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Integration of Coding and Artificial Intelligence (AI) Subjects in Primary School Curriculum as an Effort to Improve 21st Century Skills

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Abstract

The integration of coding and atificial intelligence (AI) subjects into the primary school curriculum is a strategic innovation to prepare the younger generation to face the challenges of the 21st century in the digital era and society 5.0. Through coding and AI learning, students are not only taught how to use technology, but also trained to think critically, creatively, collaboratively, and communicatively. This literature review aims to examine the urgency, challenges, and opportunities of integrating coding and AI in primary schools an effort to improve 21st century skills. The results of the study indicate that this integration can strengthen digital literacy, computational thinking skills, and encourage personalised learning that is relevant to future needs. However, the success of implementation depends heavily on infrastructure readiness, teacher competence, and adequate policy support. Multi-stakeholder collaboration is key to overcoming obstacles and ensuring equitable access to quality education. With the right strategies, the integration of coding and AI in primary schools can be a long-term investment in building a generation that is outstanding, adaptive, and ready to compete globally.

Keywords: coding, artificial intelligence, primary school curriculum, 21st century skills, digital literacy

INTRODUCTION

The integration of coding and artificial intelligence (AI) subjects into the primary school curriculum marks a new chapter in Indonesian education. This initiative is a concrete response to the rapid advancement of digital technology, which has transformed various aspects of life, including how we learn and work (Kim et al., 2021). The government, through the Ministry of Education and Culture, has implemented a strategic policy by introducing coding and AI as elective subjects at the primary, secondary, and high school levels starting from the 2025/2026 academic year. This policy is expected to equip Indonesia's youth with relevant skills to tackle the challenges of the digital age and society 5.0 (Huang & Lee, 2024); (Judijanto & Aslan, 2025).

The digital era is a period in which information and communication technology, such as the internet, computers, and smart devices, which are inseparable from human life, are driving transformation in various fields, from economics and education to social issues. Society 5.0 is the next phase of the digital era, placing humans at the centre of innovation by leveraging advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), and big data to address social challenges and enhance the quality of life (UNESCO, 2024). The concept of Society 5.0 emphasises the harmonious integration of the physical and digital worlds, where technology not only accelerates automation but also supports the creation of an inclusive, sustainable, and human-centred society (Patel, 2023).

The urgency of integrating coding and AI in primary education is driven by the need to promote literacy, but also to foster critical thinking, creativity, and problem-solving skills from an early age. In the midst of the 4th industrial revolution and the transition to a 5.0 society, mastery of digital technology has become a fundamental competency that every individual must possess. Coding and AI are not merely trends but essential requirements in today's era (Wang et al., 2024).

The government recognises that mastery of coding and AI is extremely helpful in today's increasingly complex and competitive field of education. Abdul Mu'ti, Minister of Primary and Secondary Education, emphasised that technological skills such as coding and AI are key to preparing a generation that is able to

compete on the global stage. Additionally, coding and AI education are expected to enhance numeracy, literacy and foster critical thinking, empathy, and high digital literacy among students (Garcia et al., 2024).

The implementation of this policy requires a well-thought-out and inclusive strategy. The government has held various discussions/ FGDs for school principals, teachers, and coding and AI teaching communities to formulate effective learning models that are tailored to local needs. One of the main challenges is the infrastructure gap between schools in urban and remote areas, so the integration of coding and AI is being implemented in schools that are already prepared in terms of facilities and teaching staff (Newton & Smith, 2023). The importance of multi-stakeholder collaboration is also highlighted in these efforts. The government cannot act alone but must collaborate with the private sector, academia, communities, and civil society organisations to support teacher capacity development and the provision of learning infrastructure. Training programmes and technical guidance for teachers are key steps to ensure the quality of coding and AI instruction in primary schools (Alindra & Dkk., 2024).

In terms of material, coding lessons in primary schools will use visual and interactive approaches, such as Scratch or Blockly, which are designed to suit children's cognitive development stages. Meanwhile, AI will be introduced through simple concepts that emphasise understanding logic, patterns, and the ethics of using technology (Saha, 2024).

The integration of coding and AI is also expected to promote technology-based personalised learning, enabling each student to develop their potential and interests optimally. Research indicates that technology-based learning can enhance creativity, computational thinking, and technological literacy among students, which are essential for future preparedness (Arslan & Çelik, 2022).

However, the challenges faced are not insignificant, given the limitations in terms of infrastructure, human resources, and other constraints. Therefore, regular monitoring and evaluation are essential to assess the effectiveness and impact of integrating coding and AI into the primary school curriculum (Ahmad & Zhang, 2024). This policy has also received various responses from the public. Some argue that basic literacy skills such as reading and arithmetic should remain a priority, but the majority of stakeholders who understand the importance of digital skills support the government's initiative.

Ultimately, integrating coding and AI into the primary school curriculum is a strategic step towards preparing the younger generation to not only be technologically literate, but also possess the character and skills needed in the 21st century. With synergy between the government, schools, and the community, it is hoped that Indonesian education will be able to produce a generation that is ready to face global challenges and actively contribute to the development of the nation in the digital age.

METHOD

The research method used in this study is a literature review or desk-based research with a descriptive qualitative approach, which involves collecting, reviewing, and analysing various relevant literature sources such as scientific journals, books, policy documents, and research reports related to the integration of coding and artificial intelligence (AI) in the primary school curriculum (Booth, 2020). The data obtained from the literature were systematically selected based on their relevance to the topic, then analysed to identify themes, patterns, and recommendations that support the development of 21st century skills in primary school students.

RESULT AND DISCUSSION

Integrating Coding and AI into the Primary School Curriculum Can Enhance 21st Century Skills

Coding and AI, when implemented at the primary level, are designed to prepare the younger generation to tackle the challenges of the digital age and Society 5.0. This initiative not only aligns education with technological advancements but also aims to equip students with the essential 21st-century skills required for the future (Arranz Garcia et al., 2025).

The early implementation of coding and AI in primary schools aims to build a foundation in computational thinking, logic, and problem solving. Through this learning, students are encouraged to understand how technology works, not just as users, but also as creators and innovators in the digital field. One of the main benefits of integrating coding and AI is improved critical thinking skills. Students are educated through various exercises to prepare for this. This process is crucial in developing a logical and structured way of thinking, which forms the foundation of 21st century skills (Ramadhan & Dkk., 2020).

In addition to critical thinking, learning coding and AI also encourages creativity. Students are given space to express their ideas through the creation of applications, games, or simple digital projects. This creativity is not limited to technical aspects, but also teaches students to solve everyday problems with

innovative approaches. Collaboration is another important skill honed through coding and AI projects. Many tasks are completed in teams, so students learn to share roles, communicate effectively, and work together to achieve common goals. This experience is highly relevant to the needs of the modern workplace, which demands the ability to work in cross-disciplinary teams (Tan, 2024).

The integration of coding and AI in primary schools also strengthens digital literacy. Students not only understand how to use technology but also grasp the underlying principles of the applications and devices they use. This digital literacy is an essential foundation for addressing the challenges of the information age. Additionally, exposure to AI helps students understand concepts such as data analysis, prediction, and automation. They learn how technology can be used to process information and make data-driven decisions, which is highly relevant to future needs.

Coding and AI learning in primary schools is designed with a fun approach that is appropriate for children's developmental stages. The material is delivered through games, creative projects, and simulations, so that students do not feel overwhelmed and remain enthusiastic about learning. The implementation of this curriculum also takes into account students interests and talents. Coding and AI can be offered as elective subjects, allowing students who are interested to delve deeper into the subject, while others receive a foundational introduction that is equally beneficial (Hikmawati et al., 2023). In terms of readiness, the implementation of coding and AI integration requires infrastructure support, teacher training, and multi-stakeholder collaboration. The government, schools, and educational communities need to work together to ensure equitable access and quality of learning across all regions.

Challenges include limited resources, digital divides, and resistance to change. However, with the right strategies, these obstacles can be overcome through training, mentoring, and the development of adaptive curricula. The long-term benefits of integrating coding and AI in primary schools include producing graduates who are ready to face the future workplace, which is ultimately the goal for success in the 21st century (Kotsis, 2024).

Mastering coding and AI simultaneously prepare students for careers in various fields, ranging from technology, business, to the creative industry. Students who are familiar with technology from an early age will find it easier to adapt to changes and innovations in the future. In addition to technical aspects, learning coding and AI also instils ethical values, responsibility, and the wise use of technology. Students are encouraged to understand the social and ethical impacts of technology, enabling them to become responsible users and developers of technology (Awaluddin & Hadi, 2025).

Thus, the integration of coding and AI in primary school curricula is not merely an educational innovation, but a long-term investment in building a generation that is superior, adaptive, and ready to compete in the global era. Education that is responsive to the times will be the main foundation for the nation's progress in the future.

Challenges and Opportunities in Implementing Coding and AI in the Primary School Curriculum

The integration of coding and AI at the basic level is a very appropriate step to prepare the younger generation to face the challenges of the digital era and society 5.0. However, the implementation of this policy is not without complex challenges, while also opening up great opportunities for national education transformation (Tan, 2024). One of the main challenges is the limited technological infrastructure in many primary schools, especially in remote areas. The availability of computers, internet access, and adequate laboratories remains a significant obstacle that must be overcome to ensure that coding and AI education can be implemented effectively (Yeter, 2024).

In addition, the lack of competent human resources is also a significant obstacle. Many primary school teachers do not have sufficient technological background to teach coding and AI. The lack of training and mentoring makes teachers feel less confident in implementing this new material, so a continuous and structured training programme is needed. Resistance to change also often arises, both from teachers, parents, and students. Concerns that adding coding and AI to the curriculum will overload students and reduce their focus on basic literacy skills such as reading and arithmetic remain a topic of debate among the public (Moore et al., 2024).

The digital divide between urban and rural schools widens inequality in the quality of education. Students in areas with limited access to technology are at risk of falling behind in digital skills, making efforts to equalise access very important. Implementation costs also pose a significant challenge. Procuring hardware, software, and teacher training requires substantial investment, leading many schools to rely on government assistance or external sponsors to meet these needs (Edvative Learning, 2024).

An inflexible curriculum is also an obstacle to the integration of coding and AI. A dense curriculum limits the space for new material, so effective integration strategies are needed to avoid sacrificing other subjects that are also important for student development. Public perceptions of coding and AI also need to

be addressed. Many people believe that coding is only for children interested in technology, whereas these skills are a new form of literacy that is important for all students, regardless of their academic background (Susanti, 2025).

The development of relevant material that is appropriate for the cognitive development stage of primary school children is the next challenge. Coding and AI materials must be designed in an applied, contextual, and engaging manner to ensure students do not feel overwhelmed and remain enthusiastic about learning. On the other hand, the integration of coding and AI opens up significant opportunities for technology-based learning. Students can learn according to their interests and abilities, thereby maximising their potential (Davis & MacDonald, 2024).

Coding and AI education aims to hone student creativity, critical thinking, collaboration, and digital literacy. These skills are essential for facing future challenges and will be important assets in an increasingly digital world of work. Multi-stakeholder collaboration is key to the successful implementation of this policy. Governments, schools, communities, and the industry must work together to accelerate knowledge transfer, provide infrastructure, and develop relevant teaching materials (Li & Tang, 2023).

Policy and regulatory support from the government also presents a significant opportunity to accelerate the adoption of coding and AI in primary schools. Clear policies and structured teacher training programmes can provide certainty and direction for schools in implementing the new curriculum. The use of interactive and project-based platforms in coding and AI education can enhance students motivation and engagement in the learning process, enabling them to be more active and creative in developing new ideas (Wang et al., 2024).

The integration of coding and AI also drives innovation in learning methods, such as project-based, collaborative, and exploratory learning. This can create a more meaningful learning experience that is relevant to the needs of the times. Continuous evaluation and improvement are essential in the implementation of coding and AI. This evaluation is important to identify obstacles and make improvements so that the goals of developing 21st century skills can be achieved effectively. The long-term benefits of integrating coding and AI in primary schools are the creation of graduates who are ready to face the future world of work (Liu, 2023). They will not only master technology, but also other forms of creativity. Mastering coding and AI also open up broader career opportunities across various fields, from technology, business, to the creative industry.

In addition to technical aspects, learning coding and AI also instils ethical values, responsibility, and wise use of technology. Students are encouraged to understand the social and ethical impacts of technology, enabling them to become responsible users and developers of technology. Thus, the integration of coding and AI into the primary school curriculum is not merely an educational innovation but a long- investment in building a generation that is outstanding, adaptable, and ready to compete in the global era (Baker, 2023).

The success of coding and AI integration depends heavily on infrastructure readiness, teacher competence, policy support, and multi-stakeholder collaboration. By overcoming obstacles and capitalising on existing opportunities, Indonesian education can produce a generation that is not only technologically literate, but also creative, innovative, and ready to face the challenges of the 21st century.

CONCLUSION

The integration of coding and artificial intelligence (AI) into primary school curricula is a strategic step towards equipping young people with the 21st century skills that are so essential in the digital age. Through coding and AI education, students are not only taught how to use technology, but also trained to think critically, creatively, collaboratively, and communicatively. These skills form a crucial foundation for addressing global challenges and the rapid advancement of technology.

The early implementation of coding and AI has been proven to improve student creativity, computational thinking skills, and digital literacy. In addition, this integration also encourages personalised learning, strengthens problem-solving skills, and fosters curiosity about technology. With the right approach, students can develop their potential optimally and be ready to adapt to changes in the modern world.

However, the success of coding and AI integration depends heavily on infrastructure readiness, teacher competence, and adequate policy support. Collaboration between the government, schools, and the community is key to overcoming implementation challenges and ensuring equitable access to quality education. With a well thought out strategy, the integration of coding and AI in primary schools will be a long-term investment in creating a generation that is superior, adaptive, and ready to compete in the future.

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