



The Implementation of Coding and Artificial Intelligence: A Case Study of the ICT Zainal Abidin Elementary School Curriculum

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Abstract

This study examines the implementation of coding and artificial intelligence (AI) in the curriculum at SD ICT (Sekolah Dasar Information and Communication Technology) Zainal Abidin, an elementary school in Indonesia. With the growing demand for digital literacy and technology-based competencies in the 21st century, this research aims to explore how coding and AI are integrated into the curriculum, the opportunities they offer for enhancing students' critical thinking and problem-solving skills, and the challenges encountered during implementation. Using a qualitative case study approach, data were collected through semi-structured interviews with 5 teachers and 2 school administrators, classroom observations, and analysis of curriculum documents. The interviews focused on participants' perspectives regarding the integration process, benefits, and challenges of teaching coding and AI. The collected data were analyzed using thematic analysis to identify key themes related to the integration of these subjects. The findings suggest that integrating coding and AI into the curriculum provides valuable opportunities for students to develop computational thinking, creativity, and a deeper understanding of technology. However, the research also identifies several challenges, including insufficient teacher training, limited infrastructure, and alignment issues with the national educational framework. The study highlights the importance of professional development for teachers, better resource allocation, and curriculum adjustments to ensure the sustainable integration of coding and AI in primary education. Recommendations are made for educators and policymakers to enhance the effectiveness of this integration to prepare students for a digital future better.

Keywords: Coding Education, Artificial Intelligence, Curriculum Integration, Elementary School, Digital Literacy

Introduction

In the 21st century, digital literacy has become essential as technology increasingly shapes every aspect of society. Digital literacy extends beyond basic technical skills and includes coding and artificial intelligence (AI), which are now integral parts of curricula worldwide. Coding, for instance, is not only about learning programming languages but also about developing computational thinking, a key skill that enables students to approach problems logically and systematically (Putra dkk., 2026; Sanoto dkk., 2025). Computational thinking involves problem decomposition, pattern recognition, and algorithmic thinking, which can be developed through coding activities (Wing, 2006). Research has shown that coding in primary education improves problem-solving abilities, creativity, and critical thinking skills critical for success in today's rapidly evolving technological landscape (Alino, 2025; Grover & Pea, 2013).

Alongside coding, AI education is increasingly recognized as vital for young learners, offering them insights into the algorithms and technologies that will define their future. AI literacy, as introduced in recent studies, emphasizes not only the technical aspects of interacting with AI tools but also understanding their data-driven operations, ethical

implications, and real-world applications (Luckin & Holmes, 2016). Introducing AI concepts at the elementary level provides students with the foundational knowledge to engage with these complex systems in an accessible and age-appropriate manner, preparing them for future careers in fields such as data science and automation (Khasani, 2026; Rohayati & Abdillah, 2024).

While global attention on digital literacy is rising, the adoption of coding and AI in education varies significantly across regions, particularly in developing countries. In Indonesia, national educational policies, including the Kurikulum Merdeka (Freedom Curriculum), reflect the importance of digital literacy by incorporating coding and AI as optional subjects for upper primary grades (Hosaini et. al., 2024; Mahbubi, 2024). This policy aims to equip students with foundational technology skills, ensuring they are prepared for the digital future. However, the integration of coding and AI in Indonesian primary schools is still in its early stages, with discrepancies in how schools across the country incorporate these subjects into their curricula. Challenges such as teacher training, infrastructure limitations, and resource allocation hinder widespread adoption (Dwi, 2025; Mouza et. al., 2017). The disparity in access to digital education resources, particularly between urban and rural schools, further complicates this issue.

This study focuses on SD ICT Zainal Abidin in Surakarta, Indonesia, a pioneering school in integrating coding and AI into its curriculum. As an ICT-focused institution, SD ICT Zainal Abidin's early adoption of these subjects offers valuable insights into the opportunities and challenges of integrating digital literacy in primary education within the Indonesian context (Oviana dkk., 2024). This case study provides an important example of how coding and AI can be embedded in the curriculum at the primary school level, offering opportunities to enhance students' problem-solving skills, creativity, and digital literacy (Alifah & Sukartono, 2023; Jemutai et. al., 2023).

The gap in existing literature lies in the limited research on the implementation of coding and AI at the elementary level, particularly in developing countries such as Indonesia. Previous studies have examined the integration of digital literacy in secondary and higher education (Kohnke et. al., 2025; Luckin & Holmes, 2016), but there is a lack of research on how to effectively introduce coding and AI at the primary school level. Moreover, while much of the current discourse focuses on technological integration in urban schools, there is less attention paid to how rural and underserved schools navigate these challenges. This study therefore fills a critical gap by exploring the practical implementation of coding and AI in an Indonesian primary school setting, offering new insights into the benefits and barriers of early exposure to these subjects.

This research contributes to the broader discourse on digital literacy education by providing empirical data on the integration of coding and AI at the primary school level in a developing country. By focusing on SD ICT Zainal Abidin, this study offers actionable recommendations for educators, curriculum developers, and policymakers, highlighting the need for targeted teacher professional development, better resource allocation, and curriculum adjustments to ensure the successful and sustainable integration of digital competencies in primary education.

Literature review

The integration of coding and artificial intelligence (AI) in primary education has gained widespread recognition as part of the global drive to equip students with essential digital literacy skills for the 21st century. Coding education, often seen as a tool for teaching programming languages, has evolved into a method for developing computational thinking, a foundational skill for problem-solving and innovation (Wing, 2006). Research by Grover & Pea confirms that coding education in primary schools enhances critical thinking, creativity, and problem-solving skills, which are essential for success in an increasingly digital world (Grover & Pea, 2013). Furthermore, coding promotes resilience, as it encourages students to iterate and troubleshoot, thereby deepening their understanding of failure and perseverance (Bers, 2020).

Parallel to coding, AI education is being increasingly recognized as vital for fostering a deeper understanding of the technologies that shape students' futures. Luckin & Holmes emphasize the importance of AI literacy, which goes beyond the basic interaction with AI tools to include understanding data-driven operations, ethical implications, and real-world applications. Early exposure to these concepts helps students develop foundational skills in machine learning, data analysis, and algorithmic thinking, all of which lay the groundwork for future careers in AI, data science, and automation (Luckin & Holmes, 2016).

Despite the growing integration of coding and AI across educational systems, research on their implementation remains limited, particularly at the primary school level in developing countries. While studies have focused extensively on coding and AI in secondary and higher education (Grover & Pea, 2013; Luckin & Holmes, 2016), few have explored how these subjects can be effectively integrated into primary school curricula. This gap is particularly pronounced in Indonesia, where digital literacy initiatives, including coding and AI, are still in the early stages of implementation. The challenges in implementing these subjects, particularly in rural and underserved schools, remain under-explored, particularly regarding teacher preparedness and the adequacy of infrastructure and resources (Mouza dkk., 2017).

In the Indonesian context, while national policies such as the Kurikulum Merdeka (Freedom Curriculum) aim to promote digital literacy, the integration of coding and AI into primary education is still experimental. Research by Lestari et al. shows that although coding education has improved computational thinking skills among primary students, barriers such as teacher readiness and resource constraints persist. These gaps in the literature point to the necessity for a more detailed examination of how coding and AI can be effectively implemented in Indonesian primary schools, especially in schools with limited access to resources (Quintaningrum, 2024).

The research gap lies in the lack of empirical studies on the implementation of coding and AI education at the primary school level in Indonesia, particularly in schools that have begun to integrate these subjects, such as SD ICT Zainal Abidin. Previous studies have discussed the importance of digital literacy, coding, and AI in education but have primarily focused on secondary and higher education contexts or have ignored the specific challenges faced by primary schools in developing countries. This study seeks to fill this gap by providing a case study of SD ICT Zainal Abidin, an ICT-focused school that has integrated coding and AI into its curriculum. By focusing on this school, this research aims to contribute new insights

into the practical challenges and opportunities of implementing digital literacy at the primary school level in Indonesia.

This study's novelty lies not only in its location but also in its investigation of the real-world challenges primary schools face in integrating coding and AI. While many studies highlight the importance of these subjects, few provide a detailed analysis of how these concepts are taught and what barriers schools face in their implementation. Furthermore, this research explores the broader implications of digital literacy in underserved schools, contributing to the international body of knowledge on equitable access to digital education and addressing the digital divide.

Research method

This study employs a qualitative case study design to explore the integration of coding and artificial intelligence (AI) in the curriculum at SD ICT Zainal Abidin, a primary school in Surakarta, Indonesia. A case study approach is ideal for investigating complex educational phenomena in real-world settings, providing an in-depth understanding of how these subjects are incorporated into primary education (Hennink dkk., 2020; Yin, 2018). The study aims to examine how coding and AI are taught, their impact on students' problem-solving and creativity, and the challenges educators face during implementation.

Data were collected through document analysis, semi-structured interviews, and classroom observations. Document analysis involved reviewing curriculum documents, lesson plans, and teaching materials to understand how coding and AI were structured in the school's curriculum. This approach provided insights into the scope and pedagogical strategies used to teach these subjects (Quinn Patton, 2004/2023). Semi-structured interviews were conducted with 5 teachers, the principal, and curriculum developers to explore their views on the integration process, challenges, and benefits of coding and AI education. The semi-structured format allowed flexibility while maintaining focus on the key research questions. Classroom observations were also conducted to observe the instructional methods, student engagement, and interaction with technology during coding and AI lessons. Field notes from these observations were analyzed to understand the real-time implementation of these subjects (Mahbubi, 2025; Zhang dkk., 2025).

Thematic analysis was used to identify patterns in curriculum integration, teaching practices, student outcomes, and the challenges educators face. This method provided a detailed understanding of the implementation process and allowed the study to draw meaningful conclusions about how coding and AI can be effectively integrated into primary education (Miles dkk., 2020).

To ensure trustworthiness, several strategies were applied: credibility through triangulation of multiple data sources, transferability through detailed contextual descriptions, dependability through documentation of the research process, and confirmability through minimizing personal bias in data analysis. Ethical guidelines were strictly followed, with informed consent obtained from all participants, including teachers, administrators, and parents, ensuring voluntary participation and confidentiality throughout the study.

A limitation of this study is its focus on a single case study, which may limit the generalizability of the findings. However, the insights gained from this study are valuable for

informing other schools seeking to integrate coding and AI into their curricula. As a qualitative study, it provides a deep understanding of the implementation process rather than quantifying the impact of these educational interventions.

Results

The findings of this study illustrate how coding and artificial intelligence (AI) are implemented in the curriculum at SD ICT Zainal Abidin through the interaction of institutional policy, teacher readiness, and classroom practices. Data were derived from document analysis, classroom observations, and semi-structured interviews with key stakeholders, including the principal and teaching staff.

At the institutional level, the school demonstrates a strong commitment to integrating digital competencies into primary education. This commitment is reflected in structured curriculum design and teacher development initiatives. An interview with the principal, Nonik Nataliya (P1), revealed that:

“We intentionally integrate coding and artificial intelligence into the curriculum to prepare students for future challenges. However, one of our main challenges is ensuring that all teachers are ready and confident in delivering these materials.”

This statement indicates that institutional vision and policy are clearly established, yet their effectiveness depends on teachers' classroom readiness.

Further insights from teaching staff highlight variations in pedagogical preparedness. Ana Nur Chasanah (T1), a curriculum staff member, explained:

“From a curriculum perspective, coding and AI have been systematically integrated, but in practice, teachers still need time to adapt, especially in understanding AI concepts more deeply.”

Similarly, Fadiah Azmi Rahmisari (T2), who serves as a program PIC, emphasized the challenge of implementation consistency:

“We have designed various programs to support coding and AI learning, but maintaining consistent implementation across different classes and teachers remains a challenge.”

From the perspective of student development, Qhoirul Anisa Firdaus (T3), who oversees student achievements and extracurricular activities, noted:

“Students show strong enthusiasm, especially in coding-based extracurricular activities. However, their progress also depends on how confident teachers are in guiding them during the learning process.”

These interview findings suggest that while institutional planning is well-established, practical implementation is still uneven due to differences in teacher competence and confidence.

Classroom observations further confirm that coding and AI are implemented through project-based learning approaches. Students actively engage in interdisciplinary activities combining coding, robotics, and basic AI concepts. For instance, during an observed session, students programmed simple robots to respond to environmental inputs, demonstrating early forms of algorithmic thinking and decision-making processes. This hands-on approach enables students to connect abstract concepts with real-world applications.

Student engagement during these activities was consistently high. Observations showed

that students demonstrated enthusiasm, collaboration, and persistence when working on coding projects. This finding was supported by interview data from Teacher 2 (T4), who stated:

“Students are more enthusiastic when learning through coding projects because they can directly see the results of their work.”

In terms of cognitive development, students demonstrated observable progress in problem-solving processes. They were able to break down complex tasks into smaller, manageable steps, reflecting key elements of computational thinking such as decomposition, pattern recognition, and algorithmic reasoning. However, these findings are based on qualitative observations rather than formal measurement, and therefore indicate tendencies rather than quantifiable outcomes.

Despite these positive developments, several challenges were identified. A major issue concerns teacher readiness, particularly in mastering AI-related content. Teachers acknowledged that they often rely on self-directed learning due to limited formal training. As expressed by one participant:

“We are still learning ourselves, especially for AI topics, because we have not received enough structured training.” (T4)

In addition, infrastructural limitations affect the implementation process. Although the school is relatively well-equipped, limited access to devices requires students to share computers during practical sessions. This reduces the effectiveness of learning activities, particularly in larger classes. This issue was also highlighted in interviews:

“Students often have to share computers, which makes the learning process less effective during coding practice.” (T2)

Overall, the findings indicate that the integration of coding and AI at SD ICT Zainal Abidin is progressing positively, supported by strong institutional commitment and engaging pedagogical approaches. However, challenges related to teacher readiness and resource availability continue to affect the consistency and effectiveness of classroom implementation.

Discussion

The findings of this study reveal a critical dynamic in the implementation of coding and artificial intelligence (AI) in primary education: a gap between institutional readiness and classroom-level practice. While SD ICT Zainal Abidin has established a clear institutional vision and structured curriculum integration, the variability in teacher readiness indicates that policy enactment does not automatically ensure pedagogical effectiveness. This finding is consistent with recent research emphasizing that the implementation of coding and AI education policies often encounters challenges at the level of teacher competence and classroom practice (Susanto dkk., 2026).

The interview data further highlight that teachers continue to rely on self-directed learning, particularly in mastering AI-related content. This supports the argument that teacher readiness is not merely a function of access to training but also of sustained, contextually relevant professional development. Recent studies confirm that AI and coding education in primary schools require structured and progressive training models to build both conceptual understanding and pedagogical confidence effectively. Without such support, teachers may struggle to translate curriculum design into meaningful learning experiences (Su dkk., 2024).

The implementation of project-based learning observed in this study aligns with contemporary pedagogical trends in digital education. Active, hands-on learning has been shown to enhance student engagement and creativity, particularly in coding environments where learners interact directly with problem-solving tasks. Moreover, research indicates that coding activities contribute not only to technical skills but also to broader cognitive and socio-emotional development, including collaboration and persistence (Başaran dkk., 2024). However, the findings of this study extend this perspective by demonstrating that the effectiveness of such approaches is highly dependent on teacher facilitation, which remains uneven.

Another important contribution of this study lies in its cautious interpretation of student cognitive development. While previous studies report significant improvements in computational thinking and problem-solving abilities, this research identifies observable tendencies rather than measurable outcomes. This distinction is important, as recent empirical studies also highlight that while coding and AI learning can enhance algorithmic thinking, the extent of improvement depends on instructional design and learning support mechanisms. In addition, emerging research on AI-assisted learning environments, such as ChatGPT-supported programming, shows that AI tools can enhance student confidence and learning performance, but require guided integration to be effective (Dai, 2024; Xu dkk., 2026).

The challenges identified in this study, particularly those related to teacher readiness and technological infrastructure, reflect broader systemic issues in digital education. Limited access to devices and reliance on shared resources remain significant barriers, even in relatively well-equipped schools. This finding is consistent with recent studies emphasizing that successful AI and coding integration requires not only curriculum innovation but also equitable access to technological resources and sustained investment in teacher capacity building (Dai, 2024).

From a practical perspective, this study suggests that integrating coding and AI in primary education should be approached as a long-term developmental process. Schools must move beyond short-term training initiatives toward continuous professional development systems that are adaptive to emerging technologies. In addition, school leadership plays a crucial role in bridging the gap between institutional policy and classroom implementation by fostering a supportive and collaborative learning environment for teachers.

In terms of theoretical contribution, this study provides a nuanced understanding of digital literacy implementation in primary education by highlighting the interplay between institutional structures, teacher agency, and classroom realities. It demonstrates that successful integration of coding and AI is not solely determined by curriculum design, but by the alignment between policy, pedagogy, and practice.

This study offers a novel contribution by uncovering the gap between institutional readiness and classroom-level implementation in the integration of coding and artificial intelligence (AI) in primary education. Unlike previous studies that primarily focus on the effectiveness of coding and AI learning outcomes, this research provides an in-depth qualitative analysis of how these innovations are enacted in real classroom settings. By integrating perspectives from school leadership, curriculum staff, and teachers, this study highlights the critical role of teacher agency and practical constraints in shaping the success of

digital education initiatives. Furthermore, it advances the literature by positioning coding and AI integration not merely as a technological or curricular issue, but as a complex interaction between policy, pedagogy, and institutional capacity within the context of developing education systems.

Conclusion

This study demonstrates that the integration of coding and artificial intelligence (AI) in primary education at SD ICT Zainal Abidin is driven by strong institutional commitment and innovative pedagogical approaches, particularly through project-based learning. However, the effectiveness of implementation is significantly shaped by disparities in teacher readiness and limitations in technological resources.

The findings highlight that successful integration of coding and AI is not solely dependent on curriculum design or institutional policy, but on the alignment between policy intentions and classroom practices. In this context, teacher competence emerges as a critical mediating factor that determines whether digital learning initiatives can be effectively translated into meaningful student experiences.

This study contributes to the literature by providing empirical evidence of the gap between institutional readiness and pedagogical implementation in a primary education setting, particularly within a developing country context. It underscores the importance of sustained, context-sensitive professional development and equitable access to technological infrastructure as prerequisites for successful digital transformation in education.

Future research is recommended to explore longitudinal impacts of coding and AI integration on students' cognitive and socio-emotional development, as well as to examine scalable models of teacher training that can support consistent implementation across diverse educational settings.

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