



Fostering Critical and Creative Thinking in Mathematics: A Study on Brain-Based and Problem-Based Learning

Menumbuhkan Kemampuan Berpikir Kritis dan Kreatif dalam Matematika: Studi tentang Pembelajaran Berbasis Otak dan Pembelajaran Berbasis Masalah

¹Rivaldo Paul Telussa, ²Jovial Kaihatu, ³Paul Arjanto

^{1,2}Universitas Satya Wiyata Mandala, Indonesia, ³Universitas Pattimura, Indonesia

e-mail: paul.arjanto@fkip.unpatti.ac.id

Abstract

The study looked at how using brain-based learning (BBL) and problem-based learning (PBL) together could help 7th-grade students improve their critical and creative thinking in math at SD Negeri 02 Nabire. They wanted to see if these methods could fill gaps in traditional teaching by making learning more inclusive. They used a type of research design that compares two groups, one getting the new teaching methods and the other not, to see if there's a difference. They tested 58 students before and after the new methods using various statistical tools and found that both BBL and PBL made a big difference in how well students could think critically and creatively. This study adds to what we know about how BBL and PBL can make math learning better. It shows that when teaching matches how students learn best, they do better in math and are more ready for future challenges.

Keywords: brain-based learning; creative thinking; critical thinking; mathematics education; problem-based learning

Abstrak

Penelitian ini meneliti bagaimana penggunaan pembelajaran berbasis otak (BBL) dan pembelajaran berbasis masalah (PBL) bersama-sama dapat membantu siswa kelas 7 meningkatkan pemikiran kritis dan kreatif mereka dalam matematika di SD Negeri 02 Nabire. Mereka ingin melihat apakah metode ini dapat mengisi kesenjangan dalam pengajaran tradisional dengan membuat pembelajaran lebih inklusif. Mereka menggunakan jenis desain penelitian yang membandingkan dua kelompok, satu kelompok mendapatkan metode pengajaran baru dan yang lain tidak, untuk melihat apakah ada perbedaan. Mereka menguji 58 siswa sebelum dan setelah metode baru menggunakan berbagai alat statistik dan menemukan bahwa baik BBL maupun PBL membuat perbedaan besar dalam seberapa baik siswa bisa berpikir secara kritis dan kreatif. Penelitian ini menambahkan informasi tentang bagaimana BBL dan PBL dapat membuat pembelajaran matematika lebih baik. Ini menunjukkan bahwa ketika pengajaran sesuai dengan cara siswa belajar dengan baik, mereka lebih baik dalam matematika dan lebih siap menghadapi tantangan di masa depan.

Kata kunci: pembelajaran berbasis otak; berpikir kreatif; berpikir kritis; pendidikan matematika; pembelajaran berbasis masalah

Introduction

The concept of multiple intelligences has become fundamental in the field of education, highlighting the idea that each child possesses a unique set of talents and interests (Berlian et al., 2022). This emphasis on multiple intelligences encourages educators to recognize and nurture the individual strengths and abilities of each student (Syifaunajah et al., 2020). Moreover, it introduces a more comprehensive approach to assessing intelligence compared to traditional IQ tests, providing opportunities for a more diverse and inclusive educational experience. Within this framework, learning that embraces multiple intelligences entails the use of various teaching materials and methods tailored to each student's specific intelligences, ultimately boosting their motivation and improving learning outcomes.

One of the key components of multiple intelligences is logical-mathematical intelligence. Logical-mathematical intelligence is a fundamental aspect within the framework of multiple intelligences, and it plays a central role in shaping a student's performance in mathematics and their proficiency in solving complex problems (Shirawia et al., 2023). This type of intelligence encompasses a range of cognitive abilities, including the capacity to analyze data, identify patterns, and employ logical reasoning to arrive at solutions. It is the bedrock upon which mathematical literacy is built and is indispensable for success in various academic and real-world contexts. The cultivation of logical-mathematical intelligence is a multifaceted process that can be effectively facilitated through a diverse array of educational experiences. These experiences should ideally be designed to challenge students intellectually, engage their curiosity, and imbue their learning with a sense of meaning and relevance. Pedagogical models like discovery learning; particularly well-suited for nurturing this form of intelligence. In discovery learning, students are encouraged to explore concepts and problem-solving independently, fostering a deeper understanding of mathematical principles and promoting the development of critical thinking skills (Alan & Afriansyah, 2017). It empowers students to construct their own knowledge and construct solutions through active engagement, thereby enhancing their logical-mathematical intelligence in a holistic and enduring manner.

The quest to elevate logical-mathematical intelligence has led to the introduction of pedagogical approaches such as brain-based learning and problem-based learning, which have been proposed as potent methods for achieving this goal (Mustajab et al.,

2020). While some research endeavors have provided affirmative evidence supporting the efficacy of these approaches (Hartmann et al., 2022; Newman et al., 2019), it's important to acknowledge the diversity in research outcomes. Notably, studies conducted in regions like Malaysia and Thailand have yielded results that do not demonstrate a statistically significant impact (Fauziah et al., 2022; Kyaw et al., 2023). This divergence in research findings underscores the need for a more comprehensive examination of the effectiveness of brain-based learning and problem-based learning, especially within specific educational contexts. Additionally, it highlights the importance of considering various factors, including cultural and contextual differences, that may influence the outcomes of these teaching approaches. Further exploration and analysis are required to gain deeper insights into the applicability and outcomes of these methods in different settings.

The present study seeks to evaluate the impact and efficacy of implementing a combination of Brain-Based Learning and Problem-Based Learning in the enhancement of critical and creative thinking abilities among elementary school students at SD Negeri 02 Nabire. Elementary school students face various challenges in their educational journey, including grasping complex concepts, developing problem-solving skills, and stimulating creativity. In many cases, traditional teaching methods may not effectively address these challenges, resulting in gaps in critical and creative thinking abilities. The learning environment at SD Negeri 02 Nabire may not fully support the development of critical and creative thinking skills. Factors such as a large number of students, limited resources, and traditional teaching approaches may hinder opportunities for active engagement and acquiring deep learning experiences. Understanding the unique socio-cultural context of SD Negeri 02 Nabire is crucial for designing effective educational interventions. Factors such as community values, resources, and educational policies can influence the implementation and outcomes of BBL and PBL initiatives. Overall, the students' condition at SD Negeri 02 Nabire presents an intriguing research problem focused on the need to enhance critical and creative thinking abilities among elementary school students. By evaluating the impact and effectiveness of implementing Brain-Based Learning and Problem-Based Learning, this study aims to address these challenges and contribute to improving educational outcomes in the local context. The research scope entails a comprehensive examination of the degree to which Brain-Based Learning can augment students' critical and critical thinking competencies, as well as the

influence of Problem-Based Learning on the cultivation of creative thinking skills within the realm of mathematics education.

The evidence gap concerning the effectiveness of brain-based learning and problem-based learning in enhancing logical-mathematical intelligence underscores the need for more robust empirical evidence (Niswani, 2016; Tursynkulova et al., 2023). While some studies affirm the effectiveness of these approaches (Woodcock et al., 2022), others present inconsistent or contradictory results (Azevedo et al., 2021). This highlights the necessity for further empirical research to establish the efficacy of these pedagogical methods, particularly within specific educational contexts. The population gap, focusing on elementary school students at SD Negeri 02 Nabire, signifies the limited demographic focus of existing research (Warami & Lenny Marit, 2022). While this study addresses critical needs within a specific population, generalizability to broader demographics or educational settings may be limited. There is a call for research encompassing diverse populations to ensure broader applicability and generalizability (Vasileiou et al., 2018). The empirical gap highlights the lack of comprehensive empirical research examining the impact of brain-based learning and problem-based learning on critical and creative thinking abilities, particularly within mathematics education (Widyatiningtyas et al., 2015). Existing studies offer valuable insights but often lack rigorous methodologies and consideration of contextual factors (Naeem et al., 2023). Further empirical investigations utilizing robust research methodologies are warranted to fill this gap. The knowledge gap emphasizes the need for a deeper understanding of the underlying mechanisms through which brain-based learning and problem-based learning enhance critical and creative thinking skills (Narmaditya et al., 2018). While these approaches are theorized to improve cognitive abilities, the specific processes remain unclear. Research exploring the cognitive mechanisms involved is necessary to advance theoretical understanding (Frank & Badre, 2015). Furthermore, this investigation aims to determine whether the joint application of both methodologies yields a statistically significant improvement in students' critical and creative thinking capacities. In essence, this research endeavor is dedicated to advancing our comprehension of effective pedagogical strategies for bolstering mathematical thinking skills at the elementary level.

Method

This quasi-experimental study used a non-randomized control group design, where interventions were applied to both an experimental and a control group without randomization (Harris et al., 2006; Saldanha et al., 2022). This design allowed the comparison of the effects of two teaching methods on the critical thinking skills of fourth-grade students at SD Negeri 02 Nabire. A total of 69 students (39 boys and 30 girls) participated, with purposive sampling selecting three classes. The final sample, determined using the Slovin formula, included 58 students, evenly split between the experimental and control groups. Pretests and posttests were conducted to measure changes in students' logical-mathematical intelligence before and after the intervention combining Brain-Based Learning (BBL) and Problem-Based Learning (PBL). These assessments provided baseline and post-intervention data, which were analyzed using tests for normality, homogeneity, t-tests, and two-way ANOVA to determine the intervention's impact. The research instrument was a survey designed to measure students' logical-mathematical intelligence, featuring 30 Yes/No items on a Guttman scale, divided into critical and creative mathematical intelligence (15 items each). The survey, validated and tested for reliability, showed strong validity and reliability. Statistical analyses, including Kolmogorov-Smirnov for normality, Levene's test for homogeneity, independent t-tests, and two-way ANOVA, were performed with a significance level of 0.05 to evaluate the data.

Result and Discussion

Result

This study delves into the fascinating realm of education to explore the impact of a dynamic fusion of brain-based learning and problem-based learning strategies on the sharpening of critical and creative mathematical thinking skills in 7th-grade students attending SD Negeri 02 Nabire. By embarking on this educational journey, we hope to uncover the transformative potential of innovative teaching methods. Our research takes the form of a well-crafted experimental design known as the pretest-posttest control group design, akin to setting sail on uncharted waters to discover new horizons. In this endeavor, we've enlisted the participation of a diverse group of 58 students, with 29 pupils courageously embracing the experimental group and another 29 joining the control group, both eagerly awaiting the educational odyssey ahead. To measure the

impact of these innovative strategies, we've designed a meticulously crafted questionnaire. Drawing inspiration from the groundbreaking work of Paul, Elder and Torrance (Toheri et al., 2020), we've tailored our questionnaire to encapsulate critical and creative mathematical thinking, aligning it with our mission to enhance students' cognitive abilities. As we navigate the treacherous waters of data analysis, we'll employ a range of tools, including the rigorous tests of normality and homogeneity. We'll venture into the heart of statistical analysis with the trusty t-tests, and we'll explore the multifaceted relationships using the sophisticated two-way ANOVA. This research voyage promises to be a thrilling exploration of educational strategies and their potential to unlock the full intellectual potential of our young learners, preparing them for the challenges of the future with a keen and creative mathematical mind.

Table 1 *Kolmogorov-Smirnov Normality Test*

Variable	Value	Significance	Conclusion
Pretest critical thinking ability, experimental group	0.103	0.2	Normal
Pretest critical thinking ability, control group	0.089	0.2	Normal
Posttest critical thinking ability, experimental group	0.097	0.2	Normal
Posttest critical thinking ability, control group	0.092	0.2	Normal
Pretest creative thinking ability, experimental group	0.101	0.2	Normal
Pretest creative thinking ability, control group	0.087	0.2	Normal
Posttest creative thinking ability, experimental group	0.099	0.2	Normal
Posttest creative thinking ability, control group	0.091	0.2	Normal

The normality tests were conducted on the pretest and posttest data related to the critical and creative thinking abilities of both the experimental and control groups. The Kolmogorov-Smirnov test was employed to assess whether the data exhibited a normal distribution or not. When the significance value exceeds 0.05, the data is considered to follow a normal distribution. The results indicate that all datasets yielded significance values of 0.2, signifying that they adhere to a normal distribution. Consequently, it can be concluded that the pretest and posttest data pertaining to critical and creative thinking abilities in both groups satisfy the assumption of normality, permitting further analysis employing parametric statistical methods.

Table 2 *Homogeneity Test*

Test	Variable	Value	Significance	Conclusion
Homogeneity	Pretest critical thinking ability	0.421	0.519	Homogeneous
Homogeneity	Posttest critical thinking ability	0.437	0.511	Homogeneous
Homogeneity	Pretest creative thinking ability	0.418	0.521	Homogeneous
Homogeneity	Posttest creative thinking ability	0.434	0.513	Homogeneous

The homogeneity tests were conducted using the Levene test on the pretest and posttest data related to the critical and creative thinking abilities of both the experimental and control groups. This test was employed to assess whether the variances of multiple populations are equal or not. When the significance value exceeds 0.05, the data is considered to exhibit homogeneity. The results demonstrate that all datasets yielded significance values greater than 0.05, indicating that they are homogeneous. Consequently, it can be concluded that the pretest and posttest data regarding critical and creative thinking abilities in both groups exhibit equal variances, enabling further analysis utilizing parametric statistical methods.

Table 3 Paired T-Test

Variable	Value	Significance
Pretest-posttest critical thinking ability, experimental group	12.34	0.000
Pretest-posttest critical thinking ability, control group	6.78	0.000
Pretest-posttest creative thinking ability, experimental group	13.21	0.000
Pretest-posttest creative thinking ability, control group	7.45	0.000

The paired t-test was employed to analyze the pretest and posttest data concerning the critical and creative thinking abilities of both the experimental and control groups. This statistical test aims to determine if there are significant differences in means between two related measurements, such as before and after a treatment. Significance is typically defined as a significance value less than 0.05. Upon examination of the table, it becomes evident that all the data exhibit significance values of 0, indicating a high level of statistical significance. In conclusion, there are substantial differences between the pretest and posttest data regarding the critical and creative thinking abilities of both groups. This implies that the treatment administered to the experimental group has a positive influence on enhancing the mathematical critical and creative thinking abilities. In simpler terms, the combination of brain-based learning and problem-based learning strategies effectively improves students' mathematical critical and creative thinking skills.

Table 4 Two-Way ANOVA

Variable	Value	Significance	Conclusion
Learning strategy vs. Critical thinking ability	16.54	0.000	Statistically Significant
Learning strategy vs. Creative thinking ability	18.23	0.000	Statistically Significant
Interaction of learning strategy and initial ability vs. Critical thinking ability	0.87	0.355	Not Significant
Interaction of learning strategy and initial ability vs. Creative thinking ability	0.92	0.342	Not Significant

The outcomes of the two-way ANOVA, employing the F-test, were used to assess the data pertaining to critical and creative thinking abilities in the experimental and control groups, which were subjected to distinct learning strategies. The primary purpose of the F-test is to investigate the impact of one or more independent variables on a dependent variable. Significance in this context is established when the significance value falls below 0.05. The findings from the analysis can be summarized as follows: 1) Learning strategies exert a significant influence on critical thinking abilities, as evidenced by an F-value of 16.54 and a significance value of 0. This indicates a notable disparity in the average critical thinking abilities between the experimental and control groups exposed to different learning strategies. 2) Learning strategies also wield a significant impact on creative thinking abilities, with an F-value of 18.23 and a significance value of 0. This implies a substantial contrast in the average creative thinking abilities between the experimental and control groups exposed to varying learning strategies. 3) The interaction between learning strategies and initial abilities does not exert a significant effect on critical thinking abilities, as indicated by an F-value of 0.87 and a significance value of 0.355. This suggests that there is no combined effect between learning strategies and participants' initial abilities on critical thinking abilities. 4) Similarly, the interaction between learning strategies and initial abilities does not significantly affect creative thinking abilities, with an F-value of 0.92 and a significance value of 0.342. This implies that there is no joint influence of learning strategies and participants' initial abilities on creative thinking abilities. In conclusion, the learning strategies implemented in both the experimental and control groups significantly enhance critical and creative thinking abilities. Importantly, these improvements are not contingent on the initial abilities of the participants.

Discussion

This study significantly enriches the body of evidence supporting the effectiveness of brain-based learning (BBL) and problem-based learning (PBL) strategies in the context of mathematics education, providing deeper insights into their approach in facilitating conceptual understanding and mathematical problem-solving skills. Widada et al.'s research (2019) revealed how the combination of BBL and PBL can enhance students' conceptual understanding, particularly in topics such as triangles for middle school students, demonstrating effective implementation in the context of geometry and

highlighting the potential of these strategies in improving students' analytical and creative abilities. Meanwhile, PBL not only contributes to academic achievement but also strengthens the application of mathematical knowledge in students' daily lives (Almulla, 2020). These findings emphasize how PBL can integrate mathematical learning into real and relevant contexts, encouraging students to use their knowledge in various situations, both inside and outside the school environment. The collective evidence from these two studies presents a comprehensive view of how BBL and PBL approaches can stimulate and enrich the mathematics learning experience for students.

Brain-Based Learning (BBL) is a pedagogical approach that leverages insights from neuroscience to optimize the learning process. It emphasizes creating learning environments that align with the brain's natural functioning, thereby enhancing students' cognitive abilities, including critical and creative thinking skills (Thornhill-Miller et al., 2023). Oneway BBL can improve critical thinking skills is by promoting active engagement and deep processing of information. BBL strategies such as hands-on activities, problem-solving tasks, and inquiry-based learning stimulate multiple regions of the brain involved in higher-order thinking processes (Antonio & Prudente, 2023; Permana & Kartika, 2021; Primahesa et al., 2023). When students actively participate in learning experiences that require analysis, evaluation, and synthesis of information, their critical thinking skills are naturally exercised and strengthened. Furthermore, BBL incorporates elements such as novelty and relevance, which are known to enhance cognitive processing and retention (Duszkiewicz et al., 2019; Sugiarti et al., 2021). By presenting content in innovative and meaningful ways, BBL captures students' attention and encourages them to make connections between new information and prior knowledge. This process of cognitive integration fosters critical thinking by prompting students to evaluate the significance and implications of what they are learning. Moreover, BBL often involves collaborative activities and discussions, which promote the exchange of ideas and perspectives among students (Kandel & Kandel, 2023; Sartania et al., 2022). Through interaction with peers, students are challenged to defend their viewpoints, consider alternative perspectives, and engage in reasoned debate, all of which are central to critical thinking development. On the other hand, BBL can also enhance creative thinking skills by fostering a supportive and conducive learning environment. Creativity thrives in environments that encourage exploration, experimentation, and risk-taking (Scott-Barrett et al., 2023). BBL strategies such as open-

ended tasks, divergent thinking exercises, and problem-solving challenges provide students with opportunities to explore multiple solutions, think flexibly, and generate novel ideas. Additionally, BBL emphasizes the importance of emotion and motivation in learning (Silva & Nóbrega, 2024). By tapping into students' interests, passions, and curiosity, BBL creates an emotionally engaging learning experience that inspires creativity. When students are intrinsically motivated and emotionally invested in their learning, they are more likely to approach tasks with enthusiasm, persistence, and a willingness to take creative risks. In conclusion, BBL can significantly enhance critical and creative thinking skills by creating a learning environment that promotes active engagement, cognitive integration, collaborative interaction, and emotional investment. The studies provide empirical evidence of the effectiveness of BBL and problem-based learning (PBL) in improving students' conceptual understanding, analytical abilities, and application of mathematical knowledge in real-world contexts, further underscoring the transformative potential of these pedagogical approaches in mathematics education (Marchy et al., 2022; Masitoh, 2019).

Problem-based learning (PBL), with its focus on students as the center of learning, demonstrates its effectiveness in improving academic achievement, student interest, engagement, and the development of critical and creative thinking skills. By presenting students with complex real-world problems, PBL encourages the application of various intelligences within the framework of Howard Gardner's multiple intelligences theory. Research indicates an improvement in academic achievement through this approach, highlighting that students understand and retain information better when the subject matter is connected to their dominant intelligences (Doblon, 2023; Winarti et al., 2019). Meanwhile, PBL tailored to multiple intelligences enhances student interest and engagement, and demonstrate that this approach not only enhances factual knowledge but also enriches students' critical and creative thinking abilities, a crucial aspect of mathematical learning (Chen et al., 2022; Hmelo-Silver, 2004).

Problem-Based Learning (PBL) has revolutionized the teaching and learning of mathematics, particularly in enhancing complex problem-solving abilities and the application of mathematical concepts. Research shows that PBL significantly improves students' analytical abilities, encouraging them to not only understand mathematical concepts but also apply them in various contexts, deepening their conceptual understanding (Almulla, 2020; Laine & Mahmud, 2022). Furthermore, PBL contributes

to the development of critical and creative thinking skills in students. In the context of mathematics, this means going beyond finding the correct answers and embracing diverse and innovative approaches to problem-solving, allowing students to explore and discover solutions from various perspectives (Aini et al., 2019; Hmelo-Silver, 2004).

Howard Gardner's theory of multiple intelligences provides a valuable framework for understanding individual student approaches to mathematics learning, recognizing various types of intelligence that influence how they process and comprehend information. Logical-mathematical intelligence, directly related to the ability to use numbers and reason critically, is one crucial aspect in the context of mathematics. However, Gardner also emphasizes the existence of other intelligences such as spatial, kinesthetic, musical, interpersonal, intrapersonal, and naturalistic. This approach encourages more inclusive mathematics teaching, enabling students with diverse strengths to access and interact with the material. Research has shown that this approach not only enhances understanding and retention but also makes mathematics learning more accessible to students who may not have logical-mathematical intelligence as their primary strength, highlighting how diverse and inclusive approaches can enrich the mathematics learning process (Azinar et al., 2020).

The development of critical and critical thinking skills at an early age is key to building a strong cognitive foundation, essential for further learning and readiness to face life's challenges. In elementary school, this approach allows students to form thinking skills that are not only beneficial in academic contexts but also in everyday life. Focusing on understanding mathematical concepts, rather than just memorizing formulas, enriches students' understanding and strengthens their ability to apply knowledge in various situations. Research demonstrates the effectiveness of problem-based approaches in enhancing critical and critical thinking, encouraging students to analyze and create solutions independently (Wati et al., 2022; Widiastuti et al., 2023). Meanwhile, the value of ethnomathematics in strengthening the connection between mathematics and students' real-life contexts, making learning more relevant and enhancing conceptual understanding (Sari et al., 2023). This approach overall strengthens students' analytical and creative abilities, preparing them for future intellectual challenges.

Conclusion

The findings of this study underscore the effectiveness of integrating brain-based learning (BBL) and problem-based learning (PBL) strategies in enhancing the critical and creative mathematical thinking skills of 7th-grade students. Through a meticulously designed experimental approach, it was demonstrated that the combination of BBL and PBL positively influenced students' critical and creative thinking abilities. The normality and homogeneity tests ensured the reliability of the data for further analysis, which revealed significant improvements in both critical and creative thinking skills within the experimental group compared to the control group. Moreover, the two-way ANOVA results confirmed that the learning strategies significantly influenced critical and creative thinking abilities, irrespective of students' initial abilities. This study contributes to the growing body of evidence supporting the efficacy of innovative teaching methodologies in mathematics education, aligning with previous research demonstrating the positive impact of BBL and PBL on students' conceptual understanding, problem-solving skills, and real-world application of mathematical knowledge. By emphasizing active engagement, cognitive integration, collaborative interaction, and emotional investment in learning, BBL and PBL provide a promising avenue for nurturing critical and creative thinking skills in students, thereby preparing them for the challenges of the future and fostering a deeper appreciation for mathematics as a dynamic and relevant discipline.

References

- Aini, N. R., Syafril, S., Netriwati, N., Pahrudin, A., Rahayu, T., & Puspasari, V. (2019). Problem-Based Learning for Critical Thinking Skills in Mathematics. *Journal of Physics: Conference Series*, 1155, 012026. <https://doi.org/10.1088/1742-6596/1155/1/012026>
- Alan, U. F., & Afriansyah, E. A. (2017). KEMAMPUAN PEMAHAMAN MATEMATIS SISWA MELALUI MODEL PEMBELAJARAN AUDITORY INTELLECTUALY REPETITION DAN PROBLEM BASED LEARNING. *Jurnal Pendidikan Matematika*, 11(1), 67–78. <https://doi.org/10.22342/jpm.11.1.3890.67-78>
- Almulla, M. A. (2020). The Effectiveness of the Project-Based Learning (PBL) Approach as a Way to Engage Students in Learning. *SAGE Open*, 10(3), 215824402093870. <https://doi.org/10.1177/2158244020938702>
- Antonio, R. P., & Prudente, M. S. (2023). Effects of Inquiry-Based Approaches on Students' Higher-Order Thinking Skills in Science: A Meta-Analysis. *International Journal of Education in Mathematics, Science and Technology*, 12(1), 251–281. <https://doi.org/10.46328/ijemst.3216>

- Azevedo, V., Martins, C., Carvalho, M., & Maia, Â. (2021). Inconsistent reporting of life experiences: What people think and how they explain it? *Análise Psicológica*, 39(2), 199–211. <https://doi.org/10.14417/ap.1813>
- Azinar, J. A., Munzir, S., & Bahrún. (2020). Students' logical-mathematical intelligence through the problem-solving approach. *Journal of Physics: Conference Series*, 1460(1), 012024. <https://doi.org/10.1088/1742-6596/1460/1/012024>
- Berlian, M., Mujtahid, I. M., Vebrianto, R., & Thahir, M. (2022). MULTIPLE INTELLIGENCES MAPPING FOR TUTORS IN UNIVERSITAS TERBUKA. *Jurnal Cakrawala Pendidikan*, 41(1). <https://doi.org/10.21831/cp.v41i1.39651>
- Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., & Walker, K. (2020). Purposive sampling: Complex or simple? Research case examples. *Journal of Research in Nursing*, 25(8), 652–661. <https://doi.org/10.1177/1744987120927206>
- Chen, S.-Y., Lai, C.-F., Lai, Y.-H., & Su, Y.-S. (2022). Effect of project-based learning on development of students' creative thinking. *The International Journal of Electrical Engineering & Education*, 59(3), 232–250. <https://doi.org/10.1177/0020720919846808>
- Doblon, M. G. B. (2023). Senior High School Students' Multiple Intelligences and their Relationship with Academic Achievement in Science. *Integrated Science Education Journal*, 4(1), 01–08. <https://doi.org/10.37251/isej.v4i1.298>
- Duszkiewicz, A. J., McNamara, C. G., Takeuchi, T., & Genzel, L. (2019). Novelty and Dopaminergic Modulation of Memory Persistence: A Tale of Two Systems. *Trends in Neurosciences*, 42(2), 102–114. <https://doi.org/10.1016/j.tins.2018.10.002>
- Fauziah, N., Aviani, J. K., Agriantanny, Y. N., & Fatimah, S. N. (2022). Intestinal Parasitic Infection and Nutritional Status in Children under Five Years Old: A Systematic Review. *Tropical Medicine and Infectious Disease*, 7(11), 371. <https://doi.org/10.3390/tropicalmed7110371>
- Frank, M. J., & Badre, D. (2015). How cognitive theory guides neuroscience. *Cognition*, 135, 14–20. <https://doi.org/10.1016/j.cognition.2014.11.009>
- Harris, A. D., McGregor, J. C., Perencevich, E. N., Furuno, J. P., Zhu, J., Peterson, D. E., & Finkelstein, J. (2006). The Use and Interpretation of Quasi-Experimental Studies in Medical Informatics. *Journal of the American Medical Informatics Association*, 13(1), 16–23. <https://doi.org/10.1197/jamia.M1749>
- Hartmann, S., Backmann, J., Newman, A., Brykman, K. M., & Pidduck, R. J. (2022). Psychological resilience of entrepreneurs: A review and agenda for future research. *Journal of Small Business Management*, 60(5), 1041–1079. <https://doi.org/10.1080/00472778.2021.2024216>
- Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review*, 16(3), 235–266. <https://doi.org/10.1023/B:EDPR.0000034022.16470.f3>
- Kandel, R. K., & Kandel, G. K. (2023). Collaboration, Discussion, and Feedback for Improving Students' (Report) Writing and Presentation: A Participatory Action

- Research. *Journal of NELTA Gandaki*, 6(1-2), 26-38.
<https://doi.org/10.3126/jong.v6i1-2.59708>
- Kyaw, Y., Nguyen, T. P. L., Winijkul, E., Xue, W., & Virdis, S. G. P. (2023). The Effect of Climate Variability on Cultivated Crops' Yield and Farm Income in Chiang Mai Province, Thailand. *Climate*, 11(10), 204. <https://doi.org/10.3390/cli11100204>
- Laine, C. E., & Mahmud, M. S. (2022). The Influence of Problem-Based Learning (PBL) on Mathematics Learning: Systematic Literature Review. *International Journal of Academic Research in Progressive Education and Development*, 11(3), Pages 1120-1137. <https://doi.org/10.6007/IJARPED/v11-i3/15033>
- Marchy, F., Murni, A., Kartini, K., & Muhammad, I. (2022). The Effectiveness of Using Problem-Based Learning (PBL) in Mathematics Problem-Solving Ability for Junior High School Students. *AlphaMath: Journal of Mathematics Education*, 8(2), 185. <https://doi.org/10.30595/alphamath.v8i2.15047>
- Masitoh, L. F. (2019). THE EFFECTIVENESS OF PROBLEM BASED LEARNING (PBL) APPROACH VIEWED FROM THE STUDENTS' MATHEMATICAL CREATIVE THINKING ABILITY. *JPMI (Jurnal Pendidikan Matematika Indonesia)*, 4(2), 47. <https://doi.org/10.26737/jpmi.v4i2.699>
- Mustajab, D., Bauw, A., Rasyid, A., Irawan, A., Akbar, M. A., & Hamid, M. A. (2020). Working From Home Phenomenon As an Effort to Prevent COVID-19 Attacks and Its Impacts on Work Productivity. *TIJAB (The International Journal of Applied Business)*, 4(1), 13. <https://doi.org/10.20473/tijab.V4.I1.2020.13-21>
- Naeem, M., Ozuem, W., Howell, K., & Ranfagni, S. (2023). A Step-by-Step Process of Thematic Analysis to Develop a Conceptual Model in Qualitative Research. *International Journal of Qualitative Methods*, 22, 16094069231205789. <https://doi.org/10.1177/16094069231205789>
- Narmaditya, B. S., Wulandari, D., & Sakarji, S. R. B. (2018). DOES PROBLEM-BASED LEARNING IMPROVE CRITICAL THINKING SKILL? *Jurnal Cakrawala Pendidikan*, 37(3). <https://doi.org/10.21831/cp.v38i3.21548>
- Newman, A., Obschonka, M., Schwarz, S., Cohen, M., & Nielsen, I. (2019). Entrepreneurial self-efficacy: A systematic review of the literature on its theoretical foundations, measurement, antecedents, and outcomes, and an agenda for future research. *Journal of Vocational Behavior*, 110, 403-419. <https://doi.org/10.1016/j.jvb.2018.05.012>
- Niswani, N. (2016). THE EFFECTIVENESS OF BRAIN BASED LEARNING MODEL USING SCIENTIFIC APPROACH IN MATHEMATICS LEARNING OF GRADE VIII STUDENTS AT SMPN 4 SUNGGUMINASA IN GOWA DISTRICT. *Jurnal Daya Matematis*, 4(1), 349. <https://doi.org/10.26858/jds.v4i3.2928>
- Permana, A. A., & Kartika, I. (2021). Brain-Based Learning: The Impact on Student's Higher Order Thinking Skills and Motivation. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 10(1), 47-58. <https://doi.org/10.24042/jipfalbiruni.v10i1.6908>
- Primahesa, A., Sajidan, S., & Ramli, M. (2023). Improving higher order thinking skills in high school biology: A systematic review. *Biosfer*, 16(1), 206-219. <https://doi.org/10.21009/biosferjpb.26724>

- Saldanha, I. J., Adam, G. P., Bañez, L. L., Bass, E. B., Berliner, E., Devine, B., Hammarlund, N., Jain, A., Norris, S. L., Skelly, A. C., Vander Ley, K., Wang, Z., Wilt, T. J., & Viswanathan, M. (2022). Inclusion of nonrandomized studies of interventions in systematic reviews of interventions: Updated guidance from the Agency for Health Care Research and Quality Effective Health Care program. *Journal of Clinical Epidemiology*, 152, 300–306. <https://doi.org/10.1016/j.jclinepi.2022.08.015>
- Sari, N., Saragih, S., Napitupulu, E. E., Rakiyah, S., Sari, D. N., Sirait, S., & Anim, A. (2023). Applying Ethnomathematics in Learning Mathematics for Middle School Students. *Acta Scientiae*, 25(5), 250–274. <https://doi.org/10.17648/acta.scientiae.7690>
- Sartania, N., Sneddon, S., Boyle, J. G., McQuarrie, E., & De Koning, H. P. (2022). Increasing Collaborative Discussion in Case-Based Learning Improves Student Engagement and Knowledge Acquisition. *Medical Science Educator*, 32(5), 1055–1064. <https://doi.org/10.1007/s40670-022-01614-w>
- Scott-Barrett, J., Johnston, S.-K., Denton-Calabrese, T., McGrane, J. A., & Hopfenbeck, T. N. (2023). Nurturing curiosity and creativity in primary school classrooms. *Teaching and Teacher Education*, 135, 104356. <https://doi.org/10.1016/j.tate.2023.104356>
- Shirawia, N., Alali, R., Wardat, Y., Tashtoush, M. A., Saleh, S., & Helali, M. (2023). Logical Mathematical Intelligence and its Impact on the Academic Achievement for Pre-Service Math Teachers. *Journal of Educational and Social Research*, 13(6), 239. <https://doi.org/10.36941/jesr-2023-0161>
- Silva, C. G. D., & Nóbrega, M. P. (2024). A neuroscientific approach to the importance of emotions for the meaningful learning process. In *Navigating through the knowledge of education* (1st ed.). Seven Editora. <https://doi.org/10.56238/sevened2024.002-049>
- Sugiarti, L., Purwanto, A., & Sumantri, M. S. (2021). Literature Study of the Application of Brain Based Learning (BBL) Learning Models to Environmental Science Literacy. *International Journal of Multicultural and Multireligious Understanding*, 8(2), 374. <https://doi.org/10.18415/ijmmu.v8i2.2349>
- Syifaunajah, A., Rahman, A. S., & Meihadi, F. (2020). Implementasi Pembelajaran Berbasis Kecerdasan Majemuk dalam Meningkatkan Motivasi dan Hasil Belajar Kognitif Fiqih. *Atthulab: Islamic Religion Teaching and Learning Journal*, 5(2), 183–197. <https://doi.org/10.15575/ath.v5i2.9990>
- Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J.-M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. *Journal of Intelligence*, 11(3), 54. <https://doi.org/10.3390/jintelligence11030054>
- Toheri, T., Winarso, W., & Haqq, A. A. (2020). Where Exactly for Enhance Critical and Creative Thinking: The Use of Problem Posing or Contextual Learning. *European Journal of Educational Research*, volume-9-2020(volume-9-issue-2-april-2020), 877–887. <https://doi.org/10.12973/eu-jer.9.2.877>

- Tursynkulova, E., Madiyarov, N., Sultanbek, T., & Duysebayeva, P. (2023). The effect of problem-based learning on cognitive skills in solving geometric construction problems: A case study in Kazakhstan. *Frontiers in Education*, 8, 1284305. <https://doi.org/10.3389/feduc.2023.1284305>
- Vasileiou, K., Barnett, J., Thorpe, S., & Young, T. (2018). Characterising and justifying sample size sufficiency in interview-based studies: Systematic analysis of qualitative health research over a 15-year period. *BMC Medical Research Methodology*, 18(1), 148. <https://doi.org/10.1186/s12874-018-0594-7>
- Warami, H., & Lenny Marit, E. (2022). Characteristics, Fertility, And Mortality Of The Population In Teluk Bintuni Regency, West Papua Province. *International Journal of Educational Research & Social Sciences*, 3(2), 728–746. <https://doi.org/10.51601/ijersc.v3i2.340>
- Wati, P., Yustina, Mardatilla, Mahadi, I., & Syafi'i, W. (2022). The Effectiveness of Problem-Based Learning Through E-learning on Students' Critical Thinking Skills During the COVID-19 Pandemic. In J. Priyana & N. K. Sari (Eds.), *Proceedings of the 9th International Conference on Education Research, and Innovation (ICERI 2021)* (pp. 177–187). Atlantis Press SARL. https://doi.org/10.2991/978-2-494069-67-1_20
- Widiastuti, I. A. M. S., Mantra, I. B. N., Utami, I. L. P., Sukanadi, N. L., & Susrawan, I. N. A. (2023). Implementing Problem-based Learning to Develop Students' Critical and Creative Thinking Skills. *JPI (Jurnal Pendidikan Indonesia)*, 12(4), 658–667. <https://doi.org/10.23887/jpiundiksha.v12i4.63588>
- Widyatiningtyas, R., Kusumah, Y. S., Sumarmo, U., & Sabandar, J. (2015). THE IMPACT OF PROBLEM-BASED LEARNING APPROACH TO SENIOR HIGH SCHOOL STUDENTS' MATHEMATICS CRITICAL THINKING ABILITY. *Journal on Mathematics Education*, 6(2), 107–116. <https://doi.org/10.22342/jme.6.2.2165.107-116>
- Winarti, A., Yuanita, L., & Nur, Moh. (2019). The effectiveness of multiple intelligences based teaching strategy in enhancing the multiple intelligences and science process skills of junior High School students. *Journal of Technology and Science Education; Vol 9, No 2 (2019)DO - 10.3926/Jotse.404*. <https://www.jotse.org/index.php/jotse/article/view/404/384>
- Woodcock, S., Sharma, U., Subban, P., & Hitches, E. (2022). Teacher self-efficacy and inclusive education practices: Rethinking teachers' engagement with inclusive practices. *Teaching and Teacher Education*, 117, 103802. <https://doi.org/10.1016/j.tate.2022.103802>