



The Effectiveness of Discovery Learning Assisted by PhET Simulations on IPAS Learning Outcomes Regarding Force and Motion for Fourth Grade Elementary School Students

Wahyu Hidayat^{1*}, Endang Sri Maruti², Vivi Rulviana³

^{1,2,3}Universitas PGRI Madiun

Correspondence E-mail: wh009295@gmail.com

ABSTRACT	ARTICLE INFO
<i>Low learning outcomes in the subject of Natural and Social Sciences (IPAS) regarding the topic of force and motion among elementary school students are attributed to teacher-centered instruction and the limited use of media to help students grasp abstract concepts. This study aimed to analyze the effectiveness of the Discovery Learning model assisted by PhET Simulations on the IPAS learning outcomes of fourth-grade elementary school students. A quantitative approach was employed, utilizing a quasi-experimental design with a non-equivalent control group. The study sample consisted of 47 students, divided into an experimental group (25 students) and a control group (22 students). Data were collected through learning outcome assessments comprising pre-tests and post-tests and were analyzed using normality tests, homogeneity tests, and the Independent Samples t-Test. The results revealed that the average post-test score of the experimental group (79.00) was higher than that of the control group (56.36). Hypothesis testing yielded a significance value of 0.000 ($p < 0.05$), indicating a significant difference in learning outcomes between the two groups. Thus, the Discovery Learning model assisted by PhET Simulations is effective in improving fourth-grade students' learning outcomes in IPAS regarding the topic of force and motion.</i> © 2026 Jurnal Pedagogik Pendidikan Dasar 	Article History: Submitted/Received 19 Juni 2026 First Revised 09 Aug 2026 Accepted 31 Aug 2026 First Available online 07 Sep 2026 Publication Date 31 Nov 2026 Keyword: Discovery Learning; Phet Simulation; Learning Outcomes; IPAS.

1. INTRODUCTION

Natural and Social Sciences (IPAS) is a subject designed to enable students to understand natural and social phenomena in an integrated manner through meaningful learning experiences. IPAS instruction emphasizes not only the mastery of concepts but also students' abilities to observe, reason, and solve problems related to daily life (Agustin et al., 2026). Consequently, learning outcomes serve as a crucial indicator for assessing the success of the learning process. These outcomes reflect the changes in abilities, knowledge, attitudes, and skills acquired by students after participating in the learning process (Eka et al., 2022). However, achieving desired learning outcomes in IPAS at the elementary school level still presents various challenges that require special attention.

Based on observations, interviews, and initial tests conducted at SDN Jatirejo, it was found that the IPAS learning outcomes for fourth-grade students remain low. The students' average pre-test score was 61.00, with 17 out of 25 students (68%) failing to meet the Minimum Mastery Criterion (KKM) of 75. Most students struggled to grasp abstract concepts, particularly those related to force and motion. The instructional process was dominated by the lecture method, causing students to remain passive and disengaged from learning activities. Furthermore, the limited use of instructional media hindered students' ability to connect the concepts they were studying with real-life phenomena. These conditions resulted in poor conceptual understanding and low student learning outcomes (Sihombing et al., 2024).

One alternative approach to addressing this issue is the implementation of the Discovery Learning model. This model places students at the center of the learning process, engaging them in activities where they independently discover and construct knowledge (Hatip & Setiawan, 2021). Through stages such as stimulation, problem identification, data collection, data processing, verification, and generalization, students are encouraged to actively explore the concepts being studied, thereby making the learning experience more meaningful (Winarti & Suyadi, 2020). Implementing this model has been shown to enhance student learning engagement, critical thinking skills, and academic outcomes by providing learners with the opportunity to discover concepts firsthand (Arfianti & Anisah, 2025).

In addition to appropriate instructional models, the use of interactive learning media is essential to help students grasp abstract concepts in IPAS. One such tool is PhET Simulation. PhET Simulation is an interactive, simulation-based learning medium that enables students to explore scientific concepts through virtual activities that mimic real-world conditions (Zainuri, 2022). Utilizing PhET Simulation allows for the visualization of concepts that are difficult to observe directly, thereby enhancing conceptual understanding and student engagement in the learning process (Mariza & Derlina, 2015). Furthermore, this medium provides students with the opportunity to conduct experiments independently, making the learning process more engaging and effective (Mukaramah & Kustina, 2020).

Various studies indicate that both the Discovery Learning model and PhET Simulation media have a positive influence on student learning outcomes. Research by Sari & Simanjuntak (2016) demonstrates that the use of PhET Simulation positively impacts students' physics learning outcomes. A study by Amin & Amdani, (2023) found that the Discovery Learning model, supported by interactive media, is effective in enhancing student learning outcomes. Research by Nirahua & Matulessy (2024) also shows that discovery-based learning specifically when supported by simulation media is effective for learning outcomes.

Meanwhile, (Rahmiyati et al., 2023) and (Azahra et al., 2025) reveal that the use of the Guided Discovery Learning model combined with digital media positively affects students' conceptual understanding and learning outcomes. However, most of these studies have examined Discovery Learning and PhET Simulation separately and have primarily focused on the secondary education level. Research specifically integrating the Discovery Learning model with PhET Simulation media in elementary school Science and Social Studies (IPAS) instruction remains limited.

Based on the preceding explanation, this study introduces a novel approach by utilizing the Discovery Learning model supported by PhET simulations for teaching the "Force and Motion" topic within the Natural and Social Sciences (IPAS) curriculum at the elementary school level. Integrating a discovery-oriented learning model with interactive simulation media is expected to foster a more meaningful learning experience and enhance student learning outcomes. Consequently, this study aims to analyze the effectiveness of the PhET simulation-assisted Discovery Learning model on the IPAS learning outcomes of fourth-grade elementary students. The research focuses on examining students' IPAS learning outcomes before and after the implementation of this model, as well as determining its effectiveness in improving those outcomes. The findings are expected to contribute theoretically to the development of IPAS instruction and serve as a practical reference for teachers in selecting effective learning models and media to enhance student achievement.

2. RESEARCH METHODOLOGY

This study employs a quantitative approach using a quasi-experimental design—specifically, the Nonequivalent Control Group design. This design was selected to evaluate the effectiveness of the PhET simulation-assisted Discovery Learning model on students' learning outcomes in Natural and Social Sciences (IPAS) without employing full subject randomization. The study involved an experimental group that received instruction using the PhET simulation-assisted Discovery Learning model and a control group that received conventional instruction. Learning outcomes were measured by administering pre-tests and post-tests to both groups (Hastjarjo, 2019).

The study was conducted during the 2025/2026 academic year at SDN Jatirejo and SDN Ngadirejo 02 in Wonoasri District, Madiun Regency. The study population comprised all fourth-grade students from both schools, totaling 47 students. A total sampling technique was employed, meaning the entire population served as the research sample (Sugiyono, 2023). The sample consisted of 25 fourth-grade students from SDN Jatirejo experimental group and 22 fourth-grade students from SDN Ngadirejo 02 control group. As the study utilized a non-equivalent control group design without randomization, the equivalence of the two groups' initial abilities was verified through pretest results obtained prior to the intervention. These pretest results were subsequently analyzed to ensure that the groups' initial abilities were relatively comparable, thereby allowing any differences in learning outcomes following the intervention to be attributed to the implementation of the learning model (Hallberg et al., 2018).

The research instrument consisted of a learning achievement test developed based on learning outcome indicators for the IPAS topic of force and motion (Haris et al., 2024). The instrument comprised 20 multiple-choice questions designed to measure students' cognitive abilities and conceptual understanding before and after the intervention. Data collection was conducted using a testing method involving a pre-test—administered prior to instruction to

assess students' initial proficiency—and a post-test—administered after instruction to evaluate learning outcomes. The instrument's suitability was verified through validity and reliability testing; reliability was measured using Cronbach's Alpha, with a value exceeding 0.60 indicating reliability (Subhaktiyasa, 2024).

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software, version 25. Prior to hypothesis testing, the data were assessed for normality using the Shapiro–Wilk test and for homogeneity using Levene's test at a significance level of 0.05 (Sari et al., 2024). Once the data met the assumptions of normality and homogeneity, hypothesis testing was performed using an Independent Samples t-Test to determine the difference in learning outcomes between the experimental and control groups. Testing decisions were based on a significance level of 0.05, where a p-value < 0.05 indicated a significant effect of implementing the Discovery Learning model assisted by PhET simulations on students' IPAS learning outcomes.

3. RESULTS AND DISCUSSION

3.1. Descriptive Analysis

A descriptive analysis was conducted to examine the IPAS learning outcomes of students before and after the intervention in both the experimental and control groups (Hutasuhut & Albina, 2025). The data used consisted of pre-test and post-test scores obtained following the instructional process.

Table 1. Results *Pretest, Posttest*

Class	N	Pretest	Posttest
Control	22	47,05	56,36
Experiment	25	61,00	79,00

Based on Table 1, the average post-test score for the experimental class was 79.00, whereas the control class achieved an average of 56.36. These results indicate that learning outcomes in the experimental class were higher than those in the control class. Furthermore, the learning mastery rate in the experimental class reached 72%, while the control class achieved only 31.82%. These findings suggest that instruction using the Discovery Learning model supported by PhET simulations yields better learning outcomes compared to instruction using the Direct Instruction model supported by real-world objects.

3.2. Normality Test

A normality test was conducted to determine whether the research data followed a normal distribution (Pitriani et al., 2025). The testing was performed using the Shapiro-Wilk test with a significance level of 0.05.

Table 2. Normality Test Results

Significance Level	Class	Pretest	Criteria	Posttest	Criteria
Sig > 0,05	Control	0,655	Normal	0,054	Normal
	Experiment	0,070	Normal	0,070	Normal

Based on Table 2, all significance values are greater than 0.05. Thus, the pre-test and post-test data for both classes are normally distributed, thereby meeting the requirements for parametric analysis.

3.3. Homogeneity Test

A homogeneity test was conducted to determine the equality of variances between the experimental and control classes prior to hypothesis testing (Herlinda et al., 2026). The test was performed using Levene's Test with a significance level of 0.05.

Table 3 Homogeneity Test		
Kelas Experiment dan Control		
<i>Pretest</i>	<i>Posttest</i>	<i>Sig</i>
0,949	0,087	0,3037

Based on Table 3, the significance value for the pre-test is 0.949, and for the post-test, it is 0.087. Both values exceed 0.05, indicating that the data for the experimental and control classes possess homogeneous variances. These results demonstrate that there is no significant difference in variance between the two classes. With the assumption of homogeneity met, the data are suitable for hypothesis testing using the Independent Sample t-Test..

3.4. Independent Samples t-Test

Hypothesis testing was conducted to determine the effectiveness of the Discovery Learning model assisted by PhET simulations on the Natural and Social Sciences (IPAS) learning outcomes of fourth-grade students. The analysis was performed using an Independent Samples t-Test, as the data met the assumptions of normality and homogeneity.

Table 4. Independent Samples t-Test			
Variabel	t-Hitung	Sig. (2-tailed)	Mean Difference
Learning Outcomes in IPAS	5,341	0,000	22,636

Based on Table 4, the significance value (Sig. 2-tailed) obtained is 0.000. This value is lower than the significance level used, which is 0.05 ($0.000 < 0.05$). These results indicate a significant difference in student learning outcomes between the experimental group and the control group following the application of different treatments. Furthermore, the mean difference of 22.636 indicates that the average learning outcome for the experimental group was 22.636 points higher than that of the control group. This difference demonstrates that the use of the Discovery Learning model assisted by PhET simulations contributed significantly to the improvement of students' IPAS learning outcomes. The test results are further supported by a calculated t-value of 5.341, indicating a strong difference between the two groups. Consequently, the alternative hypothesis (H_a) stating that the Discovery Learning model assisted by PhET simulations influences students' IPAS learning outcomes is accepted, while the null hypothesis (H_0) is rejected.

3.5. DISCUSSION

The research results indicate that the Discovery Learning model assisted by PhET Simulations is effective in improving the IPAS (Natural and Social Sciences) learning outcomes of fourth-grade students regarding the topic of force and motion. This is evidenced by the experimental class achieving an average post-test score of 79.00, which is higher than the control class's average of 56.36. Furthermore, the learning mastery rate in the experimental

class reached 72%, surpassing the 31.82% achieved by the control class. These findings demonstrate that, following instruction using the Discovery Learning model assisted by PhET Simulations, students possessed a better understanding of the concepts than they did prior to the intervention.

This improvement in learning outcomes is influenced by the characteristics of the Discovery Learning model, which provides students with opportunities to discover concepts through stages involving stimulation, problem identification, data collection, data processing, verification, and generalization (Amanningrum et al., 2025). At each stage, students actively engage in observing phenomena, exploring, discussing, and drawing conclusions based on their findings. The use of PhET simulations supports this process by providing interactive simulations that visualize concepts of force and motion, thereby making abstract material easier to comprehend. This approach renders the learning process more meaningful and helps students independently build a conceptual understanding. These findings align with Bruner's constructivist theory, which posits that knowledge acquired through the process of discovery is more easily understood and retained by students (Arfianti & Anisah, 2025; Winarti, Suyadi, 2020).

The effectiveness of the Discovery Learning model assisted by PhET simulations is demonstrated by the Independent Samples t-test results, which show a significance value of 0.000 (< 0.05) and a t-statistic of 5.341, indicating a significant difference in learning outcomes between the experimental and control classes. These results demonstrate that the Discovery Learning model assisted by PhET simulations is effective in improving the IPAS (Natural and Social Sciences) learning outcomes of fourth-grade students regarding the topic of force and motion.

The effectiveness of the Discovery Learning model supported by PhET simulations is also evident in students' ability to grasp abstract concepts regarding force and motion. Interactive simulations enable students to observe the relationships between concepts in a more concrete manner through exploration and virtual experimentation. This setup allows students to directly observe force and motion phenomena, conduct explorations, and receive immediate feedback on their activities. The provided visualizations help translate abstract concepts into concrete understandings, thereby making the learning process more meaningful. These findings align with who state that PhET simulations facilitate conceptual exploration through interactive learning experiences. Furthermore, Nurfaida et al., (2024) explain that PhET simulations allow students to perform virtual experiments that reinforce conceptual understanding during the learning process.

These findings are supported by research conducted by Sari & Simanjuntak, (2016) which indicated that the Discovery Learning model utilizing PhET simulations yielded higher average learning outcomes compared to conventional instruction for the topic of static fluids. Similarly, Amin & Amdani, (2023) reported that students taught using the Discovery Learning model supplemented by PhET simulations achieved superior learning outcomes compared to those in the control group. Furthermore, Nirahua & Matulessy, (2024) found that a virtual laboratory-based Discovery Learning model combined with PhET simulations had a significant positive effect on student learning outcomes. These consistent results demonstrate that discovery-based learning integrated with interactive simulations effectively supports conceptual understanding and student learning outcomes across various educational levels and subject matters. Thus, the findings of this study further reinforce the empirical evidence that the combination of Discovery Learning and PhET simulations constitutes an effective instructional strategy for enhancing student learning outcomes.

Beyond its contribution to learning outcomes, the effectiveness of the PhET Simulation-assisted Discovery Learning model can also be explained by its capacity to foster various skills that support the learning process. Rahmiyati et al., (2023) found that Discovery Learning supported by PhET Simulations enhances students' science process skills through activities such as observation, data collection, and drawing conclusions from experiments. Meanwhile, Resa Azahra, Afridha Laily Alindra, (2025) discovered that the model improves students' critical thinking abilities by encouraging them to analyze information, evaluate observations, and formulate conclusions based on the evidence obtained. These results indicate that the effectiveness of the PhET Simulation assisted Discovery Learning model is reflected not only in improved learning outcomes but also in its ability to create an active, interactive, and student-centered learning experience. Unlike most prior studies conducted in physics at the secondary education level, this research provides empirical evidence regarding the effectiveness of the PhET Simulation-assisted Discovery Learning model in elementary school Studies IPAS instruction, specifically concerning the topics of force and motion. These findings expand the body of research on discovery-based learning supported by interactive simulations while addressing limitations in previous studies regarding the educational level and learning context examined.

4. CONCLUSION

The implementation of the Discovery Learning model combined with PhET simulations has proven to positively impact the IPAS (Natural and Social Sciences) learning outcomes of fourth-grade students, particularly regarding the topics of force and motion. This discovery-based approach, aligned with interactive digital visualization, enables students to actively construct their own understanding. Through hands-on exploration, concepts of force and motion—initially abstract—can be grasped in a more tangible, relevant, and meaningful way. These findings underscore the importance of synergizing student-centered learning strategies with the use of interactive technology at the elementary school level. Integrating simulation media not only enriches classroom dynamics but also assists teachers in delivering learning experiences that are more adaptive, interactive, and contextual, catering to the students' developmental needs.

5. REFERENCES

- Agustin, N., Anastasia, S., & Adrias. (2026). Transformasi pembelajaran ipa ke ipas dalam kurikulum merdeka di sekolah dasar: systematic literature review. *Urnal Ilmiah Pendidikan Dasar, Volume 11 Nomor 02*.
- Amanningrum, T. K., Ngatman, & Chamdani, M. (2025). Penerapan model discovery learning dengan multimedia untuk meningkatkan hasil belajar ipas pada siswa kelas iv sd negeri 1 wonosari tahun ajaran 2023/2024. *Jurnal Ilmiah Kependidikan, 13*.
- Amin, R. A. R., & Amdani, K. (2023). Pengaruh model pembelajaran discovery learning berbantuan phet simulation terhadap hasil belajar siswa pada materi momentum dan impuls dikelas x sma n 1 kualuh leidong. *JURNAL IKATAN ALUMNI FISIKA, 9(1), 15*. <https://doi.org/10.24114/jiaf.v9i1.36683>
- Arfianti, L., & Anisah, Z. (2025). Peran guru dalam mengembangkan kemampuan berpikir kritis siswamelalui metode discovery learningpada mata pelajaran ipas. *PREMIERE: Journal of Islamic Elementary Education, Vol 7, No 1*. <https://doi.org/https://doi.org/10.51675/jp.v6i2>
- Azahra, R., Alindra, A. L., & Mustikaati, W. (2025). *Pengaruh penerapan model discovery learning berbantuan phet simulation terhadap kemampuan berpikir kritis siswa pada mata pelajaran ipa di sekolah dasar Resa*. 10(September), 1–11.

- Eka, P. D., Hefni, & Erningsih. (2022). *Faktor penyebab rendahnya hasil belajar siswa dan strategi guru meningkatkan pemahaman konsep siswa*. 6, 8913–8920.
- Hallberg, K., Cook, T. D., Steiner, P. M., & Clark, M. H. (2018). Pretest measures of the study outcome and the elimination of selection bias: evidence from three within study comparisons. *Prevention Science*, 19(3), 274–283. <https://doi.org/10.1007/s11121-016-0732-6>
- Haris, A., Khaeruddin, K., & Reski, S. (2024). Development of learning outcome test instruments on thermodynamics and waves based on the demands of basic competencies. *Jurnal Ilmiah Pendidikan Fisika*, 8(1), 112. <https://doi.org/10.20527/jipf.v8i1.10217>
- Hastjarjo, T. D. (2019). *Rancangan eksperimen-kuasi quasi-experimental design*. 27(2), 187–203. <https://doi.org/10.22146/buletinpsikologi.38619>
- Hatip, A., & Setiawan, W. (2021). Teori kognitif bruner dalam pembelajaran matematika. *PHI: Jurnal Pendidikan Matematika*, 5(2), 87. <https://doi.org/10.33087/phi.v5i2.141>
- Herlinda, A. N., Sapta, A., & Andri, N. (2026). *Learning on fifth graders' critical thinking and mathematical*. 10(2).
- Mariza, F. & Derlina. (2015). *Pengaruh model pembelajaran discovery learning terhadap hasil belajar siswa pada materi pokok suhu dan kalor*. 3(2).
- Mukaramah, M., & Kustina, R. (2020). *Menganalisis kelebihan dan kekurangan model discovery learning berbasis audiovisual dalam pelajaran bahasa indonesia*. 1.
- Nirahua, J., & Matulesy, D. M. (2024). *Physikos journal of physics and physics education laboratorium virtual simulasi phet terintegrasi model pembelajaran discovery learning meningkatkan hasil belajar kognitif materi gerak parabola*. 3(June), 1–9. <https://doi.org/10.30598/physikos.3.1.13216>
- Nurfaida, Haris, A., & Ariani. (2024). *Peningkatan keterampilan proses sains peserta didik melalui simulasi phet listrik dengan model discovery learning*. Vol.4, No.1. <https://doi.org/10.26858/v4i1.57757>
- Nurwahdini Hutasuhut & Meyniar Albina. (2025). Instrumen penelitian pendidikan. *Blaze : jurnal bahasa dan sastra dalam pendidikan linguistik dan pengembangan*, 3(3), 177–190. <https://doi.org/10.59841/blaze.v3i3.2976>
- Pitriani, L., Muchlis, E. E., & Stiadi, E. (2025). The influence of problem based learning model with flipped classroom on the mathematical literacy ability of class viii students at smpn 19 seluma. *International Journal of Innovation and Education Research*, Volume 4 Number 1.
- Rahmiyati, Farcis, F., & Dinata, P. A. C. (2023). Penerapan model pembelajaran discovery learning berbantuan media phet simulation untuk melatih keterampilan proses sains peserta didik di smp negeri 8 palangkaraya. *Bahana Pendidikan: Jurnal Pendidikan Sains*, 5(2), 37–45. <https://doi.org/10.37304/bpjps.v5i2.10783>
- Sari, A. P., Hasanah, S., & Nursalman, M. (2024). *Uji normalitas dan homogenitas dalam analisis statistik*. 8.
- Sari, D. P., & Simanjuntak, M. P. (2016). Pengaruh model discovery learning berbantuan media phet terhadap hasil belajar siswa. *INPAFI (Inovasi Pembelajaran Fisika)*, 4(4). <https://doi.org/https://doi.org/10.24114/inpafi.v4i4.5631>
- Sihombing, H. W., Afandi, M., & Subhan, M. (2024). *Faktor-faktor yang mempengaruhi proses pembelajaran*. 1(2), 685–691.
- Sugiyono. (2023). *Metode penelitian kuantitatif, kualitatif, dan r&d* (2nd edn). Alfabeta.
- Winarti, Suyadi. (2020). Pelaksanaan model discovery learning jerome bruner pada pembelajaran pai di smpn 3 depok sleman yogyakarta. *QALAMUNA: Jurnal Pendidikan, Sosial, dan Agama*, 12(2). <https://doi.org/10.37680/qalamuna.v12i2.503>
- Zainuri, B. N. S. (2022). *Implementasi model guided discovery learning berbantuan simulasi phet dalam pembelajaran sains: tinjauan literatur naratif*. 4(1).