



Improving the Quality of Learning Through the Integration of Literacy and Numeracy

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Abstract: Quality learning requires the systematic integration of literacy and numeracy as foundational competencies that support students' critical thinking, problem-solving abilities, and overall academic achievement. This literature review aims to identify the specific strategies used to integrate literacy and numeracy and evaluate their impact on critical thinking, conceptual understanding, and student engagement within the Indonesian education context. A narrative literature analysis was conducted by reviewing empirical studies, national education reports, and policy documents published between 2009-2023. Sources were screened based on their relevance to integration models, curriculum implementation, and measurable learning outcomes. The findings indicate that literacy-numeracy integration is most effective when implemented through contextual learning materials, project-based learning, and the Independent Curriculum, which collectively enhance students' analytical thinking and comprehension of academic concepts. Evidence also shows that literacy-focused interventions and expanded access to learning resources increase motivation and engagement, although numeracy performance remains comparatively lower and requires stronger reinforcement. Overall, this review demonstrates that meaningful integration of literacy and numeracy contributes significantly to students' readiness to engage with complex academic tasks. The study concludes that targeted integration strategies, supported by appropriate curriculum structures and equitable access to learning resources, are essential for improving learning quality across educational levels.

Keywords: Education; Integration; Literacy; Numeracy; Quality of Learning.

Introduction

Quality education is one of the main factors in improving student competence (Chittleborough et al., 2014). In the context of learning, literacy and numeracy are two basic skills that are very important in supporting understanding and mastery of material. Literacy includes the ability to read, write, and understand information critically, while numeracy relates to the

ability to understand and use mathematical concepts in everyday life (Cavanaugh et al., 2009). The lack of integration of these two aspects in learning can have an impact on the low quality of students' understanding of academic material. The importance of literacy and numeracy in the education system cannot be ignored (Kovas et al., 2013). Good literacy skills enable students to understand and analyze various types of texts, from academic texts to everyday information obtained from

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various sources (Grotlüschen et al., 2020). Meanwhile, numeracy helps students develop logical thinking skills, solve problems, and apply mathematical concepts in real life (Dietrichson et al., 2020). When these two aspects are not strengthened simultaneously, students tend to have difficulty understanding more complex academic concepts (Pensiero & Green, 2018).

Several previous studies have shown that students with low literacy and numeracy levels tend to have difficulty understanding more complex academic concepts (Maritasari et al., 2025). According to the 2018 PISA (Programme for International Student Assessment) report, the literacy and numeracy levels of students in Indonesia are still below the global average (Grotlüschen et al., 2020). In the literacy test, the average score of Indonesian students only reached 371 points, far below the OECD average of 487 points (Kurnia et al., 2024). Meanwhile, in numeracy, Indonesia recorded a score of 379, also far from the OECD average of 489 points. These results place Indonesia in 74th place out of 79 countries that took the 2018 PISA test.

Indonesia has participated in the Programme for International Student Assessment (PISA) which assesses students' abilities in reading, mathematics, and science literacy (Nag et al., 2016). In 2018, Indonesia was ranked 74th for reading literacy, 73rd for mathematics literacy, and 71st for science literacy (Huzaimah et al., 2023). Then, in the 2022 PISA results, there was an increase in ranking with reading literacy (Nguyen, 2023) rising to 71st, mathematics to 70th, and science to 67th. Indonesian government has started implementing the Merdeka Curriculum since 2021 in improving the quality of learning. This curriculum provides teachers with more flexibility in adjusting learning to students' needs, with a primary focus on improving literacy and numeracy (Gillis et al., 2016). A concrete step in supporting literacy integration is the distribution of books to schools throughout Indonesia. In the 2021-2022 period, the government distributed 16,868,247 copies of books to various schools, including schools in the Frontier, Remote, and Disadvantaged (3T) areas (Inthaphatha et al., 2023). Based on the latest data from the 2023 Indonesian Education Report about students' literacy and numeracy skills, the percentage of students who have competencies above the minimum standard is still relatively low, students' literacy skills are better than numeracy, both are still at a level that requires more attention (Ilmi et al., 2023).

These low results are caused by several main factors, such as learning methods that still tend to focus on memorization rather than problem solving, lack of teaching materials that are appropriate to the context of students' lives (Barnett et al., 2023; Mirna et al., 2025), and limited access to quality learning resources. In

addition, socio-economic factors also affect student learning outcomes (Amnuaylojaroen & Parasin, 2023). The PISA report shows that students from low-income backgrounds tend to have lower scores than those from families with better economic conditions (Saba Villarreal et al., 2023). In addition, the low level of literacy and numeracy in Indonesia can also have implications for the nation's competitiveness at the global level (Gracy et al., 2018). The ability to think critically, solve problems, and understand complex information are skills that are greatly needed in today's digital and globalization era (Ibrahim et al., 2022). Improving the quality of education through strengthening literacy and numeracy is not only the responsibility of schools, but also requires the involvement of various parties, including the government, educators, parents, and the wider community (Flannery et al., 2023).

Although various studies have discussed the importance of literacy and numeracy in education, there is still a gap in research on effective integration strategies at various levels of learning (Siebecke & Jarl, 2022). The lack of understanding of how to implement appropriate strategies in teaching literacy and numeracy is a challenge in itself (Aroonsrimarakot et al., 2023). This study aims to fill this gap by exploring learning strategies that can optimize the integration of literacy and numeracy to improve student learning outcomes (Catalán Molina et al., 2022). With the right strategy, it is hoped that students will not only understand academic concepts better, but also be able to apply them in everyday life (Gaspard et al., 2021). In this study, various learning approaches that prioritize literacy and numeracy will be examined in depth (Ten Cate et al., 2004). One approach that can be used is project-based learning, where students are given real challenges that they must complete by integrating literacy and numeracy skills (Neugebauer & Prediger, 2023). This method not only improves students' understanding of academic material, but also helps them develop collaboration, communication, and problem-solving skills (Menzies et al., 2008). The use of contextual teaching materials is also an effective strategy in improving literacy and numeracy (Gutiérrez-Fresneda, 2018). Contextual teaching materials allow students to understand concepts in real situations that are relevant to their lives (Ma et al., 2022). For example, in mathematics learning, students can be given case studies that illustrate the application of mathematical concepts in everyday activities, such as managing a budget, calculating taxes, or analyzing statistical data. This approach helps students see the connection between school lessons and their real lives (Usher et al., 2010).

The use of digital technology also has great potential in improving students' literacy and numeracy

(Abdul Ghani et al., 2022). The development of technology allows for interactive learning platforms that can be tailored to students' needs (Khairani et al., 2025; Severiens & Schmidt, 2009; Siregar et al., 2025; Tanjung et al., 2025; Tanjung et al., 2025). For example, game-based learning applications can make learning more interesting and increase students' motivation to learn (López-Pimentel et al., 2021). Access to various digital information sources allows students to develop their literacy skills by exploring various types of texts and data sources (Kim et al., 2011). This study also highlights the impact of implementing these methods on student engagement and the effectiveness of academic understanding (Jeffcoat & Tang, 2025; Lewinsohn et al., 2015). Student engagement in learning is very important because it contributes to increasing their motivation and learning outcomes (Usher et al., 2010). By implementing interesting and relevant strategies, it is hoped that students can be more active in the learning process and have a greater interest in developing their literacy and numeracy skills (Abdul Ghani et al., 2022).

In the context of implementation, support from various stakeholders is essential to ensure the success of this strategy (Severiens & Schmidt, 2009). Teachers have a key role in integrating literacy and numeracy into the curriculum and creating a conducive learning environment (Kim et al., 2011). The government also has a responsibility to provide policies that support the strengthening of literacy and numeracy, including providing training for educators and developing quality teaching materials (López-Pimentel et al., 2021). In addition, the involvement of parents and the community in supporting reading and critical thinking habits at home is also an important factor in improving students' literacy and numeracy (Lewinsohn et al., 2015). Thus, this study contributes to the development of a more comprehensive learning model in the Indonesian education system (Schmid et al., 2023). The findings of this study are expected to provide practical recommendations for educators and policy makers in improving the quality of education through the integration of literacy and numeracy (Wong & Hughes, 2023). With a more systematic and evidence-based approach, it is hoped that the quality of education in Indonesia can continue to improve, so that it can produce a generation that is more competent, creative, and ready to face global challenges in the future (Y. I. Tanjung et al., 2023; Tawafak et al., 2023).

Method

This study uses a literature study method (Sakamoto et al., 2021) by analyzing various relevant sources related to the application of literacy and

numeracy in learning (Nussbaum et al., 2023). The sources used include scientific journals, research reports, and data from credible national and international educational institutions (Jamali et al., 2023). The analysis is carried out systematically to identify patterns, trends, and the effectiveness of literacy and numeracy-based learning strategies in improving the quality of education (Peppen et al., 2021).

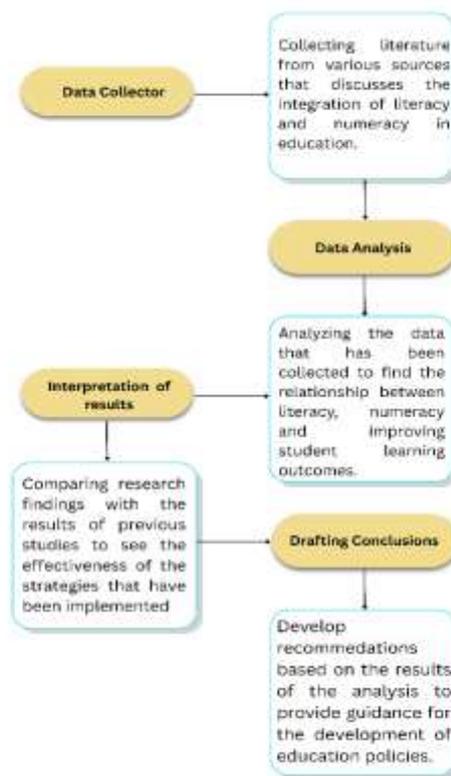


Figure 1. Research Steps

This approach is to provide a more comprehensive insight into the impact of literacy and numeracy integration on student learning outcomes and is expected to contribute to designing more effective learning strategies to improve the quality of education sustainably.

Results and Discussion

Results

Improving Critical Thinking Skills and Improving Indonesia's 2022 PISA Ranking

Critical thinking skills are essential skills that students need to have to face challenges in the modern era (Kurnia et al., 2025; Sakamoto et al., 2021). One effective way to develop it is through the integration of literacy and numeracy in learning. With this approach, students not only read texts, but also analyze data,

identify patterns, and connect concepts in various subjects. This encourages them to think more systematically and logically in solving problems. The improvement in critical thinking skills is reflected in the results of PISA 2022, where Indonesia's ranking has improved in three main areas (Nussbaum et al., 2023). In reading literacy, the ranking rose from 74 to 71, indicating an increase in students' ability to understand and evaluate information more deeply (Jamali et al., 2023). In mathematics, the ranking increased from 73 to 70, indicating that students are increasingly able to apply numerical understanding in various contexts (Peppen et al., 2021). Meanwhile, in science, Indonesia's ranking rose from 71 to 67, reflecting an increase in analytical and problem-solving skills based on scientific data. This positive trend shows that the integration of literacy and numeracy in learning has a real impact on students' ability to think critically and analytically (Fitrianingrum & Murtiyasa, 2023; Hudson, 2019). It is important to continue to strengthen learning methods based on deep understanding, so that students not only memorize the material, but are also able to apply it in everyday life. With this strategy, it is hoped that the quality of Indonesian education will continue to improve and be able to compete at the global level (Gaspard et al., 2021).

Improving Understanding of Academic Concepts through Literacy, Numeracy and the Independent Curriculum

Good literacy and numeracy skills are key to understanding various academic concepts in science, economics, and technology (Klarare et al., 2022). Students who are able to read, analyze data, and connect concepts to real contexts tend to find it easier to understand the subject matter in depth (Pensiero & Green, 2018). To support the strengthening of these skills, the Independent Curriculum is here as a solution with a more flexible learning approach based on conceptual understanding (Manu et al., 2019). As the number of schools adopting the Independent Curriculum increases, from 140,000 schools in 2022 to 160,000 schools in 2023, student learning outcomes have shown a significant increase (Gillon et al., 2019). This curriculum gives teachers the freedom to determine teaching methods that are more appropriate to students' needs, so that learning becomes more interactive and contextual (Farrell et al., 2022). Schools that implement the Independent Curriculum tend to produce students with better academic understanding because the teaching methods applied emphasize analysis, problem solving, and critical thinking skills (Martiniuk et al., 2019). This approach not only makes students understand the theory, but also able to use it in everyday life and the world of work (Chittleborough et al., 2014).

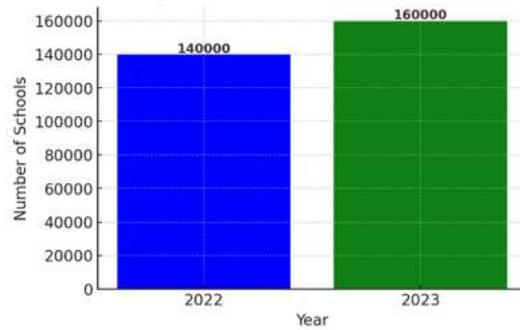


Figure 2. Increasing Adoption of Independent Curriculum

Enhancing Problem Solving Skills through Numeracy and Literacy Reinforcement

Problem-solving skills are essential skills that students need to face challenges in the academic world and everyday life (Cavanaugh et al., 2009). Students who have good numeracy skills are better able to solve mathematical problems, analyze data, and apply concepts in financial planning and decision-making (Manu et al., 2019). However, data shows that students' numeracy skills still lag behind literacy (Reder et al., 2020). Based on the latest evaluation, only 42.81% of students are above the minimum standard in numeracy, while in literacy the figure reached 56.60%. This difference indicates that students still have difficulty in understanding numerical concepts, which has an impact on their logical thinking and problem-solving skills (Kaddor & Steinbüchel, 2011). Numeracy plays a role not only in mathematics subjects, but also in real life, such as financial management and data analysis (Mononen & Niemivirta, 2023). As a step to improve literacy and numeracy, more than 17 million books have been distributed to schools in Indonesia. The provision of these reading materials aims to strengthen students' understanding of reading, interpreting information, and applying analytical thinking in solving various problems (Cowan & Powell, 2014). By increasing access to quality learning resources, it is hoped that students can be more accustomed to developing critical thinking skills and data-based problem solving (Griffey et al., 2014).

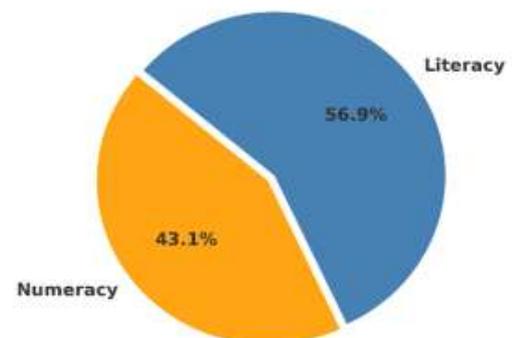


Figure 3. Comparison of Capabilities

Increasing Interest and Motivation in Learning through Literacy, Numeracy and Wider Access to Education

Interest and motivation to learn are important factors in improving students' academic outcomes. One effective way to build this motivation is by implementing literacy and numeracy-based learning methods (Oldfather & Dahl, 1994). With this approach, students can see firsthand how academic concepts are applied in everyday life, so they are more motivated to learn actively. This method has also been shown to improve critical and analytical thinking skills, because students not only memorize theories, but also learn to connect information to real situations (Reeder et al., 2020). To support the improvement of literacy and numeracy, the government and various parties have made various strategic efforts to expand access to quality education (Gillon et al., 2019).

Data shows significant developments in the distribution of learning resources and implementation of literacy methods proven by book distribution has reached 442 districts/cities, providing wider opportunities for students to access quality reading materials that support their academic understanding. The number of schools implementing literacy-based methods continues to increase, with an additional 20,000 schools added a year, indicating that more and more educational institutions are adopting a conceptual understanding-based approach (Abubakar et al., 2024). With the increased distribution of reading materials and more schools implementing literacy-based methods, students not only gain wider access to learning resources, but are also more motivated to develop reading, analysis, and problem-solving skills (Hanemann & McKay, 2015; Paramita & Fitria, 2025).

Discussion

This study reveals how the integration of literacy and numeracy in learning can improve the quality of education in Indonesia. Based on the data obtained, improvements in critical thinking, understanding of academic concepts, problem-solving skills, and students' interest and motivation in learning show a positive trend. This indicates that a literacy and numeracy-based approach plays an important role in strengthening the national education system.

Improving Critical Thinking Skills and Improving PISA 2022 Rankings

Critical thinking skills are essential skills needed by students to face global challenges (Högberg, 2023). The integration of literacy and numeracy has been shown to improve students' comprehension in reading, analyzing data, and connecting various academic concepts (Handayani et al., 2022; Morgan & Jones, 2025). Indonesia's improved ranking in PISA 2022 shows that

students are better able to understand and evaluate information systematically. With the increasing ranking in reading literacy, mathematics, and science, it can be concluded that more interactive and analytical learning methods have had a positive impact on student learning outcomes (Ritchie & Tucker-Drob, 2018).

Improving Understanding of Academic Concepts through Literacy, Numeracy and the Independent Curriculum

The implementation of the Independent Curriculum is an important factor in supporting students' academic understanding (Horiguchi et al., 2015). With the increasing number of schools implementing this curriculum, from 140,000 schools in 2022 to 160,000 schools in 2023, it can be seen that conceptual understanding-based learning methods are increasingly being implemented. This curriculum provides teachers with the flexibility to adjust teaching methods to students' needs, so that academic concepts are easier to understand and apply in everyday life (Cano et al., 2014).

Enhancing Problem Solving Skills through Numeracy and Literacy Reinforcement

Problem-solving skills are an important aspect of modern learning (Anugrahsari et al., 2025). However, data shows that there is still a gap between literacy and numeracy among students. Only 42.81% of students are above the minimum standard in numeracy, while in literacy the figure reaches 56.60%. To address this gap, the distribution of more than 17 million books to schools in Indonesia has been carried out to increase access to reading materials that help students think critically and analytically (Lopez-Pedersen et al., 2023). This step is expected to strengthen numeracy skills which are still lagging behind literacy (Gilmore et al., 2018).

Increasing Interest and Motivation in Learning through Literacy, Numeracy and Wider Access to Education

Students' learning motivation is greatly influenced by access to reading materials and learning methods that are relevant to real life (Sakerani et al., 2025; Tanjung et al., 2024). Data shows that book distribution has reached 442 districts/cities, which provides students with wider opportunities to access quality reading materials (MacDonald et al., 2022). The number of schools implementing literacy-based methods has increased by 20,000 in a year. This development shows that the literacy and numeracy approach in learning can increase students' interest in learning and encourage them to be more active in exploring academic concepts (Wortha et al., 2023).

Conclusion

This literature review demonstrates that the meaningful integration of literacy and numeracy plays an essential role in strengthening students' critical thinking, conceptual understanding, problem-solving abilities, and engagement in learning. The reviewed studies consistently show that integration is most effective when supported by contextual learning materials, project-based activities, and flexible curriculum structures that prioritize analytical skills. These models enable students to connect academic concepts with real-life applications, thereby improving the depth and quality of learning. The literature also identifies several implementation challenges, including limited teacher readiness, unequal access to learning resources, and the tendency for schools to focus on content coverage rather than higher-order thinking processes (Paramita & Fitria, 2025). Successful integration, as defined in the reviewed research, requires alignment between instructional strategies, curriculum goals, and the availability of supporting materials that promote both literacy and numeracy development. The improvement in critical thinking skills is reflected in the improvement in Indonesia's PISA ranking. The implementation of the Independent Curriculum helps students understand academic concepts better. The gap between literacy and numeracy still needs to be corrected, especially in numeracy skills. Distribution of books and application of literacy methods have increased students' motivation and interest in learning. Overall, the findings highlight that literacy-numeracy integration is most impactful when implemented systematically and supported by adequate pedagogical preparation. Future educational practices should prioritize evidence-based integration strategies, while policymakers need to ensure that schools receive the guidance and resources necessary to sustain these approaches. Strengthening these components will help improve the quality of learning across educational levels and support students' readiness for increasingly complex academic and real-world challenges.

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References

- Abdul Ghani, A. S., Abdul Rahim, A. F., Yusoff, M. S. B., & Hadie, S. N. H. (2022). Developing an interactive PBL environment via persuasive gamify elements: a scoping review. *Research and Practice in Technology Enhanced Learning*, 17. <https://doi.org/10.1186/s41039-022-00193-z>
- Abubakar, T., I., Y., Sani, R. A., Nasution, B., Yohandri, & Festiyed. (2024). Science Teachers' Understanding of Culturally Responsive Teaching on Independent Learning Curriculum. *Jurnal Penelitian Pendidikan IPA*, 10(1), 156-164. <https://doi.org/10.29303/jppipa.v10i1.4821>
- Amnuaylojaroen, T., & Parasin, N. (2023). Perspective on Particulate Matter: From Biomass Burning to the Health Crisis in Mainland Southeast Asia. *Toxics*, 11. <https://doi.org/10.3390/toxics11070553>
- Anugrahsari, I., B, N., B., N., & Syamsiah, S. (2025). The Influence of STEAM Integrated PjBL Learning Model on Communication Skills, Critical Thinking Skills and Problem-Solving Skills of Students in Biology Subject. *Jurnal Penelitian Pendidikan IPA*, 11(6), 670-687. <https://doi.org/10.29303/jppipa.v11i6.11411>
- Aroonsrimarakot, S., Laiphrakpam, M., Chathiphot, P., Saengsai, P., & Prasri, S. (2023). Online learning challenges in Thailand and strategies to overcome the challenges from the students' perspectives. *Education and Information Technologies*, 28(7), 8153-8170. <https://doi.org/10.1007/s10639-022-11530-6>
- Barnett, L. M., Jerebine, A., Keegan, R., Watson-Mackie, K., Arundell, L., Ridgers, N. D., Salmon, J., & Dudley, D. (2023). Validity, Reliability, and Feasibility of Physical Literacy Assessments Designed for School Children: A Systematic Review. *Sports Medicine*, 53(10), 1905-1929. <https://doi.org/10.1007/s40279-023-01867-4>
- Cano, F., García, Á., Justicia, F., & García, A. B. B. (2014). Enfoques de aprendizaje y comprensión lectora: El papel de las preguntas de los estudiantes y del conocimiento previo. *Revista de Psicodidactica*, 19(2), 247-266. <https://doi.org/10.1387/RevPsicodidact.10186>
- Catalán Molina, D., Porter, T., Oberle, C., Haghghat, M., Fredericks, A., Budd, K., & Trzesniewski, K. H. (2022). How to Measure Quality of Delivery: Focus on Teaching Practices That Help Students to Develop Proximal Outcomes. *Journal of Research on Educational Effectiveness*, 15(4), 898-923. <https://doi.org/10.1080/19345747.2022.2054481>
- Cavanaugh, K., Wallston, K. A., Gebretsadik, T., Shintani, A., Huizinga, M. M., Davis, D., & Rothman, R. L. (2009). Addressing literacy and

- numeracy to improve diabetes care: Two randomized controlled trials. *Diabetes Care*, 32(12), 2149–2155. <https://doi.org/10.2337/dc09-0563>
- Chittleborough, C. R., Mittinty, M. N., Lawlor, D. A., & Lynch, J. W. (2014). Effects of Simulated Interventions to Improve School Entry Academic Skills on Socioeconomic Inequalities in Educational Achievement. *Child Development*, 85(6), 2247–2262. <https://doi.org/10.1111/cdev.12309>
- Cowan, R., & Powell, D. (2014). The contributions of domain-general and numerical factors to third-grade arithmetic skills and mathematical learning disability. *Journal of Educational Psychology*, 106(1), 214–229. <https://doi.org/10.1037/a0034097>
- Dietrichson, J., Filges, T., Klokke, R. H., Viinholt, B. C. A., Bøg, M., & Jensen, U. H. (2020). Targeted school-based interventions for improving reading and mathematics for students with, or at risk of, academic difficulties in Grades 7–12: A systematic review. *Campbell Systematic Reviews*, 16. <https://doi.org/10.1002/cl2.1081>
- Farrell, L., Eadie, T., McLean Davies, L., & Sandiford, C. (2022). Literacy education for citizenship across the lifespan. *Australian Journal of Language and Literacy*, 45(3), 309–323. <https://doi.org/10.1007/s44020-022-00014-2>
- Fitrianingrum, S., & Murtiyasa, B. (2023). The Private Student's Junior High School and Their Numeracy Literacy Competency. *Jurnal Penelitian Pendidikan IPA*, 9(9), 7645–7650. <https://doi.org/10.29303/jppipa.v9i9.4640>
- Flannery, D., Gilleece, L., & Clavel, J. G. (2023). School socio-economic context and student achievement in Ireland: an unconditional quantile regression analysis using PISA 2018 data. *Large-Scale Assessments in Education*, 11(1). <https://doi.org/10.1186/s40536-023-00171-x>
- Gaspard, H., Parrisius, C., Piesch, H., Kleinhansl, M., Wille, E., Nagengast, B., & Hulleman, C. S. (2021). The Potential of Relevance Interventions for Scaling Up: A Cluster-Randomized Trial Testing the Effectiveness of a Relevance Intervention in Math Classrooms. *Journal of Educational Psychology*, 113(8), 1507–1528. <https://doi.org/10.1037/edu0000663>
- Gillis, S., Polesel, J., & Wu, M. (2016). PISA Data: Raising concerns with its use in policy settings. *The Australian Educational Researcher*, 131–146. <https://doi.org/10.1007/s13384-015-0183-2>
- Gillon, G., McNeill, B., Scott, A., Denston, A., Wilson, L., Carson, K., & Macfarlane, A. H. (2019). A better start to literacy learning: findings from a teacher-implemented intervention in children's first year at school. *Reading and Writing*, 32(8), 1989–2012. <https://doi.org/10.1007/s11145-018-9933-7>
- Gilmore, C., Clayton, S., Cragg, L., McKeaveney, C., Simms, V., & Johnson, S. (2018). Understanding arithmetic concepts: The role of domain-specific and domain-general skills. *PLoS ONE*, 13(9). <https://doi.org/10.1371/journal.pone.0201724>
- Gracy, D., Fabian, A., Basch, C. H., Scigliano, M., MacLean, S. A., MacKenzie, R. K., & Redlener, I. E. (2018). Missed opportunities: Do states require screening of children for health conditions that interfere with learning? *PLoS ONE*, 13(1). <https://doi.org/10.1371/journal.pone.0190254>
- Griffey, R. T., Melson, A. T., Lin, M. J., Carpenter, C. R., Goodman, M. S., & Kaphingst, K. A. (2014). Does numeracy correlate with measures of health literacy in the emergency department? *Academic Emergency Medicine*, 21(2), 147–153. <https://doi.org/10.1111/acem.12310>
- Grotlüschen, A., Desjardins, R., & Liu, H. (2020). Literacy and numeracy: Global and comparative perspectives. *International Review of Education*, 66, 127–137. <https://doi.org/10.1007/s11159-020-09854-x>
- Gutiérrez-Fresneda, R. (2018). Longitudinal Study on the Development of Literacy Skills During Literacy. *Revista de Psicodidáctica*, 23(2), 137–143. <https://doi.org/10.1016/j.psicod.2017.09.002>
- Handayani, N. A., Rosana, D., Wilujeng, I., Sari, M. I. P., Nofianti, E., Az-Zahro, S. F., & Ramadhanti, D. (2022). ICT Literacy Analysis of Junior High School Students Through Environmental Learning on Green Consumerism Using Padlet. *Jurnal Penelitian Pendidikan IPA*, 8(3), 1049–1054. <https://doi.org/10.29303/jppipa.v8i3.1254>
- Hanemann, U., & McKay, V. (2015). Lifelong literacy: Towards a new agenda. *International Review of Education*, 61, 265–272. <https://doi.org/10.1007/s11159-015-9497-6>
- Högberg, B. (2023). Is There a trade-off Between Achievement and Wellbeing in Education Systems? New cross-country Evidence. *Child Indicators Research*, 16(5), 2165–2186. <https://doi.org/10.1007/s12187-023-10047-9>
- Horiguchi, T., Tomoto, T., & Hirashima, T. (2015). A framework of generating explanation for conceptual understanding based on “semantics of constraints. *Research and Practice in Technology Enhanced Learning*, 10(1). <https://doi.org/10.1007/s41039-015-0002-4>
- Hudson, B. (2019). Epistemic quality for equitable access to quality education in school mathematics. *Journal of Curriculum Studies*, 51(4), 437–456. <https://doi.org/10.1080/00220272.2019.1618917>

- Huzaimah, A., Abdillah, M., Laila, N. Q., Tamudin, M., & Puji Astuti, T. M. (2023). Disregarding the Reproductive Rights of Women in Child Marriage in Indonesia. *Samarah*, 7(2), 1097-1120. <https://doi.org/10.22373/sjkh.v7i2.17392>
- Ibrahim, A. I., Sulaiman, N., & Ali, I. (2022). Simultaneous multidimensional impacts of active learning revealed in a first implementation in the MENA region. *Proceedings of the National Academy of Sciences*, 119(47). [https://doi.org/10.1073/pnas.119\(47\)](https://doi.org/10.1073/pnas.119(47))
- Ilimi, M. B., Wahyuningsih, U., & Crosita, O. Y. (2023). Determinants of fruit consumption in adult women in Indonesia. *Europe PMC*. <https://doi.org/10.12688/f1000research.133136.1>
- Inthaphatha, S., Isin-Xiong, L., Louangpradith, V., Xiong, V., Xaitengcha, V., Phengsavanh, A., & Yamamoto, E. (2023). Period shaming behavior among male students in Luang Prabang Province, Lao People's Democratic Republic: A cross-sectional study. *PLoS ONE*, 18(7). <https://doi.org/10.1371/journal.pone.0288145>
- Jamali, S. M., Ale Ebrahim, N., & Jamali, F. (2023). The role of STEM Education in improving the quality of education: a bibliometric study. *International Journal of Technology and Design Education*, 33(3), 819-840. <https://doi.org/10.1007/s10798-022-09762-1>
- Jeffcoat, J., & Tang, H. (2025). Empowering Sixth-Grade Students' Digital Literacy Through Teacher-Librarian Collaborative Teaching: A Mixed Methods Study. *Tech Know Learn*. <https://doi.org/10.1007/s10758-025-09916-9>
- Kaddor, C., & Steinbüchel, A. (2011). Implications of various phosphoenolpyruvatecarbohydrate phosphotransferase system mutations on glycerol utilization and poly (3-hydroxybutyrate) accumulation in *Ralstonia eutropha* H16. *AMB Express*, 1(1), 1-8. <https://doi.org/10.1186/2191-0855-1-16>
- Khairani, N., Elfitra, E., & Siregar, T. M. (2025). Building an E-Learning System Calculating Pension Funds Using the Cox Ingersoll Ross Interest Rate Model. *Jurnal Penelitian Pendidikan IPA*, 11(2), 742-751. <https://doi.org/10.29303/jppipa.v11i2.10198>
- Kim, J. S., Capotosto, L., Hartry, A., & Fitzgerald, R. (2011). Can a Mixed-Method Literacy Intervention Improve the Reading Achievement of Low-Performing Elementary School Students in an After-School Program?: Results From a Randomized Controlled Trial of READ 180 Enterprise. *Educational Evaluation and Policy Analysis*, 33(2), 183-201. <https://doi.org/10.3102/0162373711399148>
- Klarare, A., Rydeman, I. B., Kneck, B. S., E., W., E., & Bisholt, B. (2022). Methods and strategies to promote academic literacies in health professions: a scoping review. *BMC Medical Education*, 22(1). <https://doi.org/10.1186/s12909-022-03288-9>
- Kovas, Y., Voronin, I., Kaydalov, A., Malykh, S. B., Dale, P. S., & Plomin, R. (2013). Literacy and Numeracy Are More Heritable Than Intelligence in Primary School. *Psychological Science*, 24(10), 2048-2056. <https://doi.org/10.1177/0956797613486982>
- Kurnia, A. B., Lowrie, T., & Patahuddin, S. M. (2024). The development of high school students' statistical literacy across grade level. *Mathematics Education Research Journal*, 36(Suppl 1), 7-35. <https://doi.org/10.1007/s13394-023-00449-x>
- Kurnia, M. P. A., Waris, & Gita, R. S. D. (2025). STEM-Based Learning Using Assemblr Edu to Improve Students' Critical Thinking Skills; A Case Study in Elementary School. *Jurnal Penelitian Pendidikan IPA*, 11(7), 178-185. <https://doi.org/10.29303/jppipa.v11i7.11301>
- Lewinsohn, T. M., Attayde, J. L., Fonseca, C. R., Ganade, G., Jorge, L. R., Kollmann, J., & Weisser, W. W. (2015). Ecological literacy and beyond: Problem-based learning for future professionals. *Ambio*, 44(2), 154-162. <https://doi.org/10.1007/s13280-014-0539-2>
- 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>
- López-Pimentel, J. C., Medina-Santiago, A., Alcaraz-Rivera, M., & Del-Valle-soto, C. (2021). Sustainable project-based learning methodology adaptable to technological advances for web programming. *Sustainability (Switzerland)*, 13(15). <https://doi.org/10.3390/su13158482>
- Ma, X., Zeng, D., Wang, J., Xu, K., & Li, L. (2022). Effectiveness of bridge-in, objective, pre-assessment, participatory learning, post-assessment, and summary teaching strategy in Chinese medical education: A systematic review and meta-analysis. *Frontiers in Medicine*, 9. <https://doi.org/10.3389/fmed.2022.975229>
- MacDonald, E., Arpin, E., & Quesnel-Vallée, A. (2022). Literacy and self-rated health: Analysis of the Longitudinal and International Study of Adults (LISA). *SSM - Population Health*, 17. <https://doi.org/10.1016/j.ssmph.2022.101038>
- Manu, A., Ewerling, F., Barros, A. J. D., & Victora, C. G. (2019). Association between availability of children's book and the literacy-numeracy skills of children aged 36 to 59 months: Secondary analysis

- of the UNICEF Multiple-Indicator Cluster Surveys covering 35 countries. *Journal of Global Health*, 9(1). <https://doi.org/10.7189/jogh.09.010403>
- Maritasari, D. B., Aswasulasikin, L., & A. (2025). Development of Tests Based on Proprofs Digital Media to Measure Higher Order Thinking Skills (HOTS) of Students in Science Learning. *Jurnal Penelitian Pendidikan IPA*, 11(1), 71-77. <https://doi.org/10.29303/jppipa.v11i1.9383>
- Martiniuk, A., Colbran, R., Ramsden, R., Karlson, D., O'callaghan, E., Lowe, E., & Wotherspoon, A. (2019). Hypothesis: Improving literacy about health workforce will improve rural health workforce recruitment, retention and capability. *Human Resources for Health*, 17(1). <https://doi.org/10.1186/s12960-019-0442-9>
- Menzies, H. M., Mahdavi, J. N., & Lewis, J. L. (2008). Early intervention in reading: From research to practice. *Remedial and Special Education*, 29(2), 67-77. <https://doi.org/10.1177/0741932508315844>
- Mirna, A., K., & Palloan, P. (2025). The Influence of Problem Based Learning Model and Learning Interest on Physics Problem Solving Ability of Grade XI High School Students. *Jurnal Penelitian Pendidikan IPA*, 11(2), 77-83. <https://doi.org/10.29303/jppipa.v11i2.913>
- Mononen, R., & Niemivirta, M. (2023). Patterns of symbolic numerical magnitude processing and working memory as predictors of early mathematics performance. *European Journal of Psychology of Education*, 38(1), 311-332. <https://doi.org/10.1007/s10212-021-00596-4>
- Morgan, N., & Jones, M. A. (2025). Student Perceptions on the Use of Journal Clubs for Enhancing Academic Literacy. *Active Learning in Higher Education*. <https://doi.org/10.1177/14697874251388982>
- Nag, S., Snowling, M. J., & Asfaha, Y. M. (2016). Classroom literacy practices in low- and middle-income countries: an interpretative synthesis of ethnographic studies. *Oxford Review of Education*, 42(1), 36-54. <https://doi.org/10.1080/03054985.2015.1135115>
- Neugebauer, P., & Prediger, S. (2023). Quality of Teaching Practices for All Students: Multilevel Analysis of Language-Responsive Teaching for Robust Understanding. *International Journal of Science and Mathematics Education*, 21(3), 811-834. <https://doi.org/10.1007/s10763-022-10274-6>
- Nguyen, A. (2023). Unraveling EMI as a predictor of English proficiency in Vietnamese higher education: Exploring learners' backgrounds as a variable. *Studies in Second Language Learning and Teaching*, 13(2), 347-371. <https://doi.org/10.14746/ssllt.38278>
- Nussbaum, E. M., Dove, I. J., & Putney, L. A. G. (2023). Bridging dialogic pedagogy and argumentation theory through critical questions. *Dialogic Pedagogy*, 11(3), 7-25. <https://doi.org/10.5195/dpj.2023.548>
- Oldfather, P., & Dahl, K. (1994). Toward A Social Constructivist Reconceptualization Of Intrinsic Motivation For Literacy Learning. *Journal of Reading Behavior*, 26. <https://doi.org/10.1080/10862969409547843>
- Paramita, W., & Fitria, Y. (2025). The Influence of PjBL-Based STEAM Approach on Students' High Order Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, 11(8), 1201-1205. <https://doi.org/10.29303/jppipa.v11i8.11824>
- Pensiero, N., & Green, A. (2018). The effects of post-compulsory education and training systems on literacy and numeracy skills: A comparative analysis using PISA 2000 and the 2011 survey of adult skills. *European Journal of Education*, 53(2), 238-253. <https://doi.org/10.1111/ejed.12268>
- Peppen, L. M., Verkoeijen, P. P. J. L., Heijltjes, A. E. G., Janssen, E. M., & Gog, T. (2021). Enhancing students' critical thinking skills: is comparing correct and erroneous examples beneficial? *Instructional Science*, 49(6), 747-777. <https://doi.org/10.1007/s11251-021-09559-0>
- Reder, S., Gauly, B., & Lechner, C. (2020). Practice makes perfect: Practice engagement theory and the development of adult literacy and numeracy proficiency. *International Review of Education*, 66(2-3), 267-288. <https://doi.org/10.1007/s11159-020-09830-5>
- Ritchie, S. J., & Tucker-Drob, E. M. (2018). How Much Does Education Improve Intelligence? A Meta-Analysis. *Psychological Science*, 29(8), 1358-1369. <https://doi.org/10.1177/0956797618774253>
- Saba Villarroel, P. M., Gumpangseth, N., Songhong, T., Yainoy, S., Monteil, A., Leaungwutiwong, P., & Wichit, S. (2023). Emerging and re-emerging zoonotic viral diseases in Southeast Asia: One Health challenge. *Frontiers in Public Health*, 11. <https://doi.org/10.3389/fpubh.2023.1141483>
- Sakamoto, M., Yamaguchi, E., Yamamoto, T., & Wakabayashi, K. (2021). An intervention study on students' decision-making towards consensus building on socio-scientific issues. *International Journal of Science Education*, 43(12), 1965-1983. <https://doi.org/10.1080/09500693.2021.1947541>
- Sakerani, S., Iskandar, A. A., Ismaya, B., & Rahmah, S. (2025). The Role of Teachers as Motivators and Facilitators in Strengthening Numeracy Literacy. *Jurnal Penelitian Pendidikan IPA*, 11(9), 90-99.

- <https://doi.org/10.29303/jppipa.v11i9.12069>
- Schmid, R., Pauli, C., & Petko, D. (2023). Examining the use of digital technology in schools with a school-wide approach to personalized learning. *Educational Technology Research and Development*, 71(2), 367–390. <https://doi.org/10.1007/s11423-022-10167-z>
- Severiens, S. E., & Schmidt, H. G. (2009). Academic and social integration and study progress in problem based learning. *Higher Education*, 58(1), 59–69. <https://doi.org/10.1007/s10734-008-9181-x>
- Siebecke, D. E., & Jarl, M. (2022). Does the material well-being at schools successfully compensate for socioeconomic disadvantages? Analysis of resilient schools in Sweden. *Large-Scale Assessments in Education*, 10(1). <https://doi.org/10.1186/s40536-022-00130-y>
- Siregar, T. M., Armanto, D., Frisnoiry, S., & Ruslan, D. (2025). Effective Solutions for Implementing Android-Based Computer-Based Testing (CBT) In Vocational High Schools as A Digital Assessment Innovation. *Jurnal Penelitian Pendidikan IPA*, 11(1), 623–633. <https://doi.org/10.29303/jppipa.v11i1.10155>
- Tanjung, Y. I., Festiyed, F., Diliarosta, S., Asrizal, A., Arsih, F., Fadillah, M. A., & Makrooni, G. (2025). Culturally Responsive Teaching in Science Education and its Relationship with Technopreneurship. *Aptisi Transactions on Technopreneurship*, 7(2), 387–399. <https://doi.org/10.34306/att.v7i2.563>
- Tanjung, Y. I., Festiyed, S. D., Asrizal, F. A., & Fadillah, M. A. (2025). Developing the Physics Learning Management System (PLMS) to Support Blended Learning Models. *International Journal of Information and Education Technology*, 15(1), 18–29. <https://doi.org/10.18178/ijiet.2025.15.1.2214>
- Tanjung, Y. I. T., Festiyed, F., Diliarosta, S. D., Jubaidah, J., & Sanjaya, A. P. S. (2024). Analysis of students' problem solving skills based on Heller indicator. *Pegem Journal of Education and Instruction*, 14(4), 421–433. <https://doi.org/10.47750/pegegog.14.04.40>
- Tanjung, Y. I., Wulandari, T., Festiyed, F., Yerimadesi, Y., & Ahda, Y. (2023). Development analysis of creative thinking test instruments on natural science materials. *Jurnal Pendidikan Fisika*, 12(1), 22–27. <https://doi.org/10.24114/jpf.v12i1.43340>
- Tawafak, R. M., Al-Obaydi, L. H., Klimova, B., & Pikhart, M. (2023). Technology integration of using digital gameplay for enhancing EFL college students' behavior intention. *Contemporary Educational Technology*, 15(4). <https://doi.org/10.30935/cedtech/13454>
- Ten Cate, O., Snell, L., Mann, K., & Vermunt, J. (2004). Orienting Teaching Toward the Learning Process. *Academic Medicine*, 79(3), 219–228. Retrieved from https://journals.lww.com/academicmedicine/abstract/2004/03000/orienting_teaching_toward_the_learning_process.5.aspx
- Usher, D. C., Driscoll, T. A., Dhurjati, P., Pelesko, J. A., Rossi, L. F., Schleiniger, G., & White, H. B. (2010). *Essay A Transformative Model for Undergraduate Quantitative Biology Education*. <https://doi.org/10.1187/cbe.10>
- Wong, J. T., & Hughes, B. S. (2023). Leveraging learning experience design: digital media approaches to influence motivational traits that support student learning behaviors in undergraduate online courses. *Journal of Computing in Higher Education*, 35(3), 595–632. <https://doi.org/10.1007/s12528-022-09342-1>
- Wortha, S. M., Klein, E., Lambert, K., Dackermann, T., & Moeller, K. (2023). The relevance of basic numerical skills for fraction processing: Evidence from cross-sectional data. *PLoSOne*, 18(1). <https://doi.org/10.1371/journal.pone.0281241>