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The Effectiveness of Interactive Activity-Based Coding Instruction on Elementary School Students' Digital Literacy and Critical Thinking Skills: An Experimental Study

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Abstract

This study aims to analyze the effect of coding instruction on improving digital literacy and critical thinking skills among elementary school students. The background of this study is based on the low levels of students' digital literacy and critical thinking skills, as well as the need for learning approaches that can develop 21st-century competencies in a contextual and meaningful manner. This study employed a quasi-experimental approach using a pretest–posttest control group design. The research subjects consisted of two groups: an experimental group that received interactive activity-based coding instruction and a control group that received conventional instruction. The research instruments included a digital literacy test and a critical thinking test, both of which had undergone validity and reliability testing. Data analysis was conducted using normality tests, homogeneity tests, independent samples t-tests, paired samples t-tests, N-Gain analysis, and effect size calculations (Cohen's d). The results showed a significant difference between the experimental and control groups in posttest scores for digital literacy and critical thinking skills. The improvement in students' abilities in the experimental group was categorized as moderate based on N-Gain values, while the control group showed low improvement. In addition, the effect size indicated a very large impact of coding instruction on students' digital literacy and critical thinking skills. These findings demonstrate that coding instruction is effective in enhancing elementary school students' digital literacy and critical thinking skills and can serve as an alternative learning strategy to support the development of 21st-century competencies in primary education.
Keywords: *coding instruction, digital literacy, critical thinking, elementary school*

Introduction

The rapid development of digital technology has brought fundamental changes to the field of education, particularly in how students access, process, and utilize information (Astuti & Sari, 2025; Phuong et al., 2023; Sihole & Yugopuspito, 2025). In the context of 21st-century education, students are not only required to master basic knowledge but also to develop higher-order thinking skills and digital literacy as essential competencies (Ahman et al., 2025; Triwahyuni & Pradana, 2025; Zainil & Kenedi, 2023). Digital literacy encompasses the ability to access, understand, evaluate, and use digital-based information critically and responsibly (Adriana et al., 2024; Oktarina et al., 2025). However, learning practices in primary schools indicate that the use of technology often remains instrumental and passive, limiting its potential to foster students' digital literacy and critical thinking skills.

In response to these demands, coding education has begun to be introduced at the primary education level as a pedagogical approach aimed at developing logical, systematic, and analytical thinking (Chaniago et al., 2025; Mills et al., 2025; Syahrir et al., 2024). Coding education does

not merely focus on learning programming languages; rather, it emphasizes computational thinking processes through problem-solving activities, decision-making, and reflection on errors and solutions (Tariq et al., 2025; Zafrullah et al., 2025). Through interactive coding activities, students are trained to understand digital information flows, evaluate processes, and construct structured solutions, thereby potentially enhancing both digital literacy and critical thinking skills. Several studies have demonstrated that interactive digital-based learning activities can improve student engagement, conceptual understanding, and higher-order thinking skills (A et al., 2025; Brugliera, 2024; Nabiem et al., 2024).

Despite this potential, empirical studies that specifically examine the effectiveness of interactive activity-based coding learning on digital literacy and critical thinking skills among primary school students remain limited. Most previous research has focused on secondary or higher education levels or emphasized the technical aspects of coding without directly linking them to the development of digital literacy and critical thinking as pedagogical competencies. Furthermore, relatively few studies have employed experimental designs to systematically compare the effects of coding-based instruction with conventional learning approaches at the primary school level. This situation indicates a clear research gap that warrants further empirical investigation.

Based on these considerations, this study aims to analyze the effectiveness of interactive activity-based coding learning in enhancing digital literacy and critical thinking skills among primary school students using a quantitative experimental design. The research question addressed is whether interactive activity-based coding learning is more effective than conventional instruction in improving students' digital literacy and critical thinking skills. The novelty of this study lies in the pedagogical integration of coding learning with interactive activities designed specifically to develop digital literacy and critical thinking skills at the primary school level, supported by an experimental approach to rigorously examine its effectiveness.

Method

This study employed a quantitative approach using a quasi-experimental design with a pretest–posttest control group. This design was selected to examine the effectiveness of interactive activity-based coding instruction on students' digital literacy and critical thinking skills at the elementary school level. The experimental group received interactive coding instruction involving simple projects, hands-on practice tasks, and problem-solving challenges, while the control group was taught using conventional coding instruction characterized by teacher-centered explanations and routine exercises without interactive activities.

The study was conducted at SD Negeri Srambah, Proppo District, Pamekasan Regency. The participants consisted of two fifth-grade classes: Class V A with 18 students served as the experimental group, and Class V B with 18 students served as the control group. The classes were selected using purposive sampling to ensure comparable academic characteristics and student backgrounds.

Data were collected using three primary instruments. First, a digital literacy questionnaire was used to measure students' perceptions, attitudes, and self-confidence in using technology during coding activities. The questionnaire employed a four-point Likert scale. Second, a performance-based digital literacy test consisting of ten practical tasks was administered to assess students' ability to access, evaluate, and utilize digital information related to coding, such as searching for coding tutorials, applying code blocks, and developing simple digital projects. Third, a critical thinking essay test comprising ten open-ended questions was used to evaluate

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students' analytical, evaluative, and problem-solving skills in a coding context, including analyzing code blocks, evaluating simple algorithms, and designing basic program solutions.

All research instruments underwent expert validation conducted by two specialists in elementary education and educational technology. The validation process aimed to examine item relevance to the measured indicators, clarity of language, and suitability of coding contexts for elementary students. The results indicated that all items were appropriate for use, with a content validity index of ≥ 0.80. Subsequently, the instruments were pilot-tested in a comparable class that was not included in either the experimental or control group to ensure readability and appropriate difficulty levels. Reliability analysis revealed Cronbach's alpha coefficients of 0.82 for the digital literacy questionnaire, 0.79 for the digital literacy test, and 0.81 for the critical thinking test, indicating satisfactory reliability.

The research procedure began with the administration of pretests to measure students' initial levels of digital literacy and critical thinking in both groups. The experimental group then participated in interactive activity-based coding instruction, while the control group received conventional coding instruction. Throughout the instructional process, classroom observations were conducted to ensure the fidelity of implementation and to document student engagement. Following the intervention, posttests were administered to both groups to assess improvements in digital literacy and critical thinking skills.

Data analysis involved descriptive statistics to summarize data trends, followed by assumption testing, including normality and homogeneity tests. Hypothesis testing was conducted using paired samples t-tests to examine within-group improvements and independent samples t-tests to compare outcomes between the experimental and control groups. All statistical analyses were performed using SPSS software with a significance level set at 0.05.

Results

Descriptive Statistical Analysis

Prior to hypothesis testing, the data were analyzed using descriptive statistics to provide an initial overview of students' digital literacy and critical thinking skills in both the experimental and control groups. This analysis included the mean, standard deviation, minimum, and maximum scores of the pretest and posttest to examine the equivalence of initial abilities and the trend of improvement after the intervention.

Table 1. Descriptive Statistics of Digital Literacy and Critical Thinking

Descriptive Statistics

Variable	Group	N	Minimum	Maximum	Mean	Standard Deviation
Digital Literacy Pretest	Experimental	18	45	70	57,83	7,12
	Control	18	44	69	56,50	6,95
Digital Literacy Posttest	Experimental	18	68	95	82,67	7,85
	Control	18	50	78	64,33	7,20
Critical Thinking Pretest	Experimental	18	40	68	53,72	7,00
	Control	18	42	67	52,89	6,88
	Experimental	18	65	92	80,11	7,45

Critical Thinking Posttest	Control	18	45	79	61,44	7,10

As shown in Table 1, the initial digital literacy abilities of students in both groups were relatively comparable. The mean pretest score for digital literacy in the experimental group was 57.83 (SD = 7.12), while the control group obtained a mean score of 56.50 (SD = 6.95). After the intervention, the mean posttest score of the experimental group increased to 82.67 (SD = 7.85), whereas the control group reached 64.33 (SD = 7.20). This difference indicates a greater improvement in digital literacy among students who participated in interactive activity-based coding instruction.

A similar pattern was observed in students' critical thinking skills. The mean pretest score of critical thinking in the experimental group was 53.72 (SD = 7.00), while the control group obtained a mean score of 52.89 (SD = 6.88), indicating comparable initial abilities. In the posttest, the experimental group's mean score increased to 80.11 (SD = 7.45), whereas the control group achieved a mean score of 61.44 (SD = 7.10). These results show that the improvement in critical thinking skills was higher in the experimental group than in the control group.

Overall, the descriptive analysis indicates that students who received interactive activity-based coding instruction experienced greater improvements in both digital literacy and critical thinking skills compared to those who received conventional instruction.

Normality Test

Prior to conducting difference testing, the data on digital literacy and critical thinking skills were examined for normality using the Kolmogorov–Smirnov test to ensure that the assumptions for parametric analysis were met.

Table 2. Results of the Normality Test for Digital Literacy and Critical Thinking

Test of Normality (Kolmogorov–Smirnov[a])

		Kolmogorov-Smirnov[a]		
Variable	Group	Statistic	df	Sig.
Digital Literacy Pretest	Experimental	0,148	18	0,128
	Control	0,136	18	0,154
Digital Literacy	Experimental	0,162	18	0,092
Posttest	Control	0,145	18	0,115
Critical Thinking	Experimental	0,134	18	0,142
Pretest	Control	0,139	18	0,131
Critical Thinking	Experimental	0,155	18	0,087
Posttest	Control	0,147	18	0,099

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

As presented in Table 2, the results of the normality test indicate that all pretest and posttest data for both digital literacy and critical thinking skills, in the experimental and control groups, yielded significance values (p) greater than 0.05. These findings indicate that the data are normally distributed.

Therefore, it can be concluded that the data meet the normality assumption and are suitable for further analysis using parametric statistical tests, specifically the paired samples t-test and the independent samples t-test.

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Test of Homogeneity of Variance

In addition to the normality test, the homogeneity of variances for digital literacy and critical thinking scores between the experimental and control groups was examined using Levene's Test. This test was conducted to ensure that the variance across groups was homogeneous as a prerequisite for applying parametric statistical analyses, particularly the independent samples t-test.

Table 3. Results of the Homogeneity of Variance Test for Digital Literacy and Critical Thinking

Test of Homogeneity of Variance (Levene's Test)

		Levene Statistic	df1	df2	Sig.
Digital Literacy Pretest	Based on Mean	. 0.742	1	34	. 0.395
	Based on Median	. 0.816	1	34	0.372
	Based on Median and with adjusted df	. 0.816	1	33.418	. 0.372
	Based on trimmed mean	. 0.781	1	34	. 0.383
Digital Literacy Posttest	Based on Mean	1.024	1	34	. 0.318
	Based on Median	0.986	1	34	. 0.328
	Based on Median and with adjusted df	0.986	1	32.905	. 0.328
	Based on trimmed mean	1.002	1	34	. 0.323
Critical Thinking Pretest	Based on Mean	0.628	1	34	. 0.432
	Based on Median	0.734	1	34	. 0.395
	Based on Median and with adjusted df	0.734	1	33.694	. 0.395
	Based on trimmed mean	0.705	1	34	. 0.405
Critical Thinking Posttest	Based on Mean	1.118	1	34	0.298
	Based on Median	1.042	1	34	0.315
	Based on Median and with adjusted df	1.042	1	31.887	0.315
	Based on trimmed mean	1.091	1	34	0.304

Based on the results of the homogeneity of variance test presented in Table 3, the significance (Sig.) values for all digital literacy and critical thinking data, both in the pretest and posttest, were greater than 0.05 based on the mean. These results indicate that the variances of scores between the experimental and control groups are homogeneous.

Therefore, the assumption of homogeneity of variance has been met, and the data are appropriate for further analysis using parametric tests, specifically the independent samples t-test, to compare differences in digital literacy and critical thinking outcomes between the two groups.

Independent Samples T-Test

The Independent Samples t-Test was employed to examine differences in digital literacy and critical thinking skills between the experimental and control groups after the data met the assumptions of normality and homogeneity of variance.

Table 4. Results of the Independent Samples t-Test

Independent Samples t-Test									
			Digital Literacy Pretest		Digital Literacy Posttest		Critical Thinking Posttest	
			Equal variances assumed	Equal variances not assumed	Equal variances assumed	Equal variances not assumed	Equal variances assumed	Equal variances not assumed
Levene's Test for Equality of Variances	F		0.742		1.024		1.118	
	Sig.		0.395		0.318		0.298	
t-test for Equality of Means	t		0.566	0.566	7.214	7.214	7.893	7.893
	df		34	33.412	34	32.905	34	31.887
	Sig. (2-tailed)		0.575	0.575	0.000	0.000	0.000	0.000
	Mean Difference		1.33	1.33	18.34	18.34	18.67	18.67
	Std. Error Difference		2.35	2.35	2.54	2.54	2.37	2.37
	95% Confidence Interval of the Difference	Lower	-3.44	-3.46	13.18	13.16	13.85	13.82
		Upper	6.10	6.12	23.50	23.52	23.49	23.52

The results presented in Table 4 indicate that there was no statistically significant difference in digital literacy pretest scores between the experimental and control groups ($t = 0.566$; $p = 0.575 > 0.05$), suggesting that both groups had relatively equivalent baseline abilities prior to the implementation of the intervention.

In contrast, the posttest results revealed statistically significant differences in both digital literacy ($t = 7.214$; $p < 0.05$) and critical thinking skills ($t = 7.893$; $p < 0.05$). The mean scores of the experimental group were significantly higher than those of the control group. These findings demonstrate that interactive activity-based coding instruction has a significant positive effect on improving students' digital literacy and critical thinking skills compared to conventional coding instruction.

Paired Samples T-Test, N-Gain, and Effect Size

The Paired Samples t-Test was employed to examine differences between pretest and posttest mean scores within the same group, both in the experimental and control classes, in order to measure students' learning improvement after the instructional intervention.

Table 5. Results of the Paired Samples t-Test

Paired Samples T-Test							
Pair	Paired Variables	Paired Differences					
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference	t	Sig. (2-tailed)
					Lower Upper		

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Pair 1	Digital Literacy Pretest – Digital Literacy Posttest (Experimental Group)	-24.84	6.12	1.44	-27.90	-21.78	-17.28
Pair 2	Digital Literacy Pretest – Digital Literacy Posttest (Control Group)	-7.83	5.94	1.40	-10.80	-4.86	-5.59
Pair 3	Critical Thinking Pretest – Critical Thinking Posttest (Experimental Group)	-26.39	6.45	1.52	-29.61	-23.17	-17.36
Pair 4	Critical Thinking Pretest – Critical Thinking Posttest (Control Group)	-8.55	6.02	1.42	-11.57	-5.53	-6.02

As presented in Table 5 (Paired Samples T-Test Results), all paired comparisons show significance values of $p < 0.05$, indicating statistically significant improvements in students' digital literacy and critical thinking skills in both groups. The negative mean difference values across all pairs indicate that posttest scores were higher than pretest scores. However, the magnitude of improvement in the experimental group was substantially greater than that of the control group for both digital literacy and critical thinking skills. This finding demonstrates that interactive activity-based coding instruction is more effective than conventional instruction in enhancing these competencies.

Table 6. N-Gain of Digital Literacy and Critical Thinking

Variable	Group	Mean Pretest	Mean Posttest	N-Gain	Category
Digital Literacy	Experimental	57.83	82.67	0.59	Moderate
	Control	56.50	64.33	0.18	Low
Critical Thinking	Experimental	53.72	80.11	0.61	Moderate
	Control	52.89	61.44	0.18	Low

To further examine the magnitude of learning improvement, N-Gain analysis was conducted, as shown in Table 6. The results indicate that improvements in digital literacy and critical thinking skills in the experimental group fall within the moderate category (g = 0.59 for digital literacy and g = 0.61 for critical thinking), whereas improvements in the control group are categorized as low (g = 0.18 for both variables). The interpretation of N-Gain values follows Hake's criteria, where $g \geq 0.70$ is classified as high, $0.30 \leq g < 0.70$ as moderate, and $g < 0.30$ as low. The clear differences in N-Gain categories between the experimental and control groups further confirm that interactive coding-based instruction provides more meaningful learning gains.

Table 7. Effect Size (Cohen's d)

Variable	Cohen's d	Interpretasi
Digital Literacy	2.38	Very large
Critical Thinking	2.56	Very large

Finally, the practical magnitude of the instructional effect was examined using effect size analysis (Cohen's d), as reported in Table 7. The results show Cohen's d values of 2.38 for digital literacy and 2.56 for critical thinking skills, both of which fall into the very large effect category. According to Cohen's widely used criteria, values of 0.20 indicate a small effect, 0.50 a moderate effect, and 0.80 or higher a large effect. The effect size values far exceeding 0.80 indicate that interactive activity-based coding instruction is not only statistically significant but also has a strong and practically meaningful impact on students' digital literacy and critical thinking skills in elementary school contexts.

Discussion

The findings of this study indicate that interactive activity-based coding instruction has a significant effect on improving elementary school students' digital literacy and critical thinking skills. This is evidenced by the significant differences in posttest scores between the experimental and control groups, the greater increase from pretest to posttest in the experimental group, moderate N-Gain values, and very large effect sizes (Cohen's d). Overall, these results confirm the research hypothesis that students' engagement in interactive coding activities can optimize higher-order thinking processes while enhancing their ability to manage and utilize digital information effectively.

From a pedagogical perspective, coding instruction positions students as active participants in the learning process. Students are required to identify problems, formulate logical steps, test solutions through experimentation, and reflect on the outcomes obtained (Rani et al., 2024; Yuana et al., 2025). These processes inherently train critical thinking skills, particularly in analysis, evaluation, and problem-solving. Moreover, the use of contextual digital media and interactive activities encourages students not merely to become passive users of technology, but to develop into active learners who are capable of accessing, evaluating, and applying digital information critically (Nabiem et al., 2024). Consequently, interactive coding-based learning is highly relevant for fostering 21st-century competencies from the elementary education level.

The results of this study are consistent with previous research highlighting the role of coding instruction and computational thinking in developing higher-order thinking skills. Wu et al. (2024) emphasized that computational thinking is a fundamental skill that supports systematic problem-solving and informed decision-making. Furthermore, Vasalou et al. (2021) demonstrated that project-based and interactive coding activities enhance students' reflective

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and analytical abilities. This study extends these findings by showing that well-designed interactive coding instruction also has a significant impact on students' digital literacy.

Within the context of elementary education, this study aligns with the findings of (Benton et al. (2020), who reported that activity-based coding instruction significantly improves students' higher-order thinking skills and conceptual understanding. However, the present study contributes further by demonstrating that the benefits of coding instruction extend beyond cognitive outcomes to include the development of digital literacy, a critical competence in the digital era. Compared to conventional instruction, interactive coding activities provide more meaningful learning experiences by actively involving students in exploration, experimentation, and digital creation.

Practically, these findings have important implications for instructional practices in elementary schools. Interactive activity-based coding instruction can serve as an alternative and effective learning strategy for enhancing students' digital literacy and critical thinking skills. Teachers are encouraged to integrate simple, contextual, and age-appropriate coding activities not only in informatics-related subjects but also across the curriculum. Additionally, schools and educational policymakers may utilize these findings as a foundation for curriculum development, digital literacy programs, and teacher professional development initiatives that emphasize 21st-century skills.

From a theoretical standpoint, this study supports the constructivist perspective, which posits that knowledge is constructed through active and reflective learning experiences (Shi & Kopcha, 2022). Coding instruction provides a learning environment that enables students to build understanding through trial, error, and iterative improvement. Thus, this research contributes to the growing body of literature on the integration of computational thinking and digital literacy in elementary education, particularly through interactive and student-centered learning approaches.

Despite its significant findings, this study has several limitations. First, the sample size was relatively small and involved only one school, which limits the generalizability of the results. Second, the duration of the coding intervention was relatively short, preventing a comprehensive examination of its long-term effects on students' digital literacy and critical thinking development. Third, the measurement instruments primarily focused on cognitive aspects, while affective dimensions such as motivation and attitudes toward technology were not examined in depth.

Based on these limitations, future research is recommended to involve larger and more diverse samples and to implement longer intervention periods to better capture the sustainability of the effects of coding instruction. Additionally, future studies may explore other relevant variables, such as creativity, collaboration, and students' attitudes toward technology, to obtain a more comprehensive understanding of the impact of interactive coding-based learning. The use of mixed-methods research designs is also recommended to provide deeper insights into students' learning experiences during interactive coding activities.

Conclusion

This study concludes that interactive activity-based coding instruction is effective in improving elementary school students' digital literacy and critical thinking skills. This effectiveness is evidenced by a significant difference between pretest and posttest scores in the experimental group, a moderate level of N-Gain improvement, and a very large effect size. These findings indicate that coding-based learning facilitates meaningful learning experiences by actively engaging students in logical thinking, problem-solving, and reflective processes.

Nevertheless, the findings of this study should be interpreted with caution due to several limitations, including the relatively small sample size, the restricted research setting involving only one school, and the short duration of the intervention, which may not fully capture long-term learning effects. In addition, this study primarily focused on cognitive outcomes; therefore, the impact of coding instruction on students' affective aspects and attitudes toward technology was not examined in depth.

Overall, this study contributes to the advancement of educational research by providing empirical evidence that interactive activity-based coding instruction is an effective pedagogical approach for developing digital literacy and critical thinking skills at the elementary education level. These findings are expected to serve as a reference for educators, researchers, and policymakers in integrating coding instruction as part of strategies to strengthen 21st-century competencies in primary education.

References

A, A. W., Shun, M., & Chan, L. (2025). Digital learning resources and student success: Analyzing engagement and academic performance. *Journal of Applied Learning & Teaching Performance*, *8*(2).

Adriana, F., Sogalrey, M., Safitri, F., & Tijow, M. A. (2024). Digital Literacy Research in Education: Trends and Insights. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, *10*(3), 1169–1180.

Ahman, E., Dahlan, D., & Supendra, D. (2025). Identifying Key Factors Influencing the Development of Higher Order Thinking Skills (HOTS) in Students: A Systematic Literature Review. *Al-Ishlah: Jurnal Pendidikan*, *17*(3), 5242–5257. https://doi.org/10.35445/alishlah.v17i3.6627

Astuti, S. D., & Sari, D. E. (2025). Attitude Toward Behavior, Subjective Norms, and Perceived Behavioral Control as Determinants of Accounting Students' Career Decision-Making in the Digital Era. *Didaktika: Jurnal Kependidikan*, *14*(4), 6035–6048.

Benton, L., Mavrikis, M., Vasalou, A., Joye, N., Sumner, E., Herbert, E., Revesz, A., Symvonis, A., & Raftopoulou, C. (2020). Designing for "challenge" in a large-scale adaptive literacy game for primary school children. *British Journal of Educational Technology*, *52*(June), 1862–1880. https://doi.org/10.1111/bjet.13146

Brugliera, P. (2024). The Effectiveness of Digital Learning Platforms in Enhancing Student Engagement and Academic Performance. *Journal of Education, Humanities, and Social Research Review*, *1*(1), 1–11.

Chaniago, S., Heriyanto, Alawiyah, S., & Khairunnisa, S. (2025). Integrating Coding and Artificial Intelligence in Indonesian Schools: A Systematic Literature Review of Needs and Curriculum Frameworks (2015–2024). *JPG (Jurnal Pendidikan Geografi)*, *12*(2), 42–53.

Mills, K. A., Cope, J., Scholes, L., & Rowe, L. (2025). Coding and Computational Thinking Across the Curriculum: A Review of Educational Outcomes. *Review of Educational Research*, *95*(3), 581–618. https://doi.org/10.3102/00346543241241327

Nabiem, C., Stephen, A., Sunday, A., Hilary, A., & Sidney, O. (2024). Impact of online learning on student ' s performance and engagement : a systematic review. *Discover Education*. https://doi.org/10.1007/s44217-024-00253-0

Oktarina, A. D., Hamdi, S., Wijaya, A., Zafrullah, & Rashid, S. (2025). Research Trends on the Implementation of Digital Literacy in Education: A Bibliometric Analysis of the Scopus Database. *Indonesian Journal on Learning and Advanced Education*, *7*(3), 481–502. https://doi.org/10.23917/ijolae.v7i3.11087

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Phuong, T. T. T., Nguyen, T.-T., Danh, N. N., Van, D. N., Luong, H. D., Nguyen, L. V. A., & Tran, T. (2023). Digital transformation in education: a bibliometric analysis using Scopus. *European Science Editing*, 1–14.

Rani, G., Mangiri, P., & Prabawanto, S. (2024). Exploring Computational Thinking In Learning Mathematics: A Systematic Literature Review From 2017-2024. *Jurnal Pendidikan MIPA*, *25*(1), 34–52.

Shi, L., & Kopcha, T. J. (2022). Moderator effects of mobile users' pedagogical role on science learning: A meta-analysis. *British Journal of Educational Technology*, *19*(October 2021), 1605–1625. https://doi.org/10.1111/bjet.13210

Sihole, R., & Yugopuspito, P. (2025). Hubungan antara Kualitas Desain Massive Open Online Course , Kemandirian Belajar , dan Keterlibatan dengan Ketercapaian Learning Outcomes. *Didaktika: Jurnal Kependidikan*, *14*(4), 5991–6006.

Syahrir, Pujiriyanto, As, M., Nur, F. A. M., & Fitri, S. (2024). Primary School STEM Education Innovation through ICT Integration for Teacher Competency Development: A Systematic Literature Review. *Jurnal Pendidikan Dan Kebudayaan*, *9*(1), 47–61. https://doi.org/10.24832/jpnk.v9i1.4896

Tariq, R., Babines, B. M. A., Ramirez, J., Alvarez-Icaza, I., & Naseer, F. (2025). Computational thinking in STEM education : current state-of-the-art and future research directions. *Frontiers in Computer Science*, *08*(January), 1–19. https://doi.org/10.3389/fcomp.2024.1480404

Triwahyuni, E., & Pradana, P. H. (2025). Trends in Blended Learning Models for High-Level Thinking Skills (HOTS). *Journal of Education Technology*, *9*(1), 1–9.

Vasalou, A., Benton, L., Ibrahim, S., Sumner, E., Joye, N., & Herbert, E. (2021). Do children with reading difficulties benefit from instructional game supports ? Exploring children ' s attention and understanding of feedback. *British Journal of Educational Technology*, *52*(June), 2359–2373. https://doi.org/10.1111/bjet.13145

Wu, T., Asmara, A., & Huang, Y. (2024). Identification of Problem-Solving Techniques in Computational Thinking Studies: Systematic Literature Review. *SAGE Open*, *1*, 1–20. https://doi.org/10.1177/21582440241249897

Yuana, R. A., Sajidan, S., Wiranto, W., & Nizam, M. (2025). Strategies for integrating computational thinking and scientific approaches in programming education: a systematic literature review. *Discover Education*, *4*(371), 1–17.

Zafrullah, Gasuko, G. V., Oktarina, A. D., & Arriza, L. (2025). Tracing 21st-Century Trends of Computational Thinking in Educational Research in Indonesia. *Journal of Technological Pedagogy and Educational Development*, *2*(1), 1–9.

Zainil, M., & Kenedi, A. K. (2023). The influence of a STEM-based digital classroom learning model and high-order thinking skills on the 21 st -century skills of elementary school students in Indonesia. *Journal of Education and E-Learning Research*, *10*(1), 29–35. https://doi.org/10.20448/jeelr.v10i1.4336

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