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AI and Coding Curriculum from Elementary to Vocational High School: Impacts on Teacher and Student Competencies in the Digital Education Era

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Abstract
This study explores the integration of Artificial Intelligence (AI) and coding into the educational curriculum from elementary to vocational high school levels in Indonesia, examining its impact on teacher and student competencies in the digital era. The research employs a descriptive qualitative approach, utilizing library research to analyze challenges in AI curriculum implementation. The study identifies key issues such as teacher preparedness, technological infrastructure, the need for standardized learning modules, and students' cognitive readiness. It emphasizes the importance of aligning AI and coding education with 21st-century skills, such as critical thinking, creativity, and problem-solving, while addressing the cultural and structural challenges within the Indonesian education system. Despite challenges in infrastructure and teacher competence, AI integration is seen as essential for preparing students for a technology-driven future. The study also proposes the development of adaptive curriculum models and teacher training strategies, advocating for an inclusive, context-sensitive approach to digital literacy. The findings offer insights for policymakers and educators to enhance the quality of AI and coding education, ensuring that Indonesia's future workforce is equipped with necessary digital competencies to compete in the global economy.

Keyword: *Artificial Intelligence, Coding, Digital Curriculum, Teacher Competence, Student Competence*

INTRODUCTION
The development of information and communication technology over the past two decades has fundamentally transformed the way humans live, learn, and work. Amid the acceleration of the Fourth Industrial Revolution and the transition toward Society 5.0, digital skills are no longer complementary—they have become the foundation for future generations. One of the most essential digital competencies today is the understanding of Artificial Intelligence (AI)—a technology that not only revolutionizes industry but also reshapes social, cultural, and educational systems worldwide (Agustina & Suharya, 2025; Aliwijaya & Suyono, n.d.; Mutaqin et al., 2023).
In the field of education, many countries have responded to these changes by integrating AI literacy into school curricula. Nations such as the United Kingdom, South Korea,

China, the United States, and Finland have already implemented AI-based education from primary to secondary levels. These countries recognize the importance of preparing young generations not only to be consumers of technology but also to become creators and controllers of it. AI is no longer seen as merely a branch of computer science; it is considered a new literacy, standing alongside reading, writing, and arithmetic (Yusuf, 2024a; Zhai et al., 2021).

In response to this global trend, Indonesia's Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) has announced that, starting in the 2024/2025 academic year, AI-related content will be gradually introduced into the national curriculum for elementary (SD), junior high (SMP), senior high (SMA), and vocational schools (SMK). This initiative is part of the enhancement of the *Merdeka Curriculum*, which promotes contextual learning, project-based learning, and the development of 21st-century skills. The revised curriculum aims to help students understand fundamental AI concepts, algorithmic logic, data, and the social impacts of technology through adaptive and relevant learning approaches (Marwa, 2024).

Nevertheless, this ambitious policy presents significant challenges. Implementing AI content requires teacher preparedness, adequate digital infrastructure, and curriculum design that aligns with students' developmental stages. Teaching AI is not simple, especially at the elementary level. Without intensive training, contextual learning materials, and the right pedagogical approaches, the goal of integrating AI into school curricula may fall short—or worse, create new disparities (Apriadi & Sihotang, 2023; Arip Nurahman & Pandu Pribadi, 2022).

Moreover, teachers, who play a crucial role in implementing curriculum changes, face multidimensional challenges. Many educators, particularly at the elementary and junior high levels, lack backgrounds in ICT or programming. According to data from Pusdatin Kemendikbudristek (2023), only about 35% of teachers in Indonesia have participated in advanced digital literacy training. Teaching AI requires more than basic computer skills; it demands an understanding of data logic, machine learning, and ethical use of technology. In addition, AI education depends on supporting infrastructure, such as access to computers, stable internet connections, and AI learning platforms or software like Scratch, Teachable Machine, or Python. This poses a major challenge in 3T regions (underdeveloped, frontier, and outermost areas), where infrastructure remains limited. If not anticipated properly, AI curriculum implementation may widen the digital divide between urban and rural schools (Bbpmpjatim, 2025).

Despite these challenges, the positive potential of integrating AI into education is undeniable. AI can significantly enhance students' critical thinking, complex problem-solving, data literacy, and creativity—key indicators of 21st-century competencies. For example, students who learn to build chatbots, analyze data, or recognize patterns using simple AI tools begin to develop logical and structured thinking. Even at the elementary level, AI can be introduced through visual analogies and games that build pattern recognition and data-driven decision-making skills (Yulianti et al., 2023).

Several pilot projects initiated by schools in partnership with Kemendikbud, tech companies like Google and Microsoft, and Indonesian tech communities such as Dicoding and the Indonesian AI Association, have shown promising outcomes. Students participating in project-based AI learning programs demonstrate increased interest in learning, stronger problem-solving abilities, and greater confidence in using technology. However, the success of such initiatives heavily depends on the availability of structured teacher training, well-developed instructional materials, and access to effective learning tools (Yuliansyah & Saidah, 2025).

Furthermore, an equally important dimension of AI integration is the cultivation of ethical literacy and human values. AI is a powerful technology but also susceptible to misuse—ranging from algorithmic bias and deepfake misinformation to privacy violations. Therefore, teaching AI must not only focus on technical skills but also embed social

responsibility, ethical data use, and awareness of the societal impact of technology. Considering the complexity and transformative potential of this initiative, in-depth research is necessary to understand how AI curriculum implementation unfolds in real educational settings. Such research is crucial to assess teacher readiness, student responses, structural challenges, and the early impacts of AI instruction on student competencies. The findings will offer valuable insights to inform policy decisions, develop effective learning modules, and build a context-sensitive evaluation system aligned with Indonesia's educational realities (Wahyudiono, 2024).

To achieve these objectives, rigorous studies must uncover the actual conditions in the field, analyze the perceptions of key stakeholders, and propose curriculum models that are both appropriate and relevant. This research is not only essential for evidence-based policy-making but also provides a scientific foundation for developing teacher training programs and assessing student learning outcomes in alignment with the demands of the digital era (Tangkearung et al., 2024; Ulimaz et al., 2024).

With this background, the present study aims to explore in greater depth the readiness, perceptions, and early impacts of integrating coding and AI into school curricula in Indonesia. The focus will be directed toward how this content is received by teachers and students, the implementation challenges across various school contexts (urban versus rural), and the potential improvement of critical thinking and problem-solving skills as outcomes of AI and coding education. This study will also offer strategic recommendations and propose an adaptive curriculum model tailored to the characteristics of Indonesian education—preparing a generation not only capable of using technology but also of shaping it with values and responsibility.

METHOD

This study employs a descriptive qualitative approach through a library research method to analyze the challenges of implementing an artificial intelligence (AI) curriculum across primary to secondary education levels (SD to SMK) in Indonesia. Library research is chosen as it allows the researcher to explore a broad conceptual and empirical framework regarding the dynamics of digital education policy both nationally and globally. The data in this study were obtained from various secondary sources, including official national policy documents such as the Strategic Plan of the Ministry of Education, Ministerial Regulations, academic journals (both national and international), reports from organizations like UNESCO, the World Economic Forum, and the OECD, as well as credible online educational publications. Additionally, the study incorporates reports and documentation from AI curriculum pilot projects that have been implemented in several Indonesian regions (Pabubung, 2021).

Data analysis was conducted through thematic analysis, identifying key issues relevant to AI curriculum implementation. The challenges were categorized into several main themes: teacher preparedness, technological infrastructure, standardized curriculum and learning modules, students' cognitive readiness, school culture and professional learning communities, and digital ethics. These categories were then examined in depth to understand how they interact and impact the effectiveness of AI curriculum implementation. To enhance data validity, source triangulation was employed by comparing information from diverse references, including policy analyses, expert opinions, and field practices. The findings are presented descriptively to provide a comprehensive overview of the current situation and to offer recommendations grounded in literature-based evidence (Miftahurrohman et al., 2024).

RESULTS AND DISCUSSION

RESULTS

Integrating AI and Coding into the Curriculum

Over the past two decades, digital transformation has significantly reshaped various aspects of human life—from how we interact and work to how we access knowledge and form ways of thinking. Along with the rapid advancement of information and communication technologies, the education sector faces a critical challenge: how to prepare younger generations not merely to become consumers of technology, but also creators and controllers of it. In this context, mastering skills such as coding (programming) and artificial intelligence (AI) has become essential and should be introduced early through formal education (Igbokwe, 2023).

The integration of AI into the curriculum from elementary to secondary education plays a key role in fostering 21st-century skills, including critical thinking, creativity, collaboration, communication, and digital literacy. In modern learning environments, AI is not only treated as a topic of study but also as a learning tool that supports students in engaging with complex concepts through exploration, creativity, and reflection. Both AI and coding have become central elements in Indonesia's education reform. Their presence not only alters teaching methods but also shapes students' mindsets to become more innovative and solution-oriented (Sari & Elvira, 2024; Trinova & Zen, 2025).

AI offers opportunities for creating personalized and responsive learning experiences. With its data analysis capabilities, AI can tailor learning materials and instructional strategies based on individual student needs and characteristics. This approach makes learning more efficient, enjoyable, and motivating. Meanwhile, coding has become a vital competency for future generations. Through learning to code, students not only understand programming syntax but also develop systematic, logical, and creative thinking skills essential for solving real-world problems (Daulay & Daulay, 2025; Fajriati et al., 2024).

In terms of opportunity, integrating AI and coding into the curriculum can serve as a powerful driver of educational transformation. Beyond increasing Indonesian students' global competitiveness, these subjects can reinvigorate innovation and creativity in teaching and learning. Various studies have shown that students who learn coding exhibit significant improvements in critical thinking, collaboration, and learning motivation. AI can also be used strategically to personalize learning, monitor student progress, and enhance teaching efficiency through AI-powered learning assistants.

Moreover, the integration of AI and coding fosters active and engaging learning environments. For example, AI-based learning platforms can provide real-time feedback to students while they learn to code, accelerating understanding and improving their ability to design effective solutions. The synergy between AI and coding nurtures creativity and problem-solving. Programming often requires students to face complex challenges that demand original thinking. With the help of AI, students can analyze existing solutions and develop improved, context-appropriate alternatives (Awaluddin & Hadi, 2025; Iddian, 2025).

In Indonesia's national education system, the introduction of AI and coding opens the door to higher quality learning and better preparation for a technology-driven future. It enables more effective learning while equipping students with relevant skills for the modern workforce. A shift in mindset is also needed—students must recognize the importance of mastering AI and coding. Schools can support this by organizing non-formal activities such as tech clubs, competitions, and seminars. Through these initiatives, Indonesian educational institutions can better respond to both the opportunities and challenges of the digital era by equipping students with essential, future-ready skills.

Project-based AI learning also encourages students to tackle real-world problems. They are guided to design systems, evaluate the effectiveness of algorithms, and refine their solutions based on feedback. This process reinforces directed creativity and innovation while fostering a culture of creation in education—replacing older models that

emphasized rote memorization and reproduction of knowledge. AI also plays a significant role in shaping students' social competencies, such as teamwork and communication. AI projects are typically collaborative, encouraging students to divide tasks, engage in discussions, and present their work. These activities develop interpersonal skills, promote cross-disciplinary cooperation, and instill a sense of shared responsibility. Additionally, students enhance their ability to articulate technical ideas when they explain algorithmic concepts to teachers or peers (Iddian, 2025; Trihandaru et al., 2024).

From a digital literacy standpoint, AI helps students understand how technology works—from data input to algorithmic output. They learn to explore how everyday applications function and reflect on their societal impact. This is a deeper form of digital literacy: one that involves critical awareness of technology and its influence on opinions, policies, and social systems. Equally important is AI's role in shaping students' ethical awareness (Sugiyanti, 2019; Supriyadi & Nasution, 2024). Discussions around algorithmic bias, privacy issues, and misinformation (such as deepfakes) expose students to the ethical dilemmas of technology. They are encouraged to see technology not as a neutral tool but as something that requires wise and responsible use. This is the essence of digital citizenship—becoming individuals who are critical, ethical, and constructive within digital environments (Apriadi & Sihotang, 2023; Yusuf, 2024b).

Therefore, the implementation of AI in education serves as a catalyst for comprehensive 21st-century skill development. Learning models that emphasize exploration, collaboration, and reflection cultivate deep understanding, relevant abilities, and strong personal values. Amid the ongoing waves of technological change, an AI-based education is not just important—it is essential to shaping a generation that is adaptive, creative, and ready to navigate the future.

DISCUSSION

The Urgency of Integrating Coding and AI into the Merdeka Curriculum

Several countries have recognized the importance of equipping younger generations with digital skills and have begun incorporating coding and artificial intelligence (AI) into their national curricula. The United Kingdom, for instance, made coding lessons mandatory at the primary school level in 2014. Similarly, South Korea and Japan have started to introduce AI concepts into science and mathematics education. In China, the government has launched a major initiative to place AI at the heart of its national education strategy to strengthen its position in the global digital economy (Fikri et al., 2024).

Indonesia is now following this trend. The Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) is actively promoting the integration of coding and AI into the Merdeka Curriculum. Minister of Education Nadiem Makarim has consistently emphasized the importance of equipping students with relevant skills to face the challenges of digital disruption. A number of pilot programs have already been launched, including coding training for teachers, project-based learning on AI topics, and partnerships with tech companies like Google and Microsoft to provide digital learning content.

The Ministry of Primary and Secondary Education plans to introduce coding and AI as elective subjects at the elementary school level starting in the 2025–2026 academic year. This is a strategic move aimed at providing children with digital competencies from an early age, while also responding to the future demands of the job market. In an era of accelerating global digital transformation, digital literacy is now as essential as reading and writing. Programming skills and AI literacy are no longer exclusive to IT professionals—they are becoming foundational skills across various fields and innovations (Sahal, 2025).

Countries such as Singapore, Japan, and South Korea have long integrated computational thinking into their education systems to prepare students to remain

competitive in the digital age. The COVID-19 pandemic further accelerated the adoption of digital technologies across sectors, including education. To avoid becoming mere consumers of technology, students must be equipped with the ability to create and innovate digital products. Introducing coding and AI at an early age is expected to help students develop logical thinking, problem-solving abilities, and creative innovation. In addition, understanding AI fosters ethical reasoning, preparing students for the disruptions of automation and misinformation.

Indonesia's digital economy is growing rapidly. With a large population and increasing internet penetration, the country's digital economy was valued at around USD 90 billion, and it is projected to reach USD 130 billion by 2025. However, a major challenge remains: the readiness of the workforce. Many companies in Indonesia struggle to recruit local talent proficient in coding and AI, often relying on foreign professionals to meet their needs. The AI-based industry has tremendous potential to replace various traditional jobs. This is reflected in the 2024 Global Skills Report published by Coursera, which states that Indonesian learners are highly interested in skills such as Artificial Neural Networks, Applied Machine Learning, and Computer Graphics Techniques—three of the most sought-after skills on the platform. The same report reveals that the most desired job positions among Indonesian learners include Cloud Security Engineer, Network Engineer, and Operations Manager (Rakhmayanti, 2025).

However, the surge in demand for these skills is not matched by sufficient talent supply. Many employers report difficulties in finding qualified professionals in coding and AI, leading them to seek talent from abroad. This issue is also emphasized in the *Future of Jobs Report 2025* – Insight Report January 2025 by the World Economic Forum, which notes that generative AI is transforming nearly every industrial sector. While offering significant opportunities, this technology also brings complex challenges such as global economic uncertainty, geopolitical shifts, environmental crises, and evolving social dynamics. The report also highlights several global trends that merit attention, including increased digital access, the rising cost of living encouraging sustainable lifestyles, changing job preferences among younger generations, and a growing elderly population in need of tech-supported daily living. Amidst these global developments, Indonesia is experiencing a demographic bonus, with a large share of the population in the productive age group—who must be prepared to play a strategic role in the global future economy (Tim World Economic Forum, 2025).

By offering early exposure and training, Indonesian students can move beyond being passive users of technology and become innovators and technology developers. The integration of coding and AI into the education system is a strategic effort to enhance national competitiveness. A digitally skilled workforce is a crucial asset for navigating future labor market dynamics. As Minister of Primary and Secondary Education Abdul Mu'ti emphasized, the urgency of teaching coding and AI from a young age is a key part of preparing Indonesian youth to compete globally. He noted that many advanced countries have already incorporated high-tech education at the primary level, and Indonesia must not be left behind. The Ministry plans to offer coding and AI as elective subjects in elementary schools starting next academic year.

Minister Mu'ti also acknowledged that while there are differing views on this policy, most responses have been positive, especially from stakeholders who understand the critical role of digital skills in children's education. He believes that digital skill development will not interfere with students' mastery of basic literacy and numeracy; on the contrary, it will support and reinforce them. Beyond that, technical skills like coding and AI also drive growth in innovation and tech-based entrepreneurship. Societies with strong competencies in these areas have greater potential to develop local startups and digital solutions, reducing dependence on foreign products and services and fostering local innovation. The integration of coding and AI also helps to narrow the digital divide, giving

children from diverse backgrounds access to essential, future-relevant skills (Ananda, 2025).
Even for those who may not pursue careers directly in technology, basic coding literacy offers valuable cognitive benefits, such as enhanced logical reasoning, structured thinking, and problem-solving abilities. Given this immense potential, Indonesia has a unique opportunity to build an education ecosystem that is more adaptive, inclusive, and aligned with 21st-century demands. This step will not only accelerate the nation's digital transformation but also strengthen Indonesia's position in the global competitive landscape of the future.

School Readiness and Student Perceptions of AI and Coding Education
The integration of coding and artificial intelligence (AI) into primary and secondary school curricula is aimed at preparing Indonesian children to be more globally competitive. However, implementing this policy requires careful preparation. Between 2020 and 2022, the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek)—before it was later divided into three ministries—distributed over one million Information and Communication Technology (ICT) devices to more than 70,000 schools to support digitalization programs, as reported by VOA Indonesia on September 11, 2022.
Indonesia's Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) has announced that, starting in the 2024/2025 academic year, AI-related content will be gradually introduced into the national curriculum for elementary (SD), junior high (SMP), senior high (SMA), and vocational schools (SMK). This initiative is part of the enhancement of the *Merdeka Curriculum*, which promotes contextual learning, project-based learning, and the development of 21st-century skills. The revised curriculum aims to help students understand fundamental AI concepts, algorithmic logic, data, and the social impacts of technology through adaptive and relevant learning approaches (Riady et al., 2025).

Table 1. Stages of Learning Informatics and Coding with AI
Source: Naskah Akademik Pembelajaran Koding dan Kecerdasan Artifisial Pada Pendidikan Dasar dan Menengah (Riady et al., 2025)

Content	Elementary School (SD) – Foundational	Junior High School (SMP) – Basic (Grades 7–9)	Senior High School (SMA/SMK) – Intermediate (Grade 10)	Senior High School (SMA/SMK) – Advanced (Grades 11–12
Informatics	Foundation in the use of computing devices wisely and ethically	Computational thinking, digital literacy, and basic-level computer networking	Computational thinking, digital literacy, and intermediate-level computer networking	Computational thinking, digital literacy, advanced computer networking, programming, and data analysis
Coding and Artificial Intelligence	Foundation of logical and systematic thinking through computational	In-depth development of computational thinking, basic digital literacy, and	Development of computational thinking, intermediate-level digital	Computational thinking, advanced digital literacy, artificial intelligence

	thinking, digital literacy, and ethics	introduction to artificial intelligence	literacy, introduction to artificial intelligence, programming algorithms, and data analysis	content, programming algorithms, and data analysis

The introduction of these new subjects necessitates dedicated government budgeting for coding and AI programs, including teacher training subsidies, public awareness campaigns, and the purchase of technological equipment. With proper preparation and strong commitment, integrating AI and coding into the curriculum can become a strategic step in advancing Indonesian education and equipping younger generations for the challenges of the digital era. Ultimately, incorporating AI and coding into school curricula is not just about following global trends—it is about securing Indonesia's future role in the digital economy. If implemented effectively, this policy could become a game-changer, providing Indonesian youth with the skills they need to thrive in an increasingly advanced digital world.

To support this initiative, the Ministry of Primary and Secondary Education (Kemendikdasmen), through the Directorate of Primary Education under the Directorate General of Early Childhood, Primary, and Secondary Education (Ditjen PAUD Dikdasmen), organized a Focused Group Discussion (FGD) titled *"Developing AI and Coding Learning for Primary School Students."* Held from November 29 to December 1, 2024, the event featured key figures such as Minister Abdul Mu'ti; Vice Minister Atip Latipulhayat; Special Staff for Digital Transformation and AI, Muhammad Muchlas Rowi; Special Staff for Institutional Affairs, Didik Suhardi; and Secretary of Ditjen PAUD Dikdasmen, Praptono. The event also included participation from school principals, teachers, and AI and coding educators from various regions (Ananda, 2025).

The main objective of the discussion was to formulate effective strategies for integrating AI and coding into the primary school curriculum, targeted for implementation in the 2025–2026 academic year. This initiative is aligned with the goal of instilling 21st-century skills in students, particularly in mastering rapidly advancing digital technologies. Through the introduction of AI and coding, students are expected to develop collaboration, creative thinking, and digital literacy—all of which are essential for future careers.

Vice Minister Atip Latipulhayat emphasized that AI and coding are integral components of digital literacy. He encouraged participants to reflect on the development of technological education in Indonesia and to benchmark against countries that have long implemented tech-based learning. Atip likened the urgency of AI and coding education to how the United States introduced space education in the 1970s. He stated that AI and coding should not be feared—they are bridges to creativity and innovation for students.

Similarly, Secretary Praptono reiterated that AI and coding should not be viewed merely as technical tools, but as essential competencies for the younger generation. These skills, he argued, are fundamental in shaping children to be creative, innovative, and adaptive—capable of addressing global issues like climate change, public health, and other strategic sectors. The AI and coding subjects are officially scheduled to be included in the primary school curriculum, with students expected to begin learning them from Grade 4. Responding to this policy, Holy Ichda Wahyuni—a professor of education at Universitas Muhammadiyah Surabaya (UM Surabaya)—affirmed that technological advancement is inevitable. According to her, education is a dynamic entity, much like

human civilization, and thus cannot remain static in the face of change (Bbpmpjatim, 2025).

Holy explained that, based on the cognitive development theories of Jean Piaget and Jerome Bruner, primary school students are already capable of logical thinking and language comprehension, though not yet of fully abstract reasoning. Therefore, introducing AI and coding at this stage does not mean students will be taught complex programming languages. Instead, the content will be adapted to their developmental stage, focusing on basic logic, visual-based games, and activities that integrate visual and numerical elements. The learning process will be progressive and evolve with the students' educational levels.

Moreover, Holy emphasized that learning AI and coding can enhance logical reasoning, problem-solving skills, and provide students with early exposure to using technology wisely and responsibly. She supports the policy, especially if coding and AI are offered as elective subjects, since not all students may have interest or aptitude in technology. Other disciplines like arts and sports are equally valuable in developing children's character and potential.

However, Holy also stressed that several key preparations must precede broad implementation. These include government-led public awareness campaigns, training for schools, and communication with parents to align perspectives. This outreach must be clear, simple, and highlight the real benefits for children's development. This is crucial to address common misconceptions, such as the belief that AI and coding are overly complicated, require expensive technology, or are only suitable for certain schools. In fact, many Indonesian schools have already begun integrating these subjects using child-friendly and developmentally appropriate approaches.

Although the implementation of coding and artificial intelligence (AI) education in Indonesia has not yet reached the same scale as in more developed countries, several schools have begun introducing these subjects in various forms. Generally, the teaching of coding and AI in Indonesian schools still falls under the category of extracurricular activities that students can choose based on their interests. The main objective of these activities is not only to equip students with technical skills but also to develop computational thinking—the ability to think logically and analytically.

For example, at Hellomotion Senior High School in South Tangerang, extracurricular activities in coding and AI focus on the development of applications and digital games. Meanwhile, SDK Penabur Jakarta organizes coding and AI competitions as a means of introducing and stimulating students' creativity in the field of technology. On the other hand, SMAIT Al Haraki in Depok offers coding as an elective subject, while AI content has already been integrated into the Informatics subject. A similar approach is also implemented at SMPN 126 Jakarta, where the integration of coding and AI into Informatics lessons is carried out gradually to match students' developmental levels (Riady et al., 2025).

In some schools, this gradual approach is applied in a more systematic manner. For instance, SMP Islam Harapan Ibu in Jakarta begins instruction with basic algorithmic concepts, looping (repetitive commands), and culminates with a final project based on the iOS operating system. At SMP Negeri 2 Bandung, basic AI concepts are introduced using generative technology, while coding skills are developed through Internet of Things (IoT)-based projects, such as the creation of smart trash bins that automatically sort waste.

A progressive learning model is also implemented at SMAN 1 Bandung. At this school, coding and AI are introduced incrementally starting in Grade 10 with introductory materials, followed by applied learning in Grade 11, and concluded with a complex final project in Grade 12. The goal of this approach is to establish continuity in both conceptual understanding and technical competence among students. In addition, some schools use non-digital (unplugged) learning methods, such as those applied at SMAS Sukma

Bangsa in Sigi District. This school integrates computational thinking and unplugged coding into the Informatics subject by utilizing tangible kits. Through this method, students can learn without the use of computers, relying instead on mobile phones and simple learning tools, making the instruction more flexible and accessible—particularly in regions with limited technological infrastructure.

From these various practices, it can be concluded that the implementation of coding and AI education in Indonesian schools generally falls into three main forms: (1) integration into existing subjects, (2) development as elective subjects, and (3) implementation as part of extracurricular activities. These three approaches reflect systematic efforts to align technology education with the needs, readiness, and specific context of each school environment. In addition, a study conducted by Yuliani involved 210 elementary school students randomly selected from several different schools. The involvement of elementary school students in the study is significant, as they are the primary group directly engaged in the learning process. Including a relatively large number of participants also enabled the researcher to perform a more in-depth analysis of student responses (Asyifa, 2025).

Of the 210 students who participated in the study, 149 students—or approximately 71%—expressed agreement with the use of AI in a learning context. This indicates that the majority of students have a positive attitude toward the integration of AI into the elementary school learning process. Furthermore, 182 students—or around 87%—reported that they felt comfortable using AI to search for information. This finding suggests that most students are confident and familiar with AI as a tool for acquiring knowledge. Additionally, the results showed that 172 students—or about 82% of all participants—expected their teachers to use AI media in the classroom. This high percentage indicates that students have strong expectations for the role of AI technology in supporting classroom instruction. These findings are consistent with technological developments and global education trends that increasingly integrate AI as an effective and efficient learning tool (Marwa, 2024).

Teacher Qualifications and Competencies in Teaching Coding and Artificial Intelligence (AI)

According to Regulation of the Minister of National Education No. 16 of 2007 on the Standards of Academic Qualifications and Teacher Competencies, every educator is required to have a minimum academic qualification of D4 or Bachelor's degree (S1) and must master four core competencies: pedagogical, personal, social, and professional competencies. In the context of teaching coding and artificial intelligence (AI), teachers who are authorized to deliver these subjects must possess at least a D4/S1 degree and hold a relevant academic background in accordance with the applicable subject linearity regulations.

In addition to certified teachers, professionals or practitioners with proven experience or a strong portfolio in coding or AI may also be involved in delivering these subjects. Beyond academic qualifications, it is highly recommended that teachers have a genuine interest and motivation to explore and develop learning in the field of information technology. At the elementary school level, homeroom teachers who demonstrate interest or experience in digital technology or coding may be involved, especially where Informatics teachers are not available.

Teachers assigned to teach coding and AI must master the four core competencies mentioned earlier. From the professional competency perspective, mastery of subject matter such as computational thinking, digital literacy fundamentals, basic AI concepts, algorithmic programming, and data analysis is essential. At the elementary and junior high school levels, the curriculum will emphasize digital literacy, computational thinking, and introduction to AI. At the senior high school and vocational levels, the content expands to include algorithmic coding and more complex data analysis. For example, in

Grades 5 and 6 of elementary school, teachers are expected to help students solve real-life problems in a structured and logical manner using simple tools, understand sequences of basic commands, and become aware of potential negative impacts of technological developments.

At the junior high school level, teachers should guide students in designing basic programs, writing code using symbols, and developing simple digital products. At the senior high school and vocational levels, educators are expected to assist students in developing more complex text-based programs, incorporating advanced logic structures and additional functions.

The IN-ON-IN Model for Teacher Training in Coding and Artificial Intelligence

Educational transformation in the digital era requires a paradigm shift in teaching and learning, especially in mastering advanced technologies such as coding and artificial intelligence (AI). In response, the Ministry of Education and Culture of the Republic of Indonesia, through the Directorate General of Teachers and Education Personnel (Ditjen GTK), has designed a structured and sustainable training scheme for teachers to effectively implement coding and AI learning in a contextual and practical manner.

Teacher training programs are delivered by Technical Implementing Units (UPT) under the Directorate General of GTK for Professional Development (GTK-PG), as well as by other government-approved training institutions. For elementary schools, both homeroom teachers and Informatics teachers are eligible to participate. At the junior and senior high school levels, the training is targeted at Informatics teachers. If Informatics teachers are unavailable, teachers from STEM-related fields (MIPA) may join the training. If no STEM teachers are available, other subject teachers with demonstrable skills or prior training in Informatics, coding, or AI may also be considered.

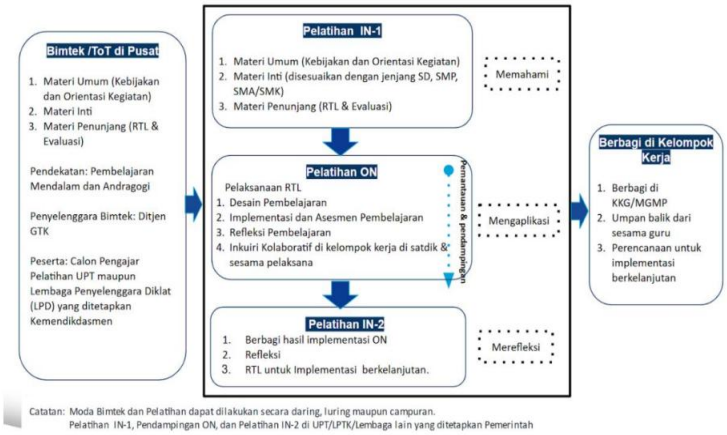

Figure 1: Technical Guidance and Coding and KA Training Scheme
Source: Naskah Akademik Pembelajaran Koding dan Kecerdasan Artifisial Pada Pendidikan Dasar dan Menengah (Riady et al., 2025)

This training model follows the IN-ON-IN approach, which consists of: *First,* In-Service Training 1 (IN-1) – theoretical knowledge delivery, *Second,* On-the-Job Training (ON) – direct classroom application, and In-Service Training 2 (IN-2) – reflection and consolidation. It is followed by collaborative sharing of best practices within teacher communities. The model not only focuses on knowledge transfer but also integrates experiential learning, reflective practice, and peer collaboration.

Before the training begins, a Technical Guidance (Bimtek) or Training of Trainers (ToT) is conducted at the national level to prepare trainers from UPTs or designated training institutions. The training content is divided into three categories: : first, General Material:

National policies and orientation on training implementation. *Second,* Core Material: Coding, digital literacy, and AI topics tailored to school level (elementary, junior high, senior/vocational). *Third,* Supplementary Material: Development of Follow-Up Action Plans (RTL) and training evaluation strategies.
The training adopts a deep learning and andragogical approach, which is designed to accommodate adult learning needs, emphasizing practical experience and two-way interaction. The 70/30 ratio—70% practice and 30% theory—ensures that teachers are better prepared to apply knowledge in their classrooms. For junior and senior high school teachers, the training is dominated by the use of technology tools in delivering coding and AI lessons. In contrast, elementary school teachers focus more on computational thinking and basic digital literacy instruction.

1. Stage 1: IN-1 Training (In-Service Training 1)
IN-1 training is the initial training provided to the participating teachers. Its main purpose is to build a deep understanding of the concepts, policies, and practices of coding and AI learning. The training materials consist of: First, an explanation of national policies related to strengthening digital competence. Second, core materials, including computational thinking concepts, digital literacy, and an introduction to AI, adjusted to the levels of elementary, junior high, or senior high/vocational schools. Third, supporting materials in the form of exercises for preparing a Follow-Up Plan (RTL) as a guide for implementing the training at each school. At this stage, participants begin to form a mindset framework and strategies that will be applied in the classroom. The learning approach is oriented towards understanding and planning.

2. Stage 2: ON Training (On-the-Job Training)
After completing IN-1, the participants enter the ON stage, which is workplace-based training conducted directly at their respective schools or educational units. This phase serves to apply what has been learned. The main activities in the ON stage include: First, implementing the RTL: teachers carry out the learning plans that were prepared during IN-1. Second, designing and implementing learning: teachers teach coding or AI topics according to their level, for example Scratch for elementary or Python for senior high. Third, assessment and learning reflection: teachers evaluate the learning process and student outcomes. Fourth, collaborative inquiry: teachers regularly discuss in working groups (KKG/MGMP) to share challenges and solutions, resulting in experience exchange and continuous improvement. This experience-based approach gives teachers the opportunity to learn actively in real contexts, making learning more meaningful and adaptive.

3. Stage 3: IN-2 Training (In-Service Training 2)
After the ON stage is completed, participants return to attend IN-2 training. The focus of this training is reflecting on the experiences gained during the ON stage, as well as strengthening sustainable implementation. The main activities are: *First,* sharing implementation results: teachers present experiences, challenges, and solutions found during the RTL implementation. *Second*, structured reflection: participants critically analyze the effectiveness of the teaching strategies used. *Third,* planning advanced RTL: the results of the reflection are used to prepare new RTL as a basis for the next teaching. This stage reunites teachers from various schools to build shared understanding and formulate strategies for long-term learning quality improvement.
As a form of sustainability, teachers who have completed the IN-ON-IN stages are expected to become agents of change in their communities. They are asked to*: first,* Share best practices in forums such as KKG (Teacher Working Group) or MGMP (Subject Teacher Deliberation). *Second,* Receive and provide feedback among fellow teachers to improve teaching quality. *Third,* Develop a Sustainable Implementation Plan

so that coding and AI learning does not stop as a training project but becomes part of routine learning.
This stage also aims to build an active and collaborative learning community, strengthening reflective practices in teacher professional development. The IN-ON-IN training model is based on blended learning and experiential learning approaches, which have been empirically proven effective. Referring to Jennings (2016) research, Thus, training is not sufficient if it only consists of one-way lectures. Maximum impact will only be achieved if teachers truly apply the training results, reflect, discuss, and continuously improve. This training is proven effective based on the adult learning model delivered by Jennings (2016), where 10% of learning comes from formal training, 20% from discussions and social interaction, and 70% comes from direct experience in the workplace. Therefore, training will not be optimally impactful if it stops at material transfer alone; integrated learning with real practice and peer discussion is much more effective.
The teacher training scheme for coding and artificial intelligence teaching through the IN–ON–IN model is a strategic approach that addresses the need for teacher competence development in the digital era. This scheme integrates theoretical learning, real practice, reflection, and continuous collaboration.
With structured and work-experience-oriented training, teachers are not only equipped with technical knowledge but are also trained to become reflective and innovative learners. Support from the teacher community and post-training coaching systems are key factors for long-term success. Massive and equitable implementation of this scheme is expected to improve the quality of digital technology teaching in Indonesia and drive an inclusive, relevant, and adaptive educational transformation for the 21st century (Riady et al., 2025).

Challenges of the AI Curriculum Discourse from Elementary to Vocational School Levels

The discourse on implementing an Artificial Intelligence (AI) curriculum at the primary and secondary education levels in Indonesia marks a significant shift in the direction of national education policy. This step is a response to the changing times that demand the integration of digital technology into everyday life, including the world of education. However, behind the great potential AI offers to improve learning quality and shape 21st-century competencies, there are several challenges that cannot be ignored. These challenges are systemic, pedagogical, and technical in nature and have direct implications for teacher and student readiness (Ismaya et al., 2025; Tangkearung et al., 2024).
However, the realization of this idea is not without complex challenges, both structurally and culturally. One of the main obstacles is the digital infrastructure gap between regions. Schools in the 3T areas (underdeveloped, frontier, and outermost) still face limited internet access, a lack of computers, and a shortage of educators competent in technology.

1. Unequal Teacher Readiness

One of the main challenges in this discourse is the uneven competency of teachers across education levels. AI is a relatively new field in the context of formal education, and most teachers—especially at the elementary and junior high levels—do not yet have basic knowledge or skills in programming, data literacy, or artificial intelligence systems. Elementary school teachers generally come from general education backgrounds, not information technology or computer science. This results in a gap between the technical competencies required to teach AI and the actual capacity of the available teachers. Without sufficient training and mentoring, teachers will struggle to adopt the AI curriculum effectively (Wahid & Amalia, 2020).

2. Limited Infrastructure and Technological Facilities

AI learning heavily relies on digital devices and internet connectivity. Unfortunately, not all schools—especially those in 3T areas—have adequate facilities. Limited computers, unstable internet connections, and the absence of ICT laboratories are major obstacles in integrating this technology into classrooms.Urban schools may be more prepared due to better access to technology, but differing regional conditions can widen the gap in educational quality. If not balanced by affirmative programs from the government, implementing the AI curriculum could instead exacerbate the national digital divide.

3. Lack of Standardized Modules and Curriculum

Currently, AI learning in schools that have started to integrate it is still based on individual or local initiatives, without standardized national learning modules. The absence of uniform standards makes it difficult for teachers to determine the depth of content, teaching methods, and benchmarks for student success. AI learning requires a gradual curriculum tailored to students' cognitive development at each level. Content for elementary students must fundamentally differ from that of vocational school students. However, due to the lack of a clear national curriculum structure, its implementation risks being inconsistent or even confusing for students (Anwar, 2019).

Cognitive Challenges for Students

AI is a field that requires abstract thinking, systems understanding, and data analysis—skills not easily mastered by students, especially at an early age. At the elementary level, students are still in the concrete operational stage (according to Piaget), so AI concepts need to be taught using highly visual, contextual, and play-based approaches. If not adjusted to the cognitive development stage of students, complex AI material risks causing confusion or learning resistance, which is counterproductive to the curriculum's objectives.

1. Limited Teacher Training and Mentorship

The AI curriculum discourse will only succeed if supported by a systematic and continuous teacher training system. Unfortunately, teacher training in technology is still sporadic and has not yet reached all regions equally. Many training programs are one-off events without concrete follow-up such as mentoring, reflection, and collaboration after implementation. Without learning from direct experience and guidance from facilitators or mentors, teacher competency development will stagnate. AI is not merely new content—it represents a transformation in how teaching and thinking occur within the educational process (Grandy Sihotang et al., 2025).

2. Weak School Culture and Learning Communities

Beyond teachers and infrastructure, school culture is also a major challenge. Many schools still view AI and technology as "add-ons" rather than essential components of future education. Not all principals and education managers have strong awareness or support for AI integration in learning. Teacher communities such as KKG (Teacher Working Groups) or MGMP (Subject Teacher Forums) should serve as collaborative spaces for developing AI content, but often remain suboptimal in creating innovative materials. The lack of professional discourse among educators results in AI learning being implemented individually, without synergy between schools or teachers (Goesrifai, 2024).

AI is not merely a technological tool; it also involves ethical and responsibility dimensions. Unfortunately, digital ethics is still not a core component of the AI curriculum discourse. In fact, children learning about AI should also be taught about algorithmic bias, data manipulation, digital privacy, and the social impact of technology. Without ethics

education accompanying the AI curriculum, students risk becoming technologically proficient but unwise users, which could eventually lead to moral issues in the digital society (Alfikri et al., 2024).

CONCLUSION

The implementation of an artificial intelligence (AI) curriculum at the primary to secondary education levels in Indonesia represents a strategic response to the demands of the digital era and the transformation of educational systems. However, this initiative faces numerous substantial challenges that are structural, pedagogical, and technical in nature. *First,* the uneven preparedness of teachers is a major concern, especially at the elementary and junior high levels, where most educators lack foundational knowledge in programming, data literacy, or AI systems. This issue is exacerbated by the lack of sustainable and practice-oriented teacher training and mentoring programs. Second, disparities in digital infrastructure—particularly in underdeveloped, frontier, and outermost regions (3T)—pose significant obstacles. Limited access to devices, unstable internet connectivity, and the absence of ICT laboratories hinder meaningful technology integration into classrooms.

Third, the absence of a standardized national AI curriculum and learning modules results in fragmented and inconsistent implementation. Most AI instruction currently relies on local initiatives without a clear national framework, making it difficult for educators to define learning outcomes or instructional strategies. Fourth, from a student-centered perspective, AI as a subject requires abstract and systemic thinking, which is particularly challenging for younger learners. In this regard, teaching methods must be adapted to the cognitive development stages of each education level—particularly using visual, contextual, and game-based approaches for elementary students.

Fifth, weak school culture and professional learning communities further slow the adoption of AI in education. Many schools and educational leaders still view technology as supplementary rather than integral to the future of learning. Teacher collaboration forums such as KKG (Teacher Working Groups) and MGMP (Subject Teacher Conferences) are often underutilized for developing innovative AI content. Lastly, the ethical dimension of AI remains largely unaddressed in current discussions. As students engage with AI technologies, it is crucial that they are also educated on digital ethics, including algorithmic bias, data manipulation, privacy, and the societal implications of AI. Therefore, the successful implementation of an AI curriculum requires more than the development of learning materials. It demands a holistic and inclusive national strategy, including targeted support for under-resourced regions, experiential teacher training programs, age-appropriate curriculum development, and the cultivation of collaborative, reflective school cultures. Furthermore, embedding ethical considerations within the curriculum is essential to ensure students become not only technologically competent but also responsible digital citizens. With coordinated, cross-sectoral efforts, Indonesia has the potential to transform AI education into a powerful driver for inclusive, relevant, and future-ready learning in the 21st century.

REFERENCES

Agustina, A., & Suharya, Y. (2025). Penerapan Teknologi Kecerdasan Buatan (Artificial Intelligence, Ai) Dalam Bidang Pendidikan Menuju Generasi Indonesia Emas 2045. *Prosiding Temu Ilmiah Nasional Guru, 1*(16).

Alfikri, M. Y., Handayani, S., & Chanifudin, C. (2024). Tantangan dan Peluang Implementasi Kurikulum Merdeka di Madrasah: Menuju Madrasah Unggul yang Berdaya Saing. *HEMAT: Journal of Humanities Education Management*

Accounting and Transportation, *1*(2), 698–702. https://doi.org/10.57235/hemat.v1i2.2816

Aliwijaya, A., & Suyono, H. C. (n.d.). *Peluang Implementasi Artificial Intelligence Di Perpustakaan: Kajian Literatur*.

Ananda, A. (2025). *Pelajaran "Coding": Inovasi Masa Depan atau Beban Baru?* https://www.kompas.id/artikel/pembelajaran-coding-dan-ai-inovasi-masa-depan-atau-beban-baru

Anwar, C. (2019). *Multikultural, Globalisasi dan Tantangan Pendidikan Abad Ke-21*. Diva Pres.

Apriadi, R. T., & Sihotang, H. (2023). Transformasi Mendalam Pendidikan Melalui Kecerdasan Buatan: Dampak Positif bagi Siswa dalam Era Digital. *Jurnal Pendidikan Tambusai*, *7*(3).

Arip Nurahman & Pandu Pribadi. (2022). Pemanfaatan Kecerdasan Buatan pada Media Pembelajaran Berbantuan Google Assistant: Penelitian Tindakan Kelas pada Materi Hukum Newton. *Jurnal Genesis Indonesia*, *1*(01), 24–32. https://doi.org/10.56741/jgi.v1i01.17

Asyifa, N. F. (2025). *Artificial Intelligence (AI) dalam Pengembangan Kurikulum: Transformasi Pendidikan di Era Digital*. https://www.kompasiana.com/naufalfaza/6538d3f8110fce5a8d0c01f2/artificial-intelligence-ai-dalam-pengembangan-kurikulum-transformasi-pendidikan-di-era-digital?page=2&page_images=1

Awaluddin, A., & Hadi, M. S. (2025). Integrasi Pembelajaran Coding Dan Kecerdasan Buatan Di Sekolah Dasar: Tantangan Dan Peluang. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, *10*(1). https://doi.org/10.23969/jp.v10i01.21753

Bbpmpjatim. (2025). *Kemendikdasmen Bahas Pembelajaran Coding dan AI untuk Siswa Sekolah Dasar*. https://bbpmpjatim.kemdikbud.go.id/site/detailpost/kemendikdasmen-bahas-pembelajaran-coding-dan-ai-untuk-siswa-sekolah-dasar

Daulay, M. I., & Daulay, D. H. (2025). Pemanfaatan Artificial Intelligence (AI) untuk Anak Usia Dini. *Jurnal Mutiara Pendidikan*, *5*(1), 158–167. https://doi.org/10.29303/jmp.v5i1.8681

Fajriati, A., Wisroni, W., & Handrianto, C. (2024). Pemanfaatan Teknologi Artificial Intelligence (Ai) Dalam Pembelajaran Berbasis Peserta Didik Di Era Digital. *Wahana Pedagogika: Jurnal Ilmiah Pendidikan Dan Pembelajaran*, *6*(2), 71–85. https://doi.org/10.52166/wp.v6i2.7890

Fikri, M. R. N., Muttaqien, F., & Noor, M. I. (2024). Strategi Implementasi Kecerdasan Buatan untuk Memperkuat Pendidikan Islam pada Generasi Z di Indonesia. *Journal Islamic Education*, *3*(1).

Goesrifai, G. (2024). *Artificial Intelligence dan Masa Depan Perpustakaan Akademik: Inovasi, Tantangan, dan Etika*. https://www.kompasiana.com/agusrifai1457/66fcab48c925c4635a357a42/artificial-intelligence-dan-masa-depan-perpustakaan-akademik-inovasi-tantangan-dan-etika?page=3&page_images=1

Grandy Sihotang, Rindu Antika, Talitha Zahira, & Nurul Hadawiyah Harahap. (2025). Optimisme Mahasiswa Kimia Penulisan Teks Akademik di Era AI, Peluang dan Tantangan Pendidikan Sains Indonesia. *Jurnal Pendidikan Dan Ilmu Sosial (JUPENDIS)*, *3*(2), 237–250. https://doi.org/10.54066/jupendis.v3i2.3167

Iddian, S. (2025). Implementasi Pembelajaran Coding dan Artificial Intelligency pada Jenjang Pendidikan Dasar. *Proceedings Diniyyah Pekanbaru*, *1*(1).

Igbokwe, I. C. (2023). Application of Artificial Intelligence (AI) in Educational Management. *International Journal of Scientific and Research Publications, 13*(3).

Ismaya, I., Ridwan, M. M., Galib, A. A. C., & Syahdan, S. (2025). Peluang dan Tantangan Pengintegrasian Kecerdasan Buatan dalam Pendidikan Literasi Informasi. *Literatify : Trends in Library Developments*, *6*(1), 122-137. https://doi.org/10.24252/literatify.v6i1.54646

Marwa, H. (2024). *Mendikdasmen: Coding dan AI Akan Masuk Kurikulum Sekolah Mulai Semester Depan*. https://www.tempo.co/politik/mendikdasmen-coding-dan-ai-akan-masuk-kurikulum-sekolah-mulai-semester-depan-1201780

Miftahurrohman, Supriyanti, & Jaelani Jaelani. (2024). Dampak Penerapan Kecerdasan Buatan (AI) Untuk Manajemen Kurikulum Pendidikan Tinggi Di Jawa Tengah. *E-Bisnis : Jurnal Ilmiah Ekonomi Dan Bisnis*, *17*(1), 339–352. https://doi.org/10.51903/e-bisnis.v17i1.1790

Mutaqin, F. M., Jubaedah, I., Koestianto, H., & Setiabudi, D. I. (2023). Efektif Artificial Intelligence (Ai) Dalam Belajar dan Mengajar. *Seroja : Jurnal Pendidikan*, *1*(2). https://doi.org/10.572349/seroja.v1i2.582

Pabubung, M. R. (2021). Epistemologi Kecerdasan Buatan (Ai) Dan Pentingnya Ilmu Etika Dalam Pendidikan Interdisipliner. *Jurnal Filsafat Indonesia*, *4*(2), 152–159. https://doi.org/10.23887/jfi.v4i2.34734

Rakhmayanti, I. (2025). *Penetrasi Internet Capai 79%, Gimana Peluang Ekonomi Digital RI?* https://www.cnbcindonesia.com/tech/20241030111321-37-584145/penetrasi-internet-capai-79-gimana-peluang-ekonomi-digital-ri#:~:text=Seperti%20diketahui%2C%20Menko%20Airlangga%20sebelumnya%20sempat%20memaparkan,akan%20berada%20dalam%20kisaran%20USD%20130%20miliar.&text=Dengan%20implementasi%20Digital%20Economy%20Framework%20Agreement%20(DEFA)%2C,akan%20meningkat%20hingga%20dapat%20mencapai%20USD2%20triliun.

Riady, S., Setiawan, D., Ismah, I., Purwarianti, Eng. A., Jihad, A., Rachmahana, R. S., Audah, A., & Izzatusholekha, I. (2025). *Naskah Akademik Pembelajaran Koding dan Kecerdasan Artifisial Pada Pendidikan Dasar dan Menengah*. Pusat Kurikulum dan Pembelajaran & Pusat Standar dan Kebijakan Pendidikan Badan Standar, Kurikulum, dan Asesmen Pendidikan Kementerian Pendidikan Dasar dan Menengah Republik Indonesia.

Sahal, U. (2025). *AI-Coding Bakal Masuk Pelajaran SD di Indonesia, Ini Kata Pakar Pendidikan UM Surabaya*. https://www.um-surabaya.ac.id/article/ai-coding-bakal-masuk-pelajaran-sd-di-indonesia-ini-kata-pakar-pendidikan-um-surabaya

Sari, L. N., & Elvira, Y. (2024). *Kerja Sama Internasional untuk Mendukung Pemanfaatan dan Pengembangan Artificial Intelligence (AI) di Indonesia*. https://setkab.go.id/kerja-sama-internasional-untuk-mendukung-pemanfaatan-dan-pengembangan-artificial-intelligence-ai-di-indonesia/

Sugiyanti, U. (2019). Mengaplikasikan teknologi holografi dan artificial intelligence (ai) di Perpustakaan digital. *Media Informasi*, *28*(2), 216–227. https://doi.org/10.22146/mi.v28i2.4139

Supriyadi, S., & Nasution, Z. (2024). Teknologi Artificial Intelligence (AI) dan Literasi Digital Mahasiswa terhadap Hasil Belajar Mata Kuliah Evaluasi Pembelajaran. *Jurnal Teknodik*, *28*(2).

Tangkearung, S. S., Palimbong, D. R., & Maramba', S. (2024). Peran Kecerdasan Buatan dalam Menghadapi Tantangan Pendidikan Masa Depan. *Elementary Journal: Jurnal Pendidikan Guru Sekolah Dasar*, *7*(1). https://doi.org/10.47178/rd91rp96

Tim World Economic Forum. (2025). *Future of Jobs Report 2025*. World Economic Forum.

Trihandaru, S., Parhusip, H. A., Setiawan, A., & Susanto, B. (2024). *Coding Untuk Siswa: Panduan Komprehensif Memahami Coding Statistika, Matematika, AI, dan IoT*. Uwais Inspirasi Indonesia.

Trinova, Z., & Zen, W. L. (2025). Studi Literatur Perbandingan Inovasi Dalam Pembelajaran Berbasis Artificial Intelligencess di Indonesia Dan Thailand. *Innovative: Journal Of Social Science Resear*, *5*(2). https://doi.org/10.31004/innovative.v5i2.18467

Ulimaz, A., Cahyono, D., Dhaniswara, E., Arifudin, O., & Rukiyanto, B. A. (2024). Analisis Dampak Kolaborasi Pemanfaatan Artificial Intelligences (AI) Dan Kecerdasan Manusia Terhadap Dunia Pendidikan Di Indonesia. *Nnovative: Journal Of Social Science Research,* *4*(2), 9312-9319. https://doi.org/10.31004/innovative.v4i3.11544

Wahid, U., & Amalia, N. (2020). Tantangan Humas Pemerintah Daerah dalam Upaya Publikasi Inovasi Program Smart City. *Nyimak: Journal of Communication*, *4*(1). http://dx.doi.org/10.31000/nyimak.v4i1.2300

Wahyudiono, A. (2024). Eksplorasi pengembangan penilaian akademik berbasis kecerdasan buatan dan big data dalam mendukung manajemen pendidikan modern. *Jurnal Konatif: Jurnal Ilmiah Pendidikan*, *2*(2), 94–109. https://doi.org/10.62203/jkjip.v2i2.66

Yuliansyah, H., & Saidah, N. (2025). Tranformasi Kurikulum Berbasis Kecerdasan Buatan Sebagai Strategi Adaptasi Pendidikan Abad 21: Artificial Intelligence-Based Curriculum Transformation as a 21st Century Education Adaptation Strategy. *Educan : Jurnal Pendidikan Islam*, *9*(1), 53–66. https://doi.org/10.21111/educan.v9i1.13352

Yulianti, G., Benardi, B., Permana, N., & Wijayanti, F. A. K. (2023). Transformasi Pendidikan Indonesia: Menerapkan Potensi Kecerdasan Buatan (AI). *Journal of Information Systems and Management (JISMA),* *2*(6), 102–106. https://doi.org/10.4444/jisma.v2i6.1076

Yusuf, M. (2024a). Peran Artificial Intelligence (AI) sebagai Pendukung Otomatisasi Perpustakaan. *Pustakaloka*, *16*(1). https://doi.org/10.21154/pustakaloka.v16i1.7516

Yusuf, M. (2024b). Strategi implementasi AI untuk meningkatkan ketersediaan dan aksesibilitas perpustakaan digital. *Jurnal Ilmu Perpustakaan Dan Informasi*, *13*(1).

Zhai, X., Chu, X., Chai, C. S., Jong, M. S. Y., Istenic, A., Spector, M., Liu, J.-B., Yuan, J., & Li, Y. (2021). A Review of Artificial Intelligence (AI) in Education from 2010 to 2020. *Complexity*, *2021*(1), 8812542. https://doi.org/10.1155/2021/8812542