JPPIPA 10(10) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Differences of Students' Learning Outcomes Using the Discovery Learning Model and Problem Based Learning in Science Learning at Primary Schools

Loso Judijanto[1], Muhammad Sukron Fauzi[2], Yudi Hendrilia[3], Dalimawaty Kadir[4], Nerru Pranuta Murnaka[5], Fachruzzaki[6*]

[1] IPOSS Jakarta, Jakarta, Indonesia.
[2] Universitas Mulawarman, Samarinda, Indonesia.
[3] STT Kanaan Nusantara Ungaran, Semarang, Indonesia.
[4] Universitas Muslim Nusantara Al-Washliyah, Medan, Indonesia.
[5] STKIP SURYA, Tangerang, Indonesia.
[6] Universitas Jember, Jember, Indonesia.

Received: March 14, 2024
Revised: September 03, 2024
Accepted: October 25, 2024
Published: October 31, 2024

Corresponding Author:
Fachruzzaki
zakiunej@unej.ac.id

DOI: 10.29303/jppipa.v10i10.9046

Abstract: The paper aims to compare the effectiveness of two learning models, namely Discovery Learning (DL) and Problem Based Learning (PBL), in improving student learning outcomes in science subjects. This type of research is experimental research. The population in this study were all class IV students at SDN 002 SK (Samarinda City), totaling three classes. The calculation results show that the average pretest score in experimental class I is 45.12, which is higher compared to 35.60 in experimental class II. After treatment, the average posttest score in experimental class I increased to 85.80, while in experimental class II it reached 82.11. The average N-Gain for both classes was 0.74, indicating a significant increase in learning outcomes in both classes, although experimental class I showed slightly better results. More in-depth analysis based on high and low learning outcome categories shows consistent differences in the effectiveness of learning models. Hypothesis testing using the T Test, which is applied because the data distribution is normal and the variance is homogeneous, shows a calculated t-value of 8.60 which far exceeds the t_table of 2.070. This causes rejection of H_0 and acceptance of H_1, indicating that the Discovery Learning (DL) model in experimental class I provides better learning results than the Problem Based Learning (PBL) model in experimental class II.

Keywords: Discovery learning; Learning results; Merdeka curriculum; PBL

Introduction

In the context of the Merdeka Curriculum, educational phenomena such as globalization and technological advances have a major impact on student learning outcomes. The Merdeka Curriculum supports the implementation of more flexible and inclusive learning methods through the use of online platforms and interactive tools (Sanjaya et al., 2022). This approach allows the application of learning models that are more suited to students' needs and learning styles, such as Discovery Learning (DL) and Problem Based Learning (PBL). This method is designed to develop 21st century skills, such as problem solving and digital literacy, which are essential in an increasingly connected and dynamic world. By emphasizing project-based learning and practical experience, the Merdeka Curriculum aims to make learning more relevant and engaging, as well as

How to Cite:
Judijanto, L., Fauzi, M. S., Hendrilia, Y., Kadir, D., Murnaka, N. P., & Fachruzzaki. (2024). The Differences of Students' Learning Outcomes Using the Discovery Learning Model and Problem Based Learning in Science Learning at Primary Schools. *Jurnal Penelitian Pendidikan IPA*, *10*(10), 7354–7360. https://doi.org/10.29303/jppipa.v10i10.9046

increasing student engagement and overall understanding (Hasanah et al., 2023). The Merdeka Curriculum supports flexible learning methods such as Discovery Learning and Problem Based Learning, utilizing technology to improve 21st century skills and the relevance of learning for students.

However, despite significant progress in various aspects of education, disparities in access and quality of education remain a major challenge. The Merdeka Curriculum faces challenges in overcoming injustices that arise from differences in regions and socio-economic groups (Fannisa et al., 2023). To address this gap, continued efforts are needed to ensure that all students have an equal opportunity to obtain a quality education. By adapting to social, technological and economic changes, the Merdeka Curriculum seeks to respond to the demands of an ever-evolving era and improve learning outcomes in various contexts, while ensuring that all students benefit from existing educational innovations (Yoto et al., 2024). The Merdeka Curriculum adapts to social, technological and economic changes to meet the demands of the times, improve learning outcomes and ensure all students benefit from educational innovation.

The phenomenon of low student learning outcomes is often influenced by various factors, as explained by education experts. Lodge et al. (2018) emphasized that the mismatch of material with students' level of cognitive development can hinder understanding and application of knowledge, which has an impact on learning outcomes. According to Alivernini et al. (2023), identifying motivation as a crucial factor, low intrinsic or extrinsic motivation can reduce student involvement in learning. In addition, Martínez-López et al. (2023) and Zhang et al. (2024) also suggests that a lack of social support and role models can influence learning outcomes. Teaching methods that are inappropriate or less relevant to students' needs can make it difficult for them to understand the material (Darling-Hammond et al., 2020; Tharayil et al., 2018). Environmental factors, such as the family's economic and social conditions, also play an important role (Agostino & Ruberto, 2021; Falk et al., 2023). All of these factors show that low learning outcomes are often the result of complex interactions between cognitive aspects, motivation, teaching methods and the environment, thus requiring a holistic approach to improvement.

Learning models such as Discover Learning and Problem-Based Learning (PBL) offer innovative approaches to address this gap and improve learning outcomes. Discover Learning encourages students to explore and discover knowledge through direct experience and an Merdeka exploration (Ramadhan et al., 2023; Harefa et al., 2024). Discovery Learning (DL) emphasizes exploration and discovery of concepts through students' direct experiences, with the teacher as a facilitator (Afrrannisah et al., 2021; Yu, 2024). Students learn through observation and experimentation, encouraging creative and Merdeka thinking. This method can increase students' motivation and understanding, especially when they have limited access to resources, because they learn through discovery and practical application. On the other hand, Problem-Based Learning (PBL) focuses on real-world problem solving as the center of learning, which develops critical and collaborative skills (Brata & Mahatmaharti, 2020; Yu & Zin, 2023).

PBL can help students from various backgrounds to better understand subject matter in a relevant and contextual way, increasing their ability to apply knowledge in real situations. Applying these two models in the context of educational disparities can help overcome some of the existing challenges. By encouraging active and collaborative learning, as well as providing opportunities for practical problem solving, Discover Learning and PBL can improve the quality of learning and overall learning outcomes. In line with that research Chusni (2022) and Paramitha et al. (2023), shows that the Discovery Learning Model is more effective than Problem Based Learning in improving student achievement in studying the preparation of official letters, so that it can be an alternative for teachers in Correspondence subjects. However, it is important to ensure that all students, including those from disadvantaged backgrounds, have equal access to this learning method to maximize its benefits. By adapting to social, technological, and economic changes, and by implementing innovative learning approaches, education systems can be more effective in improving learning outcomes and achieving educational equality.

Based on the study above, the aim of this research is to identify differences in student learning outcomes using the Discovery Learning model compared to the Problem-Based Learning model in science learning. This research aims to evaluate the effectiveness of the two learning models in improving student learning outcomes, by measuring the extent to which each approach can influence students' understanding, engagement and academic achievement in science subjects.

Method

This type of research is experimental research. Experimental research Quantitative is research that uses experimental methods to test hypotheses by measuring the relationship between variables numerically (Taherdoost, 2022). This research uses a Factorial design research type with the static group comparison design. The static group comparison design is a design that uses

two groups by introducing different treatments to the two groups. In this research, the differences in science and science learning outcomes using the Discovery Learning and Problem Based Learning models were seen. As can be seen in table 1 which involves two experimental groups.

Table 1. The Static Group Comparison Design

Result	Model PjBL (A_1)	Model PBL (A_2)
High Learning Results (B_1)	A_1B_1	A_2B_1
Low Learning Results (B_2)	A_1B_2	A_2B_2

Information:
Group of High learning results using Model DL
Group of Low learning results using Model DL
Group of High learning results using Model PBL
Group of Low learning results using Model PBL

Population and Sample

Population is a generalized area consisting of objects or subjects that have certain quantities and characteristics determined by the researcher. So, it can be said that the population is all objects that have the same characteristics. The population in this study were all class IV students at SDN 002 SK (Samarinda City), totaling three classes. The number of students can be seen in the table below:

Table 2. Average of STS (Summative of Mid Semester) IPAS Grade IV

Class	Total Students	Average
IVA	27	85.50
IVB	27	84.03
IVC	27	79.69
	81	

Sample

The sample is part of the population, a sample is a part of a population that has similar characteristics, and must be representative if the population is too large to study completely. In research, two types of samples are needed, namely the experimental class and the control class. The sampling technique uses non-probability sampling with purposive sampling to select students with similar average scores, as well as probability sampling with proportionate stratified random sampling to determine experimental classes I and II. Based on the table, the number of students has the same and the average class scores that are close to the same are class VA and class VB. After getting the sample class, the two classes were randomly drawn, then class VA was obtained as experiment I and class VB as experiment II.

Results and Discussion

Description of the Differences in Science Learning Results of Experiment I and Experiment II Students

Data on learning outcomes in this research were obtained from the pretest and posttest in each experimental class I and II. The test consists of 30 objective questions. After the pretest and posttest, a normalized gain calculation was carried out to assess the increase in learning outcomes, and the results can be seen in the figure below:

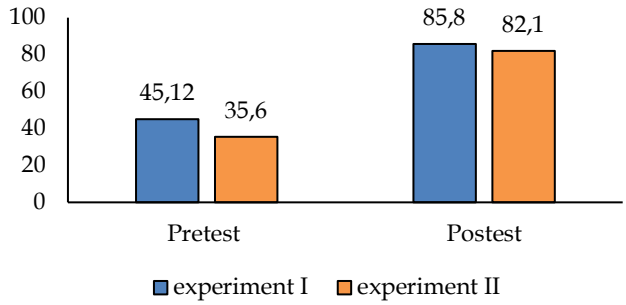

Figure 1. Student learning result test data in experiment I and experiment II classes

The average pretest score of students in experimental class I, which reached 45.12, was higher compared to 35.60 in experimental class II. After treatment, the average posttest score in experimental class I increased to 85.80, while experimental class II reached 82.11. In addition, the average N-Gain of experimental class I is 0.74, which shows a more significant increase in learning outcomes compared to with N-Gain for experimental class II which is also 0.74. Overall, although both classes showed a high category of increased learning outcomes, the experimental class I showed slightly better performance in terms of scores and increased learning outcomes.

Description of the Differences in High Student Learning Results in Experiment I and Experiment II

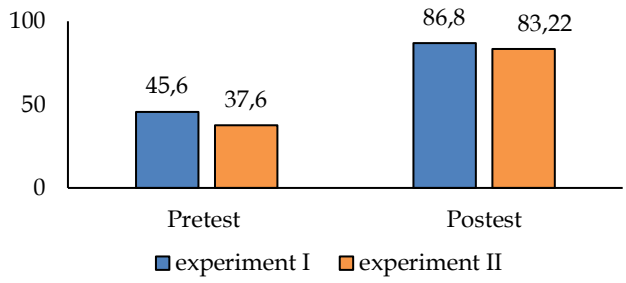

Figure 2. Students' results description of the differences in low student learning results in experiment I and experiment II

Table 3. Students' Learning Results

Learning results	Results	N	$\bar{x}$	$\bar{g}$	G min	G max
Experiment I	Pretest	12	41.01	0.76	0.43	0.90
	Postest		86.66			
Experiment II	Pretest	15	30.55	0.74	0.55	0.88
	Postest		83.89			

Hypothesis Testing

In accordance with the research method applied, because the student learning outcomes test data showed a normal distribution and homogeneous variance, to test hypotheses 1, 2, and 3, the T test was used. This method was chosen to ensure that the statistical analysis carried out was in accordance with the characteristics data. The results of hypothesis testing using the T Test provide information which will be explained below.

Hypothesis

The first hypothesis in this study was designed to evaluate differences in student learning outcomes in science subjects between the DL learning model and the PBL model. This research aims to identify whether there are significant differences in student learning outcomes when using the two models. The results of the first hypothesis test carried out will be presented below:

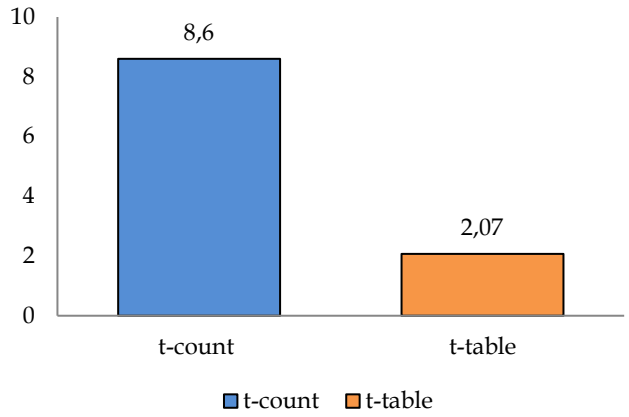

Figure 3. First hypothesis calculation results

In the table presented, the t-test analysis of the N-gain calculation in experimental class I and experimental class II shows the calculated t_value of 8.60, while the t_table value is 2.070. With a calculated t_value that is much greater than t_table, the decision taken is to reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1). This indicates that there are significant differences in student learning outcomes between the two classes after the treatment was implemented. In other words, the learning outcomes of students taught using the DL model in experimental class I were proven to be better than the learning outcomes of students taught using the PBL model in experimental class II. These findings confirm that the DL method is more effective in improving learning outcomes in science learning compared to the PBL method.

Discussion

This research aims to compare the effectiveness of two learning models, namely DL and PBL, in improving student learning outcomes in science subjects. The results of the research show that the application of the DL model in experimental class I produces better learning outcomes compared to the application of the PBL model in experimental class II. This finding is based on pretest and posttest analysis using a written test containing 30 objective questions. The average pretest score in experimental class I which reached 45.12 was higher compared to 35.60 in experimental class II, which shows that students in experimental class I started from a higher level of initial knowledge (Van Riesen et al., 2018; Mundelsee & Jurkowski, 2021).

After implementing the treatment, the average posttest score in experimental class I increased to 85.80, while in experimental class II it increased to 82.11. This shows a significant increase in learning outcomes in both classes. The average N-Gain for experimental classes I and II are both 0.74, indicating that both learning models provide a high increase in learning outcomes (Abdurahman et al., 2023). However, the difference in posttest scores shows that the DL model is more effective in improving student learning outcomes. Analysis based on high and low learning outcome categories shows consistency in the differences in effectiveness between the two models. For students with high learning outcomes, experimental class I showed an average pretest score of 45.60 and posttest 85.80, while experimental class II recorded a pretest score of 37.30 and posttest 83.22. This difference indicates that students with high learning outcomes in experimental class I gained greater benefits from the DL model compared to the PBL model (Bashith & Amin, 2017; Otoluwa et al., 2024).

For students with low learning outcomes, experimental class I also showed better results, with an average pretest score of 41.01 and posttest 86.66, while experimental class II had a pretest score of 30.55 and posttest 83.89. This confirms that the DL model is more effective in improving student learning outcomes, regardless of their initial ability level. The results of hypothesis testing using the T Test support this finding. The calculated t_value is 8.60 which far exceeds the t_table of 2.070, indicating that the difference in learning outcomes between the two classes is significant. By rejecting the null hypothesis (H_0) and accepting the alternative hypothesis (H_1), it can be concluded that the application of the DL model in experimental class I is significantly more effective than the PBL model in

experimental class II in improving student learning outcomes.

This research shows that the DL model is more effective in improving student learning outcomes compared to the PBL model. It is relevant with a study conducted by Hardy et al. (2014), Kamaluddin et al. (2019), Yannier et al. (2020), and Blinkoff et al. (2023), which emphasizes the importance of active exploration and knowledge discovery in the learning process. According to Munira et al. (2023), Handayani et al. (2024), that students learn better through hands-on experience. In the context of the Merdeka Curriculum, which prioritizes a more flexible approach and is based on student needs, the application of the DL model is in accordance with the principles of the curriculum (Kerimbayev et al., 2023; Southworth et al., 2023; Sanger, 2020).

Previous research, such as by Tong et al. (2022) and Al Shloul et al. (2024), also shows that learning that encourages active exploration is more effective in improving students' understanding and skills. The results of this research provide valuable insight for educators and curriculum developers to choose learning methods that are more appropriate in improving student academic achievement (Han, 2021; Contrino et al., 2024; Neliwati et al., 2023). Further research is needed to explore the integration of the DL model in the Merdeka Curriculum and to expand these findings to other learning contexts.

Conclusion

Based on the research results, it can be concluded that there are significant differences in student learning outcomes between DL and PBL learning models. This research used a pretest and posttest with a written test containing 30 objective questions to measure learning outcomes in experimental classes I and II. The results show that the average pretest score in experimental class I (45.12) is higher than in experimental class II (35.60). After implementing the treatment, the average posttest score in experimental class I increased significantly to 85.80, while in experimental class II it reached 82.11. Although the average N-Gain for both classes was 0.74, which indicates a significant increase in learning outcomes, experimental class I showed better results overall. Hypothesis testing using the T Test shows a calculated t_value of 8.60, which far exceeds the t_table of 2.070, so that the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted. This indicates that the Discovery Learning (DL) method in experimental class I is more effective in improving learning outcomes compared to the Problem Based Learning (PBL) method in experimental class II. These findings confirm that the application of the DL model is more successful in increasing student academic achievement compared to the PBL model.

Author Contributions

Conceptualization, L. J.; methodology, M. S. F.; validation, Y. H.; formal analysis, D. K; investigation, N. P. M.; resources, F.; data curation, L. J.: writing—original draft preparation, M. S. F.; writing—review and editing, Y. H.: visualization, D. K. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abdurahman, A., Asfahani, A., Sudarwati, N., Warwer, F., & Asrijal, A. (2023). The influence of problem-based learning model on students' learning outcomes. *International Journal of Trends in Mathematics Education Research*, *6*(3), 247–255. https://doi.org/10.33122/ijtmer.v6i3.226

Afrrannisah, A., Yusrizal, Y., & Nur, S. (2021). Implementasi Model Guided Discovery Learning Berbantuan Audio Visual Untuk Meningkatkan Minat Belajar Dan Pemahaman Konsep Siswa Pada Materi Elastisitas Dan Hukum Hooke. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 297–304. https://doi.org/10.29303/jppipa.v7iSpecialIssue.1164

Agostino, M., & Ruberto, S. (2021). Environment-friendly practices: Family versus non-family firms. *Journal of Cleaner Production*, *329*, 129689. https://doi.org/10.1016/j.jclepro.2021.129689

Al Shloul, T., Mazhar, T., Abbas, Q., Iqbal, M., Ghadi, Y. Y., Shahzad, T., Mallek, F., & Hamam, H. (2024). Role of activity-based learning and ChatGPT on students' performance in education. *Computers and Education: Artificial Intelligence*, *6*, 100219. https://doi.org/10.1016/j.caeai.2024.100219

Alivernini, F., Manganelli, S., Lucidi, F., & Cavicchiolo, E. (2023). Understanding and supporting the motivation of students from low-income families. *Contemporary Educational Psychology*, *73*, 102177. https://doi.org/10.1016/j.cedpsych.2023.102177

Bashith, A., & Amin, S. (2017). The Effect of Problem Based Learning on EFL Students' Critical Thinking Skill and Learning Outcome. *Al-Ta Lim Journal*, *24*(2), 93. https://doi.org/10.15548/jt.v0i0.271

Blinkoff, E., Nesbitt, K. T., Golinkoff, R. M., & Hirsh-Pasek, K. (2023). Investigating the contributions of active, playful learning to student interest and educational outcomes. *Acta Psychologica*, *238*,

103983. https://doi.org/10.1016/j.actpsy.2023.103983

Brata, D. P. N., & Mahatmaharti, A. K. (2020). The implementation of Problem Based Learning (PBL) to develop student's soft-skills. *Journal of Physics: Conference Series*, *1464*(1), 012020. https://doi.org/10.1088/1742-6596/1464/1/012020

Chusni, M. M. (2022). Effectiveness of discovery learning-based multiple representation module on enhancing the critical thinking skills of the students with high and low science process skills. *Jurnal Inovasi Pendidikan IPA*, *8*(2), 199–209. https://doi.org/10.21831/jipi.v8i2.49340

Contrino, M. F., Reyes-Millán, M., Vázquez-Villegas, P., & Membrillo-Hernández, J. (2024). Using an adaptive learning tool to improve student performance and satisfaction in online and face-to-face education for a more personalized approach. *Smart Learning Environments*, *11*(1), 6. https://doi.org/10.1186/s40561-024-00292-y

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Falk, A., Kosse, F., Schildberg-Hörisch, H., & Zimmermann, F. (2023). Self-assessment: The role of the social environment. *Journal of Public Economics*, *223*, 104908. https://doi.org/10.1016/j.jpubeco.2023.104908

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

Han, F. (2021). The Relations between Teaching Strategies, Students' Engagement in Learning, and Teachers' Self-Concept. *Sustainability*, *13*(9), 5020. https://doi.org/10.3390/su13095020

Handayani, S., Nur Amalina, E., Nur Asiah, A., & Prasetyo Wati, A. (2024). Study of ``Merdeka Belajar'' Curriculum for Cultivating Student Character: Evidence from Indonesia. *KnE Social Sciences*. https://doi.org/10.18502/kss.v9i4.15086

Hardy, J. H., Day, E. A., Hughes, M. G., Wang, X., & Schuelke, M. J. (2014). Exploratory behavior in active learning: A between- and within-person examination. *Organizational Behavior and Human Decision Processes*, *125*(2), 98–112. https://doi.org/10.1016/j.obhdp.2014.06.005

Harefa, M. M., Usman, H., & Lestari, I. (2024). Analysis Of The Implementation Of The Merdeka Curriculum In 3t Areas (Underdeveloped, Frontier And Outermost) (Elementary School In Namohalu Esiwa Sub-District). *Jurnal Elementaria Edukasia*, *7*(1), 2195–2207. https://doi.org/10.31949/jee.v7i1.8623

Hasanah, I., Rodiah, S., & Afifah, L. (2023). Facilities and Infrastructures' Implications Towards Teachers' Pedagogical Content Knowledge (PCK) Welcoming Merdeka Belajar Curriculum. *Journal Of Digital Learning And Distance Education*, *1*(8), 319–328. https://doi.org/10.56778/jdlde.v1i8.73

Kamaluddin, M., & Widjajanti, D. B. (2019). The Impact of Discovery Learning on Students' Mathematics Learning Outcomes. *Journal of Physics: Conference Series*, *1320*(1), 012038. https://doi.org/10.1088/1742-6596/1320/1/012038

Kerimbayev, N., Umirzakova, Z., Shadiev, R., & Jotsov, V. (2023). A student-centered approach using modern technologies in distance learning: A systematic review of the literature. *Smart Learning Environments*, *10*(1), 61. https://doi.org/10.1186/s40561-023-00280-8

Lodge, J. M., Kennedy, G., Lockyer, L., Arguel, A., & Pachman, M. (2018). Understanding Difficulties and Resulting Confusion in Learning: An Integrative Review. *Frontiers in Education*, *3*, 49. https://doi.org/10.3389/feduc.2018.00049

Martínez-López, Z., Nouws, S., Villar, E., Mayo, M. E., & Tinajero, C. (2023). Perceived social support and self-regulated learning: A systematic review and meta-analysis. *International Journal of Educational Research Open*, *5*, 100291. https://doi.org/10.1016/j.ijedro.2023.100291

Mundelsee, L., & Jurkowski, S. (2021). Think and pair before share: Effects of collaboration on students' in-class participation. *Learning and Individual Differences*, *88*, 102015. https://doi.org/10.1016/j.lindif.2021.102015

Munira, W., & Suryana, N. (2023). Implementation the "Merdeka Curriculum" in History Education. *JUSPI (Jurnal Sejarah Peradaban Islam)*, *7*(1), 45. https://doi.org/10.30829/juspi.v7i1.15660

Neliwati, N., Hasanah, U., Pringadi, R., Sirojuddin, A., & Arif, M. (2023). Curriculum Management in Improving The Quality of Student Learning and Academic Achievement. *Munaddhomah: Jurnal Manajemen Pendidikan Islam*, *4*(1), 115–121. https://doi.org/10.31538/munaddhomah.v4i1.233

Otoluwa, S. M., Uloli, R., Abdjul, T., Mursalin, Odja, A. H., & Ntobuo, N. E. (2024). The Influence of the PBL Model to Student Learning Outcomes on Heat and its Transfer Concepts. *Jurnal Penelitian*

Pendidikan IPA, *10*(7), 4357–4363. https://doi.org/10.29303/jppipa.v10i7.8003

Paramitha, A. P., Istiqomah, N., & Mastura, S. (2023). The influence of problem-based learning and discovery learning models on learning outcomes. *Jurnal Penelitian Ilmu Pendidikan*, *16*(1). https://doi.org/10.21831/jpipfip.v16i1.52423

Ramadhan, D. P., Kuswandi, D., & Soepriyanto, Y. (2023). Exploring Genius Hour: A literature study on concepts, benefits, and their application at every level of education in various countries. *Jurnal Inovasi Teknologi Pendidikan*, *10*(3), 218–232. https://doi.org/10.21831/jitp.v10i3.61479

Sanger, C. S. (2020). Inclusive Pedagogy and Universal Design Approaches for Diverse Learning Environments. In *Diversity and Inclusion in Global Higher Education* (pp. 31–71). Springer Singapore. https://doi.org/10.1007/978-981-15-1628-3_2

Sanjaya, W., Erita, Y., Putri, R. S., & Indriyani, N. (2022). Teachers' Readiness and Ability in Designing Teaching Modules in The Independent Curriculum. *Journal Of Digital Learning And Distance Education*, *1*(7), 288–296. https://doi.org/10.56778/jdlde.v1i7.46

Southworth, J., Migliaccio, K., Glover, J., Glover, J., Reed, D., McCarty, C., Brendemuhl, J., & Thomas, A. (2023). Developing a model for AI Across the curriculum: Transforming the higher education landscape via innovation in AI literacy. *Computers and Education: Artificial Intelligence*, *4*, 100127. https://doi.org/10.1016/j.caeai.2023.100127

Taherdoost, H. (2022). What are Different Research Approaches? Comprehensive Review of Qualitative, Quantitative, and Mixed Method Research, Their Applications, Types, and Limitations. *Journal of Management Science & Engineering Research*, *5*(1), 53–63. https://doi.org/10.30564/jmser.v5i1.4538

Tharayil, S., Borrego, M., Prince, M., Nguyen, K. A., Shekhar, P., Finelli, C. J., & Waters, C. (2018). Strategies to mitigate student resistance to active learning. *International Journal of STEM Education*, *5*(1), 7. https://doi.org/10.1186/s40594-018-0102-y

Tong, D. H., Uyen, B. P., & Ngan, L. K. (2022). The effectiveness of blended learning on students' academic achievement, self-study skills and learning attitudes: A quasi-experiment study in teaching the conventions for coordinates in the plane. *Heliyon*, *8*(12), e12657. https://doi.org/10.1016/j.heliyon.2022.e12657

Van Riesen, S. A. N., Gijlers, H., Anjewierden, A., & De Jong, T. (2018). The influence of prior knowledge on experiment design guidance in a science inquiry context. *International Journal of Science Education*, *40*(11), 1327–1344. https://doi.org/10.1080/09500693.2018.1477263

Yannier, N., Hudson, S. E., & Koedinger, K. R. (2020). Active Learning is About More Than Hands-On: A Mixed-Reality AI System to Support STEM Education. *International Journal of Artificial Intelligence in Education*, *30*(1), 74–96. https://doi.org/10.1007/s40593-020-00194-3

Yoto, Marsono, Suyetno, A., Mawangi, P. A. N., Romadin, A., & Paryono. (2024). The role of industry to unlock the potential of the *Merdeka* curriculum for vocational school. *Cogent Education*, *11*(1), 2335820. https://doi.org/10.1080/2331186X.2024.2335820

Yu, H. (2024). Enhancing creative cognition through project-based learning: An in-depth scholarly exploration. *Heliyon*, *10*(6), e27706. https://doi.org/10.1016/j.heliyon.2024.e27706

Yu, L., & Zin, Z. M. (2023). The critical thinking-oriented adaptations of problem-based learning models: A systematic review. *Frontiers in Education*, *8*, 1139987. https://doi.org/10.3389/feduc.2023.1139987

Zhang, B., Yin, X., & Ren, Z. (2024). Can perceived social support influence academic achievement of master's students? Evidence from a University in China. *Education and Information Technologies*. https://doi.org/10.1007/s10639-024-12693-0