

IMPLEMENTING DEEP LEARNING TO ENHANCE STUDENTS' LITERACY AND NUMERACY SKILLS

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ABSTRACT

Literacy and numeracy skills are essential basic skills for student learning success, but achievement levels in Indonesia are still far from expectations. Deep learning methods are proposed as a modern solution that focuses on meaningful conceptual understanding, active student participation, and the development of critical, reflective, and creative thinking skills. By using approaches such as problem-based learning, project-based learning, and collaborative discussions supported by digital technology, deep learning can efficiently combine literacy and numeracy in real learning situations. The application of this approach not only serves to improve reading, comprehension, and numeracy skills in a practical way but also helps shape adaptable and independent characters, in line with the vision of the Merdeka Curriculum. It is hoped that applying deep learning in literacy and numeracy will produce a generation of students who are superior and ready to face the challenges of the 21st century comprehensively and sustainably.

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INTRODUCTIONS

Literacy and numeracy are foundational skills that play a crucial role in fostering students' learning success. Literacy involves not only the ability to read and comprehend texts but also encompasses critical thinking, analytical skills, and effective communication (Lopez-Pedersen et al., 2023). Conversely, numeracy refers to the ability to apply

mathematical knowledge in everyday contexts, including problem-solving, data interpretation, and making informed decisions based on numerical information (Carpendale et al., 2025). Within the Merdeka Curriculum, literacy and numeracy are regarded as essential pillars of cross-disciplinary learning, underscoring the idea that mastering these skills is integral to the educational experience (Yulindaria et al., 2025).

Literacy and numeracy in Indonesia continue to face significant challenges. According to various international and national studies, including PISA, Indonesian students' literacy and numeracy scores remain low compared to those of other countries (Juandi & Dasari, 2024). This situation highlights a gap between students' achievement and the educational goals set for them. Several factors contribute to this issue, including poor numeracy skills, limited access to learning resources, a lack of diversity in teaching methods, and insufficient interest in reading. If these challenges are not addressed promptly, they could impede students' future progress (Gelbgiser & Gabay-Egozi, 2025).

To address this challenge, it is important to explore new learning strategies that can enhance comprehension and retention. One promising approach is deep learning, which emphasizes the mastery of essential concepts, the development of critical thinking skills, and the ability to connect information to real-world applications (Novita Barokah & Umi Mahmudah, 2025). This method can significantly assist students in understanding literacy and numeracy concepts and applying them effectively in their daily lives (Haitao et al., 2025; Tara et al., 2025).

There is a belief that utilizing deep learning techniques in literacy and numeracy education can enhance the quality of education in Indonesia (Lopez-Pedersen et al., 2023). This approach enables teachers to design learning experiences that are more interactive, collaborative, and centered around the students. This aligns with the vision of the Merdeka Curriculum, which promotes education tailored to the unique potential and needs of each student. Consequently, it is hoped that the implementation of deep learning in educational practices will produce a generation that is not only literate and numerate but also adaptive to the global challenges of the 21st century (Deda et al., 2023; Jian Wang, 2023).

THEORETICAL FRAMEWORK

The Concepts of Literacy and Numeracy

Literacy and numeracy are fundamental skills that form the basis for mastering other skills. Literacy refers to the ability to understand, use, evaluate, and reflect on different types of written text, allowing individuals to acquire knowledge and engage effectively in society (Bulfone et al., 2024; Edy Saputra et al., 2024). In contrast, numeracy involves the ability to apply mathematical concepts, facts, procedures, and tools to solve problems in various everyday situations. These skills go beyond simply reading and counting; they enable students to think logically, critically, and reflectively (Indrawatiningsih et al., 2024; Yulindaria et al., 2025).

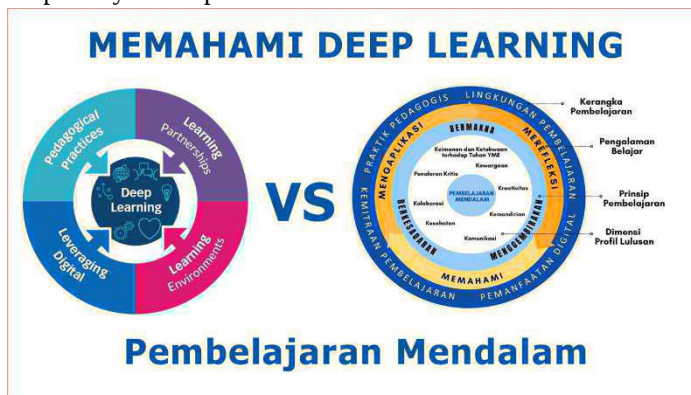
In 21st-century education, literacy and numeracy are becoming increasingly important. These skills are essential for equipping young people to become lifelong learners in an era marked by rapid information flow and complex global issues. While numeracy is necessary for making data- and number-based decisions, literacy is crucial for critically selecting, analyzing, and interpreting information. International assessments, such as PISA, measure a nation's educational quality based on reading literacy, mathematical literacy, and scientific literacy, highlighting the importance of these skills (Achmad Zukhruf Alfaruqi & Nurwahidah Nurwahidah, 2025; Juandi & Dasari, 2024). Therefore, to enhance the competitiveness of Indonesia's younger generation, mastery of literacy and numeracy is essential.

The Concept of Deep Learning in Education

Deep learning in education emphasizes a meaningful understanding of concepts instead of mere memorization of facts (Cao et al., 2025; Peng et al., 2025). This approach encourages students to connect new ideas with their prior knowledge, develop critical thinking skills, and apply what they've learned in real-world

contexts(Masud et al., 2025). It aligns with the Merdeka Curriculum paradigm, which focuses on independence, meaningfulness, and differentiation in the learning process(Long et al., 2025).

The main principles in deep learning include relevance, interconnectedness, and meaningfulness (Maharani et al., 2025; Rad et al., 2025). Relevance means that the material being studied is related to the needs and real experiences of learners, thereby fostering intrinsic motivation. Interconnectedness emphasizes the integration of concepts across subjects, allowing students to see the relationship between theory and practice. Meanwhile, meaningfulness refers to a learning process that helps students gain a deep understanding, so that the knowledge acquired is more durable and can be transferred to new situations (Novita Barokah & Umi Mahmudah, 2025; Nurdiana et al., 2024). With these principles, deep learning creates a learning process that is more contextual, collaborative, and oriented towards long-term competency development.



Source : <https://www.youtube.com/watch?v=YIzvYTHivzU>

The Relationship Between Deep Learning and Literacy and Numeracy. Deep Learning encourages students to think critically, understand concepts in depth, and develop lasting problem-solving skills. In education, literacy and numeracy are key foundations that enable students to meet the challenges of the digital age. Deep Learning strengthens these skills by fostering a practical and deeper understanding. As a result, students not only memorise but also connect knowledge to real-life contexts(Enjang Warman et al., 2025).

The connection between Deep Learning and literacy and numeracy is also realised through learning strategies that integrate meaningful and enjoyable experiences and encourage active student engagement (Hafidzni et al., 2025; Peng et al., 2025). In the era of deep Learning, literacy encompasses the ability to read, write, and critically understand information, while numeracy relates to the understanding and application of numerical concepts and data. Deep Learning enables students to hone both of these skills simultaneously, allowing them to manage information and solve problems effectively and creatively (Masud et al., 2025; Tara et al., 2025).

Table 1 Literature Study: The Relationship between Deep Learning and Literacy and Numeracy

No	Source	Findings	Key Focus
1	Hafidzni et al. (2025), Journal of Mandalika Literature	The integration of Deep Learning and HOTS encourages the development of critical, creative, and reflective thinking patterns in students, with the caveat of challenges in teacher readiness and infrastructure.	Contextual, inclusive, and evidence-based learning strategies for literacy and numeracy in the 21st century

No	Source	Findings	Key Focus
2	Artikel kajian pustaka di Jurnal Pendidikan (2025)	Deep Learning enhances critical thinking, problem-solving, and conceptual understanding among literacy and numeracy students in elementary schools through mindful, meaningful, and joyful learning approaches.	Application of Deep Learning based on meaningful and interactive learning experiences
3	Ginting (2025), Studi Eksploratif	Deep Learning algorithms contribute to improving reading, comprehension, and writing skills.	The Effectiveness of Deep Learning in Enhancing Literacy
4	Hasanah et al. (2024)	Integrating numeracy through Deep Learning-based contextual learning improves students' understanding of numeracy.	Application of Deep Learning-based contextual numeracy learning
5	Studi literatur di Cahaya Mandalika (2025)	The Deep Learning approach in the digital era is essential for optimising student literacy and numeracy through the development of HOTS.	The Importance of Numeracy Literacy Based on Higher Order Thinking Skills and Deep Learning
6	Jerkin Journal (2025)	The Deep Learning approach positively influences students' understanding and motivation in literacy and numeracy.	The Role of Deep Learning in Student Motivation and Comprehension

METHOD

The implementation of deep learning integration in literacy and numeracy learning can be done through various innovative learning strategies. One of them is problem-based learning (PBL), where students are presented with real-world problems that require them to apply critical thinking skills. In this process, students not only learn to understand texts or information related to the problem (literacy), but are also challenged to use data, numbers, and logical calculations (numeracy) to find solutions. Thus, PBL encourages students to relate abstract concepts to everyday contexts (Alashwal & Barham, 2025; Murphy et al., 2025).

Project-Based Learning (PjBL) can also be a practical approach. Through collaborative projects, students practice integrating literacy in the form of report writing, article writing, or idea presentations, while developing numeracy through data analysis, graph visualisation, and calculations that support project results. Such projects provide opportunities for students to engage in more in-depth learning, as they are actively involved, creative, and responsible for the outcomes of their work (Marini et al., 2025; Novalia et al., 2025; Rehman et al., 2024).

Another method that supports deep learning is reflective and collaborative discussion, where students are invited to engage in small-group dialogue to examine a topic (Ceballos et al., 2026; Gower et al., 2025). These discussions not only foster literacy skills in the form of argumentative and critical idea presentation, but also numeracy through the process of explaining mathematical solution steps to friends. Joint reflection encourages students to re-understand the knowledge they have acquired, making learning more meaningful (Edy Saputra et al., 2024; Indrawatiningsih et al., 2024).

The use of technology and digital learning resources is key to supporting the implementation of deep learning. Teachers can utilise various interactive applications, simulations, or digital platforms that enable students to analyse

data, read digital information, and visualise numerical calculations (Grigaliūnienė et al., 2025; Maharani et al., 2025). This technology-based approach not only improves digital literacy skills but also strengthens numeracy skills in a contemporary context.

In addition to the above strategies, inquiry-based learning is also highly relevant. Students are trained to ask questions, conduct research, and draw conclusions based on literature and data (Egitim, 2024; Hinostroza et al., 2024). This process integrates literacy through reading, comprehension, and information selection with numeracy, which requires data analysis, numerical interpretation, and hypothesis testing (Haitao et al., 2025; Nzomo et al., 2023).

If teachers act as facilitators, all of these strategies will be successful. Teachers do not just impart information; they also help students learn, ask critical questions, and make decisions based on data (Long et al., 2025). Therefore, incorporating deep learning into literacy and numeracy education not only improves academic outcomes but also builds the critical, reflective, and adaptive mindsets needed in the 21st century (Egitim, 2024; Hinostroza et al., 2024).

RESULT AND DISCUSSIONS

Literacy and numeracy learning uses a deep learning approach. This method primarily improves students' critical, analytical, and reflective thinking skills (Long et al., 2025; Yuliana Latif et al., 2025). With a learning approach centred on deep understanding and active exploration, students do not just passively receive information; they are also taught to think critically, evaluate, and connect concepts logically. These thinking skills are essential for learning and making good choices in various aspects of life.

Deep learning in literacy improves students' ability to understand, analyse, and summarise the content of a text (Haitao et al., 2025; Peng et al., 2025). Students do not just read texts superficially; they are also taught to identify essential ideas, draw conclusions, and evaluate the information they obtain. These skills enhance reading comprehension, laying a foundation for communication, academic, and critical literacy skills that are essential for everyday life and the future workplace.

A deep learning approach to numeracy enables students to solve contextual problems involving data and numbers logically and systematically (Alnasyan et al., 2024; Cao et al., 2025). This approach teaches students to perform mathematical calculations mechanically while also introducing them to the concepts underlying mathematical operations and how data can be interpreted and applied in real-world situations. Thus, the numeracy skills learned are improved (Hafidzni et al., 2025).

Meaningful and sustainable learning can be achieved through the application of deep learning (Masud et al., 2025). The learning process, which involves reflection, active engagement, and experimentation, creates an unforgettable and profound learning experience for students (Nurdiana et al., 2024). This motivates them to learn independently and internalise their knowledge, so that learning does not stop in the classroom. Meaningful and sustainable learning educates students to become lifelong learners who can overcome the challenges of life and an ever-changing world.

CHALLENGES AND SOLUTIONS

The deep learning approach is used in literacy and numeracy learning (Maharani et al., 2025). This method primarily improves students' critical, analytical, and reflective thinking skills. Learning methods that focus on deep understanding and active exploration help students not only passively acquire information; they also teach them to think critically, evaluate, and connect ideas logically (Rad et al., 2025). These thinking skills are essential for further learning and making good decisions in various aspects of life.

In the field of literacy, deep learning improves students' ability to understand, analyse, and summarise the content of reading materials comprehensively (Novita Barokah & Umi Mahmudah, 2025; Nurdiana et al., 2024).

Students do not just read texts superficially, but are also taught to identify key concepts, draw conclusions, and evaluate the information they obtain. These skills enhance reading comprehension, which in turn lays a foundation for the communication, academic, and critical literacy skills essential for everyday life and the future workplace.

A deep educational approach to numeracy learning helps students develop the ability to solve contextual problems involving data and numbers logically and systematically. This approach teaches students to perform mathematical calculations mechanically while also introducing them to the concepts underlying mathematical operations and how data can be interpreted and applied in real-life situations. Thus, their numeracy skills grow (Tara et al., 2025).

Meaningful and sustainable learning can be achieved through the application of deep learning. The learning process, which involves reflection, active engagement, and experimentation, creates an unforgettable and profound learning experience for students. This motivates them to learn independently and internalise their knowledge, so that learning does not stop in the classroom. Meaningful and sustainable learning educates students to become lifelong learners who can navigate the challenges and developments of the world and their lives (Enjang Warman et al., 2025).

CONCLUSION

Deep learning methods have been shown to significantly improve students' literacy and numeracy skills (Long et al., 2025). Deep learning fosters the development of critical, analytical, and reflective thinking skills by emphasising comprehensive conceptual understanding and promoting active student engagement. This method also strengthens cognitive aspects and builds innovative, adaptive character traits in students, preparing them to face the challenges of the modern world (Peng et al., 2025). Therefore, implementing deep learning aligns with the objectives of the Merdeka Curriculum to cultivate a generation of independent and competitive students.

Recommendations

For deep learning approaches to be used successfully, teachers must continually improve their skills in various deep learning strategies (Alnasyan et al., 2024). Every educational institution must prioritise teacher training that focuses on developing instructional skills, implementing innovative approaches, and mastering educational technology (Jian Wang, 2023). In addition, schools must create and maintain a learning environment that supports the improvement of literacy and numeracy by organising the environment, providing various types of learning resources, and building a strong culture of reading and arithmetic.

To maximise the learning process, educational technology must also be used continuously. Students must maximise the use of digital devices, interactive learning applications, and online resources as supporting media that not only increase their access to knowledge but also make learning more contextual and personal (Masud et al., 2025; Shaari et al., 2012). Improvements in student literacy and numeracy can be achieved optimally and sustainably by working together through deep learning strategies, supportive school environments, and educational technology.

The implementation of Deep Learning in strengthening literacy and numeracy is also supported by technological advances, including artificial intelligence (AI) interventions that personalise learning according to individual student needs. Thus, teachers can focus more on facilitating in-depth learning, while technology helps identify specific needs and provide relevant learning resources. This approach is one of the strategic solutions to improve the quality of education and prepare students to face future challenges holistically and adaptively (Alnasyan et al., 2024; Long et al., 2025).

References

- Achmad Zukhruf Alfaruqi, & Nurwahidah Nurwahidah. (2025). Reflection on Indonesia's PISA Scores and the 2024 Madrasah Teacher Competency Assessment Results: Challenges in Enhancing Teacher Competence. *JURNAL PENDIDIKAN IPS*, 15(1), 11–19. <https://doi.org/10.37630/jpi.v15i1.2559>

- Alashwal, H. A., & Barham, A. I. (2025). Sustaining problem-based learning: A mixed-methods exploration of its long-term effects on primary students' mathematical problem solving. *Social Sciences and Humanities Open*, 12. <https://doi.org/10.1016/j.ssaho.2025.101717>
- Alnasyan, B., Basher, M., & Alassafi, M. (2024). The power of Deep Learning techniques for predicting student performance in Virtual Learning Environments: A systematic literature review. In *Computers and Education: Artificial Intelligence* (Vol. 6). Elsevier B.V. <https://doi.org/10.1016/j.caeai.2024.100231>
- Bulfone, G., Bressan, V., Zerilli, I., Favara, G., Magnano San Lio, R., Mazzotta, R., Barchitta, M., Alvaro, R., & Agodi, A. (2024). Nursing students' health literacy skills: A scoping review for driving research. In *International Journal of Educational Research Open* (Vol. 7). Elsevier Ltd. <https://doi.org/10.1016/j.ijedro.2024.100379>
- Cao, Y., Choo, W. C., & Matemilola, B. T. (2025). Value-at-risk forecasting- based on textual information and a hybrid deep learning-based approach. *International Review of Economics and Finance*, 103. <https://doi.org/10.1016/j.iref.2025.104403>
- Carpendale, E. J., Green, M. J., White, S. L. J., Williams, K. E., Tzoumakis, S., Watkeys, O. J., Harris, F., O'Hare, K., & Laurens, K. R. (2025). Middle childhood social-emotional competencies mediate the effects of school-entry literacy and numeracy skills on secondary school reading and numeracy attainment. *Learning and Individual Differences*, 124. <https://doi.org/10.1016/j.lindif.2025.102778>
- Ceballos, H., Bogaart, T. van den, van Ginkel, S., Spandaw, J., & Drijvers, P. (2026). How collaborative problem solving promotes higher-order thinking skills: A systematic review of design features and processes. *Thinking Skills and Creativity*, 59. <https://doi.org/10.1016/j.tsc.2025.102001>
- Deda, Y. N., Disnawati, H., & Daniel, O. (2023). How Important of Students' Literacy and Numeracy Skills in Facing 21st-Century Challenges: A Systematic Literature Review. *Indonesian Journal of Educational Research and Review*, 6(3), 563–572. <https://doi.org/10.23887/ijerr.v6i3.62206>
- Edy Saputra, Lola Mandasari, Novidayanti M., Loso Judijanto, & Jitu Halomoan Lumbantoruan. (2024). Literacy and Numeracy Difficulty Factors in the Independent Learning Curriculum. *Jurnal Pendidikan Dan Pengajaran*, 57(1), 92–103. <https://doi.org/10.23887/jpp.v57i1.67433>
- Egitim, S. (2024). Promoting gender-inclusive leadership perceptions among Japanese university students: A nine-week critical inquiry-based action learning program. *International Journal of Educational Research Open*, 7. <https://doi.org/10.1016/j.ijedro.2024.100362>
- Enjang Warman, Sajidin, Rachmat Setiawan, Arie Gifary, Waska Warta, Agus Mulyanto, & Hanafiah. (2025). Pendekatan Deep Learning pada Pembelajaran di Sekolah Dasar Gekbrong 1 Cianjur. *Jurnal Pengabdian Masyarakat Dan Riset Pendidikan*, 4(1), 1521–1528. <https://doi.org/10.31004/jerkin.v4i1.1773>
- Gelbgiser, D., & Gabay-Egozi, L. (2025). The gendered value of education in the 'college-for-all' era and the role of literacy and numeracy skills. *Research in Social Stratification and Mobility*, 99. <https://doi.org/10.1016/j.rssm.2025.101074>
- Gower, S., Srdarov, S., Nichols, P., Ely-Harper, K., Young, M., & Brown, J. (2025). Reflective practice: an integrative review of collaborations between nursing and creative arts students. In *Teaching and Learning in Nursing*. Elsevier Inc. <https://doi.org/10.1016/j.teln.2025.07.024>
- Grigaliūnienė, M., Lehtinen, E., Verschaffel, L., & Depaepe, F. (2025). Systematic Review of Research on Pedagogical Content Knowledge in Mathematics: Insights from a Topic-Specific Approach. *ZDM - Mathematics Education*, 57(4), 777–794. <https://doi.org/10.1007/s11858-025-01684-1>
- Hafidzni, N., Putri Yasmine, N., & Yasin, M. (2025). Kajian Literatur Penerapan Deep Learning Pedagogis dan Hots untuk Meningkatkan Literasi dan Numerasi Menuju Indonesia Emas 2045. In *Journal of Mandalika Literature* (Vol. 6, Issue 3).
- Haitao, H., Quanwei, C., Weihua, W., Xiaojun, W., & Ziming, W. (2025). Study on Life Prediction Method for Rail Vehicle Critical Components Based on Deep Learning Models and Track Load Spectra, High-speed Railway. <https://doi.org/10.1016/j.hspr.2025.09.006>

- Hinostroza, J. E., Armstrong-Gallegos, S., & Villafaena, M. (2024). Roles of digital technologies in the implementation of inquiry-based learning (IBL): A systematic literature review. In *Social Sciences and Humanities Open* (Vol. 9). Elsevier Ltd. <https://doi.org/10.1016/j.ssaho.2024.100874>
- Indrawatiningsih, N., Qomariyah, S., Nubita, A. R., & Muarofah, L. (2024). Effectiveness of Differentiated Learning in Improving Literacy and Numeracy of Primary School Students. *Asian Journal of Education and Social Studies*, 50(5), 8–17. <https://doi.org/10.9734/ajess/2024/v50i51337>
- Jian Wang. (2023). Research on Teaching Strategies of Deep Learning in High School Mathematics from the Perspective of Core literary. *International Journal of New Developments in Education*, 5(7). <https://doi.org/10.25236/IJNDE.2023.050717>
- Juandi, D., & Dasari, D. (2024). Indonesian Students' Numeracy Skills Based On PISA Mathematical Problems In Secondary School: A Meta-Synthesis. 25(1), 14–26. <https://doi.org/10.23960/jpmipa/v25i1.14-26>
- Long, Q., Li, S., An, R., Yasmin, F., & Akbar, A. (2025). Deep learning as a bridge between intercultural sensitivity and learning outcomes: A comparative study of English-medium instruction delivery modes in Chinese higher education. *Acta Psychologica*, 259. <https://doi.org/10.1016/j.actpsy.2025.105410>
- Lopez-Pedersen, A., Mononen, R., Aunio, P., Scherer, R., & Melby-Lervåg, M. (2023). Improving Numeracy Skills in First Graders with Low Performance in Early Numeracy: A Randomized Controlled Trial. *Remedial and Special Education*, 44(2), 126–136. <https://doi.org/10.1177/07419325221102537>
- Maharani, L., Rakhmat Riyadi, A., & Maulida, N. (2025). DEEP LEARNING DALAM PEMBELAJARAN MATEMATIKA DI SD (Vol. 10).
- Marini, A., Safitri, D., Niladini, A., Zahari, M., Dewiyani, L., & Muawanah, U. (2025). Developing a website integrated with project-based learning: Evidence of stimulating creativity among elementary school students in Indonesia. *Social Sciences and Humanities Open*, 11. <https://doi.org/10.1016/j.ssaho.2025.101402>
- Masud, G. H. Al, Shanto, R. I., Sakin, I., & Kabir, M. R. (2025). Effective depression detection and interpretation: Integrating machine learning, deep learning, language models, and explainable AI. *Array*, 25. <https://doi.org/10.1016/j.array.2025.100375>
- Murphy, C., Connell, S., Gantley, M., & Barrett, T. (2025). Students' perspectives on the congruence and effectiveness of a problem-based learning approach to teach recovery-oriented practice: A mixed method study. *Nurse Education in Practice*, 84. <https://doi.org/10.1016/j.nepr.2025.104298>
- Novalia, R., Marini, A., Bintoro, T., & Muawanah, U. (2025). Project-based learning: For higher education students' learning independence. *Social Sciences and Humanities Open*, 11. <https://doi.org/10.1016/j.ssaho.2025.101530>
- Novita Barokah, & Umi Mahmudah. (2025). Transformasi Pembelajaran Matematika SD Melalui Deep Learning: Strategi untuk Meningkatkan Motivasi dan Prestasi. *Bilangan : Jurnal Ilmiah Matematika, Kebumihan Dan Angkasa*, 3(3), 48–61. <https://doi.org/10.62383/bilangan.v3i3.521>
- Nurdiana, A., Zulianti, H., Ciciria, D., Fitria, N., & Rara Kirana, A. (2024). Practical Applications of Deep Learning in Mathematics to Enhance Student Engagement and Conceptual Mastery. 8(4), 1361–1373. <https://doi.org/10.31764/jtam.v8i4.33102>
- Nzomo, C., Rugano, P., Njoroge Mungai, J., & Gitonga Muriithi, C. (2023). Inquiry-based learning and students' self-efficacy in Chemistry among secondary schools in Kenya. *Heliyon*, 9(1). <https://doi.org/10.1016/j.heliyon.2022.e12672>
- Peng, Z., Li, J., Zhong, Y., & Hao, H. (2025). Interpretable damage sensitive feature extraction for drive-by structural health monitoring using knowledge distillation-based deep learning. *Journal of Sound and Vibration*, 618. <https://doi.org/10.1016/j.jsv.2025.119303>
- Rad, M. S., Huang, J. (Vincent), Hosseini, M. M., Choudhary, R., Siezen, H., Akabari, R., Jamaspishvili, T., El-Zammar, O., Patel, P., Carello, S. J., Nasr, M. R., & Rodd, B. (2025). Deep learning for digital pathology: A critical overview of methodological framework. *Journal of Pathology Informatics*, 100514. <https://doi.org/10.1016/j.jpi.2025.100514>

- Rehman, N., Huang, X., Mahmood, A., AlGerafi, M. A. M., & Javed, S. (2024). Project-based learning as a catalyst for 21st-Century skills and student engagement in the math classroom. *Heliyon*, 10(23). <https://doi.org/10.1016/j.heliyon.2024.e39988>
- Shaari, R., Mahmud, N., Wahab, S. R. A., Rahim, K. A., Rajab, A., & Panatik, S. A. (2012). Deep as a Learning Approach in Inspiring Creative and Innovative Minds among Postgraduate Students in Research University. *Procedia - Social and Behavioral Sciences*, 40, 152–156. <https://doi.org/10.1016/j.sbspro.2012.03.175>
- Tara, K., Sakib, S., Islam, M. H., Mohonta, S. C., Anower, M. S., & Sugi, T. (2025). Bio-impedance spectroscopy-based classification of mental acuity in university students via machine-learning and deep-learning approaches. *Methods*, 242, 89–96. <https://doi.org/10.1016/j.ymeth.2025.07.009>
- Yuliana Latif, E., Idrus, R., Ayu Perdana, C., Author, C., & Negeri, S. (2025). CJPE: Cokroaminoto Jurnal of Primary Education Peningkatan Kemampuan Literasi dan Numerasi Siswa melalui Pembelajaran Berbasis Deep Learning pada Siswa Kelas IV SD Negeri 103 Kalosi.
- Yulindaria, L., Ruyadi, Y., Nurdin, E. S., & Dahliana, A. (2025). Integrative Learning Models For Numeracy Literacy And Character Development: Insights From A Bibliometric Analysis. *IJORER: International Journal of Recent Educational Research IJORER*, 6(3). <https://doi.org/10.46245/ijorer.v6i3.861>.