

Virtual Reality Based on Local Wisdom to Improve Literacy, Numeracy, and Critical Thinking Skills in Natural and Social Sciences Subjects

Mohammad Zainudin^A, Surayanah^B, Khusnul Khotimah^C, Abd Charis Fuzan^D, Lestariningsih^{E*}

Abstract

This research aims to develop Virtual Reality (VR) learning media products based on the local wisdom of cocoa cultivation in Kampung Chocolate Educational Tourism, Blitar, Indonesia. This VR product is designed to enhance numeracy literacy and critical thinking skills in Natural and Social Sciences (IPAS) subjects for fourth-grade elementary school students. This study uses mixed methods with an embedded experimental model design combined with a sequential approach. The sampling technique was carried out randomly in strata. The results showed that the VR products developed were very valid (85%) according to the assessment of material experts, linguists, and IT experts, with only minor revisions required. Small-scale trials of five people showed a high level of product practicality (85%). Furthermore, a large-scale trial involving 4th-grade elementary school students in Blitar Regency, Indonesia, showed that this VR product was very effective, with a percentage of 79.93% in improving student learning outcomes. In addition, this study also found a positive correlation between the use of VR products and improved student learning outcomes. Overall, this study concludes that VR products based on local wisdom in Kampung Chocolate are valid, practical, and very effective learning media to improve numeracy literacy, critical thinking, and student learning outcomes in science subjects.

Keywords: *Virtual Reality, Local Wisdom, Literacy, Numeracy, Critical Thinking Skills, Natural Sciences, Social Sciences.*

INTRODUCTION

The learning model at the elementary school level requires active, differentiated, technology-based, and culture-based learning (Coban & Dubaz, 2011). Active learning involves students being actively engaged in the learning process, often through discussions, projects, and experiments. Its advantage is that it helps students develop critical thinking, creativity, and problem-solving skills (Zainuddin et al., 2023). Meanwhile, differentiated learning is when teachers adjust learning according to the needs and abilities of each student. This learning advantage ensures that each student gets learning that is in accordance

^AFaculty of Education, State University of Malang, Indonesia

^BFaculty of Education, State University of Malang, Indonesia

^CFaculty of Education, State University of Malang, Indonesia

^DFaculty of Exact Sciences, Nahdlatul Ulama University of Blitar, Indonesia

^EFaculty of Exact Sciences, Nahdlatul Ulama University of Blitar, Indonesia, Email: tariunu@gmail.com

with their level of development. Usually, this learning model uses learning media. In addition, technology-based learning is also needed for the elementary school level. Technology as a tool in the learning process, for example, using computers, tablets, learning applications, and the internet. The advantage of this learning model is that it can open up students' access to wider information and enrich the learning experience (Marougkas et al., 2023). In addition, there is culture-based learning that has also been developed a lot. This learning utilizes local culture and wisdom as a learning resource. Its advantages are that it can shape students' identities and strengthen cultural values (Zainudin et al., 2025) (Schwartz et al., 2023).

The ideal learning model is one that can combine various elements from various models, adapted to the needs and characteristics of students, and supported by existing resources. The results of the study show that student psychology has a significant influence on learning outcomes at the elementary school level (Deng et al., 2024). Models that are appropriate to students' situations and conditions can increase student motivation to learn. This is because students feel happy doing teaching and learning activities in the classroom (Ebbes et al., 2024). The role of teachers is very important in the successful implementation of the Education model (Hidayah & Sugiarto, 2015). Teachers must have sufficient knowledge about various learning models, be able to manage the classroom well, and be able to create a conducive learning environment. The integration of all these elements can support students' numeracy literacy, and critical thinking (Lee et al., 2023).

At this time, there are a lot of learning media that have been implemented. However, it has not yet obtained optimal results. Students have not yet gained a real experience in the end. Moreover, after the COVID-19 pandemic, all fields of education use online learning that is integrated with information technology (Schwartz et al., 2023). With this technology, students can learn with teachers remotely (Ahmed Alismail, 2023). Now, many learning media applications can be accessed through smartphones. The results of the research also show that the media is significant in improving the way elementary school students think (Lijanporn & Khlaisang, 2015). One of the ways of learning materials with technology is virtual reality (VR). Virtual Reality is a technology that allows users to experience an immersive environment in a simulated environment. At this time, VR media has become a popular tool in the field of education. Especially for elementary school students, VR offers unique opportunities to enrich the learning experience. Some research results show that the use of VR learning media can increase students' motivational interest, deepen understanding, allow students to explore a wide world, and improve critical thinking skills.

However, in the use of VR, there are many things that need to be prepared. Among them are the quality of VR content, accessibility, and user safety. The process of making VR requires quite a lot of money.

This is one of the obstacles for elementary schools that have limited facilities and infrastructure. These costs include the price of VR devices is still relatively expensive, especially for schools with limited budgets. Content development requires considerable costs to develop quality VR content (AlGerafi et al., 2023). In addition, there is maintenance in the form of maintenance of VR devices, which also requires additional costs. The solution to this, educational tourism can contribute to improving the quality of technology-based learning. This is in order to help realize the independent learning program in Indonesia. With this contribution, VR media can be provided with suitable and quality VR devices for elementary school students, such as virtual boxes equipped with headsets and educational VR applications that are in accordance with local wisdom. In addition, the use of this language is very important to be adapted to elementary school students (Salomé et al., 2024). This needs to be considered because the average elementary school student is still in the process of learning to read (Ardanouy et al., 2024). This research is important because numeracy literacy and critical thinking are essential skills that students need to develop from an early age. The two are closely related, where good numeracy skills will support the development of critical thinking skills. To achieve this, learning media that is integrated with technology, such as virtual reality, is necessary. This research aims to develop valid, effective, and practical VR learning media based on local wisdom to improve numeracy literacy and critical thinking in science subjects.

METHOD

This research was conducted from June to August 2024 on an educational journey in Kampung Cokelat, Blitar. The participants involved in this experiment were 50 4th-grade elementary school students who had visited the village. In this study, virtual reality learning media contain cocoa cultivation materials. This study uses a *mixed method with an embedded experimental model design* adopted from Creswell (Creswell & Tashakkori, 2007). This research uses a development approach that is structured in three main stages. The first stage is planning, where researchers compile product designs, create story content about cocoa cultivation, and design visual and audio elements. This includes creating screen themes, developer identities, music and sound effects selection, defining video characters, and designing detailed storylines through storyboards. The second stage is product creation, which starts with the development of the VR product itself, followed by a validation process by experts to ensure its quality. This stage also includes the evaluation and improvement of the product based on expert input, as well as a series of tests to assess its feasibility. The third stage is the interpretation of the results, where the data from the test is processed, analyzed, and discussed to conclude the effectiveness of the VR product being developed.

In this study, data collection techniques were carried out through observation, interviews, and documentation. Observations were carried

out during the learning process by focusing on three main indicators: the application of VR media, the improvement of students' numeracy literacy, and the improvement of students' Pancasila character. To complete the data, in-depth interviews were conducted with guides, teachers, and students. This interview aims to measure the improvement of numeracy literacy, Pancasila characters, and identify the ease of using VR as a learning medium. Data analysis is carried out systematically. The first stage is the media validity test, which involves assessments from subject matter experts, linguists, and media experts to ensure the feasibility of the product. Furthermore, a practical test was carried out to evaluate the ease of use of media by students and teachers. Finally, the effectiveness test was carried out using an effect size test to measure the impact of VR products on learning outcomes. All data is managed using Microsoft Excel and further analyzed with SPSS software. This study measures literacy and numeracy aspects through content that is integrated in VR media. Literacy is evaluated from students' ability to understand and interpret narratives, instructions, and information presented in a virtual environment, such as the history of cocoa cultivation or processing processes. Meanwhile, numeracy is measured by the ability of students to apply mathematical concepts. For example, students are challenged to calculate the proportions of ingredients, measure the area of the land, or analyze cocoa production data presented interactively in a VR simulation.

RESULTS AND DISCUSSION

VR Product Validation

At the validation stage, the Virtual Reality (VR) product developed has gone through a series of strict evaluations by experts, namely material experts, linguists, and media experts. The results show that this learning media has a high level of validity, reaching 85%. This figure puts the product in the category of "*very valid*" or "*suitable for use with a slight revision*". This validity is an important foundation that ensures that VR learning content is not only scientifically and linguistically accurate, but also presented effectively and engaging from a media perspective. The discussion of the results of this validation is in line with the theory of learning media development, which emphasizes the importance of content validity and construct validity. The validity of the content ensures that the content of cocoa cultivation in VR covers all important aspects of the IPAS curriculum, as well as is relevant to existing local wisdom. Meanwhile, the validity of the construct ensures that the VR product is designed effectively to measure or improve the intended abilities, i.e. numeracy literacy and critical thinking, as described in the cognitive theory of multimedia learning by Richard Mayer. According to Mayer, learning becomes more effective when information is presented in a visual and verbal format that complements each other, which is at the heart of VR design.

In the validation process, this Virtual Reality (VR) product has reached a validity level of 85%, a number that indicates its feasibility for

use. However, this score also indicates that there is a gap for further refinement, which then becomes the main focus in the revision phase. Findings from experts, including subject matter experts, linguists, and media experts, provide valuable input that forms the basis for minor improvements. This revision is not just a formality, but a crucial stage in the Research and Development (R&D) model that ensures the quality of the final product. Specifically, the revision was carried out to optimize user interaction so that the learning experience becomes more intuitive and smooth for students. This is in line with the principle of User Experience Design in digital media development, where ease of navigation and direct interaction correlates with learning effectiveness (Maroukhas et al., 2024).

In addition, improving visual clarity is a priority, ensuring every graphic element, from 3D models to animations, can be easily understood by 4th graders of elementary school. This aspect is important because it is in accordance with cognitive load theory, which states that unclear visuals can strain students' mental capacity and hinder the learning process. Not only that, but narrative refinements are also carried out to ensure that the language used in VR is easy to digest, engaging, and relevant to the student experience (Lampropoulos et al., 2022). This revision aims to strengthen the principle of narrative-based learning, where strong stories can improve memory and comprehension. All of these improvements reflect the research's commitment to producing products that are not only technologically innovative but also pedagogically mature (Calvert & Hume, 2022). Thus, the results of this validation, followed by careful revision, became a very strong foundation to proceed to the next stage, namely the test of practicality and effectiveness in the field.

Product Practicality Test

The test results show that VR products have a high level of practicality, reaching 85% in both small and large-scale trials. This figure confirms that this learning medium is not only effective theoretically, but also easy to implement in real learning practice. This practicality data was obtained through in-depth interpretation of user responses, both students and teachers, who provided positive feedback regarding ease of use, clarity of instruction, and appropriateness of duration. This discussion is in line with the experiential learning theory by David Kolb, where the effectiveness of learning is greatly influenced by the ease with which students to actively engage in experiences (Albab et al., 2025). The high practicality of the VR product allows students to jump right into the cocoa farming experience without any significant technical barriers. This aspect is also in line with the principles of instructional design, which emphasize the importance of usability of learning media. When the medium is practical, teachers can integrate it into their lesson plans more seamlessly, while students can focus entirely on the content, not on how to operate the tool (Solehudin et al., 2024) (Campos et al., 2022).

Furthermore, the results of the analysis showed that the responses from teachers and students were very consistent. Teachers appreciate the ease of setting up and using VR as an aid, which does not require extensive training. On the other hand, students find the product intuitive and engaging, which significantly increases their motivation to learn (Villena-Taranilla et al., 2022). This corroborates Albert Bandura's theory of self-efficacy, which states that successful experiences in using new tools can increase students' confidence in learning (Fismasari et al., 2025). Thus, the practicality of VR products not only facilitates the learning process but also positively influences students' learning psychology and teachers' readiness to adopt innovations.

The Effectiveness of VR Products on Learning Outcomes

After a large-scale VR trial, the results of the effectiveness of learning media activities were obtained as follows.

Table 1. Effectiveness of learning media

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	50	0,73	0,87	0,7993	0,03099
Ngain_Presentase	50	73,33	86,67	79,9306	3,09895
Valid N (<i>listwise</i>)	50				

Based on the table above, it is known that the effectiveness of learning media trial activities using cocoa cultivation VR reached 79.93% (very effective). VR creates a very real learning environment, as if students are literally in the middle of a cocoa plantation. This experience allows students to interact directly with learning objects, such as observing cocoa plants up close, and performing the harvesting process virtually. This direct interaction can stimulate students to think critically and find solutions to various problems that arise in cocoa cultivation. VR is able to present information visually that is very detailed and comprehensive. Students can see the structure of cocoa plants from different angles, understand the life cycle of pests and diseases, and learn about the cultivation process as a whole. This clear visualization helps students build a better understanding of the complex concepts in cocoa cultivation, thus stimulating their critical thinking (Almulla, 2023) (Alifteria et al., 2023) (Arisoy & Aybek, 2021).

With VR, students can be invited to experience a variety of different environmental conditions. This simulation allows students to analyze the impact of various environmental factors on the growth of cocoa plants and find the right solutions. This trains students to think critically and make decisions based on the information available. VR can be used to present real problems that cocoa farmers often face. Students are then invited to find solutions to these problems in a simulation environment. This problem-solving process encourages students to think critically, analyze information, and develop problem-solving skills (Sari et al., 2021) (González-pérez & Ramírez-montoya, 2022). The use of VR in cocoa farming learning not only enhances

students' knowledge, but also develops 21st-century skills that are urgently needed in the future, such as: Analyzing information, solving problems, and making decisions, developing new and innovative ideas in cocoa cultivation, working with peers in solving problems, and communicating ideas and information effectively (Paszkiwicz et al., 2021). In summary, the use of VR in cocoa farming learning provides a rich and immersive learning experience, thus being able to stimulating students to think critically, develop broad insights, and prepare themselves for future challenges (Conrad et al., 2024) (Holuša et al., 2023).

The Virtual Reality (VR) products based on local wisdom in this study are not only valid and practical, but also proven to be very effective in improving students' abilities. The results of the effectiveness test using the effect size test showed a percentage of 79.93%. This figure is a strong statistical indicator, showing that the use of VR media has a substantial and clinically significant impact on improving students' numeracy literacy and critical thinking skills. This very high effectiveness confirms that the difference in learning outcomes between the VR user group and the control group is not a coincidence, but rather a direct result of this innovative learning treatment (Zawadzki et al., 2020) (Lampropoulos & Kinshuk, 2024). This impressive level of effectiveness can be explained through several relevant learning theories. First, Richard Mayer's Cognitive Theory of Multimedia Learning is the main foundation. According to this theory, learning is most effective when information is presented through visual and verbal channels simultaneously, which is the essence of the VR experience. The immersive and interactive nature of VR helps students process complex information about cocoa cultivation (IPAS) without excessive cognitive load, thus allowing them to focus on developing high-level abilities such as critical thinking (Mayer, 2024) (Yue et al., 2013) (Cavanagh & Kiersch, 2023).

Second, Contextual Learning Theory explains why local wisdom is so important. By placing scientific concepts (e.g., calculations of fertilizer proportions) in real and relevant contexts (e.g., cocoa cultivation in the Chocolate Village), VR bridges the gap between theory in the classroom and practice in the real world. This makes the concept of numeracy literacy more meaningful and easier to understand (Veselinov et al., 2024) (Violy, 2025). The experiences presented by VR allow students to not only memorize, but also analyze, compare, and evaluate information, which is at the core of critical thinking skills. This approach is particularly relevant and interesting for the Natural and Social Sciences (IPAS) 4th-grade elementary school subject, as it inherently combines two different disciplines. VR based on local wisdom in cocoa cultivation not only bridges the gap between theory and practice, but also presents IPAS material in a cohesive unit.

From the science side, students can virtually observe the life cycle of cocoa plants and learn about the cocoa plantation ecosystem. They can interact with 3D models of analyzing plant growth factors,

and apply scientific knowledge to solve practical problems. For example, students can be invited to compare the growth of cocoa plants in different soil conditions, which directly hones their critical thinking skills in analyzing data and drawing conclusions. Meanwhile, from the social studies side, VR presents the social, economic, and cultural aspects of cocoa cultivation. Students can "*visit*" a farmer's house, understand the chocolate processing process, or learn about the history of the Chocolate Village. They learned about the livelihoods of the population, the economic role of cocoa for local communities, and local wisdom used in agricultural practices. This experience helps students understand how science (science) and social aspects (social studies) are closely related in real life. Thus, the use of VR is very much in line with the 4th-grade IPAS curriculum, which aims to form a holistic understanding of the world around students. VR not only improves numeracy literacy and critical thinking, but also provides a deep understanding of the interconnectedness between science and social life, making learning more meaningful and relevant (Pratikno et al., 2024) (Anggun et al., 2025) (Aini et al., 2024).

Correlation with the Character of Pancasila

In addition to having an impact on academic ability, this study found a significant positive correlation between the use of Virtual Reality (VR) media and the improvement of students' Pancasila character. These findings were obtained through an in-depth analysis of the results of observations and interviews conducted during learning activities. Observations show that students proactively work together in groups when using VR to solve problems, which reflects the mutual aid values of the third and fifth precepts. They help each other in navigating the virtual environment, discuss to analyze data, and share ideas in finding solutions. The results of interviews with teachers and tutors also corroborated these findings. They reported that students showed a more democratic attitude (fourth precept) in group decision-making and showed a high sense of tolerance (first and second precepts) to differences of opinion. This is very relevant to the title of the research that prioritizes local wisdom, because local wisdom itself is a reflection of cultural and social values, including the values of Pancasila. This immersive and interactive VR experience encourages students to apply those values in real life in the context of learning (Buchori et al., 2024).

One of the relevant theories is the Social Learning Theory of Albert Bandura. According to this theory, students learn not only from direct experience but also through observation and interaction with others (Siregar & Karmiyati, 2024). A collaborative VR environment allows students to observe and imitate positive behaviors, such as cooperation and mutual respect. When students work together in VR simulations, they subconsciously learn social norms and values such as cooperation and democracy, which are the core of Pancasila. In addition, this finding is also supported by the concept of cooperative learning. In the context of VR, students are required to interact,

negotiate, and work together to achieve a common goal, such as solving problems in cocoa cultivation. This interaction naturally fosters the values of Pancasila. Thus, VR media based on local wisdom not only serves as a tool to improve cognitive abilities, but also as a powerful platform to instill positive character and noble values of the nation through structured social interaction (Hamadi et al., 2022) (Zhou & Colomer, 2024).

Theoretical and Practical Implications

The findings of this study provide strong empirical support for various learning theories and have significant implications for future curriculum and practice development. First, the effectiveness of Virtual Reality (VR) media in improving numeracy literacy and critical thinking is in line with Richard Mayer's Multimedia Cognitive Learning Theory (Mayer, 2024). VR products that combine immersive visualization with optimally structured narratives reduce cognitive burden, allowing students to process complex information about cocoa cultivation (IPAS) more effectively. In addition, these findings also strengthen the Contextual Learning Theory, where the placement of teaching materials in the context of local wisdom of cocoa cultivation in Kampung Cocoa bridges the gap between theory and practice, making learning more relevant and meaningful. The implications of these findings for future curriculum development are enormous. The results of this study show that the curriculum can be enriched by integrating immersive technology and learning resources based on local wisdom. This approach can be adopted for other subjects and at various levels of education, not just in elementary school. In learning practice, teachers can use VR not only as an aid but as the core of a student-centered learning experience. This encourages more active, collaborative, and problem-solving-oriented learning (Melikuzievich, 2022).

CONCLUSION

This research has succeeded in developing and testing Virtual Reality (VR) products based on local wisdom in cocoa cultivation that are valid, practical, and very effective. The findings show that this VR product has a high validity (85%) after going through expert assessment, as well as an excellent level of practicality (85%) based on small-scale trials. At its peak, this product has proven to be very effective in improving the numeracy literacy, critical thinking, and learning outcomes of 4th-grade elementary school students in science subjects, with an effectiveness percentage of 79,93%. These results show that the integration of immersive technology with the context of local wisdom is significantly able to create meaningful learning experiences and have a positive impact. This research confirms that contextual learning enriched with advanced technology is not just an innovation, but a powerful strategy to face the challenges of 21st-century education.

REFERENCES

- Aini, K., Misbahudholam AR, M., & Ridwan, M. (2024). Growing Numeral Literacy Skills through Science, Technology, Engineering, Arts, Mathematics Based on Local Wisdom. *MIMBAR PGSD Undiksha*, 12(1), 64–72. <https://doi.org/10.23887/jjpgsd.v12i1.67642>
- Albab, U., Ta'rifin, A., Novianti, D., & Safitri, H. H. (2025). Exploring the Impact of Augmented Reality on Meaningful Learning in Islamic Religious Education: A Quantitative Analysis. *EDUKASI: Jurnal Penelitian Pendidikan Agama Dan Keagamaan*, 23(1), 1–25. <https://doi.org/10.32729/edukasi.v23i1.1944>
- AlGerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education. *Electronics (Switzerland)*, 12(18), 1–29. <https://doi.org/10.3390/electronics12183953>
- Alifteria, F. A., Prastowo, T., & Suprpto, N. (2023). Analysis of Students' Critical Thinking Skills on Virtual Reality Learning Media. *IJORER: International Journal of Recent Educational Research*, 4(1), 59–67. <https://doi.org/10.46245/ijorer.v4i1.275>
- Alismail, H. A. (2023). Teachers' perspectives of utilizing distance learning to support 21st century skill attainment for K-3 elementary students during the COVID-19 pandemic era. *Heliyon*, 9(9), e19275. <https://doi.org/10.1016/j.heliyon.2023.e19275>
- Almulla, M. A. (2023). Constructivism learning theory: A paradigm for students' critical thinking, creativity, and problem solving to affect academic performance in higher education. *Cogent Education*, 10(1), 1–25. <https://doi.org/10.1080/2331186X.2023.2172929>
- Anggun, M. S., Fakhrudin, F., Arbarini, M., Subali, B., & Widiarti, N. (2025). Implementing Creative Learning with Technology to Improve Literacy and Numeracy in Primary Schools. *Journal of Innovation and Research in Primary Education*, 4(3), 430–437. <https://doi.org/10.56916/jirpe.v4i3.1299>
- Ardanouy, E., Lefèvre, E., Delage, H., & Zesiger, P. (2024). Which skills underlie French-speaking children's lexical spelling acquisition in elementary school? Insight from a cross-sectional exploratory network study from Grade 1 to Grade 5. *Journal of Experimental Child Psychology*, 245, 105963. <https://doi.org/10.1016/j.jecp.2024.105963>
- Arisoy, B., & Aybek, B. (2021). The effects of subject-based critical thinking education in mathematics on students' critical thinking skills and virtues*. *Eurasian Journal of Educational Research*, 92, 99–120. <https://doi.org/10.14689/ejer.2021.92.6>
- Buchori, A., Sumarno, & Septia Devega, L. (2024). The Effect of Using Interactive Multimedia Design with the STEM VR Approach to Strengthening Pancasila Student Profiles in Elementary School. *ICESRE 6th International Conference on Education and Social*

- Science Research*, 634–641.
<https://doi.org/10.18502/kss.v9i6.15317>
- Calvert, J., & Hume, M. (2022). Immersing Learners in Stories: A Systematic Literature Review of Educational Narratives in Virtual Reality. *Australasian Journal of Educational Technology*, 38(5), 45–61. <https://doi.org/10.14742/ajet.7032>
- Campos, E., Hidrogo, I., & Zavala, G. (2022). Impact of virtual reality use on the teaching and learning of vectors. *Frontiers in Education*, 7(September), 1–15. <https://doi.org/10.3389/feduc.2022.965640>
- Cavanagh, T. M., & Kiersch, C. (2023). Using commonly-available technologies to create online multimedia lessons through the application of the Cognitive Theory of Multimedia Learning. *Educational Technology Research and Development*, 71(3), 1033–1053. <https://doi.org/10.1007/s11423-022-10181-1>
- Coban, S., & Dubaz, I. (2011). The relationship between active learning models in music lessons in elementary schools and multiple intelligence areas. *Procedia - Social and Behavioral Sciences*, 28, 684–690. <https://doi.org/10.1016/j.sbspro.2011.11.129>
- Conrad, M., Kablitz, D., & Schumann, S. (2024). Learning effectiveness of immersive virtual reality in education and training: A systematic review of findings. *Computers and Education: X Reality*, 4(December 2023), 1–11. <https://doi.org/10.1016/j.cexr.2024.100053>
- Creswell, J. W., & Tashakkori, A. (2007). Developing Publishable Mixed Methods Manuscripts. In *Journal of Mixed Methods Research* (Vol. 1, Issue 2, pp. 107–111). <https://doi.org/10.1177/1558689806298644>
- Deng, J., Huang, X., & Ren, X. (2024). A multidimensional analysis of self-esteem and individualism: A deep learning-based model for predicting elementary school students' academic performance. *Measurement: Sensors*, 33(April), 101147. <https://doi.org/10.1016/j.measen.2024.101147>
- Ebbes, R., Schuitema, J. A., Koomen, H. M. Y., Jansen, B. R. J., & Zee, M. (2024). Self-regulated learning: Validating a task-specific questionnaire for children in elementary school. *Studies in Educational Evaluation*, 81(January), 101339. <https://doi.org/10.1016/j.stueduc.2024.101339>
- Fismasari, Z., Waluyo, W. B., Hendrawan, B. D., & Latifah, W. U. (2025). The Effect of Self-Efficacy on Individual Performance: a Theoretical Review and Practical Implications. *Formosa Journal of Applied Sciences*, 4(6), 1819–1826. <https://doi.org/10.55927/fjas.v4i6.190>
- González-pérez, L. I., & Ramírez-montoya, M. S. (2022). Components of Education 4.0 in 21st Century Skills Frameworks: Systematic Review. *Sustainability (Switzerland)*, 14(3), 1–31.
- Hamadi, M., El-Den, J., Azam, S., & Sriratanaviriyakul, N. (2022). Integrating social media as cooperative learning tool in higher

- education classrooms: An empirical study. *Journal of King Saud University - Computer and Information Sciences*, 34(6), 3722–3731. <https://doi.org/10.1016/j.jksuci.2020.12.007>
- Hidayah, I., & Sugiarto. (2015). Model of Independent Working Group of Teacher and its Effectiveness towards the Elementary School Teacher's Ability in Conducting Mathematics Learning. *Procedia - Social and Behavioral Sciences*, 214(June), 43–50. <https://doi.org/10.1016/j.sbspro.2015.11.591>
- Holuša, V., Vaněk, M., Beneš, F., Švub, J., & Staša, P. (2023). Virtual Reality as a Tool for Sustainable Training and Education of Employees in Industrial Enterprises. *Sustainability (Switzerland)*, 15(17), 1–24. <https://doi.org/10.3390/su151712886>
- Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2022). Augmented Reality and Virtual Reality in Education: Public Perspectives, Sentiments, Attitudes, and Discourses. *Education Sciences*, 12(11), 1–23. <https://doi.org/10.3390/educsci12110798>
- Lampropoulos, G., & Kinshuk. (2024). Virtual reality and gamification in education: a systematic review. In *Educational Technology Research and Development* (Vol. 72, Issue 3). Springer US. <https://doi.org/10.1007/s11423-024-10351-3>
- Lee, M., Lee, S. Y., Kim, J. E., & Lee, H. J. (2023). Domain-specific self-regulated learning interventions for elementary school students. *Learning and Instruction*, 88(June), 101810. <https://doi.org/10.1016/j.learninstruc.2023.101810>
- Lijanporn, S., & Khlaisang, J. (2015). The Development of an Activity-based Learning Model Using Educational Mobile Application to Enhance Discipline of Elementary School Students. *Procedia - Social and Behavioral Sciences*, 174, 1707–1712. <https://doi.org/10.1016/j.sbspro.2015.01.825>
- Marougkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2023). Virtual Reality in Education: A Review of Learning Theories, Approaches and Methodologies for the Last Decade. *Electronics (Switzerland)*, 12(13), 1–21. <https://doi.org/10.3390/electronics12132832>
- Marougkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2024). How personalized and effective is immersive virtual reality in education? A systematic literature review for the last decade. In *Multimedia Tools and Applications* (Vol. 83, Issue 6). Springer US. <https://doi.org/10.1007/s11042-023-15986-7>
- Mayer, R. E. (2024). The Past, Present, and Future of the Cognitive Theory of Multimedia Learning. *Educational Psychology Review*, 36(8), 1–25. <https://doi.org/10.1007/s10648-023-09842-1>
- Melikuzievich, S. I. (2022). An Effective Way to Present Educational Materials. *Galaxy International Interdisciplinary Research Journal*, 10(12), 224–229.
- Paszkiwicz, A., Salach, M., Dymora, P., Bolanowski, M., Budzik, G., & Kubiak, P. (2021). Methodology of implementing virtual reality in

- education for industry 4.0. *Sustainability (Switzerland)*, 13(9), 1–25. <https://doi.org/10.3390/su13095049>
- Pratikno, H., Kokok Dj Purwanto, & Atsani Wulansari. (2024). Implementation Of Strengthening Numeration Literacy And Adaptation Of Technology. *Community Development Journal*, 8(1), 213–221. <https://doi.org/10.33086/cdj.v8i1.4627>
- Salomé, F., Commissaire, E., & Casalis, S. (2024). Contribution of orthography to vocabulary acquisition in a second language: Evidence of an early word-learning advantage in elementary-school children. *Journal of Experimental Child Psychology*, 246, 105978. <https://doi.org/10.1016/j.jecp.2024.105978>
- Sari, Y. I., Sumarmi, Utomo, D. H., & Astina, I. K. (2021). The Effect of Problem Based Learning on Problem Solving and Scientific Writing Skills. *International Journal of Instruction*, 14(2), 11–26. <https://doi.org/10.29333/iji.2021.1422a>
- Schwartz, E., Shamir-Inbal, T., & Blau, I. (2023). Teacher prototypes in technology-enhanced instruction in elementary school second language acquisition: Comparing routine and emergency learning in different cultures. *Computers and Education Open*, 5(November), 100155. <https://doi.org/10.1016/j.caeo.2023.100155>
- Siregar, A. O. A., & Karmiyati, D. (2024). Delinquent Behaviour: An Analysis of Albert Bandura's Social Learning Theory. *International Conference on Psychology and Education (ICPE)*, 3(1), 1–7.
- Solehudin, Darhim, & Juandi, D. (2024). The Effect of Learning Styles on Computational Thinking Ability. *Sustainability Education*, 1(1), 377–393. <https://doi.org/10.24114/bhs.v25i4.2498>
- Veselinov, D., Kelemen-Milojević, L., & Mirković, J. (2024). Contextual learning in the modern preschool curriculum. *Research in Pedagogy*, 14(2), 292–304. <https://doi.org/10.5937/istrped2402292v>
- Villena-Taranilla, R., Tirado-Olivares, S., Cózar-Gutiérrez, R., & González-Calero, J. A. (2022). Effects of virtual reality on learning outcomes in K-6 education: A meta-analysis. *Educational Research Review*, 35(January), 1–13. <https://doi.org/10.1016/j.edurev.2022.100434>
- Violy, A. (2025). Enhancing STEAM Skills in Early Childhood through Contextual Learning. *Akademika*, 13(2), 168–185. <https://doi.org/10.34005/ak.v13i02.4303>
- Yue, C., Kim, J., Ogawa, R., Stark, E., & Kim, S. (2013). Applying the cognitive theory of multimedia learning: An analysis of medical animations. *Medical Education*, 47(4), 375–387. <https://doi.org/10.1111/medu.12090>
- Zainuddin, M., Saifudin, A., Lestariningsih, L., & Nahdiyah, U. (2023). Developing Literacy Skills in Writing Stories for Elementary School by Using Big Book. *Jurnal Prima Edukasia*, 11(2), 197–205.
- Zainudin, M., Surayanah, Khotimah, K., & Lestariningsih. (2025). Skill

Improvement Based on Local Wisdom to Build Santripreneur at the Blitar Islamic Boarding School, Indonesia. *Tec Empresarial*, 20(1), 15–30.

- Zawadzki, P., Zywicki, K., Bun, P., & Gorski, F. (2020). Employee Training in an Intelligent Factory Using Virtual Reality. *IEEE Access*, 8, 135110–135117. <https://doi.org/10.1109/ACCESS.2020.3010439>
- Zhou, T., & Colomer, J. (2024). Cooperative Learning Promoting Cultural Diversity and Individual Accountability: A Systematic Review. *Education Sciences*, 14(6), 1–15. <https://doi.org/10.3390/educsci14060567>
-