create students who have noble morals and are devout to God Almighty and are able to develop the talents and abilities that exist within themselves." Education is something that is very essential in the process of humanization in a cultured society. In today's era of globalization, tremendous changes are occurring in human life. It is unavoidable that the tsunami of globalization has entered every inch of modern human life (Alfauzia, n.d.).

Quality human resources are people who are able to understand knowledge and apply that knowledge in everyday life that is beneficial for themselves and the surrounding community, therefore we need knowledge to compete with the outside world and one way we can do this is by developing education (Agustina, Wahyudi, & Sri Putu Verawati, 2024). Physics is a subject that discusses natural phenomena with the aim of enabling students to think and reason (Panggabean, Rahman, & Simanullang, 2025). Through these thinking and reasoning abilities, students can ultimately develop and expand their thinking power and knowledge, Supardi (Arifudin, 2021) notes.

According to Njaung (Bangun et al., 2024), in physics learning, the end result is not the primary focus; understanding every principle, theory, and concept in physics is also crucial. Students must understand the physics concepts and facts they know to improve their abilities and solve problems. Most physics concepts are abstract, and many students don't understand the relationships between concepts or the key concepts needed to understand them. As a result, students begin to struggle to grasp basic concepts while learning (Ulandari, Amry, & Saragih, 2022).

According to Gunel, Hand, and Gunduz, as quoted by Abdurrahman in (Putria, Serevina, & Budi, 2019) physics as a subject requires understanding and the ability to represent different concepts being studied. According to Yulianti & Wiyanto (in Yeni, 2021), physics is one of the subjects considered difficult by some students. This perception is evidenced by students' opinions that physics is too formulaic, boring, and lacks mastery of physics. Students' ignorance of the usefulness of physics in everyday life is the reason they quickly become bored and uninterested in physics (Khurniati, Harun, & Nur Aini, 2023).

In general, physics is one of the subjects that is less popular with most students because learning physics requires a fairly high level of understanding, and is considered complicated because it requires understanding the relationship between principles, theories, and concepts (Fannisa, Anggraini, Romdani, & Dewi, 2023). This is one of the factors that cause low student learning outcomes in physics learning. In everyday life, there are many factors that cause low student learning outcomes, one of which is the rapid development of technology, capable of

creating sophisticated gadgets equipped with a very large number of game applications, as well as television shows that ultimately distract students from lessons and increase students' laziness in learning and ultimately have a negative impact on student learning outcomes, especially in physics learning (Debi & Wahyuni, 2018).

From the results of the author's interviews with students and physics teachers at GKPI Padang Bulan Medan Private High School, it can be concluded that the learning outcomes of students at GKPI Padang Bulan Medan Private High School are still relatively low. This is caused by the lack of student involvement in the learning process (Malahayati, Corebima, & Zubaidah, 2015). The physics teacher also said that he still does not use applications as a medium in learning and is said to still use conventional methods. Then the low learning outcomes of students are also influenced by the incomplete equipment in the laboratory for conducting practicums so that students are less able to understand physics concepts in real terms, because they cannot be directly practiced (Noervadila & Astidari, 2019). This has the potential to cause students to be reluctant to study physics more seriously, because the material they learn is too much in the form of formulas. To achieve learning objectives, it is necessary to apply learning tools (Burgess & Matar, 2020).

Teachers as the spearhead of learning are required to be creative in preparing the learning tools used, of course by paying attention to all aspects that influence learning, one of which is the potential diversity of intelligence possessed by students (Arisandy, Marzal, & Maison, 2021).

According to Buhungo in (Panda & Boy, 2021) learning tools are one way that can be used to optimize the learning process by selecting methods, models and designs that can increase students' interest and motivation to learn so that this can have a big impact on student learning outcomes (Hadi, Prihasti Wuriyani, Yuhdi, & Agustina, 2022).

Therefore, to improve student learning outcomes in physics learning, a problem-based learning model assisted by a virtual laboratory application, namely PhET, is used. Therefore, the author conducted a study entitled "The Effect of Problem-Based Learning Assisted by the PhET Simulation Application on Student Learning Outcomes in Temperature and Heat Materials."

RESEARCH METHODS

The type of research used by the author is pre-experimental, with a one group pretest-posttest design. This research was conducted at GKPI Padang Bulan Medan Private High School in the even semester of the 2024/2025 academic year. In this study, the population was all students of class XI of GKPI Padang Bulan Medan Private High School. In this study, the research sample was 30 students of class XI-1 of Padang Bulan Medan Private High School in the 2024/2025 academic year, drawn by purposive sampling (Sianturi & Simatupang, 2019). There is a reason why this technique is used, namely when determining the selected sample, it is indeed appropriate and meets the requirements to achieve the research objectives, besides this technique is also easy to apply, and usually the selected samples are students who are open and easy to approach by researchers.

- a. The independent variable is problem-based learning assisted by the PhET Simulation application.

b. The dependent variable is the cognitive learning outcomes of students.

Data analysis is the activity that occurs after data has been collected from all respondents or other data sources. Data analysis techniques involve grouping data based on variables and respondent types, and performing calculations to test the proposed hypotheses (Suhardiman, Nur Asni, Andi Ika Prasasti Abrar, & Ummul Hasanah, 2022).

RESULTS AND DISCUSSION

Research result

This study used a pre-experimental study involving one class given different treatments, namely problem-based learning (PBL) supported by the PhET simulation application. Before the PBL model was implemented, a pre-test was administered to students to assess their initial abilities. Subsequently, they were given a different treatment, namely learning that implemented the problem-based learning model supported by the PhET application. A post-test was then administered to determine student learning outcomes after the treatment (Budi, 2022).

Construct validity test

In this study, the validity of observations and the validity of the questions given to 3 validators were carried out, namely: 1. Physics lecturers, 2. Physics subject teachers, and 3. Physics students. Calculations were carried out using Excel. Based on the results of the validity analysis using the Aiken 'V' value by three experts, an index of 0.79 was obtained and was classified as "high". Based on the results of the analysis of the validity test of 30 questions to three validators, namely lecturers, teachers and students. In accordance with *the product moment correlation coefficient*, the results obtained from validator-I were 29 questions declared valid, from validator-II 28 questions were valid (RASYIDAH, 2018).

Validity Test

This validity test is used to prove the accuracy and precision of an instrument. This validity test was given to 11th grade students at Asuhan Daya High School. Based on the results of the validity test, if the calculated r value is $> r_{table}$, then the question is declared valid, and if the calculated r value is $< r_{table}$, then the question is declared invalid, where $r_{table} = 0.43$.

Reliability Test

At this stage, the research results were declared reliable according to the results of the data analysis obtained and according to the coefficient value of the K-R20 provisions, namely 0.60-1.0, it was declared reliable (Rahman, Mushlihuiddin, Refugio, & Zulnaidi, 2024).

Test the Level of Difficulty of Questions

The analysis of the test data using Excel resulted in a score above 0.40, which falls into the moderate category. Therefore, it can be concluded that 20 questions fall into the moderate category (Wulandari, Sutrio, Doyan, & Rahayau, 2024). The average pretest and posttest scores were 24.42 and 83.65, respectively, with standard deviations of 15.19 and 5.21. A complete data analysis can be seen in Appendix 9.

Test Requirements Analysis

- a. *pre-test* and *post-test* scores were normally distributed. If the calculated $L < L_{table}$, the data are considered normally distributed, where $L_{table} = 0.173$. The complete results of the pre-test and post-test normality tests are included in Appendix 10.
- b. Gain Normality Test. The gain normality test was conducted to assess the improvement in student learning outcomes. Based on the N-Gain grouping criteria, the results obtained were classified as high, at 0.77, while the N-Gain percentage results met the criteria for being effective, at 77%.

One-tailed t-test results

Based on data analysis using the SPSS version 25 application, the one-tailed t-test obtained a sig. (1-tailed) value of 0.000, which states that the sig. $p\text{-value} < 0.05$ and concludes that H_0 is accepted.

Grinnel's Reliability

The results of the analysis of student observation data assisted by the Excel application obtained an average result of 94.09 and is in the reliable category.

Discussion of Research Results

Research using the pre-experimental method is used to determine the effect of a particular treatment on the same group. This research begins by administering a pretest to a predetermined sample group without any prior instruction, with the aim of assessing the students' initial abilities. The effect of the treatment can then be determined by analyzing the post-test data given after the treatment (Aisyah, Rahman, & Sianipar, 2024).

The pretest score of students has an average value of 24.42 with a standard deviation of 15.18 and the posttest score has an average value of 83.65 with a standard deviation of 5.2. Based on the one-tailed t-test for $\alpha = 0.05$, the results obtained are $p\text{-value} < 0.05$ then H_0 is accepted. So it can be concluded that there is a significant change in problem-based learning assisted by the PhET application on the learning outcomes of class XI students of GKPI Padang Bulan Medan Private High School (Lestari & Luritawaty, 2021).

This study aims to examine the impact of problem-based learning using the PhET simulation application on eleventh-grade students at GKPI Padang Bulan Medan Private High School. The results show that problem-based learning using the PhET simulation application significantly improves the learning outcomes of eleventh-grade students at GKPI Padang Bulan Medan Private High School (Marta Towe, 2021)

CONCLUSION

Based on the results of the research and data analysis, it can be concluded that there is an increase in student learning outcomes as seen from the results of the pretest and posttest where the average pretest score is 24.42 and the average posttest score is 83.65. Based on the results of the one-sided t-test hypothesis calculation, namely sig. ($p\text{-value}$) < 0.05 or H_0 is accepted so it can

be concluded that there is a significant change from before being given treatment to those who have been given treatment.

Based on data analysis, it can be concluded that problem-based learning assisted by the PhET simulation application has an effect on the learning outcomes of class XI students at GKPI Padang Bulan Medan Private High School.

Suggestion

Some suggestions put forward based on this research are:

1. For future researchers who will use problem-based learning assisted by PhET, it is hoped that they will be able to guide students in using learning applications well and guide students to find and solve their own problems, and must be able to be motivators and facilitators for students.
2. For further research that applies problem-based learning, it is important to apply the steps of the problem-based learning model better and

REFERENCES

- Agustina, S., Wahyudi, W., & Sri Putu Verawati, N. N. (2024). Pengaruh Model Project Based Learning Berbantuan Simulasi Phet Terhadap Kemampuan Berpikir Kritis Fisika Peserta Didik SMAN 8 Mataram. *Jurnal Pendidikan, Sains, Geologi, dan Geofisika (GeoScienceEd Journal)*, 5(1), 75–80. <https://doi.org/10.29303/goescienceed.v5i1.293>
- Aisyah, S. N., Rahman, A. A., & Sianipar, B. (2024). Penerapan Pembelajaran Berdiferensiasi pada Model Problem Based Learning untuk Meningkatkan Keaktifan Belajar Matematika Siswa SMA. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, 4(2), 992–1002. <https://doi.org/https://doi.org/10.51574/kognitif.v4i2.1882>
- Alfauzia, R. (n.d.). *Pengaruh Penggunaan laboratorium Virtual PhET (Physics Education Technology) Terhadap Motivasi Belajar Siswa*. Jakarta: FITK UIN Syarif Hidayatullah Jakarta. Opgehaal van <https://repository.uinjkt.ac.id/dspace/handle/123456789/74628>
- Arifudin, M. (2021). Penggunaan laboratorium virtual phet untuk meningkatkan hasil belajar fisika siswa sma. *JIRA: Jurnal Inovasi dan Riset Akademik*, 2(6), 906–916.
- Arisandy, D., Marzal, J., & Maison, M. (2021). Pengembangan Game Edukasi Menggunakan Software Construct 2 Berbantuan Phet Simulation Berorientasi pada Kemampuan Berpikir Kreatif Siswa. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 5(3), 3038–3052. <https://doi.org/10.31004/cendekia.v5i3.993>
- Budi, A. S. (2022). Electronic Student Worksheets Of Physics (Eswop) Berbantuan Phet Untuk Pembelajaran Inkuiri Selama Covid19. *Journal of Innovation Research and Knowledge*, 2(4), 993–998.
- Burgess, A., & Matar, E. (2020). Team-Based Learning (TBL): Theory, Planning, Practice, and Implementation. In D. Nestel, G. Reedy, L. McKenna, & S. Gough (Eds.), *Clinical Education for the Health Professions: Theory and Practice* (bll 1–29). Singapore: Springer Singapore. https://doi.org/10.1007/978-981-13-6106-7_128-1

- Debi, M., & Wahyuni, I. (2018). Pengaruh Model Scientific Inquiry Menggunakan Media Phet Terhadap Keterampilan Proses Sains Ditinjau Dari Adversity Quotient Siswa Pada Pelajaran Fisika Di Sma Swasta Eria Medan. *Jurnal Ikatan Alumni Fisika Universitas Negeri Medan*, 4(4), 16–21. <https://doi.org/https://doi.org/10.24114/jiaf.v4i4.12389>
- Fannisa, A. A., Anggraini, D., Romdani, K. N., & Dewi, M. T. (2023). Challenges of Learning Social Science in the “Merdeka” Curriculum in Elementary Schools. *MANDALIKA : Journal of Social Science*, 1(2), 52–59. <https://doi.org/10.56566/mandalika.v1i2.117>
- Hadi, W., Prihasti Wuriyani, E., Yuhdi, A., & Agustina, R. (2022). Desain Pembelajaran Diferensiasi Bermuatan Problem Based Learning (Pbl) Mendukung Critical Thinking Skill Siswa Pada Era Kenormalan Baru Pascapandemi Covid-19. *Basastra*, 11(1), 56. <https://doi.org/10.24114/bss.v11i1.33852>
- Khurniati, N. L., Harun, L., & Nur Aini, A. (2023). Pengaruh Model Problem Based Learning Berbantuan Geogebra. *Jurnal Matematika dan Pendidikan*, 5(5), 335–341.
- Lestari, I., & Luritawaty, I. P. (2021). Peningkatan Kemampuan Pemahaman Konsep Matematis Siswa dengan Model Think Pair Share dan Problem Based Learning. *Plusminus: Jurnal Pendidikan Matematika*, 1(2), 353–362. <https://doi.org/10.31980/plusminus.v1i2.907>
- Malahayati, E. N., Corebima, A. D., & Zubaidah, S. (2015). Hubungan keterampilan metakognitif dan kemampuan berpikir kritis dengan hasil belajar biologi siswa sma dalam pembelajaran problem based learning (PBL). *Jurnal Pendidikan Sains*, 3(4), 178–185. <https://doi.org/http://dx.doi.org/10.17977/jps.v3i4.8168>
- Marta Towe, M. (2021). Analisis Pemahaman Konsep Siswa Dengan Menggunakan Problem Based Learning (Pbl) Pada Materi Luas Permukaan Balok. *Asimtot : Jurnal Kependidikan Matematika*, 3(2), 113–124. <https://doi.org/10.30822/asimtot.v3i2.1364>
- Noervadila, I., & Astidari, T. (2019). Pengaruh Metode Pembelajaran Problem Based Learning (Pbl) Dan Keterampilan Metakognisi Terhadap Hasil Belajar Siswa Smk Negeri 2 Situbondo. *Jurnal IKA PGSD (Ikatan Alumni PGSD) UNARS*, 7(2), 165–179. <https://doi.org/https://doi.org/10.36841/pgsdunars.v7i2.497>
- Panda, F. M., & Boy, B. Y. (2021). Implementation of PhET Virtual Laboratory Media-Based Physics Learning on The Progress of Student Concept Mastery During the Covid-19 Pandemic Implementasi Pembelajaran Fisika Berbasis Media Laboratorium Virtual PhET Terhadap Perkembangan Penguasaan Kons. *Jurnal Geliga Sains (JGS): Jurnal Pendidikan Fisika*, 9(2), 123–128.
- Panggabean, T., Rahman, A. A., & Simanullang, L. (2025). Penerapan Model Problem Based Learning dengan Pendekatan Saintifik untuk Meningkatkan Hasil Belajar Siswa. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, 5(1), 305–315. <https://doi.org/https://doi.org/10.51574/kognitif.v5i1.1952>
- Putria, A. N., Serevina, V., & Budi, A. S. (2019). Lembar Kerja Elektronik Peserta Didik Dilengkapi Simulasi Phet Berbasis Inkuiri Terbimbing Untuk Meningkatkan Penguasaan Konsep Fisika Pada Siswa Sma. *Prosiding Seminar Nasional Fisika (E-Journal) Snf2019 UNJ*, 8, SNF2019-PE-135–142. Pendidikan Fisika dan Fisika FMIPA UNJ. <https://doi.org/10.21009/03.SNF2019.01.PE.17>

- Rahman, A. A., Mushlihuddin, R., Refugio, C. N., & Zulnaldi, H. (2024). Problem-based learning innovation through realism and culture: Impact on mathematical problem solving and self-efficacy in primary school students. *Al-Jabar: Jurnal Pendidikan Matematika*, 15(1), 251–264.
- RASYIDAH, K. (2018). *Pengaruh LKS yang dilengkapi Phet Simulations terhadap keterampilan scientific writing dan hasil belajar usaha dan energi di SMA*. <https://doi.org/http://repository.unej.ac.id/handle/123456789/87471>
- Sianturi, I., & Simatupang, S. (2019). Pengaruh Model Pembelajaran Scientific Inquiry Terintegrasi Phet Terhadap Hasil Belajar Siswa Kelas Xi Pada Materi Pokok Elastisitas Zat Padat Dan Hukum Hooke. *Jurnal Ikatan Alumni Fisika Universitas Negeri Medan*, 5(1).
- Suhardiman, S., Nur Asni, Andi Ika Prasasti Abrar, & Ummul Hasanah. (2022). Meta Analisis Pengaruh Media Simulasi E-Learning PhET terhadap Hasil Belajar dalam Pembelajaran Fisika. *Jurnal Pendidikan MIPA*, 12(3), 779–791. <https://doi.org/10.37630/jpm.v12i3.652>
- Ulandari, L., Amry, Z., & Saragih, S. (2022). Development of Learning Materials Based on Realistic Mathematics Education Approach to Improve Students' Mathematical Problem Solving Ability and Self-Efficacy. *International Electronic Journal of Mathematics Education*, 14(2), 375–383. Opgehaal van <https://www.iejme.com>
- Wulandari, N. O., Sutrio, Doyan, A., & Rahayau, S. (2024). The Influence of Project Based Learning Model on Creative Thinking Skills and Physics Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, 10(12), 10660–10669. <https://doi.org/10.29303/jppipa.v10i12.9738>