

The Effect of Guided Inquiry Learning with Virtual Laboratory on Junior High School Students' Physics Learning Outcomes

Wilfridus Nggandung^{1*}, Agus Wedi¹, & Deka Dyah Utami¹

¹Educational Technology Study Program, State University of Malang, Indonesia

*Corresponding Author: wilfridus.nggandung.2401218@students.um.ac.id

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Abstract - Low physics achievement among junior high school students, particularly on the topics of work and energy, indicates the need for more effective instructional strategies. This study examined the effect of a guided inquiry approach assisted by PhET simulations on students' learning outcomes in Work and Energy. A nonequivalent control group design was employed, involving 30 students in the experimental class and 30 students in the control class. The instrument consisted of 20 multiple-choice items designed to assess students' understanding of fundamental concepts in Work and Energy. The results showed that the implementation of the PhET-assisted guided inquiry approach significantly improved students' learning outcomes. This conclusion was supported by the results of an independent t-test and a high effect size. Nevertheless, the study was limited to a single topic and relied solely on quantitative data. Future research is therefore recommended to investigate other physics topics and to incorporate qualitative.

Keywords: Guided Inquiry, Learning Outcomes, PhET, Physics, Virtual Laboratory.

INTRODUCTION

Physics education at the junior high school level is an important component of education. Physics education at this level can serve as a foundation for applying physics concepts and prepare students to study physics in greater depth at the next level (Abubakar, 2012). Physics learning is not only about memorizing formulas, but also honing other skills such as critical thinking and problem solving (Silaban & Nainggolan, 2022). Understanding physics from an early age also helps and makes it easier for students to adapt to current developments in science and technology (Kaur et al., 2023). Thus, physics learning in schools must be optimized to obtain the right learning outcomes. These learning outcomes will later reflect other skills that students must master.

However, facts show that student learning outcomes in physics learning are still low. For example, in the subject of work and energy, students achieved learning

outcomes in the sufficient category with a percentage of 57% (Lana et al., 2021). Many students have misconceptions in various sub-topics of work and energy (Maison et al., 2020). Students are also unable to interpret the basic concepts of work and energy during the learning process (Singh & Rosengrant, 2003). As a result, students' understanding of this material is still limited. In order to solve this problem, it is necessary to identify the causes of low student learning outcomes.

Various factors contribute to low student learning outcomes in physics education. Students tend to memorize formulas without understanding the basic concepts, so that what is embedded in their understanding is only limited to equations without understanding their true meaning (Capriconia & Mufit, 2022; Pristianti & Prahani, 2022). Physics learning in the classroom, which remains teacher-centered, also leads to low student learning outcomes (Assem et al., 2023). In addition, the

assumption that physics is a difficult subject also becomes a doctrine that influences students' perceptions of physics (Ali, 2021). As a result, many students find it difficult to understand physics concepts correctly and find the relationships between concepts in it.

Previous studies have conducted numerous investigations to improve student learning outcomes in junior high school physics education. The STEM-integrated Project-Based Learning model has been proven effective in improving physics learning outcomes (Rochim et al., 2022). Innovative learning models such as Make a Match also yield positive results in improving student learning outcomes (Wibowowati, 2022). Previously, an increase in physics learning outcomes with the problem-based learning model has been reported (Velly, 2021). In line with the research topic, the use of the guided inquiry model integrated with PhET has also been carried out (Yulianti et al., 2021). The difference with the researcher's study is that previous studies focused on students' critical thinking skills. Thus, they did not explain the effect on student learning outcomes.

Although previous studies have been conducted to improve student learning outcomes through various learning models, integration with virtual laboratories such as PhET is still limited and needs further research. The use of virtual laboratories is generally associated with online learning, resulting in suboptimal interaction and student motivation (Puspitasari et al., 2022; Wigati et al., 2023). Therefore, this study aims to analyze the effect of the PhET-assisted guided inquiry learning model on junior high school students' physics learning outcomes. The integration of PhET with the inquiry learning model is carried out through offline classroom learning mechanisms. The results of this study are expected to provide new information regarding the use of

learning models integrated with virtual laboratories.

RESEARCH METHODS

The research is a quasi-experiment with a nonequivalent control group design. This design uses two groups with different treatments, and each group is not randomly assigned. This design will compare the difference in the average posttest scores between the experimental class and the control class. The objective is to determine the effect of implementing guided inquiry learning assisted by PhET on junior high school students' physics learning outcomes. The nonequivalent control group design is presented in Table 1.

Table 1. nonequivalent control group design

Group	Pre-test	Treatment	Post-test
Experiment	O ₁	X ₁	O ₂
Control	O ₃	X ₂	O ₄

Description:

O₁, O₃ : Pretest before treatment

O₂, O₄ : Posttest after treatment

X₁ : Guided inquiry learning assisted by PhET

X₂ : Conventional learning without PhET

The research was conducted at a private junior high school in Nunukan Regency in September–October 2025. This study involved eighth-grade junior high school students. The research sample was selected through purposive sampling and involved 60 students consisting of 30 students in the experimental group and 30 students in the control group. Each sample group took two tests, namely a pretest and a posttest. In addition, each group received different treatments. The experimental group applied guided inquiry learning assisted by PhET, and the control group applied conventional learning without PhET assistance.

The research instrument used a learning outcome test. The test was developed on the subject of work and

energy. The instrument consisted of 20 multiple-choice questions tailored to the basic competencies that students must master. Each student completed the test questions independently through a paper-based test. The test results were in the form of student learning outcome score data presented in ratio data.

The research was conducted in three main stages, namely pretest, treatment, and post test. The post test was administered to determine the initial profile of students' physics learning outcomes. Each group received the same questions and was given the same amount of time to complete them. The treatment stage of the research used two different types of learning. The experimental class received guided inquiry learning with the help of PhET. The control class received conventional learning without the use of PhET. In the posttest stage, each group was given another test to measure their learning outcomes after the research treatment. The posttest was conducted in the same manner as the pretest. The pretest and posttest data were then analyzed in accordance with the research objectives.

Research data analysis uses descriptive statistics and inferential statistics. Descriptive statistical analysis is used to describe the average learning outcomes of students based on data type and class. Inferential statistical analysis is used to test the difference in posttest averages between the experimental and control groups. The analysis begins with a prerequisite test, namely a normality test and a homogeneity test. Data that has been declared normal and homogeneous is analyzed using parametric statistics. The parametric statistical analysis used is the independent sample t-test. The independent sample t-test was chosen because the data from the experimental and control groups are not paired data. In addition, an Effect

Size test was also conducted to measure the magnitude of the effect of the treatment implemented in the study.

RESULTS AND DISCUSSION

Results

Descriptive Statistics

Descriptive statistics are used to describe the data in general. Based on the analysis results, it can be seen that there is a difference in the average learning scores of students on the posttest. A summary of the analysis results is presented in Figure 1.

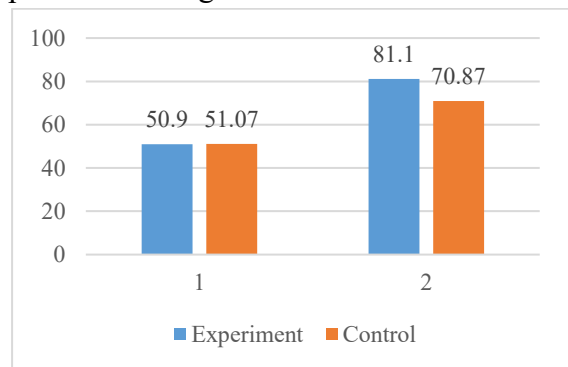


Figure 1. Average student learning scores

Inferential Statistics

Inferential statistical analysis is used to test research data. Inferential statistics begin with a statistical prerequisite analysis. The results of the prerequisite test are presented in Table 2.

Table 2. Results of normality and homogeneity tests

Group	Normality test		Homogeneity test
	Pretest	Posttest	
Experiment	0.534	0.897	0.642
Control	0.24	0.16	0.403

The table shows that all research data is normally distributed. This is evidenced by a p-value score >0.05 , which indicates that the data is normally distributed. In addition, the homogeneity test results show that the pretest and posttest data have a homogeneous distribution. This is evidenced by a -value score >0.05 . Thus, statistical

analysis was performed using an independent sample t-test parametric statistical analysis.

Table 3. Results of the independent sample t-test

Mean posttest		Mean difference	Sig. 2 tailed	Result
Experiment	Control			
81.10	70.87	10.23	<	Sig.
			0.001	

The analysis results show that there is a significant difference in student learning outcomes between guided inquiry learning assisted by PhET and conventional learning without PhET. These results were obtained from a sig. score (2-tailed) ≤ 0.05 , which indicates a significant difference. These results indicate that guided inquiry learning assisted by PhET has a greater effect than conventional learning.

Effect Size

The effect size test using Cohen's d showed a value of 1.604. This value falls into the large effect category ($d > 0.80$). Thus, guided inquiry learning assisted by PhET has a very strong effect on improving students' physics learning outcomes compared to the control group.

Discussion

The findings show that the PhET-assisted guided inquiry learning model has a significant effect on junior high school students' learning outcomes in Work and Energy. These findings were obtained based on statistical analysis and effect size tests in the high category. The use of PhET in learning provides opportunities for students to participate directly in the learning process. In addition, the use of the guided inquiry model also makes it easier for students to understand concepts with direct guidance and supervision from teachers. Thus, this study provides information on learning

models and approaches that have a positive impact on student learning outcomes. Learning about work and energy is important to maximize because it forms the basis for science research in general (Sapriyadin et al., 2023).

Before the study, both the experimental and control classes had similar levels of understanding. At this stage, students still had limited understanding of Work and Energy. As explained in previous studies, students were unable to describe and explain problems when faced with Work and Energy questions (Syahril & Jarnawi, 2023). In solving physics problems, students also lacked thoroughness, which led to errors in the final results (Malotong & Zaky, 2022). This was because students had low motivation and interest in learning physics concepts, which had an impact on their initial learning outcomes (Hasanati & Purwaningsih, 2021).

Increased student learning outcomes due to the implementation of PhET-assisted guided inquiry. As explained in previous studies, guided inquiry learning combined with appropriate media can support the achievement of physics comprehension (de Jong et al., 2023). In addition, research (Arifin et al., 2025) also explains that guided inquiry learning that is implemented properly can have a positive effect on learning outcomes. The integration of PhET learning can also help students understand concepts through virtual experiments (Banda & Nzabahimana, 2023). The use of PhET can increase student participation and motivation in learning abstract physics (Pranata, 2024).

The implementation of direct learning by integrating inquiry-based learning with PhET provides students with a good understanding of the subject matter. Students can apply the concepts they have learned to the results of experiments

conducted in virtual laboratories (Meronda et al., 2025). In addition, this approach also improves students' critical thinking skills and problem-solving abilities in a more systematic and empirically-based manner (Ardisa et al., 2022; Hidayatullah et al., 2025).

The findings of this study contribute to efforts to develop physics education in junior high schools. Teachers can use the results and findings of this study to apply a guided inquiry model integrated with virtual laboratories such as PhET to implement learning in schools. In addition, the findings of this study can also maximize student learning outcomes and create effective learning. This will certainly have a positive impact on improving the quality of human resources in the future.

However, this research is still limited in its implementation to the subjects of work and energy and the use of quantitative data. Further research can investigate similar topics in various other physics subjects that experience a variety of student learning outcome problems. In addition, the use of qualitative data can also be used to strengthen quantitative findings so that the conclusions obtained in the research are appropriate and describe the actual facts.

CONCLUSION

This study shows that the implementation of the PhET-assisted guided inquiry learning model has a significant effect on junior high school students' learning outcomes in physics on the subject of Work and Energy. These results are reinforced by statistical analysis showing that the average posttest scores of students in the experimental class were higher than those in the control class. In addition, the effect size score of 1.604, which is in the high category, also shows that the treatment provided has enormous benefits. Thus, the

use of guided inquiry integrated with virtual laboratories such as PhET has been proven effective in improving student learning outcomes in physics learning on the subject of Work and Energy. However, this study is limited to the subject of work and energy and the use of quantitative data. Further research can explore different subjects and use qualitative data as supporting data for quantitative data to strengthen the conclusions obtained.

REFERENCES

- Abubakar, S. (2012). Role of Physics Education for Technological Development for Employment and Self Productivity in Nigeria. *Journal of Educational and Social Research*, 2(10).
<https://doi.org/10.5901/jesr.2012.v2n10p166>
- Ali, M. (2021). Kendala Dan Persepsi Peserta Didik SMA Negeri 1 Kelumpang Barat Terhadap Pembelajaran Fisika. *Cendekia: jurnal ilmiah pendidikan*, 9(1), 97–112.
<https://doi.org/10.33659/cip.v9i1.192>
- Ardisa, I., Verawati, N. N. S. P., Gunawan, G., & Ayub, S. (2022). Effect of PhET Simulation-Assisted Guided Inquiry Learning Model on Students' Critical Thinking Ability in Elasticity Material. *Jurnal Pendidikan Fisika Dan Teknologi*, 8(2), 262–269.
<https://doi.org/10.29303/jpft.v8i2.4391>
- Arifin, Z., Sukarmin, S., Saputro, S., & Kamari, A. (2025). The effect of inquiry-based learning on students' critical thinking skills in science education: A systematic review and meta-analysis. *Eurasia Journal of Mathematics, Science and Technology Education*, 21(3), em2592.
<https://doi.org/10.29333/ejmste/15988>

- Assem, H. D., Nartey, L., Appiah, E., & Aidoo, J. K. (2023). A Review of Students' Academic Performance in Physics: Attitude, Instructional Methods, Misconceptions and Teachers Qualification. *European Journal of Education and Pedagogy*, 4(1), 84–92. <https://doi.org/10.24018/ejedu.2023.4.1.551>
- Banda, H. J., & Nzabahimana, J. (2023). The Impact of Physics Education Technology (PhET) Interactive Simulation-Based Learning on Motivation and Academic Achievement Among Malawian Physics Students. *Journal of Science Education and Technology*, 32(1), 127–141. <https://doi.org/10.1007/s10956-022-10010-3>
- Capriconia, J., & Mufit, F. (2022). Analysis of Concept Understanding and Students' Attitudes towards Learning Physics in Material of Straight Motion. *Jurnal Penelitian Pendidikan IPA*, 8(3), 1453–1461. <https://doi.org/10.29303/jppipa.v8i3.1381>
- de Jong, T., Lazonder, A. W., Chinn, C. A., Fischer, F., Gobert, J., Hmelo-Silver, C. E., Koedinger, K. R., Krajcik, J. S., Kyza, E. A., Linn, M. C., Pedaste, M., Scheiter, K., & Zacharia, Z. C. (2023). Let's talk evidence – The case for combining inquiry-based and direct instruction. *Educational Research Review*, 39, 100536. <https://doi.org/10.1016/j.edurev.2023.100536>
- Hasanati*, A., & Purwaningsih, E. (2021). Influence of Interest In Learning and How to Learn on Understanding Concepts: Work and Energy Cases. *Jurnal Pendidikan Sains Indonesia*, 9(2), 305–316. <https://doi.org/10.24815/jpsi.v9i2.19203>
- Hidayatullah, Z., Ariandani, N., Qusyairi, M., & Marzuki, M. (2025). Impact of Deep Learning–Based PhET Instruction on Problem-Solving Skills: The Role of Learning Motivation. *Jurnal Pendidikan Fisika Dan Teknologi*, 11(2), 392–398. <https://doi.org/10.29303/jpft.v11i2.10233>
- Kaur, T., Kersting, M., Blair, D., Adams, K., Treagust, D., Santoso, J., Popkova, A., Boubilil, S., Zadnik, M., Li, J., Wood, D., Horne, E., & Mcgoran, D. (2023). *Developing and implementing an Einsteinian science curriculum from Years 3 to 10-Part A: Concepts, rationale and learning outcomes*.
- Lana, K., Ismail, S., & Kie Raha, S. (2021). Penerapan Model Pembelajaran Problem Basid Learning (PBL) Untuk Meningkatkan Hasil Belajar Fisika Kelas VIII SMP Negeri 1 Waikafia pada Materi Usaha dan Energi. *Kuantum: Jurnal Pembelajaran Dan Sains Fisika*, 2(2), 38–59. <https://doi.org/10.5281/zenodo.5730921>
- Malotong, A., & Zaky, M. (2022). Identification of the Factors Causing Difficulty in Learning Physics in the Material of Work and Energy in High School Students. *Jurnal Kreatif Online (JKO)*, 10(3), 106–113. <http://jurnal.fkip.untad.ac.id/index.php/jko>
- Meronda, D. A., Widarti, H. R., & Yahmin, Y. (2025). Virtual Laboratories in Science Education: A Systematic Review of Effectiveness on Conceptual Understanding and Learning Outcomes. *Jurnal Pendidikan MIPA*, 26(3), 2020–2042. <https://doi.org/10.23960/jpmipa.v26i3.pp2020-2042>
- Pranata, O. D. (2024). Physics education technology (PhET) as a game-based learning tool: A quasi-experimental study. *Pedagogical Research*, 9(4), em0221. <https://doi.org/10.29333/pr/15154>

- Pristianti, M. C., & Prahani, B. K. (2022). Profile of Students' Physics Problem Solving Skills and Problem Based Learning Implementation Supported by Website on Gas Kinetic Theory. *Jurnal Pendidikan Progresif*, 12(1), 375–393. <https://doi.org/10.23960/jpp.v12.i1.202229>
- Puspitasari, L., Subiki, S., & Supriadi, B. (2022). Pengaruh Media PhET Simulation Terhadap Motivasi Dan Hasil Belajar Fisika Siswa SMK. *Jurnal Pendidikan Fisika*, 11(2), 89. <https://doi.org/10.24114/jpf.v11i2.37682>
- Rochim, R. A., Prabowo, P., Budiyanto, M., Hariyono, E., & Prahani, B. K. (2022). *The Use of STEM-Integrated Project-based Learning Models to Improve Learning Outcomes of Junior High School Students*. <https://doi.org/10.2991/assehr.k.211229.034>
- Sapriyadin, D., Sutopo, S., & Wisodo, H. (2023). Influence of Inquiry Learning on Concept Mastery Ability and Physics Problem Solving Ability of Students on Work and Energy Material. *Jurnal Penelitian Pendidikan IPA*, 9(2), 734–744. <https://doi.org/10.29303/jppipa.v9i2.3253>
- Silaban, B., & Nainggolan, J. (2022). The Mastery of Science Concepts in Solving Physics Problems for Junior High School Students. *JPI (Jurnal Pendidikan Indonesia)*, 11(4). <https://doi.org/10.23887/jpiundiksha.v11i4.54039>
- Singh, C., & Rosengrant, D. (2003). Multiple-choice test of energy and momentum concepts. *American Journal of Physics*, 71(6), 607–617. <https://doi.org/10.1119/1.1571832>
- Syahril, A., & Jarnawi, M. (2023). Analysis Of Students' Difficulties In Solving Physics Problems In Business And Energy Materials. *Jurnal Pendidikan Fisika Tadulako Online*, 11(1), 27–33. <http://jurnal.fkip.untad.ac.id/index.php/jpft>
- Velly, D. (2021). Increasing the Motivation and Learning Outcomes of Students through the Application of the Problem Based Learning Model in Learning Physics. *Journal of Science and Science Education*, 2(1), 52–57. <https://doi.org/10.29303/jossed.v2i1.719>
- Wibowowati, L. (2022). Increasing Students' Interest and Learning Outcomes with the Make a Match Learning Model in Junior High School Physics Science Learning. *Impulse: Journal of Research and Innovation in Physics Education*, 2(1), 16–26. <https://doi.org/10.14421/impulse.2022.21.02>
- Wigati, W. R., Syahril, S., & Maaruf, Z. (2023). Pengaruh Model Inkuiri Terbimbing Berbasis Virtual Laboratorium Terhadap Kemampuan Berpikir Kritis Pada Materi Usaha Dan Energi. *Jurnal Pendidikan Fisika*, 12(1), 104. <https://doi.org/10.24114/jpf.v12i1.45385>
- Yulianti, E., Zhafirah, N. N., & Hidayat, N. (2021). Exploring Guided Inquiry Learning with PhET Simulation to Train Junior High School Students Think Critically. *Berkala Ilmiah Pendidikan Fisika*, 9(1), 96. <https://doi.org/10.20527/bipf.v9i1.9617>