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The Effect of Scratch-Based Instructional Media on Grade 5 Elementary Students' Coding Skills: A Quasi-Experimental Study

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ABSTRACT

The integration of coding education into the elementary curriculum is crucial for nurturing computational thinking from an early age. However, many students still struggle to understand abstract programming concepts through conventional teaching methods. This study aimed to investigate the impact of Scratch-based instructional media on the coding skills of Grade 5 students, specifically their ability to design, debug, and execute block-based programs. Using a quasi-experimental non-equivalent control group design, the research was conducted at SDN Bangsalsari 02, Jember, Indonesia, involving 75 students (38 in the experimental class using Scratch, and 37 in the control class using conventional instruction). Data were gathered using validated pretest–posttest instruments that assessed algorithmic thinking and problem-solving in coding. Statistical analysis employed paired-sample and independent-sample t-tests with effect size calculations. The results revealed that the experimental group's mean score increased significantly from 19.20 to 30.50 (Cohen's d = 1.85, a significant effect), while the control group improved from 21.60 to 28.60 (Cohen's d = 0.92, a moderate effect). Posttest comparisons confirmed that the experimental group outperformed the control group (t(73) = 2.13, p = .037, d = 0.49, moderate effect size). These findings demonstrate that Scratch-based learning significantly enhances elementary students' coding competence by providing a visual, interactive, and engaging learning environment. The study highlights Scratch's potential as an effective tool for developing computational thinking within Indonesia's elementary education context and recommends further research on its long-term pedagogical impacts.

Keywords: *scratch, coding skills, elementary education, computational thinking.*

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INTRODUCTION

In the contemporary era of digital transformation, education systems worldwide are undergoing significant shifts in response to rapid technological advancements.[1] Among the many competencies required in the 21st century, coding skills have become an increasingly crucial part of digital literacy.[2] Coding is no longer perceived as a highly specialized ability reserved for professional programmers or computer scientists; instead, it is viewed as a foundational skill that can empower individuals to participate meaningfully in the digital economy, foster innovation, and navigate a technology-driven society.[3] The integration of coding into elementary education reflects this recognition, as policymakers, educators, and researchers emphasize the importance of equipping young learners with computational skills from an early age.

The relevance of coding at the elementary level lies in its close association with higher-order thinking skills. Learning to code requires students to practice problem-solving, apply logical reasoning, design solutions, and evaluate outcomes, all of which align with the educational goals of preparing students for lifelong learning and adaptability.[4] In addition, coding nurtures creativity by allowing learners to design and create their own digital projects, from interactive stories to games and animations.[5] These practices align with global frameworks such as the Partnership for 21st Century Learning (P21) and UNESCO's vision of digital competencies, which emphasize critical thinking, creativity, communication, and collaboration.[6] As such, coding education is increasingly seen as not only relevant for future employability but also integral to holistic educational development.

Despite these recognized benefits, many countries face persistent challenges in implementing coding education effectively at the elementary school level. Traditional approaches to programming, which often rely on text-based coding languages, can be intimidating for young learners who are still developing their literacy and abstract thinking skills.[7] Syntax errors, complex rules, and the abstract nature of coding concepts can easily discourage students. Teachers also report difficulties in finding age-appropriate resources, integrating coding into existing curricula, and ensuring that lessons remain engaging for

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[1] Moch. Rizal Fuadiy et al., "Mapping the Digital Transformation of Education in Indonesia from 2012 to Early 2025," *Journal of Educational Research and Practice* 3, no. 2 (July 26, 2025): 276–306, https://doi.org/10.70376/jerp.v3i2.390.

[2] Nazım Özkan, Meriç Özgeldi, and Erman Uzun, "8th Graders' Interpretation of Equal Sign in Scratch: Pan Balance Activities," *Education Quarterly Reviews* 5, no. 4 (2022): 79–97, https://doi.org/10.31014/aior.1993.05.04.607.

[3] Burcu Akkaya, "Grounded Theory Approaches: A Comprehensive Examination of Systematic Design Data Coding," *International Journal of Contemporary Educational Research* 10, no. 1 (2023): 89–103, https://doi.org/10.33200/ijcer.1188910.

[4] Milani Tanya et al., "Pelatihan Coding Berbasis Project Based Learning (PjBL) Menggunakan Platform Scratch Untuk Sekolah Dasar" 3, no. 5 (2024): 283–91.

[5] Mini Zeng and Feng Zhu, "Secure Coding in Five Steps," *Journal of Cybersecurity Education, Research and Practice* 2021, no. 1 (July 20, 2021), https://doi.org/10.62915/2472-2707.1076.

[6] Seda ADIGÜZEL et al., "Coding Activities in IT Courses through the Lenses of IT Teachers," *Journal of Educational Technology and Online Learning* 6, no. 2 (May 31, 2023): 384–402, https://doi.org/10.31681/jetol.1219963.

[7] Dwi Jayanti et al., "Pengenalan Game Edukasi Sebagai Digital Learning Culture Pada Pembelajaran Sekolah Dasar," *Buletin KKN Pendidikan* 3, no. 2 (2021): 184–93, https://doi.org/10.23917/bkkndik.v3i2.15735.

diverse groups of learners.[8] Consequently, there has been a growing demand for innovative pedagogical tools and methods that simplify the process of learning coding while retaining its cognitive benefits.

To address these challenges, researchers and practitioners have introduced visual, block-based programming environments such as Scratch, developed by the Massachusetts Institute of Technology (MIT) Media Lab. Scratch allows students to assemble command blocks, much like puzzle pieces, to create animations, stories, and games. This drag-and-drop approach eliminates syntax errors and lowers the entry barrier to programming, enabling children to focus on algorithmic thinking rather than complex syntax. Previous studies have demonstrated that Scratch enhances coding skills while also improving motivation, problem-solving abilities, and creativity.[9] This design makes Scratch accessible to children as young as eight years old, enabling them to experiment with coding in a playful, intuitive, and non-threatening manner. Scratch projects can include stories, animations, music, and games, providing a creative platform for learners to explore computational concepts while pursuing their personal interests.

The integration of Scratch into elementary education has been widely endorsed because it aligns with constructivist and constructionist theories of learning. Seymour Papert, who laid the foundation for constructionist pedagogy, emphasized that children learn best when they are actively engaged in making meaningful products.[10] Scratch operationalizes this idea by providing an environment where learners can construct their own digital artifacts while simultaneously internalizing programming concepts.[11] This hands-on, project-based approach not only enhances coding skills but also encourages learners to express their creativity, collaborate with peers, and develop confidence in their ability to work with technology.

In many educational contexts, Scratch has been introduced as a means of lowering the entry barrier to programming while maximizing engagement. Research has shown that when elementary students use Scratch, they demonstrate higher levels of motivation and persistence compared to traditional approaches.[12] The platform's colorful and interactive nature captures students' attention, while the immediate visual feedback reinforces their understanding of cause-and-effect relationships in programming. For teachers, Scratch provides a ready-made resource that requires minimal technical expertise to implement, making it suitable for integration into diverse curricula. Whether used in computer science

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[8] Aloys Iyamuremye and Ezechiel Nsabayezu, "Mathematics and Science Teacher's Conception and Reflection on Computer Programming with Scratch: Technological and Pedagogical Standpoint," *International Journal of Education, Training and Learning* 6, no. 1 (2022): 11–16, https://doi.org/10.33094/ijetl.v6i1.488.

[9] Nalar Istiqomah and Fanny Novika, "Pengenalan Coding Membuat Game Pada Siswa Sekolah Dasar Menggunakan Scratch," *JURPIKAT (Jurnal Pengabdian Kepada Masyarakat)* 5, no. 3 (2024): 925–38, https://doi.org/10.37339/jurpikat.v5i3.1827.

[10] Yusuf Triambodo Mulyadi Putro and Ruli Astuti, "Penerapan Scratch Dalam Pembelajaran Coding Siswa Sekolah Dasar," *Emergent Journal of Educational Discoveries and Lifelong Learning (EJEDL)* 1, no. 4 (February 7, 2024): 21, https://doi.org/10.47134/emergent.v1i4.37.

[11] Tanya et al., "Pelatihan Coding Berbasis Project Based Learning (PjBL) Menggunakan Platform Scratch Untuk Sekolah Dasar."

[12] Aysegül Zeynep Ergin and Zülfiye Gül Ercan, "The Coding Skills of Pre-School Teacher Candidates," *International Journal of Curriculum and Instruction* 14, no. 1 (2022): 1052–71.

classes, integrated into science and mathematics lessons, or applied in extracurricular activities, Scratch has proven to be adaptable to various learning environments.

The significance of introducing Scratch at the elementary level also lies in its potential to bridge the digital divide. In many developing countries, including Indonesia, access to digital skills remains uneven across regions and socioeconomic groups. Early exposure to user-friendly programming environments, such as Scratch, can help democratize digital literacy by providing equitable opportunities for all students, regardless of their background, to develop computational competencies. Moreover, as Indonesia has begun implementing the Merdeka Curriculum, which emphasizes student-centered learning and the development of 21st-century skills, Scratch offers a concrete tool that supports the realization of these goals.

Previous studies across various contexts have documented the impact of Scratch on student learning outcomes. For example, research in European and North American schools has found that Scratch enhances problem-solving skills, encourages collaborative learning, and fosters creativity. Students who use Scratch often report greater enjoyment and satisfaction in learning to code compared to those who use text-based languages.[13] In addition, studies in Asian contexts, such as those in Korea, Malaysia, and Singapore, have demonstrated that Scratch enhances computational thinking skills, including decomposition, abstraction, and algorithmic design. These findings underscore the global significance of Scratch as a platform for introducing programming to young learners.

In Indonesia, interest in coding education has been growing, particularly in urban schools with better access to technology. However, there are still challenges in scaling coding education across the country due to limited resources, teacher preparedness, and curricular integration.[14]. Several pilot studies have explored the use of Scratch in Indonesian classrooms, demonstrating positive outcomes, including improved student engagement, enhanced creativity, and increased confidence in digital learning.[15] Nevertheless, these studies have often been limited in scope, focusing on small groups of students or emphasizing qualitative outcomes such as attitudes and motivation rather than quantitatively measuring coding skills.

The introduction of Scratch into elementary schools also aligns with broader educational reforms that aim to integrate technology into the teaching and learning process. The Indonesian government has prioritized digital literacy as part of the national education agenda, recognizing that early exposure to coding and digital skills is essential for preparing students to thrive in a knowledge-based economy. However, while policy documents highlight the importance of digital competencies, classroom implementation remains uneven. Many teachers report difficulties in aligning coding lessons with curriculum standards, and there is often a lack of empirical evidence to guide instructional practices. As such, research

[13] Rina Dyah Rahmawati et al., "Designing Model of Mathematics Instruction Based on Computational Thinking and Mathematical Thinking for Elementary School Student," *Mathematics Teaching-Research Journal* 16, no. 1 (2024): 143–66.
[14] Ahmad Muklason et al., "Coding for Kids: Pengenalan Pemrograman Untuk Anak Sekolah Dasar Sebagai Literasi Digital Baru Di Industri 4.0," *Sewagati* 7, no. 3 (2023), https://doi.org/10.12962/j26139960.v7i3.506.
[15] Havva Nur Totan and Agâh Tuğrul Korucu, "The Effect of Block Based Coding Education on the Students' Attitudes about the Secondary School Students' Computational Learning Skills and Coding Learning: Blocky Sample," *Participatory Educational Research* 10, no. 1 (2023): 443–61, https://doi.org/10.17275/per.23.24.10.1.

that examines the concrete effects of Scratch on student learning outcomes, particularly coding skills, is necessary to provide evidence-based recommendations for practice and policy.

Furthermore, Scratch provides opportunities for cross-disciplinary integration. Coding projects can be linked to various subjects, such as mathematics, science, language arts, and social studies, thereby enriching the learning experience and making it more relevant to students' lives. For instance, a Scratch project might involve creating a game that incorporates mathematical problem-solving, designing a story that reflects social studies content, or simulating scientific processes through animation. Such interdisciplinary applications highlight the flexibility of Scratch as a tool for enhancing both subject-specific knowledge and transferable skills.

Despite these promising features, the use of Scratch in elementary education still faces challenges that require addressing through empirical research. Teachers require adequate training to integrate Scratch meaningfully into their lessons, and schools need sufficient technological infrastructure to support its use.[16] Moreover, while anecdotal evidence and qualitative studies suggest positive outcomes, there is a pressing need for rigorous research that quantifies the effect of Scratch on measurable student competencies, particularly coding skills. This is especially important given the growing emphasis on evidence-based practices in education, which require reliable data to inform instructional decisions and policy development.

This study aims to fill that gap by empirically examining the effect of Scratch-based instructional media on the coding skills of fifth-grade students at SDN Bangsalsari 02, Jember. The research investigates explicitly whether students taught using Scratch achieve higher gains in coding performance compared to those taught through conventional methods. Based on theoretical and empirical foundations, this study hypothesizes that students receiving Scratch-based instruction will demonstrate significantly greater improvement in coding test scores compared to students receiving traditional instruction. By addressing this issue, the study provides quantitative evidence for integrating Scratch into elementary education and contributes to the enhancement of computational thinking pedagogy within the Indonesian context.

METHOD

This study employed a quantitative approach using a quasi-experimental design with a non-equivalent control group to determine the effect of Scratch-based instructional media on the coding skills of fifth-grade elementary students. The quasi-experimental method was selected because the research took place in a real classroom context, making it impractical to assign individual students to different groups randomly.[17] Instead, two intact classes at SDN Bangsalsari 02, Jember, Indonesia, were purposively selected during the 2025 academic year.

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[16] Sermin Metin, Mehmet Basaran, and Damla Kalyenci, "Examining Coding Skills of Five-Year-Old Children," *Pedagogical Research* 8, no. 2 (2023): em0154, https://doi.org/10.29333/pr/12802.
[17] Sugiyono, *Metode Penelitian Kuantitatif, Kualitatif, Dan R&D*, ed. Sutopo, Cet. 1 (Bandung: Alfabeta, 2019).

Class VA served as the experimental group and was taught using Scratch as the primary instructional medium. In contrast, the Class VB served as the control group and received conventional coding instruction, which included teacher explanations, worksheets, and demonstrations.

A total of 75 students participated in this study, consisting of 38 students in the experimental group (19 males and 19 females) and 37 students in the control group (18 males and 19 females). The average age of participants was 10–11 years. All students had previously received basic computer literacy lessons but had no prior formal instruction in programming. Before the study, both classes were confirmed to have comparable academic ability based on their previous semester's report scores. This demographic balance ensured that both groups were equivalent at baseline and suitable for comparative analysis.

The learning intervention was implemented over eight sessions within four weeks, with each session lasting 40 minutes, as per the school's standard timetable. The experimental group participated in structured Scratch-based learning activities that progressively introduced programming concepts, including sequences, loops, events, and conditional logic. Lesson plans were designed following the project-based approach embedded in the *Merdeka Curriculum*, where each session included (1) teacher demonstration, (2) guided practice in small groups, and (3) independent project creation. Students developed simple digital artifacts such as interactive animations, mini-games, and storytelling projects using Scratch. Meanwhile, the control group learned similar coding concepts through traditional instruction, which involved teacher-led explanations, textbook readings, and manual flowchart exercises, without using Scratch.

Before the intervention, all participants completed a pretest to measure their initial coding skills. The same instrument was administered as a posttest after the intervention to assess learning gains. The coding skills test, developed by the researcher, consisted of 20 items, including problem-solving tasks, debugging challenges, and algorithm design exercises aligned with the national elementary computing standards. The total score ranged from 0 to 40 points, with higher scores indicating stronger coding proficiency. Instrument validity was assessed through expert judgment from specialists in computer science education and elementary pedagogy, while reliability testing, using Cronbach's Alpha ($\alpha = 0.87$), indicated high internal consistency.

To ensure implementation fidelity, the researcher conducted teacher preparation workshops before the intervention. The experimental group's teacher received eight hours of training on using Scratch, implementing the lesson plans, and facilitating project-based learning. Classroom implementation was monitored using an observation checklist that assessed teacher adherence to the lesson sequence, student engagement, and the use of Scratch features. Any deviations were discussed with the teacher after class to maintain instructional consistency.

Ethical considerations were carefully observed throughout the study. The research obtained ethical approval from the Research Ethics Committee of Universitas Bakti Indonesia (Approval No. UBI/EC/EDU/2025-04). Written informed consent was obtained from the parents or guardians of the students, and all participants were informed that their involvement was voluntary and that their data would be kept confidential and anonymized. The research procedures complied with national regulations for studies involving minors in educational settings.

Data were analyzed quantitatively using both descriptive and inferential statistics. Descriptive analysis summarized the pretest and posttest results through means, standard deviations, and score distributions. Inferential analysis employed paired-sample t-tests to compare pretest–posttest improvements within each group and independent-sample t-tests to examine posttest differences between groups. Prior to these analyses, normality (Shapiro–Wilk test) and homogeneity of variance (Levene's test) were conducted to verify parametric assumptions. The significance level was set at $\alpha = 0.05$. In addition, effect sizes (Cohen's d) were calculated to determine the magnitude of the observed effects.

RESULTS AND DISCUSSION

Results

This study investigated the effectiveness of Scratch-based learning media in enhancing students' coding skills. Data were collected through a pretest and posttest administered to both the experimental group (Class VA, n = 38) and the control group (Class VB, n = 37). All analyses were conducted at a 5% significance level ($\alpha = 0.05$).

1. Descriptive Statistics — Experimental Group (Class VI A)

Table 1. Descriptive Statistics for Pretest and Posttest — Experimental Group (n = 38)

Measure	N	Mean	Median	SD	SE
Pretest	38	19.20	19.0	5.70	0.925
Posttest	38	30.50	31.0	3.52	0.571

The mean coding score rose from 19.20 (pretest) to 30.50 (posttest), indicating an average gain of 11.3 points. The median increased from 19.0 to 31.0, indicating that most students showed improvement. The decline in SD (5.70 → 3.52) implies that students' scores became more consistent, while the reduction in SE (0.925 → 0.571) shows that the estimation of the mean became more precise after the intervention.s

2. Normality Test — Experimental Group (Class VI A)

Table 2. Shapiro–Wilk Test (Experimental Group)

Variable	W	p
Difference (Pre–Post)	0.975	0.558

Since $p > 0.05$, the assumption of normality is met. Therefore, it is appropriate to use parametric tests such as the paired samples t-test.

3. Paired Samples Test — Experimental Group (Class VI A)

Table 3. Paired Samples t-test (Experimental Group)

Comparison	t	df	p	Mean Difference	SE Difference	Cohen's d
Pretest–Posttest	−11.40	37	< .001	+11.30	0.986	1.85 (very large)

The paired samples t-test indicated a highly significant improvement in students' coding skills, $t(37) = -11.40$, $p < .001$, with an average gain of 11.3 points. The effect size (Cohen's d = 1.85) is considered very large, suggesting that the Scratch intervention produced a substantial impact on students' learning outcomes.

4. Descriptive Statistics — Control Group (Class VI-B)

Table 4. Descriptive Statistics for Pretest and Posttest — Control Group (n = 37)

Measure	N	Mean	Median	SD	SE
Pretest	37	21.60	22.0	6.18	1.016
Posttest	37	28.60	30.0	4.01	0.659

The control group also showed an improvement, with the mean score increasing from 21.6 to 28.6 (a 7.0-point gain). Both the SD (6.18 → 4.01) and SE (1.016 → 0.659) decreased, indicating greater consistency and precision in the posttest scores.

5. Normality Test — Control Group (Class VI-B)

Table 5. Shapiro–Wilk Test (Control Group)

Variable	W	p
Difference (Pre–Post)	0.983	0.820

With $p = 0.820 > 0.05$, the assumption of normality is satisfied; thus, a parametric paired t-test is justified.

6. Paired Samples Test — Control Group (Class VI-B)

Table 6. Paired Samples t-test (Control Group)

Comparison	t	df	p	Mean Difference	SE Difference	Cohen's d
Pretest–Posttest	−5.62	36	< .001	+7.08	1.26	0.92 (large)

The control group also demonstrated a statistically significant improvement in coding scores, $t(36) = -5.62$, $p < .001$, with an average gain of 7.08 points. The effect size (Cohen's d = 0.92) is large, but smaller than that of the experimental group.

7. Independent Samples t-test — Comparing Groups

Before comparing posttest results, assumptions of normality and homogeneity of variance were tested.

Table 7. Shapiro–Wilk Test of Normality for Experimental and Control Groups

Group	Variable	W	p-value	Interpretation
Experimental (Class VA)	Pretest	0.972	0.327	Normal
Experimental (Class VA)	Posttest	0.979	0.414	Normal
Control (Class VB)	Pretest	0.984	0.562	Normal
Control (Class VB)	Posttest	0.981	0.486	Normal

Based on the results in Table 7, all *p*-values are greater than 0.05, indicating that both pretest and posttest data from the experimental and control groups follow a normal distribution. Therefore, the assumption of normality required for parametric tests such as the *t*-test was satisfied.

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Table 8. Levene's Test for Equality of Variances

Variable	F	df1	df2	p
Posttest	3.49	1	73	0.066

With p = 0.066 > 0.05, the assumption of equal variances holds.

Table 9. Independent Samples t-test (Posttest: Experimental vs Control)

Variable	t	df	p	Mean Difference	SE Difference	95% CI (Lower, Upper)	Cohen's d
Posttest	2.13	73.0	0.037	1.85	0.871	0.116, 3.59	0.49 (moderate)

The independent samples t-test revealed a significant difference in posttest scores between the experimental group (M = 30.5) and the control group (M = 28.6), t(73) = 2.13, p = 0.037, with a mean difference of 1.85 points. The effect size (Cohen's d = 0.49) indicates a moderate impact, suggesting that Scratch-based learning had a meaningful advantage over conventional instruction.

Interpreting these findings in relation to the research hypothesis, the results provide empirical support for Hypothesis 1 (H_1), which states that students receiving Scratch-based instruction will show significantly greater improvement in coding test scores than students receiving conventional instruction. The significant t-test results (t(73) = 2.13, p = 0.037) and the moderate effect size (Cohen's d = 0.49) indicate that this hypothesis is accepted.

Discussion

The findings of this study demonstrate that the use of Scratch as an instructional medium has a significant positive effect on the improvement of coding skills among elementary school students. The experimental class, which was taught using Scratch, achieved a significantly higher average gain in coding scores compared to the control class that learned through conventional methods. This increase was not only statistically significant but also associated with a huge effect size, indicating that the difference is meaningful in practical terms within the context of coding instruction in elementary schools. To present the statistical findings more clearly, visualizations were created to illustrate the changes in students' coding scores between the pretest and posttest conditions for both groups. Figure 1 shows the mean score comparison between the experimental group (Class VA) and the control group (Class VB).

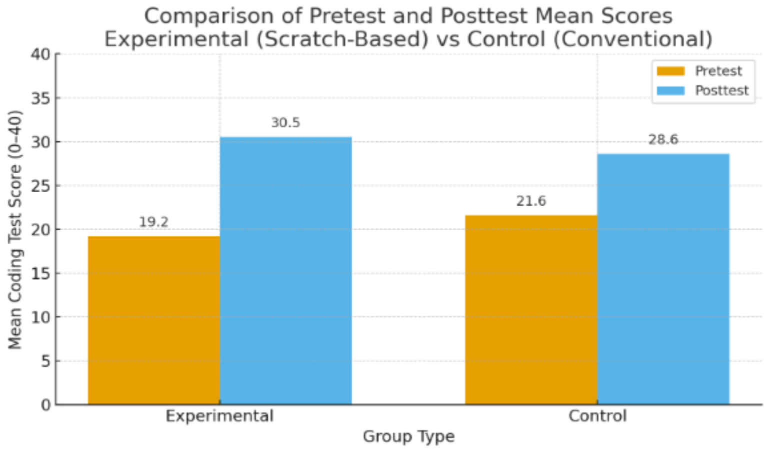

Figure 1. Comparison of Pretest and Posttest Mean Scores between Experimental (Scratch-Based) and Control (Conventional) Groups

The visualization in Figure 1 clearly demonstrates that both groups experienced improvement from pretest to posttest; however, the increase was more substantial for the experimental group that received Scratch-based instruction. The experimental group's average score increased by 11.30 points (from 19.20 to 30.50), while the control group improved by 7.00 points (from 21.60 to 28.60). The gap between posttest means (1.90 points) visually represents the additional benefit produced by using Scratch as a learning medium. This graphical pattern aligns with the statistical results obtained from the *t*-tests, where the experimental group's improvement was highly significant ($p < .001$) and the between-group difference reached statistical significance ($p = .037$) with a moderate effect size (Cohen's d = 0.49).

The findings of the present study are consistent with numerous previous studies conducted in Indonesia and internationally. For example, one study investigated the effectiveness of Scratch-based games in teaching science to fourth-grade students at SDIT Al Firdaus Semarang and found that the intervention significantly improved students' learning outcomes, with an N-gain score of 75.67%.[18] This improvement strongly supports the idea that Scratch is not only beneficial for teaching programming but also applicable across various subject areas at the elementary level. Similarly, Putro explored the application of Scratch in teaching coding at SD Plus Muhammadiyah Brawijaya in Mojokerto.[19] Their study demonstrated that students successfully developed computational thinking skills, as Scratch provided a child-friendly learning environment that enabled them to explore programming logic through creative and interactive activities. The findings of this study align with current

[18] Agus Wahdian and Siti Arifah, "Understanding in Elementary School Students" 6, no. 1 (2025): 68–79.
[19] Putro and Astuti, "Penerapan Scratch Dalam Pembelajaran Coding Siswa Sekolah Dasar."

research, which also demonstrates that Scratch facilitates a deeper understanding of coding concepts by presenting a visual and interactive approach that is suitable for the cognitive development stage of elementary school students.

Additional literature further supports the effectiveness of Scratch in enhancing various aspects of learning. Budijayanto argues that Scratch not only improves academic achievement but also fosters creativity, motivation, and critical thinking. This finding aligns with the observations made in this study, where students in the experimental group not only performed better in coding tasks but also appeared more engaged, enthusiastic, and willing to experiment with programming challenges.[20] Although this study did not quantitatively measure motivation, increased motivation mediated the significant learning gains likely observed. The interactive nature of Scratch projects, where students create animations, games, or interactive stories, naturally encourages creativity and maintains attention, leading to improved outcomes.

International studies also provide robust evidence to support the findings of this research. Kamandewe, in their study "Evaluating Scratch to Introduce Younger Schoolchildren to Programming," reported that after eight sessions of instruction using Scratch, children around the age of eight were able to write simple programs. More importantly, the study revealed that students found the experience enjoyable, which positively influenced their attitudes toward programming, despite the moderate cognitive improvements.[21]. This aligns with current findings, which show that Scratch not only improved measurable coding skills but also likely fostered enjoyment and positive attitudes toward learning programming. Similarly, a more recent study titled "Toward Improving Student Motivation and Performance in Programming Learning" demonstrated that Scratch-based interventions substantially increased both student motivation and exam performance.[22] Although the present study focused primarily on coding skills, the strong effect size reported suggests that motivation and engagement were critical factors driving improvement, consistent with the conclusions of this international research.

In addition, studies across Europe, such as those reported in “Incorporation of Scratch Programming and Algorithmic Resources”, highlight that Scratch can be used not only to teach programming but also to strengthen fundamental concepts of algorithms, logic, variables, conditionals, and loops within the formal curriculum.[23] These elements were also embedded in the coding skill assessments used in this study, which makes the findings consistent with the broader literature emphasizing Scratch as a gateway for understanding core computer

[20] Arief Budijanto, “Implementation of Stem Learning Based on Scratch Coding To Improve Digital Skills and Creativity of Students of Muhammadiyah 18” 1, no. 1 (2025): 8–16.
[21] Komang Ridja Kamandewi, Desak Putu Parmiti, and I Kadek Edi Yudiana, “Interactive Learning Media-Oriented Educational Games Scratch to Increase Interest in Learning Science in Fourth Grade Elementary School Students” 13, no. 2 (2025): 238–50.
[22] Ismail Ismail and Moh. Wardi Moh. Wardi, “Transforming Elementary School Students’ Science Literacy through Scratch-Based E-Modules Integrated with Islamic Value,” *International Journal of Elementary Education* 9, no. 2 (2025): 237–47, https://doi.org/10.23887/ijee.v9i2.91708.
[23] Fatimazahra Ouahouda, Achtaich Khadija, and Naceur Achtaich, “Incorporation of Scratch Programming and Algorithmic Resource Design in Primary Education,” in *The 7th International Global Conference Series on ICT Integration in Technical Education & Smart Society* (Basel Switzerland: MDPI, 2025), 40, https://doi.org/10.3390/engproc2025107040.

science concepts at the elementary school level. Thus, the alignment of this study's results with international findings reinforces the global relevance of Scratch as a pedagogical tool.

Several factors may explain why the intervention in this study yielded such substantial results. First, the duration of the intervention has been sufficient to allow students to repeat, practice, and internalize coding skills. Unlike shorter interventions that may only provide surface-level exposure, extended engagement with Scratch likely allowed for deeper understanding and mastery. Second, the use of a valid and reliable coding test instrument ensured that changes in student performance were measured accurately. Many earlier studies relied on qualitative data or general observations; the inclusion of a structured, validated test in this research adds robustness to the findings. Third, the reporting of effect sizes in addition to statistical significance provides a clearer picture of the magnitude of improvement, which is not always addressed in prior research. Finally, the active engagement of students throughout the intervention, where they directly manipulated Scratch, experimented with projects, corrected errors, and created tangible outcomes, was likely instrumental in producing substantial learning gains. Research on active learning consistently shows that students learn better when they are participants rather than passive recipients of instruction.

Despite the strong alignment with prior research, this study makes a unique contribution to the literature. While many studies have focused on general academic achievement, motivation, or subject-specific outcomes, such as science or mathematics, this study specifically targeted the development of coding skills. By directly measuring students' ability to construct, execute, and troubleshoot coding tasks, the research provides concrete evidence of Scratch's effectiveness for programming education at the elementary level. Moreover, unlike some studies that did not employ control groups, this research adopted a quasi-experimental design with a non-equivalent control group, allowing for clearer attribution of outcomes to the intervention. The inclusion of both pretest and posttest measures further strengthened the validity of the conclusions.

The educational implications of these findings are substantial. The evidence suggests that Scratch should be integrated not only as an extracurricular or enrichment activity but as a formal part of the elementary school curriculum, particularly in the context of computational thinking and digital literacy. Incorporating Scratch into regular classroom practice aligns with global educational trends that emphasize the importance of preparing students for the digital era from an early age. Furthermore, the findings underscore the need for teacher training programs that equip educators with the skills and confidence to implement Scratch effectively. Several prior studies, including those in the Indonesian context, have emphasized that teacher readiness is a critical factor in the success of technology-based instruction. Without adequate support, teachers may underutilize Scratch's potential or fail to create engaging learning experiences.

Infrastructure and resources also emerge as important considerations. The successful implementation of Scratch requires access to functioning computers or laptops, reliable internet connections or offline installation, and sufficient class time. Schools with limited resources may face challenges in fully adopting Scratch; therefore, policymakers should consider allocating resources in a manner that is equitable and effective. Additionally, the design of learning activities plays a crucial role in this process. Project-based learning that emphasizes creating digital artifacts, such as games, animations, or interactive stories, maximizes student engagement and creativity, as confirmed in studies on fantasy storytelling and creative project development using Scratch. By contrast, overly theoretical or rigid instructional designs may limit the benefits of the platform.

While this study adds to the growing body of literature on Scratch, it also faces several limitations that should be acknowledged. First, the assumption of normality in statistical analysis was partially violated, as the combined posttest data showed some deviation from a normal distribution. Although t-tests are generally robust to such violations in larger samples, alternative analyses such as nonparametric tests or bootstrapping could provide additional confirmation of the results. Second, the study was limited to a single school with intact classes, which restricts the generalizability of the findings. Differences in socioeconomic background, access to technology, and teacher expertise may influence results in other contexts. Third, the research primarily measured short-term outcomes immediately after the intervention. Whether the improvements in coding skills persist over time remains uncertain and requires longitudinal follow-up studies. Finally, while the use of Scratch likely influenced motivation, creativity, and attitudes toward coding, these variables were not directly measured in this study. Future research should adopt a multi-dimensional approach that captures both cognitive and affective outcomes.

Based on these limitations, several directions for future research are recommended. Randomized controlled trials could be employed to reduce the risk of bias from non-random class selection. Longitudinal studies are necessary to evaluate the durability of learning gains over months or years, particularly as students encounter increasingly complex programming tasks. Future research should also measure non-cognitive outcomes such as motivation, creativity, confidence, and attitudes toward coding, since these factors may mediate learning outcomes. Exploring moderating variables such as gender, socioeconomic background, and prior computer experience would also provide a more nuanced understanding of how Scratch benefits different groups of learners. Multi-site studies across diverse schools and regions help establish the generalizability of findings in different cultural and educational contexts. Moreover, developing contextually relevant Scratch projects that incorporate local culture or real-life themes could enhance student engagement and relevance, making coding education more meaningful.

This study strengthens the growing body of evidence demonstrating that Scratch is an effective medium for teaching coding at the elementary school level. The intervention not only produced statistically significant improvements but also yielded large and practically meaningful effects. These findings are consistent with both Indonesian and international research that highlights Scratch's advantages in fostering computational thinking, creativity, and motivation. At the same time, this study makes a unique contribution by directly measuring coding skills using validated instruments and employing a quasi-experimental design with a control group. The broader implications suggest that integrating Scratch into formal curricula, supporting teachers with training, and ensuring adequate infrastructure are essential for maximizing its benefits. While challenges and limitations remain, the evidence presented here provides a strong foundation for further exploring and implementing Scratch as a key component of programming education in elementary schools.

CONCLUSION

This study concludes that Scratch is a highly effective medium for improving elementary school students' coding skills. Students who learned with Scratch showed significantly greater gains than those in the control group, with a large effect size indicating both statistical and practical significance. These findings are consistent with previous research in Indonesia and abroad, which highlights Scratch's ability to foster computational thinking, motivation, and creativity through its visual, interactive, and user-friendly design. Despite limitations such as the single-school sample and the study's short-term scope, the results provide strong evidence that Scratch can be effectively integrated into the formal curriculum. To maximize its impact, teacher training, adequate infrastructure, and project-based instructional design are essential. Future research should investigate the long-term effects, measure non-cognitive outcomes, and evaluate the intervention in diverse educational contexts.

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