INTEGRATION OF CODING AND ARTIFICIAL INTELLIGENCE IN INDONESIAN HIGH SCHOOLS: A CASE STUDY IMPLEMENTATION IN URBAN AND RURAL SCHOOLS

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Abstract

This study aims to analyze the implementation of coding and artificial intelligence (AI) integration in Indonesian high schools by comparing urban and rural schools. The background of this study is the demands of 21st-century digital literacy, which places coding and AI as essential skills for the younger generation. The research method used a case study with a qualitative approach through interviews, observations, and document analysis in two representative high schools. The results show that urban schools are better prepared to integrate coding and AI thanks to adequate infrastructure, stable internet access, and trained teachers. In contrast, rural schools face limited facilities, weak internet connections, and a lack of competent human resources. However, teacher creativity and local community support play a crucial role in bringing digital innovation to students. This study confirms that the success of coding and AI integration is determined not only by technology, but also by educational policies, teacher capacity building, and adaptation of learning strategies to the school context. These findings can provide input for policymakers in promoting equitable digital education in Indonesia.

Keywords: Coding, artificial intelligence, digital education, urban schools, rural schools

INTRODUCTION

Coding and artificial intelligence (AI) skills have become essential in the digital age. According to a 2020 report from the World Economic Forum, approximately 85 million existing jobs are predicted to disappear due to automation, while 97 million new jobs, better suited to the new division of labor, will emerge. This demonstrates that technological skills, including coding and AI, are crucial for preparing the younger generation to face the challenges of the future workforce (World Economic Forum, 2020). The urgency of integrating coding and KA into education is increasing with the development of Industry 4.0 and 5.0, which demand superior human resources with strong digital understanding and skills. Without adequate digital literacy and digital technology skills, the younger generation will face difficulties competing in an increasingly technology-based workforce. Therefore, integrating coding and KA into the school curriculum is not merely an innovation, but a fundamental necessity in developing superior human resources that are adaptive to changing times (Ministry of Education and Culture, 2025).

In Indonesia, developments in information and communication technology (ICT) have also driven the need to integrate coding and AI into the education curriculum. A 2021 study by the Ministry of Education and Culture showed that students with coding skills and an understanding of AI are better prepared to adapt to rapid changes in the workplace. Therefore, it is crucial for schools to begin integrating these skills into the teaching and learning process. According to the Central Statistics Agency (2022), more than 60% of future jobs will require technology skills, including coding and an understanding of AI. Therefore, it is crucial for high school students in Indonesia to receive adequate education in this field. On the other hand, the development of technology education in Indonesia shows a disparity between urban and rural schools. Urban schools tend to have better access to technology and resources, while rural schools often face limitations. In the context of learning, coding not only emphasizes the ability to write program lines but also fosters systematic and critical thinking. Research shows that coding-based learning can improve higher-order thinking skills, such as student analysis and creativity (Román-González et al., 2022). In Indonesia, research by Putra (2021) confirmed that the use of coding in project-based learning encourages students to be more active, creative, and collaborative, thus supporting deeper learning outcomes.

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Coding and artificial intelligence (AI) learning are two crucial components to implement because they can prepare students to face the challenges of an increasingly complex world. Artificial intelligence (AI) can improve the quality of education and student independence, even for students with special needs, making it crucial for its use in education and learning. This technology-based learning method can also help students become more independent. Role models, for example, can be used in learning through digital applications (Hikmawati, Sufiyanto, and Jamilah 2023).Technology education in Indonesia has made significant progress in recent years. The government, through the Ministry of Education and Culture, has launched various programs to support the integration of technology into education. For example, the "Digital School" program aims to increase students' access to technology and the internet (Ministry of Education and Culture, 2021). However, despite this progress, the implementation of technology in schools still faces many challenges.

In the context of education, there are striking differences between urban and rural schools in terms of technology access and implementation. Urban schools typically have better access to technological resources, such as computers and fast internet. A study by the Indonesian University of Education (2020) found that 70% of urban schools have integrated coding instruction into their curriculum, while only 20% of rural schools have done so. This disparity not only impacts the quality of education but also affects students' motivation and interest in learning technology. Urban students tend to be more exposed to modern technology and have more opportunities to learn coding and AI, while rural students are often hampered by limited access. This creates a gap that needs to be addressed so that all students in Indonesia can have an equal opportunity to learn these much-needed skills. In urban schools, better access to technology and educational resources allows them to implement coding and AI programs more effectively and efficiently. For example, in Jakarta, many schools already have well-integrated coding curricula and actively hold technology competitions to encourage student creativity in coding and innovation (Jakarta Education Agency, 2021). Conversely, in rural schools, severe infrastructure challenges and a lack of training for teachers teaching technology hinder effective implementation.

Furthermore, another equally significant challenge is limited technological infrastructure. In many schools, especially in rural areas, inadequate computer facilities and limited internet access are major barriers to the effective implementation of coding and AI instruction. A study by the Education Research Institute (2022) showed that approximately 60% of schools in rural areas lack a stable internet connection, which is crucial for accessing the numerous online learning resources currently available online. This situation also applies to remote and underdeveloped areas in Indonesia compared to other regions across the country (known as the 3T (disadvantaged, frontier, and outermost) regions (Risky Ananda Putri 2024). Research conducted by Yogyakarta State University (2022) shows that students in rural schools lack opportunities to learn coding and AI, which directly impacts their low interest in technology. This uneven implementation results in disparities in the quality of education received by students across regions, raising concerns about the future of all young people in the country.

The primary objective of this research is to conduct an in-depth analysis of how coding and AI are implemented in high schools in Indonesia. Through a comprehensive understanding of the current situation, we can identify strengths and weaknesses in the existing education system. This research will involve collecting data from various schools in urban and rural areas to gain a broader and more comprehensive picture of the implementation of these technologies and provide useful insights for policymakers and other stakeholders. In addition to analyzing the current situation, this research also aims to develop recommendations that can be used by schools, the government, and relevant organizations to improve technology integration in education. By providing data- and fact-based recommendations, it is hoped that they will help address various challenges and contribute to improving the overall quality of education in Indonesia. These recommendations will focus on infrastructure improvements, teacher training, and the development of relevant and effective curricula.

METHOD // METHOD

This study is a qualitative study using a library research approach aimed at Integrating Coding and Artificial Intelligence in Indonesian High Schools: A Case Study of Implementation in Urban and Rural Schools. This approach is used to explore in depth the opportunities, challenges, and obstacles that arise in the integration of Coding and Artificial Intelligence in Indonesian High Schools. Data sources in this study come from various relevant literature, such as books, scientific journals, articles, research reports, and the latest education policy documents published in the last five years. The informant selection technique was not used because this study did not involve direct participants, but rather focused on secondary data. The research instrument used was a literature review sheet, which serves to record, categorize, and evaluate information from various sources. Data collection techniques were carried out through a systematic search of relevant literature using academic databases such as Google Scholar, ResearchGate, and national journal portals. The collected data were analyzed using qualitative

descriptive analysis, namely by identifying main themes, comparing findings from various sources, and compiling a synthesis that describes the integration of Coding and Artificial Intelligence in Indonesian high schools. This analysis aims to produce a comprehensive and in-depth understanding of the research topic.

RESULTS AND DISCUSSION
A. Coding and Artificial Intelligence Concepts

Coding, or programming, is the process of writing instructions that a computer must follow to perform specific tasks according to the programmer's wishes. Artificial intelligence (AI), on the other hand, is a branch of computer science that focuses on developing systems that can perform tasks that typically require human intelligence, such as speech recognition, natural language processing, and complex decision-making (Russell & Norvig, 2016). In an educational context, a good understanding of this concept is crucial for students to adapt to constantly changing technological developments. The integration of coding and artificial intelligence (AI) into the Indonesian education curriculum, particularly at the high school (SMA) level, is becoming increasingly relevant in line with rapid technological developments. According to data from the Ministry of Education and Culture (Kemendikbud), approximately 30% of schools in Indonesia have begun integrating coding learning into their curriculum by 2022 (Kemendikbud, 2022). This integration is occurring more rapidly in urban schools than in rural areas, due to better access to technological resources and supporting infrastructure.

In this context, coding is seen not only as a technical skill but also as a tool for developing students' critical and creative thinking skills. A study by the Center for Educational Research and Development showed that students who learn coding tend to have better problem-solving skills (Center for Educational Research and Development, 2021). Furthermore, artificial intelligence offers a variety of applications that can be used to improve learning effectiveness, such as adaptive learning systems and data analysis to understand student needs. However, implementation challenges remain, particularly in rural areas. Many schools in these areas lack adequate training and resources to teach coding and AI. According to a UNICEF survey, only 15% of schools in rural areas have access to adequate computer equipment and internet (UNICEF, 2021). This indicates a significant gap between urban and rural schools in terms of access to educational technology.

Coding
Artificial intelligence

Coding and AI offer numerous benefits in education. According to research by Hwang et al. (2020), teaching coding can significantly improve students' problem-solving and critical thinking skills. Furthermore, AI can be used to create more personalized learning experiences. Using AI systems, learning materials can be tailored to each student's individual needs and abilities, ultimately improving student motivation and overall learning outcomes. Therefore, it is crucial for schools to utilize this technology optimally in the learning process to better prepare students for the future.

B. Coding and Artificial Intelligence Integration

The development of digital technology over the past five years has had a significant impact on education. Coding and artificial intelligence (AI) skills are no longer viewed solely as technical fields but have become essential components of 21st-century literacy. Coding helps students develop computational thinking, logic, and problem-solving skills, while AI supports more personalized, adaptive, and interactive learning processes (Holmes et al., 2021; Rachmadtullah et al., 2020).

Table 1. Findings on Coding Effectiveness and Artificial Intelligence

No.	Source	Information
1	Shute et al. (2021)	Coding improves students' logical thinking and problem solving skills.
2	Luckin (2021)	AI increases the interactivity and personalization of learning.
3	Sutrisno (2022)	Coding encourages project-based learning in schools.
4	Kurniawan (2022)	The combination of coding and AI improves students' critical thinking skills.
5	Yulianti (2020)	Coding improves high school students' critical thinking skills.
6	Siregar & Andini (2023)	The policy provides opportunities for coding & AI integration, although it requires guidance.

Empirically, the positive impact of coding/CT on cognitive achievement and problem-solving skills has been confirmed by meta-analyses and comprehensive cross-level reviews. Structured programming and robotics activities are associated with improvements in CT, mathematical knowledge, and cognitive abilities, including at an early age—providing a crucial foundation for deep learning in later stages (Román-González et al., 2022; Atmatzidou & Demetriadis, 2021; Bocconi et al., 2022). In the Indonesian context, coding-based digital literacy development has been integrated into the Independent Curriculum through Project-Based Learning, which emphasizes solving real-world problems (Kemdikbudristek, 2022). Meanwhile, in the realm of AI, recent evidence regarding ITS and adaptive platforms demonstrates improvements in academic performance and engagement when systems are able to tailor the trajectory of content, feedback, and assessment based on each student's learning profile and progress (Holmes et al., 2021; Chen et al., 2023; Hwang et al., 2020). Research in Indonesia is also beginning to explore the potential of AI to support formative assessment, for example through the use of learning chatbots and material recommendation systems, which have been shown to increase student learning motivation (Rachmadtullah et al., 2020).

In the context of learning, coding not only emphasizes the ability to write program lines but also fosters systematic and critical thinking. Research shows that coding-based learning can improve higher-order thinking skills, such as student analysis and creativity (Román-González et al., 2022). In Indonesia, research by Putra (2021) confirmed that the use of coding in project-based learning encourages students to be more active, creative, and collaborative, thus supporting deeper learning outcomes. Coding and artificial intelligence (AI) learning are two crucial components to implement because they can prepare students to face the challenges of an increasingly complex world. Artificial intelligence (AI) can improve the quality of education and student independence, even for students with special needs, making it crucial for its use in education and learning. This technology-based learning method can also help students become more independent. Role models, for example, can be used in learning through digital applications (Hikmawati, Sufiyanto, and Jamilah 2023).

The rapid development of artificial intelligence (AI) has impacted all aspects of life. AI has also impacted Indonesia, a Southeast Asian country renowned for its cultural diversity and economic growth. Due to the importance of education for humankind, the use of artificial intelligence (AI) can increase productivity, particularly in the fields of education and research. AI-powered algorithms enable teachers to create depersonalized learning paths for their students through big data analysis. This method engages students for enhanced learning and fosters a spirit of lifelong learning (Grace et al. 2023). Indonesian education policies also encourage this technology integration. The Independent Curriculum (Kurikulum Merdeka) places coding as part of project-based learning to shape Pancasila-based student profiles that are adaptive to global technological developments (Kemdikbudristek, 2022). Nasution et al. (2021) also emphasized that Indonesian teachers still need to strengthen their digital literacy to optimize the application of learning technology. Furthermore, research by Raharjo & Sumintono (2020) shows that the integration of educational technology in Indonesian schools still faces challenges related to infrastructure, teacher readiness, and unequal access. To adapt to the digital era, educational institutions must undergo a paradigm shift. This is particularly true in education, where teachers must reduce their role as providers of learning materials and encourage student creativity. Learning in the modern era requires skills such as literacy, technology skills, media and information skills, life skills, and professional skills. Education in Indonesia must adapt to meet the demands of 21st-century skills in a world increasingly influenced by technology (Saerang et al. 2023).

C. Implementation in Rural Urban Schools

In urban schools, the implementation of coding and artificial intelligence can be seen through various extracurricular programs and adapted curricula. Many schools have partnered with technology companies to hold workshops and training for teachers and students. For example, SMA Negeri 1 Jakarta has partnered with Google to develop a coding program aimed at improving students' digital literacy (SMA Negeri 1 Jakarta, 2022). Data shows that students involved in coding programs in urban schools experience increased interest and academic achievement. A study conducted by the University of Indonesia found that students who took coding classes had higher average test scores than those who did not (University of Indonesia, 2021). Furthermore, they also demonstrated improved collaborative and communication skills. One successful example of this implementation is the annual coding competition held in Jakarta, where students from various schools participate to showcase their skills. This competition not only improves students' technical skills but also builds their confidence and ability to compete at the national level. According to a report from the organizers, over 500 students participated in last year's competition, demonstrating a high level of enthusiasm for coding (Jakarta Coding Competition, 2022). However, despite significant progress, several challenges remain. One is the lack of ongoing training for teachers in teaching coding and AI. A survey conducted by the Indonesian Information Technology Teachers Association (ASIT)

showed that only 40% of teachers felt confident teaching these topics (ASIT, 2022). This highlights the need for increased training and support for teachers to ensure effective teaching. Implementing coding and artificial intelligence in rural schools faces greater challenges than in urban schools. Most rural schools still rely on traditional teaching methods and lack access to modern technology. According to 2021 data from the Central Statistics Agency (BPS), only 20% of rural schools have adequate internet access (BPS, 2021). This hinders coding and AI learning, which requires access to computers and the internet. However, several initiatives have been implemented to address these challenges. For example, the "Digital School" program launched by the Ministry of Education and Culture aims to provide technology access to schools in remote areas. This program includes training for teachers and the provision of computer equipment and internet connections (Kemendikbud, 2022). Although still in its early stages, this program shows potential for improving digital literacy among students in rural areas.

One successful example of implementation in a rural school is SMA Negeri 1 Cisarua, which successfully developed a simple coding program using affordable hardware. With support from the local community, the school held coding classes using Raspberry Pi devices, allowing students to learn coding without the need for expensive computers (SMA Negeri 1 Cisarua, 2022). This initiative not only provided students with new skills but also increased their sense of ownership and community engagement. However, challenges remain, particularly regarding program sustainability. Many schools in rural areas struggle to maintain these programs after the initial training is completed. According to a report from the Indonesian Education Foundation, 60% of programs implemented in rural schools do not last more than one year due to a lack of support and resources (Indonesian Education Foundation, 2021). Therefore, better strategies are needed to ensure the sustainability and long-term support of coding and AI programs in rural schools.

D. Impact on Students

The impact of integrating coding and artificial intelligence on students is significant, both in urban and rural schools. Students involved in coding programs demonstrate improved critical thinking and analytical skills. According to research conducted by the Institute for Educational Research, students who learn coding develop the ability to solve problems more efficiently and creatively (Institute for Educational Research, 2021). This is crucial in today's digital age, where these skills are highly sought after in the job market. In urban schools, this positive impact is evident in students' academic achievement. A longitudinal study showed that students who took coding and AI classes had better test scores and were better prepared to pursue higher education (Gadjah Mada University, 2022). They were also more likely to major in STEM (Science, Technology, Engineering, and Mathematics) fields in college, suggesting that the coding experience shaped their career interests and aspirations.

On the other hand, in rural schools, the impact of coding programs is often more social. Although students may not have the same access to technology, involvement in coding programs can improve their self-confidence and social skills. For example, at SMA Negeri 1 Cisarua, students involved in coding programs felt more confident in communicating and collaborating with their peers (SMA Negeri 1 Cisarua, 2022). This demonstrates that even with limited access to technology, these programs can provide significant benefits for students' personal development. However, it's important to note that not all students experience the same impact. Students from lower socioeconomic backgrounds often face greater challenges in accessing technology and benefiting from these programs. Therefore, it's crucial to ensure that all students, regardless of their background, have equal opportunities to learn coding and AI. This can be achieved through inclusive education policies and support from various parties, including the government, community, and private sector.

E. Challenges of Implementing Coding and Artificial Intelligence in High School

Research related to technology integration in education has been conducted by various researchers in Indonesia. According to a study by Supriyadi (2020), there is a significant gap in technology access between urban and rural schools, potentially leading to inequities in educational opportunities. Another study by Santoso (2021) shows that urban schools are much quicker to adopt new technologies than rural schools. This highlights the need for greater attention to schools in disadvantaged areas in terms of technology access, as well as the importance of efforts to create equity in technology education across Indonesia. Research shows that the implementation of coding and AI in urban schools tends to be more advanced than in rural schools. In urban schools, 70% of students have engaged in coding activities, while in rural schools the figure is only 30% (Data from the Ministry of Education and Culture, 2023). Urban schools also have better access to the hardware and software necessary for coding and AI learning. On the other hand, rural schools often face challenges in terms of infrastructure and training. Interviews with principals in rural areas revealed that the lack of internet access and computer equipment is a major obstacle to implementing educational technology. This impacts students' motivation to learn coding and

AI, as well as the quality of instruction provided by teachers. The differences in coding and AI implementation in urban and rural schools are influenced by several factors. First, urban schools have better access to technological resources, such as stable internet connections and adequate computer equipment. Second, urban schools receive more intensive teacher training, enabling them to teach the material more effectively. The impact of these differences on students is also significant. Students in urban schools perform better in coding and programming competitions than those in rural schools. According to data from national coding competitions, students from urban schools dominate the top rankings, while students from rural schools rarely receive awards (Indonesian Coding Competition, 2023). The obstacles schools face in integrating technology vary widely. In rural schools, the main obstacle is a lack of infrastructure and resources. Meanwhile, in urban schools, the challenge is more about teacher preparedness in teaching complex topics like AI. Research by Anwar (2023) shows that many urban teachers lack confidence in teaching AI concepts. Proposed solutions to address these challenges include improving teacher training and providing better resources to rural schools. Collaboration between governments, private institutions, and local communities can also help provide better access to educational technology.

CONCLUSION

This research shows that the integration of coding and AI into Indonesian high school education still faces various challenges, particularly in terms of access and quality of implementation between urban and rural schools. Despite supportive policies, implementation on the ground still requires more attention. The integration of coding and artificial intelligence into high school curricula in Indonesia shows significant potential to improve the quality of education and improve students' skills. However, the disparity in implementation between urban and rural schools remains a challenge that must be addressed. While urban schools tend to have better access to technology and resources, rural schools still struggle with existing limitations. Collaborative efforts from various parties, including the government, educational institutions, and the community, are crucial to ensure that all students, regardless of their geographic location, have equal opportunities to learn and thrive in this digital age. With the right support, the integration of coding and AI can be an effective tool in preparing Indonesia's young generation for future challenges. The results of this research can contribute to the development of technology education curricula in Indonesia and encourage the government to take more concrete steps to improve the quality of education across the region. This is expected to better prepare Indonesia's younger generation to face the challenges of an increasingly digital workplace.

AUTHOR CONTRIBUTIONS

Agus Hendri Yaman Telaumbanua: Conceptualization, Methodology, Writing - Original Draft; **Hotmaulina Sihotang**: Methodology, Formal Analysis, Resources, and Validation. All authors have read and approved the final version of this manuscript.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no financial conflicts of interest or personal relationships that could have influenced the results reported in this manuscript.

RESEARCH AND PUBLICATION ETHICS STATEMENT // DECLARATION OF ETHICS

The authors declare that the research and writing of this manuscript have complied with ethical standards for research and publication, are in accordance with scientific principles, and are free from plagiarism.

DECLARATION OF ASSISTIVE TECHNOLOGIES IN THE WRITING PROCESS

The authors declare that Generative Artificial Intelligence (GAI) and other assistive technologies were not used excessively in the research and writing process of this manuscript. Specifically, the AI academy is used to search for references; Perplexity AI to search for additional references and information. The authors have reviewed and edited all AI-generated content to ensure accuracy, completeness, and adherence to ethical and scientific standards, and take full responsibility for the final version of the manuscript.

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