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Improving Critical Thinking Skills of Elementary Students Through Science Learning with Interactive Teaching Materials and Problem Based Learning

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Abstract: This study aims to evaluate the effectiveness of interactive multimedia-based learning with Problem Based Learning (PBL) model in improving critical thinking skills of elementary school students in Natural and Social Sciences subjects. This research uses a development method with quantitative and qualitative approaches. The results of validation from the aspects of material, media, and language showed high ratings, and the product was declared practical by teachers and students. Students were actively involved in learning, and the results of statistical analysis showed significant differences between the control group and the experimental group in learning activities. This shows that this method is effective in improving students' critical thinking skills. Nonetheless, this study has limitations in terms of generalization of the results. Future research is expected to expand the scope of the study and consider additional factors for the development of more effective learning methods.

Keywords: Multimedia; Problem Based Learning; Science

Introduction

Education currently plays a crucial role in human life, changing behavior to become independent (Faisal et al., 2020; Hakim et al., 2023; Syahmani et al., 2023). The government implements Merdeka curriculum to improve the quality of education, integrated with technological developments such as big data, digitalization, and virtual reality (Afrina et al., 2021; Ahmad et al., 2021; Akram et al., 2022). Teachers are the key to educational success, faced with demands to familiarize critical thinking and problem solving, creative, innovative, and skilled in communication and collaboration (García-Martínez et al., 2021; Kawuryan et al., 2021; Kearney & Garfield, 2022).

The Merdeka Curriculum introduces teaching modules as a substitute for lesson plans, simplifying teacher administration to focus on learning varieties (Susanti et al., 2023; Wijayaningputri et al., 2024). In the midst of the digitalization era, learning combines literacy, knowledge, skills, attitudes, and technology (Lestari et al., 2021; Ong et al., 2020; Sukarelawan et al., 2021). Science, as part of the Merdeka curriculum studies to improve students' literacy and numeracy competencies. Teachers must develop teaching materials integrated with technology to create a conducive learning environment (Fauzan et al., 2023; Marzoan, 2024; Noorhapizah et al., 2024).

The whole learning process relies heavily on the understanding of concepts delivered through well-designed teaching materials (Bubou & Job, 2021; Duong et al., 2022; Marougkas et al., 2023). Teacher and student handbooks provide general teaching materials but need to be developed according to students' needs, interests and environmental conditions. Teaching materials that stimulate and engage students can facilitate

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understanding and improve the quality of learning (Maryanti et al., 2021; Prasetyo et al., 2021; Ropawandi et al., 2023).

The preliminary study was conducted in three elementary schools in Kuranji Sub-district, namely SD Negeri 33 Kalumbuk, SD Negeri 24 Kalumbuk, and SD Negeri 09 Korong Gadang, on July 10-15, 2023.The study methods included observation, interview, and questionnaire analysis. The observation results show that schools still use conventional learning media even though they are equipped with projectors, internet networks, and tablets.

However, some teachers do not use learning media when teaching. The use of technology in learning in the current era is very important, with interactive multimedia having advantages such as clarifying material with images and animations, training students' abilities, motivating them with awards, and providing freedom of choice of material (Ahmed & Opoku, 2022; Hardhienata et al., 2021; Rahmatullah et al., 2022).

During interviews with fifth grade teachers in each school, it was found that teachers have not actively used teaching materials that should help them in delivering material to students. They tend to rely on textbooks and student worksheets as the main reference in the learning process, which makes learning activities still teacher-centered and does not match the approach expected in the Merdeka curriculum, which emphasizes student-centered learning. Teachers' difficulties in developing teaching materials are due to their lack of understanding of the Merdeka curriculum, especially because they are experiencing a transition period from the previous curriculum.

From the questionnaire analysis, it was found that teachers in the schools rarely use technology in learning, although the Merdeka curriculum emphasizes the use of technology. Teachers at SD Negeri 33 Kalumbuk, SD Negeri 24 Kalumbuk, and SD 09 Korong Gadang agreed that technology, especially interactive multimedia, makes learning more interesting and increases student participation. However, they admitted to having difficulties in creating technology teaching materials that are interesting for students, often using materials from the Ministry of Education and Culture's official website. The questionnaire results from students also show agreement with the use of interactive multimedia in learning, which helps improve their technological skills and digital literacy. However, teachers do not familiarize students with critical thinking skills in learning evaluation. Learning approaches and teaching materials that support this development are needed (Akram et al., 2022).

Unfortunately, many teachers do not fully utilize technology in learning, although there is various software that can be used to create interactive multimedia. The utilization of interactive multimedia can motivate students and make them more independent in learning. However, many teachers have never used applications such as Adobe Flash to create interactive multimedia. This is contrary to the demands of the current curriculum and also hinders the development of students' critical thinking skills (Akram et al., 2022; Dogan et al., 2021; Francom et al., 2021; Winter et al., 2021).

In the classroom, learning is still focused on explaining material and memorizing exercises, without giving students the opportunity to think critically. In fact, critical thinking is very important for students to face various problems in everyday life. Therefore, the use of learning media that can improve students' critical thinking skills needs to be emphasized more (Arisoy & Aybek, 2021).

Interactive multimedia-based teaching materials with PBL models are needed to improve students' critical thinking skills. PBL is a learning model that provides direct experience in solving problems, encourages students to think critically, and makes learning more active. The use of interactive multimedia in PBL not only involves listening and reading, but also provides direct experience between students and computers. It helps students' all-round development and enriches learning with creativity and innovation (Arifin et al., 2021; Lidyasari et al., 2023; Sartono et al., 2022; Sekarwangi et al., 2021).

In learning science, there are still few teachers who create situations for students to think critically. Usually, teachers only explain the material and give memorization exercises. Previous research on interactive multimedia in elementary schools includes media development using Adobe Flash by Muhammad et al. (2023) and interactive multimedia-based teaching materials by Syupriyanti & Desyandri (2021).

Interactive multimedia can stimulate student interest with direct interaction through computers. It is believed to be effective for learning in the Merdeka curriculum, having increased students' learning enthusiasm in elementary schools. Based on this, the author is interested in researching "Development of Science Teaching Materials with Interactive Multimedia using the Problem Based Learning Model to Improve Critical Thinking Skills in Elementary Schools".

Method

This study used a research and development method with quantitative and qualitative approaches. The development stage of science teaching materials was carried out through several steps, namely needs

analysis, learning design, prototype development, field trials, and revision. The needs analysis was conducted with an initial survey to identify the needs of teachers and students. The learning design was designed based on the Problem Based Learning (PBL) model by utilizing interactive multimedia.

Prototype development is carried out by producing interactive multimedia-based teaching materials according to the design that has been made. Field trials were conducted to test the effectiveness of the teaching materials developed in a real school environment. Furthermore, the results of the trial will be evaluated to revise and improve the teaching materials that have been developed. Data collection methods include observation, interview, and questionnaire. Data analysis was carried out using statistical techniques for quantitative data and descriptive analysis for qualitative data. Research design and method should be clearly defined.

Result and Discussion

The design of this study adapts the ADDIE development model, which is a development model consisting of five stages which include Analyze, Design, Development, Implementation, evaluation.

Analysis Stage

The first stage of this research is the analysis stage, including:

Curriculum Analysis

Researchers conducted several stages, including stabilizing learning outcomes, formulating the flow of learning objectives, understanding the learning materials contained in the Merdeka Curriculum teaching guidebook, understanding the strengthening of the Pancasila Student Profile, and adjusting learning materials for each student.

Needs Analysis

A needs analysis was conducted to identify problems and constraints in SCIENCE learning, as well as to find out the causes, implementation of learning, and the use of media and teaching materials. This stage involved observations and interviews with Grade 5 teachers in three schools. The results of the analysis were used to determine learning needs and find appropriate solutions to overcome the problems identified.

Analyze Student Characteristics

Student analysis includes general characteristics, initial abilities, and learning styles. This was done through discussions with teachers and questionnaire analysis. It was found that most students lacked understanding of the material, causing the learning process to be less interesting. Students only use modules, LKS, and LKPD as a complement, with minimal use of technology-based teaching materials.

Design Stage

The Design stage is the design and production of interactive learning multimedia for SCIENCE subjects based on preliminary studies, theories, and related research, as well as the preparation of flowcharts and storyboards.

Figure 1. Main Page Display

Figure 2. Main Menu Display

Figure 3. Material Display

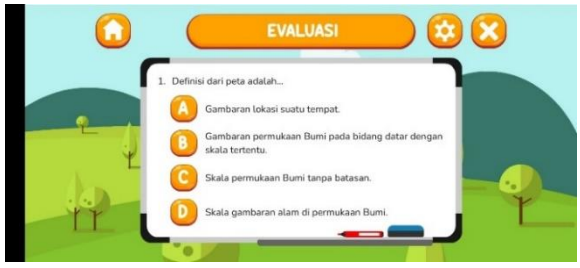

Figure 4. Evaluation view

Creating a flowchart is the first step in the design process, which describes a series of cycles and relationships between interactions in a program visually. The flowchart presents the steps of the procedure from start to finish, making it easier to understand and operate the developed product. Furthermore, storyboard is a coordination of images displayed in sequence, helping media designers to start the perception of a document or learning. Storyboard is created after flowchart as a visual guide in designing media.

Development Stage

The next stage after design is to test the feasibility of the product by validating to expert validators in media, material, and language. Validation The developed product will be validated by 5 expert validators in media, material, and language using a validation sheet instrument that has been prepared by the researcher. Data from this validation will be analyzed to determine whether the product is valid or not.

Table 1. Material validation

Aspects assessed	Rater			Average
	V1	V2	V3	
Accuracy	80	96	100	92
Completeness	100	100	100	100
Interest	100	100	100	100
Providing learning opportunities	90	100	100	97
Providing help to learn	80	100	80	87
Motivating quality	80	100	100	93
Flexibility of learning	80	100	100	93
Social quality of instructional interaction	90	100	100	97
Can have an impact on students	100	80	100	93
Can have an impact on teachers and their learning	80	100	100	93
Total	880	976	980	945
Score (%)	88	97.6	98	94.54
Average (%)				94.53

The material validation results showed an average score of 94.53%, with the completeness aspect getting the highest score, reaching 100%. This shows that the evaluated material is very complete. Other aspects such as interest, flexibility of learning, and social quality of instructional interactions also received high scores above 90%. However, the aspect of providing assistance to learn received the lowest score of 87%, indicating the need for improvement in providing assistance to students. Although there were variations in scores between raters, overall, the materials were rated as good enough to meet the criteria.

Table 2. Media validation

Assessed Aspects	Assessment Score (%)		Average (%)
	V1	V2	
Display	86	80	83
Readability	80	80	80
Usability	80	90	85
Total	246	250	248
Score (%)	81.9	83.3	82.6
Average			83
Category			Very high

The media validation results showed an average score of 83%, with the display aspect reaching 83%. Although there were variations in scores between raters, the average score was still in the very high category. This indicates an excellent assessment from both assessors of the appearance, readability, and usefulness of the evaluated media.

Table 3. Language validation

Aspects Assessed	Assessment Score (%)	
	V1	V2
Readability of Text	80	88
Straightforward	84	92
Conformity with language rules	80	92
Effective and efficient use of language	84	96
Total	328	368
Score (%)	82	92
Average		87
Category		Very high

Language validation showed an average score of 87%, with text readability reaching 82% and straightforwardness 92%. Overall, the assessment was in the very high category, indicating that the materials were rated as excellent in terms of readability, straightforwardness, adherence to language rules, and effective and efficient use of language by both assessors.

Practicality

Researchers analyzed data from teacher and student practicality instruments and test instruments beforehand. This aims to assess the practicality and effectiveness of the products developed.

The results of the practicality showed that the developed product was very practical to be used by both groups of teachers. The aspects of ease of use, usefulness, appearance, and time received an

assessment of very practical. The average practicality score reached 93.625%, indicating ease of use and great benefits for teachers.

Table 4. Teacher practicality

Aspects assessed	G1	G2	Average	Description
Ease of Use	80	100	90.00	Very Practical
Usability	93	96	95	Very Practical
Display	80	100	90	Very Practical
Time	100	100	100	Very Practical
Average	88.3	99	93.62	Very Practical

Table 5. Practicality to students

Aspects assessed	Average	Description
Ease of Use	92.50	Very Practical
Usability	94.69	Very Practical
Display	95.56	Very Practical
Time	90	Very Practical
Average	94.11	Very Practical

The results of the practicality evaluation showed that the product was very practical for students, with all aspects - ease of use, benefits, appearance, and time - rated as very practical. The average practicality score reached 94.11%, indicating ease of use and great benefits for students.

Effectiveness

The evaluation stage consists of formative and summative evaluation. Formative evaluation is conducted during the program, checking the quality of the developed product and determining any necessary improvements. Summative evaluation is conducted after the program ends to evaluate its effect on student learning outcomes and overall learning quality.

Table 6. Effectiveness of student learning activities

Learning Activity	Percentage (%)
Viewing Activity	91
Speaking Activity	85
Listening Activity	90
Writing Activity	90
Mental Activity	93
Emotional Activity	98
Average	91.17

Evaluation results show a high level of student engagement in learning. The percentage of student activities ranged from 85% to 98%, with an average of 91.17%. Emotional activities reached the highest percentage (98%), while speaking activities got the lowest (85%). This shows students' engagement in visual, auditive and mental aspects of learning.

Table 7. Pretest-posttest test

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Pretest Result	Based on Mean	0.01	1	41	0.92
	Based on Median	0.02	1	41	0.88
	Based on Median and with adjusted df	0.02	1	40.24	0.88
	Based on trimmed mean	0.01	1	41	0.91

The Table 7 shows the results of the homogeneity of variance test for the pretest. The results show that there is no significant difference in variability between the groups on the pretest. Thus, the requirement of homogeneity of variance was met, allowing for further statistical analysis.

Table 8. T-test tests of normality

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pretest Results	Experiment	0.13	24	.200*	0.93	24	0.11
	Control	0.15	19	.200*	0.92	19	0.12
Posttest Results	Experiment	0.16	24	0.11	0.95	24	0.30
	Control	0.16	19	.200*	0.91	19	0.09

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction.

The Table 8 shows that the normality test results for the pretest and posttest indicate that the data tends to be normally distributed. Both experimental and control groups at both stages of the test showed insignificant statistical values, indicating no significant difference in data distribution.

Table 9. Levene's test (pretest result)

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Pretest Result	Equal variances assumed	0.01	0.92	0.37	41	0.71
	Equal variances not assumed			0.37	38.45	0.71

The Table 9 and 10 shows the results of Levene's Test for equality of variances and t-test for equality of means on pretest and posttest. On the pretest, homogeneity of variance was met with significance above 0.05. However, there was no significant difference between the groups. While on the posttest, the variance was not homogeneous, showing a significant difference between the groups, either with or without the assumption of homogeneity of variance.

Table 10. Levene's test (posttest result)

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Posttest Results	Equal variances assumed	13.60	0.00	6.07	41	0.00
	Equal variances not assumed			5.61	23.76	0.00

Table 11. Levene's Test for Equality of Variances

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Student Learning Activity	Equal variances assumed	2.16	0.15	9.42	41	0.00	15.00	1.611	11.75	18.26
	Equal variances not assumed			9.8	39.48	0.00	15.00	1.533	11.91	18.11

The Table 11 shows the statistical test results for student learning activities. The variances are considered equal, fulfilling the assumption of homogeneity of variance, and showing significant differences between groups in student learning activity, either with or without the assumption of homogeneity of variance.

This study evaluates the effectiveness of interactive multimedia-based learning with the Problem Based Learning (PBL) model to improve the critical thinking skills of elementary school students in the subject of Natural and Social Sciences (Science). The material validation results show that the developed material is very complete, with aspects such as interest, learning flexibility, and social quality of instructional interaction getting high scores, although the aspect of providing assistance for learning requires improvement. Media and language validation showed excellent ratings.

The developed product was rated as highly practical by both teachers and students, with formative and summative evaluations conducted during and after the program. Students showed a high level of engagement in learning, and the results of the homogeneity of variance and normality tests showed normally distributed data. Statistical analysis of student learning activities showed significant differences between groups in student learning activities.

Problem-based learning involves giving students real problems or situations that require solving. For example, they may be given a simple experiment or presented with a natural phenomenon to study. Thus, students are actively involved in the learning process and are expected to think critically in finding solutions. Question stimulation is also an important part of science learning with interactive teaching materials. Through animations, simulations or virtual experiments, students can develop deep questions about scientific concepts.

Reflection and subsequent discussion are key in deepening students' understanding. After an exploration or experiment, students are invited to reflect on their results. Group discussion or individual reflection helps students relate the concepts learned to their own experiences, encouraging critical thinking about what they observed and its implications. Data analysis is the next step in science learning. Students are invited to analyze data generated from experiments or observations, find patterns, and make conclusions (Crisianita & Mandasari, 2022; Howell, 2021; Yulianti & Sulistyawati, 2021).

This involves critical thinking in interpreting information. Evaluation of evidence and arguments is also a focus in science learning. Students question the validity of evidence, understand a given argument, and identify weaknesses or strengths in the argument. Continuous learning is then emphasized, where students are encouraged to continue exploring scientific concepts, asking new questions and seeking answers to those questions (Arisoy & Aybek, 2021; Vincent-Lancrin, 2023).

By using a combination of interactive teaching materials and problem-based approaches in science learning, elementary students can be empowered to develop their critical thinking skills early on. This not only prepares them in understanding scientific concepts, but also in developing thinking skills that are important in everyday life (Ouahani & Hiba, 2023).

The implications of this study are significant in the context of education. The finding that the use of interactive multimedia with PBL model can effectively improve students' critical thinking skills provides a strong basis for the development of more effective learning approaches. The practical implication is that schools can adopt this learning approach to improve student learning outcomes. By applying this proven effective learning method, it is expected to create a more dynamic learning environment, oriented towards student engagement (Arifin et al., 2021; Pratiwi et al., 2023; Sekarwangi et al., 2021), and enabling the development of their critical thinking skills. As a result, this research makes a meaningful contribution to the development of higher quality and innovative education (Agbo et al., 2021).

The limitations of this study need to be considered in interpreting the results. Firstly, the generalizability of the results may be limited as the study was conducted in a specific school environment only, so the results may not be fully applicable to other school contexts. Secondly, there are other variables not considered in this study that might influence the results, such as environmental factors or student characteristics that were not measured. Therefore, although this study provides valuable insights, further research involving a wider sample and considering additional factors is needed to gain a more comprehensive understanding of the effectiveness of interactive multimedia learning with PBL model in improving students' critical thinking skills.

The hope for future research is to expand the scope of this study by involving more schools and diverse student populations. By involving a wider sample, future research can provide a more holistic understanding of the effectiveness of interactive multimedia learning with PBL model in improving students' critical thinking skills. In addition, further research can investigate other factors that may affect the effectiveness of this learning, such as environmental factors, student characteristics, or other contextual factors. Thus, it is hoped that future research can provide deeper and more comprehensive insights and provide a strong foundation for the development of more effective and innovative learning methods in the future.

Conclusion

This study evaluates the effectiveness of interactive multimedia learning with PBL for elementary school students in SCIENCE. Material, media, and language validation showed high ratings, and the product was rated practical by teachers and students. Students were actively engaged in learning, and statistical results showed significant differences between groups in learning activities. The implication in education is that this method is effective in improving students' critical thinking skills. However, this study has limitations, including limited generalization of the results. The hope for future research is to expand the scope of the study and consider additional factors for the development of more effective learning methods.

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Author Contributions
Conceptualization, M.O.; methodology, B. M.; validation, M. K. R.; formal analysis, M. N; investigation, K. F.; resources, S. M. K.; data curation, E. K. R.: writing—original draft preparation, F. M.; writing—review and editing, R. A. P.: visualization, M.O. All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest.

References

Afrina, A., Abbas, E. W., & Susanto, H. (2021). The Role of Historical Science in Social Studies Learning Materials for Increasing Values of Student's Nationalism. *The Innovation of Social Studies Journal*, *3*(1), 1–8. https://doi.org/10.20527/iis.v3i1.3769

Agbo, F. J., Oyelere, S. S., Suhonen, J., & Tukiainen, M. (2021). Scientific Production and Thematic

Breakthroughs in Smart Learning Environments: A Bibliometric Analysis. *Smart Learning Environments*, *8*(1), 1. https://doi.org/10.1186/s40561-020-00145-4

Ahmad, S. F., Rahmat, M. K., Mubarik, M. S., Alam, M. M., & Hyder, S. I. (2021). Artificial Intelligence and Its Role in Education. *Sustainability*, *13*(22), 12902. https://doi.org/10.3390/su132212902

Ahmed, V., & Opoku, A. (2022). Technology Supported Learning and Pedagogy in Times of Crisis: The Case of COVID-19 Pandemic. *Education and Information Technologies*, *27*(1), 365–405. https://doi.org/10.1007/s10639-021-10706-w

Akram, H., Abdelrady, A. H., Al-Adwan, A. S., & Ramzan, M. (2022). Teachers' Perceptions of Technology Integration in Teaching-Learning Practices: A Systematic Review. *Frontiers in psychology*, *13*, 920317. https//doi.org/10.3389/fpsyg.2022.920317

Arifin, Z., Tegeh, I. M., & Sukmana, A. I. W. I. Y. (2021). Independent Learning Through Interactive Multimedia Based on Problem Based Learning. *Jurnal Edutech Undiksha*, *9*(2), 244–253. https://doi.org/10.23887/jeu.v9i2.41292

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*, 99–119. https://doi.org/10.14689/ejer.2021.92.6

Bubou, G., & Job, G. (2021). Benefits, Challenges and Prospects of Integrating E-Learning into Nigerian Tertiary Institutions: A Mini Review. *International Journal of Education and Development using Information and Communication Technology*, *17*(3), 6–18. Retrieved from https://eric.ed.gov/?id=EJ1335685

Crisianita, S., & Mandasari, B. (2022). The Use of Small-Group Discussion to Imrpove Students'speaking Skill. *Journal of English Language Teaching and Learning*, *3*(1), 61–66. https://doi.org/10.33365/jeltl.v3i1.1680

Dogan, S., Dogan, N. A., & Celik, I. (2021). Teachers' Skills to Integrate Technology in Education: Two Path Models Explaining Instructional and Application Software Use. *Education and Information Technologies*, *26*(1), 1311–1332. https://doi.org/10.1007/s10639-020-10310-4

Duong, X. Q., Nguyen, N. H., Nguyen, M. T., & Thao-Do, T. P. (2022). Applying STEM Engineering Design Process Through Designing and Making of Electrostatic Painting Equipment in Two Rural Schools in Vietnam. *Jurnal Pendidikan IPA Indonesia*, *11*(1), 1–10. https://doi.org/10.15294/jpii.v11i1.31004

Faisal, F., Gi, G. M., & Martin, S. N. (2020). Analysis of Government-Funded Research in Indonesia from 2014-2018: Implications for Research Trends in Science Education. *Jurnal Pendidikan IPA Indonesia*, *9*(2), 146–158. https://doi.org/10.15294/jpii.v9i2.23174

Fauzan, F., Ansori, R. A. M., Dannur, M., Pratama, A., & Hairit, A. (2023). The Implementation of the Merdeka Curriculum (Independent Curriculum) in Strengthening Students' Character in Indonesia. *Aqlamuna: Journal of Educational Studies*, *1*(1), 136–155. https://doi.org/10.58223/aqlamuna.v1i1.237

Francom, G. M., Lee, S. J., & Pinkney, H. (2021). Technologies, Challenges and Needs of K-12 Teachers in the Transition to Distance Learning During the COVID-19 Pandemic. *TechTrends*, *65*(4), 589–601. https://doi.org/10.1007/s11528-021-00625-5

García-Martínez, I., Montenegro-Rueda, M., Molina-Fernández, E., & Fernández-Batanero, J. M. (2021). Mapping Teacher Collaboration for School Success. *School Effectiveness and School Improvement*, *32*(4), 631–649. https://doi.org/10.1080/09243453.2021.1925700

Hakim, A., Efwinda, S., Damayanti, P., Syam, M., Mutmainah, O., & Norsaputra, A. (2023). Improving Climate Literacy of High School Students Through Physics Teaching Materials Based on STEM. *Jurnal Pendidikan IPA Indonesia*, *12*(4). https://doi.org/10.15294/jpii.v12i4.43188

Hardhienata, S., Suchyadi, Y., & Wulandari, D. (2021). Strengthening Technological Literacy in Junior High School Teachers in The Industrial Revolution Era 4.0. *JHSS (Journal of Humanities and Social Studies)*, *5*(3), 330–335. https://doi.org/10.33751/jhss.v5i3.4220

Howell, R. A. (2021). Engaging Students in Education for Sustainable Development: The Benefits of Active Learning, Reflective Practices and Flipped Classroom Pedagogies. *Journal of Cleaner Production*, *325*, 129318. https://doi.org/10.1016/j.jclepro.2021.129318

Kawuryan, S. P., Sayuti, S. A., & Dwiningrum, S. I. A. (2021). Teachers Quality and Educational Equality Achievements in Indonesia. *International Journal of Instruction*, *14*(2), 811–830. https://doi.org/10.29333/iji.2021.14245a

Kearney, W. S., & Garfield, T. A. (2022). Student Readiness to Learn and Teacher Effectiveness: Two Key Factors in Middle Grades Mathematics Achievement. In *Dialogues in Middle Level Education Research Volume 1* (pp. 29–46). https://doi.org/10.4324/9781003225867

Lestari, H., Sopandi, W., Sa'ud, U. S., Musthafa, B., Budimansyah, D., & Sukardi, R. R. (2021). The Impact of Online Mentoring in Implementing Radec Learning to the Elementary School Teachers' Competence in Training Students' Critical Thinking Skills: A Case Study During Covid-19 Pandemic. *Jurnal Pendidikan IPA Indonesia*, *10*(3), 346–356. https://doi.org/10.15294/jpii.v10i3.28655

Lidyasari, A. T., Rokhman, M. N., Nugroho, A. N. P., & Anggito, A. (2023). The Effectiveness of Interactive Multimedia-Based Learning Methods to Increase the Motivation of Elementary School Teachers in the JSIT Kulonprogo Environment. *Al-Bidayah: Jurnal Pendidikan Dasar Islam*, *15*(1), 41–56. https://doi.org/10.14421/albidayah.v15i1.1024

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*, *12*(13), 2832. https://doi.org/10.3390/electronics12132832

Maryanti, R., Nandiyanto, A. B. D., Hufad, A., & Sunardi, S. (2021). Science Education for Students with Special Needs in Indonesia: From Definition, Systematic Review, Education System, to Curriculum. *Indonesian Journal of Community and Special Needs Education*, *1*(1), 1–8. https://doi.org/10.17509/ijcsne.v1i1.32653

Marzoan, M. (2024). Implementation of the Merdeka Curriculum to Strengthen Literacy Skills in Early Grades of Elementary Schools. *Jurnal Ilmiah Mandala Education*, *10*(1), 272–277. http://dx.doi.org/10.58258/jime.v10i1.6692

Muhammad, I., Samosir, C. M., Elmawati, E., & Marchy, F. (2023). Analisis Bibliometrik: Penelitian Adobe Flash Cs6 dalam Pembelajaran Matematika. *JPMI: Jurnal Pendidikan Matematika Indonesia*, *8*(1), 25-34. Retrieved from https://journal.stkipsingkawang.ac.id/index.php/JPMI/article/download/4005/pdf

Noorhapizah, N., Prihandoko, Y., Pratiwi, D. A., & Saputra, M. D. (2024). Effectiveness of the 'BANGKIT' Program to Support the Implementation of 'Merdeka' Curriculum in Primary Schools in a Wetland Environment. *Journal of Education Method and Learning Strategy*, *2*(01), 8–16. https://doi.org/10.59653/jemls.v2i01.302

Ong, E. T., Keok, B. L., Yingprayoon, J., Singh, C. K. S., Borhan, M. T., & Tho, S. W. (2020). The Effect of 5E Inquiry Learning Model on the Science Achievement in the Learning of Magnet Among Year 3 Students. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 1–10. https://doi.org/10.15294/jpii.v9i1.21330

Ouahani, N., & Hiba, B. (2023). Critical Thinking Practice in Moroccan Higher Education: An Evaluation. *International Journal of Linguistics, Literature and Translation*, *6*(1), 91–97. https://doi.org/10.32996/ijllt.2023.6.1.12

Prasetyo, T., Rachmadtullah, R., Samsudin, A., & Aliyyah, R. R. (2021). General Teachers' Experience of the Brain's Natural Learning Systems-Based Instructional Approach in Inclusive Classroom. *International Journal of Instruction*, *14*(3), 95–116. https://doi.org/10.29333/iji.2021.1436a

Pratiwi, K. I. A., Margunayasa, I. G., & Trisna, G. A. P. S. (2023). Project Based Learning Interactive Multimedia with Orientation of Environmental Problems Assisted by Articulate Storyline 3 for Grade V Elementary Schools. *Journal of Education Technology*, *7*(2). https://doi.org/10.23887/jet.v7i2.59615

Rahmatullah, A. S., Mulyasa, E., Syahrani, S., Pongpalilu, F., & Putri, R. E. (2022). Digital Era 4.0: The Contribution to Education and Student Psychology. *Linguistics and Culture Review*, *6*(S3), 89–107. https://doi.org/10.21744/lingcure.v6nS3.2064

Ropawandi, D., Husnin, H., & Halim, L. (2023). Comparison of Student Achievement in Electricity Using Augmented Reality between Offline and Online Classes. *Jurnal Pendidikan IPA Indonesia*, *12*(1), 55–66. https://doi.org/10.15294/jpii.v12i1.35403

Sartono, E., Sekarwangi, T., & Herwin, H. (2022). Interactive Multimedia Based on Cultural Diversity to Improve the Understanding of Civic Concepts and Learning Motivation. *World Journal on Educational Technology: Current Issues*, *14*(2), 356–368. https://doi.org/10.18844/wjet.v14i2.6909

Sekarwangi, T., Sartono, K. E., Mustadi, A., & Abdulah, A. (2021). The Effectiveness of Problem Based Learning-Based Interactive Multimedia for Elementary School Students. *International Journal of Elementary Education*, *5*(2), 308–314. https://doi.org/10.23887/ijee.v5i2.31603

Sukarelawan, M. I., Jumadi, J., Kuswanto, H., Soeharto, S., & Hikmah, F. N. (2021). Rasch Analysis to Evaluate the Psychometric Properties of Junior Metacognitive Awareness Inventory in the Indonesian Context. *Jurnal Pendidikan IPA Indonesia*, *10*(4), 486–495. https://doi.org/10.15294/jpii.v10i4.27114

Susanti, Y., Nurhajati, D., Kencanawati, D., Riwayatiningsih, R., Sukmayani, F. A., & Aprilia, N. (2023). Self-Peer Assessment Method in Writing

English Teaching Module Based on Merdeka Curriculum. *Education and Linguistics Knowledge Journal*, *5*(2), 144–161. https://doi.org/10.32503/edulink.v5i2.4219

Syahmani, S., Hafizah, E., Sholahuddin, A., Sauqina, S., Prasetyo, Y. D., & Rahman, N. F. A. (2023). Metacognitive Conceptual Change (MCC) Learning Model: Improving Students' Conceptual Change Through Metacognitive Skills, Motivation, and Scientific Knowledge. *Jurnal Pendidikan IPA Indonesia*, *12*(3), 423–438. https://doi.org/10.15294/jpii.v12i3.45737

Syupriyanti, L., & Desyandri, D. (2021). Pengembangan Bahan Ajar Berbasis Multimedia Interaktif Adobe Flash di Kelas IV Sekolah Dasar. *Jurnal Inovasi Pendidikan dan Pembelajaran Sekolah Dasar*, *5*(2), 149-159. https://doi.org/10.24036/jippsd.v5i2.114568

Vincent-Lancrin, S. (2023). Fostering and Assessing Student Critical Thinking: From Theory to Teaching Practice. *European Journal of Education*, *58*(3), 354–368. https://doi.org/10.1111/ejed.12569

Wijayaningputri, A. R., Innany, M., & Murtyas, G. D. (2024). Application of Teaching Module as an Implementation of "Curriculum Merdeka" for Fourth-Grade Students at Kuala Lumpur Indonesian School. In *Strengthening Professional and Spiritual Education Through 21st Century Skill Empowerment in a Pandemic and Post-Pandemic Era* (pp. 178–183). https://doi.org/10.1201/9781003376125-24

Winter, E., Costello, A., O'Brien, M., & Hickey, G. (2021). Teachers' Use of Technology and the Impact of Covid-19. *Irish Educational Studies*, *40*(2), 235–246. https://doi.org/10.1080/03323315.2021.1916559

Yulianti, T., & Sulistyawati, A. (2021). Online Focus Group Discussion (OFGD) Model Design in Learning. *Proceedings of the 2nd International Conference on Progressive Education, ICOPE 2020*. 16-17 October 2020, Universitas Lampung, Bandar Lampung, Indonesia. http://dx.doi.org/10.4108/eai.16-10-2020.2305199