Wahana Pendidikan Fisika (2026) 11 (1): 11-17
https://doi.org/10.17509/wapfi.111.20
2406-9205 (Print) | 2477-4820 (Online)

ORIGINAL RESEARCH

# The effect of using PhET simulation media using problem based learning model on improving cognitive learning outcomes of students at MAN Kota Kupang on hydrostatic pressure material

**Nurul Yaqiin Syamsudin, Yusniati H. Muh. Yusuf, Nikodemus U. J. Hauwali**

Received: 24 July 2025 · Accepted: 4 March 2026 · Published Online: 10 March 2026


**Abstract**

This study aims to examine the effect of using PhET Simulation media using the Problem Based Learning (PBL) model on improving students' cognitive learning outcomes and to determine the differences in improving students' cognitive learning outcomes using PhET simulation media and those using PowerPoint media. The type of research used is a quasi-experimental design with a pre-test post-test control group design. The population in this study were all 102 students of grade XI in a senior high school in Kupang City in the 2024/2025 academic year. Sampling was carried out using a simple random sampling technique so that 25 students from grade XI A3 were obtained as an experimental class using the Problem Based Learning model assisted by PhET Simulation media and 25 students from grade XI A4 as a control class using PowerPoint media. The research instrument was a 10-item essay test consisting of cognitive indicators at levels C3, C4, and C5 according to the revised Bloom's taxonomy. Cognitive learning outcome data were analyzed using paired sample t-test and independent sample t-test with a significance level of 5%. The results of the analysis showed that the significance value in the experimental class was 0.000 <0.05, which means there is a significant effect of the use of PhET simulation media using the PBL model on students' cognitive learning outcomes. Meanwhile, the results of the independent sample t-test showed a significance value of 0.016 <0.05, which means there is a difference in the increase in cognitive learning outcomes between the experimental class and the control class. Thus, it can be concluded that the use of PhET simulation media using the problem-based learning model has a significant effect on improving students' cognitive learning outcomes on the material of hydrostatic pressure.

**Keywords**: PhET Simulation · Problem Based Learning · Students' Cognitive Learning Outcomes · Hydrostatic Pressure

## INTRODUCTION

Education in Indonesia plays a crucial role in human resource development. Despite various improvement programs, the quality of learning still faces challenges such as low teacher awareness in lesson design, inadequate infrastructure, and monotonous teaching methods (Telaumbanua, 2022). In practice, learning at the high school level tends to be teacher-centered, which makes students passive and makes it difficult to understand the material, particularly physics (Hutasoit, 2021).

✉ Nurul Yaqiin Syamsudin
nurulyaqiinsyamsudin04@gmail.com

Universitas Nusa Cendana. Kupang, Indonesia.

**How to Cite**: Syamsudin, N.Y., Yusuf, Y.H.M., & Hauwali, N.U.J., (2026). The effect of using PhET simulation media using problem based learning model on improving cognitive learning outcomes of students at MAN Kota Kupang on hydrostatic pressure material. *Wahana Pendidikan Fisika, 11*(1), 11-17. https://doi.org/10.17509/wapfi.111.20

Physics, as a science that studies natural phenomena, is actually very important for developing students' critical and analytical thinking skills. However, many students find it difficult due to its abstract nature and the limited use of supporting learning media. The results of interviews and documentation studies conducted at a high school in Kupang City indicate that students' physics learning outcomes in hydrostatic pressure are still relatively low. Based on daily test scores for the odd semester of the 2024/2025 academic year, the average score for grade XI students was 62, while the Minimum Completion Criteria (KKM) set by the school is 75. Of the total 102 students, only 38 students (37.25%) achieved the KKM, while 64 students (62.75%) did not complete the course and had to take remedial courses. These data indicate that most students still experience difficulties in understanding the concept of hydrostatic pressure, so more interactive and contextual learning innovations are needed. Cognitive learning outcomes—which include understanding, application, analysis, synthesis, and evaluation (Sucipto, 2017) are important indicators of learning success. Low results are often caused by a less interesting learning process (Fatikasari et al., 2020), so learning strategies are needed that can increase student involvement actively and contextually (Ridwan, 2021).

One recommended approach is the problem-based learning (PBL) model, which emphasizes solving real-world problems. This model is considered effective in improving learning outcomes when integrated with interactive learning media such as PhET simulations (Sudiarta, 2019). This media provides simulations that enable students to understand abstract physics concepts visually and concretely (Verdian et al., 2021). Unlike PowerPoint, which is commonly used but less effective for conveying complex concepts (Adrian et al., 2023), PhET simulations provide a more interactive and engaging learning experience. A study by Maharani et al. (2024) also showed that integrating PhET simulations with PBL models significantly improved student learning outcomes.

The use of PhET simulations is also considered economical and flexible because it does not require a physical laboratory and can be accessed online from various devices (Koryataini et al., 2024). This is very helpful for schools with limited facilities, while also increasing students' interest and curiosity in the material presented visually and dynamically. However, the effectiveness of this media still depends on the teacher's ability to manage learning in a structured manner so that interactions with the simulation truly impact conceptual understanding. Thus, it is important to test the effectiveness of using problem-based learning-based PhET simulations in physics learning, particularly on hydrostatic pressure. This material is often considered difficult by students because it involves the concept of pressure, which cannot be directly observed. With the help of simulations, students can see and understand the relationship between depth, fluid density, and pressure in a concrete way, which is expected to improve students' cognitive learning outcomes (Wisnuputri et al., 2023).

Research conducted by Maharani et al (2024), shows that the Problem Based Learning model assisted by PhET Simulation media has an effect on physics learning outcomes in the material of work and energy with a moderate increase category (N-Gain 0.59 in the experimental class). However, the study focused on mechanics material and used a nonequivalent control group design with a purposive sampling technique. The novelty of this study lies in the application of the Problem Based Learning model assisted by PhET Simulation to the material of hydrostatic pressure which has different conceptual characteristics and tends to be more abstract because it involves mathematical relationships between depth, density, and

https://doi.org/10.17509/wapfi.111.20

fluid pressure. In addition, this study used a pre-test post-test control group design with a simple random sampling technique, thus providing different methodological strengths in testing the effectiveness of treatments on groups of students who used PhET media and groups of students who used PowerPoint media as a representation of conventional media commonly used in schools.

Based on this background, the objectives of this study are: 1. To determine the effect of using PhET simulation media using the Problem Based Learning model on improving students' cognitive learning outcomes. 2. To determine the difference in improving students' cognitive learning outcomes between those using PhET simulation and those using PowerPoint.

## METHOD

This research is a quantitative research with an experimental approach. The quantitative approach was used because this study aims to measure the effect of treatment on student learning outcomes in the form of numbers through tests (Sugiyono, 2016). The design used was a pre-test post-test control group design, which involved two groups: an experimental group that was given treatment in the form of the use of PhET simulation media based on problem-based learning (PBL), and a control group that used PowerPoint media. This research was conducted in one of the high schools in Kupang City in the 2024/2025 academic year, according to the physics lesson schedule in grade XI. The population in this study were all 102 students of grade XI A. The research sample was taken using a simple random sampling technique, namely random sample selection without regard to certain strata. Based on the Slovin formula, a sample of 50 students was obtained, consisting of 25 students from grade XI A3 and XI A4 (Sugiyono, 2016).

The research steps were carried out in three stages: initial, implementation, and final. In the initial stage, a preliminary study was conducted through interviews and observations, problem formulation, and the preparation of learning tools and instruments. The implementation stage included the implementation of a pre-test, the provision of treatment to each class, and a post-test. The final stage included data analysis, hypothesis testing, conclusion of results, and reporting. The data collection technique used a written test instrument in the form of 10 essay questions that measured students' cognitive abilities based on Bloom's Taxonomy categories C3 (application), C4 (analysis), and C5 (evaluation).

**Table 1.** Learning outcome instrument matrix

| No. | Learning Indicators | Cognitive Level | Question Number |
|---|---|---|---|
| 1 | Application of the concept of hydrostatic pressure in calculations | C3 | 1,2 |
| 2 | Analyzing the relationship between depth and hydrostatic pressure | C4 | 3,4 |
| 3 | Analyze the pressure at two points in a liquid | C4 | 5 |
| 4 | Interpreting the relationship of variables in hydrostatic pressure | C4 | 6 |
| 5 | Evaluate the concept of hydrostatic pressure in a statement | C5 | 7 |
| 6 | Evaluating solutions to hydrostatic pressure problems | C5 | 8 |
| 7 | Providing scientific arguments related to the phenomenon of hydrostatic pressure | C5 | 9,10 |

This test was used during the pre-test and post-test to measure learning outcomes. Before use, the instrument was validated by experts to ensure the quality of the questions. The

collected data were analyzed using SPSS version 25 software. Normality tests were conducted using the Shapiro-Wilk test, while homogeneity tests were conducted using the Levene test (Nuryadi, 2017). Furthermore, the data were analyzed using a paired sample t-test to see the effect within one group, and an independent sample t-test to compare the results between the experimental and control groups. The decision-making criteria were based on a significance value <0.05 to indicate a significant effect or difference (Arikunto, 2013).

## RESULTS AND DISCUSSION

The data described in this study includes student learning outcome data. Descriptive statistics of the pretest and posttest results in the experimental and control classes include the number of students, maximum score, minimum score, mean, and standard deviation. These statistics are presented to provide an initial overview of the data distribution before conducting hypothesis testing.

**Table 2**. The average value of students' pretest and posttest results

| Class | | *N* | Min | Max | Average | St. Dev |
|---|---|---|---|---|---|---|
| Experiment | Pretest | 25 | 20 | 70 | 41.8 | 15.240 |
| Experiment | Posttest | 25 | 65 | 90 | 76.6 | 6.377 |
| Control | Pretest | 25 | 20 | 65 | 40.4 | 11.547 |
| Control | Posttest | 25 | 50 | 80 | 65.8 | 7.500 |

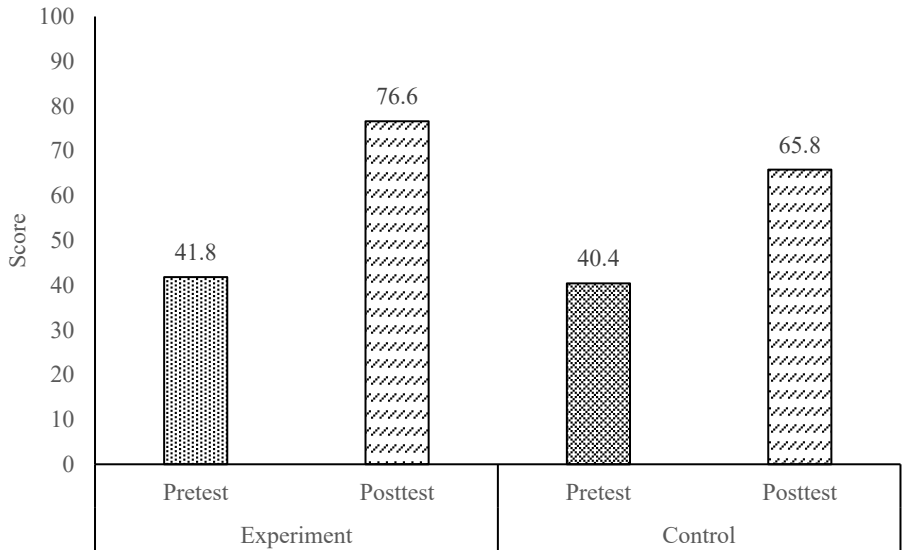


**Figure 1.** Student pretest and posttest results data

Before students were given treatment in the form of implementing PhET simulation media and PowerPoint media, students were first given a posttest to test their initial abilities. After being given the pretest, students in both classes were given treatment and ended with a posttest. The average student score obtained was the average pretest score of the experimental class of 41.8, while the control class was 40.4. The average posttest score of the experimental class increased to 76.6, while the control class became 65.8. The average increase in the experimental class was 34.8 points, higher than the control class which was only 25.4 points.

In addition to reviewing the overall average value increase, learning outcomes can also be analyzed based on the measured cognitive aspects, namely C3 (application), C4 (analysis), and C5 (evaluation). Based on the characteristics of the questions and the ongoing learning process, the use of PhET Simulation based on Problem Based Learning contributes to the development

https://doi.org/10.17509/wapfi.111.20

of students' abilities in applying concepts, analyzing relationships between variables, and drawing conclusions from observed phenomena (Rianti et al., 2024; Yuanata et al., 2023). In the C3 (application) aspect, students are trained to use the concept of hydrostatic pressure in solving contextual problems presented through simulations. Interactive visualizations help students understand the relationship between depth, density, and pressure, thus simplifying the process of applying formulas in various situations.

In aspect C4 (analysis), the Problem-Based Learning model encourages students to identify problems, connect concepts, and analyze observations from the simulation. The discussion and exploration process carried out during the learning process provides an opportunity for students to develop analytical thinking skills more deeply. Meanwhile, in aspect C5 (evaluation), students are directed to draw conclusions and provide assessments of the results of the virtual experiment. Although separate score groupings were not conducted for each aspect, the increase in post-test scores indicates that the integration of PhET Simulation with the Problem-Based Learning model contributes to improving cognitive abilities at various levels of thinking (Yani & Widiyatmoko, 2023).

The normality test using Shapiro-Wilk showed that the data were normally distributed, both for the pre-test and post-test in both classes (significance value > 0.05). The homogeneity test also showed that the data had homogeneous variance (Sig value > 0.05). Analysis using a paired sample t-test showed a significant increase in learning outcomes in both the experimental and control classes (Sig. 2-tailed < 0.05). However, based on the independent sample t-test, there was a significant difference between the post-test results of the two classes, with a significance value < 0.05. This means that the use of PhET simulation is significantly more effective than PowerPoint.

The significant improvement in the experimental class proves that the use of PBL-based PhET Simulation can improve students' cognitive learning outcomes. This is supported by the finding that students were more active, interested, and easily understood the concept of hydrostatic pressure through interactive and contextual simulations. In contrast, students in the control class who only used PowerPoint experienced lower improvement because the media was passive and provided less concrete learning experiences. These results align with research by Maharani et al. (2024) and Verdian et al. (2021) which stated that the use of simulation media such as PhET is effective in improving students' understanding of abstract concepts in physics.

## CONCLUSION

Based on the results of the research that has been done, it can be concluded as follows: 1. The use of PhET simulation media with a problem-based learning model has a significant effect on improving students' cognitive learning outcomes. This is shown by the results of the paired sample t-test in the experimental class, obtained a significance value of 0.000 (<0.05), as well as an increase in the average pre-test score of 41.8 to a post-test of 76.6. This shows that there is a difference in the average increase in pre-test post-test of 83.25%. This means that the use of PhET simulation media with a problem-based learning model has a significant effect on improving students' cognitive learning outcomes. 2. There is a significant difference in improving cognitive learning outcomes between students who use PhET simulation media and students who use PowerPoint media. Based on the results of the independent sample t-test, a significance value of 0.000 (<0.05) was obtained, which shows that the learning outcomes of

https://doi.org/10.17509/wapfi.111.20

students in the experimental class are statistically higher than those in the control class. This proves that the use of PhET simulation is more effective than PowerPoint media.

## REFERENCES

Adrian, W., Palloan, P., & Khaeruddin. (2023). Efektivitas Media Pembelajaran Power Point terhadap Hasil Belajar Fisika Peserta Didik Kelas XI SMAN 1 Malunda. *Jurnal Penelitian Pendidikan Fisika*, *8*(2), 115–120.

Arikunto, S. (2013). *Prosedur Penelitian: Suatu Pendekatan Praktik*. PT Rineka Cipta.

Fatikasari, R., Matius, B., & M. Junus. (2020). Hasil Belajar Kognitif Peserta Didik Melalui Penerapan Model Pembelajaran Inkuiri Berbantuan Media Simulasi PhET Kelas XI IPA SMA Negeri 1 Anggana Materi Fluida Statis. *Jurnal Literasi Pendidikan Fisika (JLPF)*, *1*(01), 65–72.

Hutasoit, S. A. (2021). Pembelajaran Teacher Centered Learning (TCL) dan Project Based Learning (PBL) dalam Pengembangan Kinerja Ilmiah dan Peninjauan Karakter Siswa. *Jurnal Pendidikan Indonesia*, *2*(10), 1775–1799.

Koryataini, L., Sumo, M., Minnah, L., Solehah, S., & Khoiroh, A. R. A. (2024). *Analisis Penggunaan Media Pembelajaran PhET pada Materi Gelombang Berjalan dan Stasioner: A Review Literatur*. *2*(3), 120–138.

Maharani, N. N., Hikmawati, H., Susilawati, S., & Gunada, I. W. (2024). Pengaruh Model Problem Based Learning Berbantuan Media PhET Simulation Terhadap Hasil Belajar Pada Materi Usaha dan Energi. *Jurnal Ilmiah Profesi Pendidikan*, *9*(1), 539–545.

Nuryadi. (2017). *Dasar-Dasar Statistik Penelitian*. Sibuku Media.

Rianti, R., Gunawan, G., Verawati, N. N. S. P., & Taufik, M. (2024). The effect of problem based learning model assisted by phet simulation on understanding physics concepts. *Lensa: Jurnal Kependidikan Fisika*, *12*(1), 28-43.

Ridwan, S. L. (2021). Peningkatan Kemampuan Berpikir Kritis dan Hasil Belajar Peserta didik Melalui Model Pembelajaran Discovery Learning. *Jurnal Didaktika Pendidikan Dasar Kemendikbud, 5 (3)*, 637–656.

Sucipto, S. (2017). Pengembangan Ketrampilan Berpikir Tingkat Tinggi dengan Menggunakan Strategi Metakognitif Model Pembelajaran Problem Based Learning. *Jurnal Pendidikan (Teori Dan Praktik)*, *2*(1), 77. https://doi.org/10.26740/jp.v2n1.p77-85

Sudiarta, N. (2019). Penerapan Model Pembelajaran Problem Based Learning untuk Meningkatkan Hasil Belajar Fisika Materi Suhu dan Kalor. *Journal of Education Action Research*, *3*(4), 440.

Sugiyono. (2016). *Metode Penelitian Kuantitatif*. CV. Alfabeta.

https://doi.org/10.17509/wapfi.111.20 

Telaumbanua, D. (2022). Analisis Kualitas Pembelajaran Dan Hasil Belajar Fisika. *Educativo: Jurnal Pendidikan*, *1*(1), 278–282. https://doi.org/10.56248/educativo.v1i1.38

Verdian, F., Jadid, M. A., & Rahmani, M. N. (2021). Studi Penggunaan Media Simulasi PhET dalam Pembelajaran Fisika. *Jurnal Pendidikan Dan Ilmu Fisika*, *1*(2), 39.

Wisnuputri, A. F., Izzulhaq, A., & Setiaji, B. (2023). Lkpd Hukum Newton Berbasis Kearifan Lokal Nglarak Blarak Berbantuan Phet. *OPTIKA: Jurnal Pendidikan Fisika*, *7*(1), 1–9.

Yani, L. P., & Widiyatmoko, A. (2023). The effectiveness of the PhET-assisted creative problem solving model on students' creative thinking abilities and cognitive learning outcomes. *Jurnal Inovasi Pendidikan IPA*, *9*(2), 146-156.

Yuanata, B. E., Dwikoranto, D., & Setiani, R. (2023). Profile of the PhET Assisted Problem-Based Learning Model for Improving Critical Thinking Skills of High School Students. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram*, *11*(3), 870-880.

https://doi.org/10.17509/wapfi.111.20