THE IMPLEMENTATION OF CODING AND ARTIFICIAL INTELLIGENCE IN INCLUSIVE EDUCATION: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

The rapid integration of digital technology in education has emphasized the need for learning systems that are not only technologically advanced but also inclusive and equitable. This study aims to systematically review the implementation of coding and artificial intelligence (AI) in inclusive education and to examine their contributions to accessibility, personalization, and learning equity for students with special needs. This study employed a Systematic Literature Review (SLR). A total of 68 publications were identified from Scopus, Springer, DOAJ, Sinta, and Google Scholar databases. After applying inclusion criteria publication between 2019 and 2024, relevance to AI or coding in inclusive education, and methodological rigor 20 studies were selected for in-depth analysis. The selected studies were analyzed thematically using the Universal Design for Learning (UDL) framework as an analytical lens. The findings indicate that AI technologies, including speech-to-text systems, adaptive learning platforms, and image recognition tools, significantly enhance accessibility and personalized learning for students with hearing, visual, and cognitive impairments. Coding activities support the development of computational thinking, creativity, collaboration, and learner autonomy, particularly among students with special educational needs. However, implementation challenges remain, including limited digital infrastructure, insufficient teacher readiness, and a lack of local empirical research in developing countries such as Indonesia. This study uniquely integrates coding and artificial intelligence within the framework of inclusive education and contextualizes the findings in developing countries, particularly Indonesia, where empirical research on AI- and coding-based inclusive learning remains limited.

***Keywords**: Coding, Artificial Intelligence, Inclusive Education, Systematic Literature Review, Universal Design for Learning.*

ABSTRAK

Integrasi teknologi digital yang cepat dalam pendidikan telah menekankan perlunya sistem pembelajaran yang tidak hanya maju secara teknologi tetapi juga inklusif dan adil. Penelitian ini bertujuan untuk meninjau secara sistematis penerapan coding dan kecerdasan buatan (AI) dalam pendidikan inklusif dan untuk memeriksa kontribusinya terhadap aksesibilitas, personalisasi, dan kesetaraan pembelajaran bagi siswa berkebutuhan khusus. Studi ini menggunakan Tinjauan Literatur Sistematis (SLR). Sebanyak 68 publikasi diidentifikasi dari database Scopus,

Springer, DOAJ, Sinta, dan Google Scholar. Setelah menerapkan publikasi kriteria inklusi antara 2019 dan 2024, relevansi dengan AI atau pengkodean dalam pendidikan inklusif, dan ketelitian metodologis 20 studi dipilih untuk analisis mendalam. Studi yang dipilih dianalisis secara tematik menggunakan kerangka kerja Universal Design for Learning (UDL) sebagai lensa analitis. Temuan menunjukkan bahwa teknologi AI, termasuk sistem ucapan-ke-teks, platform pembelajaran adaptif, dan alat pengenalan gambar, secara signifikan meningkatkan aksesibilitas dan pembelajaran yang dipersonalisasi bagi siswa dengan gangguan pendengaran, penglihatan, dan kognitif. Kegiatan pengkodean mendukung pengembangan pemikiran komputasi, kreativitas, kolaborasi, dan otonomi peserta didik, khususnya di kalangan siswa berkebutuhan pendidikan khusus. Namun, tantangan implementasi tetap ada, termasuk infrastruktur digital yang terbatas, kesiapan guru yang tidak memadai, dan kurangnya penelitian empiris lokal di negara berkembang seperti Indonesia. Studi ini secara unik mengintegrasikan pengkodean dan kecerdasan buatan dalam kerangka pendidikan inklusif dan mengkontekstualisasikan temuan di negara berkembang, khususnya Indonesia, di mana penelitian empiris tentang pembelajaran inklusif berbasis AI dan coding masih terbatas.

Kata kunci: Pengkodean, Kecerdasan Buatan, Pendidikan Inklusif, Tinjauan Literatur Sistematis, Desain Universal untuk Pembelajaran.

A. Introduction

The rapid advancement of digital technology has fundamentally transformed educational systems worldwide. Education is no longer centered solely on content mastery but increasingly emphasizes higher-order thinking skills, creativity, digital literacy, and adaptability to technological change. Within this transformation, coding and artificial intelligence (AI) have emerged as critical competencies that shape how learners interact with knowledge and technology in the 21st century.

Coding education enables learners to develop computational thinking, problem-solving skills, and logical reasoning. Through coding, students are not merely technology users but become active creators of digital solutions. At the same time, artificial intelligence has expanded the capacity of educational technologies to personalize learning, automate feedback, and adapt instructional content based on individual learner needs. These technological advancements offer significant potential to improve learning effectiveness and engagement across diverse educational contexts.

Parallel to technological development, inclusive education has

become a central global educational agenda. Inclusive education emphasizes the right of all learners including students with disabilities and special educational needs to access quality education in equitable and supportive learning environments. The goal of inclusive education is to remove physical, cognitive, social, and emotional barriers that hinder learners from participating fully in educational processes. However, despite the increased adoption of digital learning platforms, many educational technologies remain inaccessible to learners with visual, hearing, or cognitive impairments, potentially reinforcing educational inequality rather than reducing it.

Recent studies indicate that artificial intelligence can play a crucial role in addressing accessibility challenges in inclusive education. AI-driven technologies such as speech recognition, adaptive learning systems, and intelligent tutoring systems can tailor learning experiences to individual learner profiles. Similarly, coding education has been shown to support not only technical skills but also social, cognitive, and emotional development, particularly among students with special needs.

Although international research on AI and coding in inclusive education has grown significantly, empirical studies in developing countries especially Indonesia remain limited. This gap is concerning given Indonesia's diverse learner population and recent educational reforms under the Merdeka Curriculum, which emphasize learner-centered, differentiated, and inclusive learning approaches. Therefore, this study aims to systematically review recent literature on the implementation of coding and artificial intelligence in inclusive education, focusing on their educational contributions, implementation challenges, and future directions relevant to the Indonesian context.

Artificial Intelligence and Coding in Inclusive Education

The integration of artificial intelligence and coding into inclusive education reflects a broader shift toward technology-enhanced learning environments that emphasize flexibility, personalization, and learner empowerment. Artificial intelligence

enables educational systems to respond dynamically to learner diversity by adapting instructional content, learning pace, and feedback mechanisms based on individual needs. For students with disabilities, such adaptive systems offer meaningful opportunities to overcome traditional learning barriers related to sensory, cognitive, or physical limitations (Al-Azawei, Serenelli, & Lundqvist, 2020; UNESCO, 2023).

Coding education complements this technological advancement by positioning learners as active creators rather than passive consumers of technology. Through coding activities, students develop computational thinking skills that support problem-solving, logical reasoning, and creativity (Grover & Pea, 2021). In inclusive settings, coding also fosters collaboration and social interaction, as learners work together to design, test, and refine digital solutions. Studies indicate that visual programming environments are particularly effective for students with special educational needs because they reduce cognitive load and provide concrete representations of abstract concepts (Durak & Saritepeci, 2022; Ahmed et al., 2022).

When integrated, artificial intelligence and coding create inclusive learning ecosystems that support differentiation and learner autonomy. AI-driven systems can personalize coding tasks based on learner performance, while coding activities help students understand and critically engage with intelligent technologies. This integration aligns with the principles of Universal Design for Learning, which advocate multiple means of representation, engagement, and expression to accommodate learner diversity (CAST, 2018).

B. Research Method

This study employed a Systematic Literature Review (SLR) to comprehensively analyze recent research on the implementation of coding and artificial intelligence in inclusive education. The SLR approach was selected to ensure a rigorous, transparent, and replicable process for identifying, evaluating, and synthesizing relevant literature.

Search Strategy and Data Sources

The literature search was conducted using five academic databases: Scopus, Springer, DOAJ, Sinta, and Google Scholar**.** These databases were selected to ensure broad coverage of international and national scholarly publications. The search process used a combination of keywords, including *artificial intelligence in education*, *coding education*, *computational thinking*, *inclusive education*, and *special needs education*. Boolean operators (AND, OR) were applied to refine the search results and enhance relevance.

Selection Criteria

The inclusion criteria were clearly defined to maintain focus and quality:

(1) publications published between 2019 and 2024**;**

(2) studies explicitly discussing artificial intelligence or coding in educational contexts;

(3) relevance to inclusive education or learners with special educational needs;

(4) peer-reviewed journal articles or academic books with clear methodological descriptions.

Studies were excluded if they did not address inclusive education, lacked methodological clarity, or were not written in English or Indonesian.

Screening and Selection Process

The initial search yielded 68 publications. Titles and abstracts were first screened to remove irrelevant studies. Full-text screening was then conducted based on the inclusion criteria, resulting in 20 studies selected for final analysis. This stepwise screening process ensured that only relevant and methodologically sound studies were included.

Data Analysis Technique

The selected studies were analyzed using thematic analysis. Key findings were coded and grouped into recurring themes. To strengthen analytical coherence, the Universal Design for Learning (UDL) framework was used as the primary analytical lens. The analysis focused on three core themes:

(1) the role of artificial intelligence in improving accessibility in inclusive education;

(2) the contribution of coding to the development of computational

thinking among learners with special needs;
(3) the integration of artificial intelligence and coding within inclusive learning environments.

This focused methodological approach ensured consistency in analysis and strengthened the validity of the synthesized findings.

Validity and Trustworthiness of the Review

To ensure the validity and trustworthiness of this systematic literature review, several strategies were applied. First, multiple databases were used to minimize publication bias and increase the comprehensiveness of the literature coverage. Second, clearly defined inclusion and exclusion criteria were applied consistently throughout the screening process to ensure relevance and methodological quality. Third, thematic analysis was conducted using a structured coding process, allowing patterns and themes to emerge systematically across studies. Finally, the use of the Universal Design for Learning (UDL) framework provided a consistent theoretical lens for interpreting findings, enhancing analytical coherence and credibility of the review results.

Research Limitations

Although this systematic literature review was conducted using a rigorous and transparent methodology, several limitations should be acknowledged. First, the review relied on secondary data, and therefore the findings are dependent on the quality and scope of the selected studies. Second, the inclusion of only English and Indonesian publications may have excluded relevant studies published in other languages. Third, variations in research design, participant characteristics, and educational contexts across studies limited the ability to directly compare outcomes. Despite these limitations, the review provides a comprehensive overview of current trends and evidence related to artificial intelligence and coding in inclusive education.

C.Research and Discussion Results

This section presents and discusses the main findings of the systematic literature review. Based on thematic analysis, the findings are

organized into four major themes: (1) artificial intelligence for inclusive learning access, (2) coding as a tool for developing computational thinking, (3) the integration of artificial intelligence and coding in inclusive education, and (4) implementation challenges and opportunities in the Indonesian context.

Table 1. Summary of Selected Studies on AI and Coding in Inclusive Education

Author & Year	Country	Focus	Participants	Key Findings
Gong (2024)	China	AI (Speech to text)	Students with hearing impairment	Improved classroom participation
Park & Ryu (2023)	Korea	AI (Reading Support)	Dyslexic learners	Increased reading accuracy
Durak & Saritepeci (2022)	Turkey	Coding (Scratch)	Students with ASD	Improved focus and self-confidence
Ahmed et al. (2022)	UK	Coding	Children with special needs	Enhanced collaboration and creativity
Kim & Lim (2024)	Korea	AI (Adaptive Learning)	Inclusive classrooms	Personalized learning outcomes

Artificial Intelligence for Inclusive Learning Access

The reviewed studies consistently indicate that artificial intelligence plays a significant role in improving learning accessibility for students with special educational needs. AI-based technologies such as

speech-to-text systems enable real-time transcription of verbal instruction, allowing students with hearing impairments to participate more actively in classroom learning (Gong, 2024; Kim & Lim, 2024). Similarly, AI-powered reading assistance tools have been shown to support learners with dyslexia by improving reading accuracy and comprehension through personalized feedback (Park & Ryu, 2023).

Adaptive learning systems are another prominent application of AI in inclusive education. These systems dynamically adjust learning content, pacing, and difficulty based on learners' performance data. Research by Hwang, Xie, Wah, and Gašević (2023) demonstrates that adaptive AI systems can significantly enhance learner engagement and academic outcomes, particularly for students with learning difficulties. Such findings align with the Universal Design for Learning (UDL) principle of providing multiple means of representation and engagement (CAST, 2018).

However, the literature also highlights that the effectiveness of AI-based inclusive learning depends heavily on contextual factors. In developing countries, including Indonesia, limited digital infrastructure and uneven internet access remain major barriers to implementation (Suryani, 2022; Kemendikbudristek, 2023). Furthermore, low levels of AI literacy among teachers hinder the optimal use of these technologies in inclusive classrooms (Hadi, 2024). These findings suggest that while AI holds strong potential for inclusive education, systemic support is essential for sustainable implementation.

Coding and the Development of Computational Thinking

The analysis reveals that coding education plays a crucial role in fostering computational thinking skills among learners with diverse abilities. Computational thinking involves problem decomposition, pattern recognition, abstraction, and algorithmic thinking, all of which are fundamental skills for the digital era (Grover & Pea, 2021). Visual programming environments such as Scratch and Blockly are frequently cited as inclusive tools due to their intuitive interfaces and low cognitive barriers.

Durak and Saritepeci (2022) found that Scratch-based coding activities significantly improved focus, task persistence, and self-confidence among students with autism spectrum disorder. Similarly, Ahmed, Hassan, Khan, Malik, and Rahman (2022) reported that inclusive coding activities enhanced collaboration and creativity among children with special needs, enabling them to actively participate in classroom learning alongside their peers.

Beyond technical skill development, coding activities also contribute to social and emotional learning. Coding projects often involve collaboration, peer feedback, and iterative problem-solving, which support communication skills and social interaction. These findings reinforce the view that coding should be positioned not merely as a technical subject but as an inclusive pedagogical strategy that supports holistic learner development.

Integration of Artificial Intelligence and Coding in Inclusive Education

The integration of artificial intelligence and coding generates synergistic benefits for inclusive learning environments. AI can be used to personalize coding tasks by adjusting task complexity, providing automated hints, and offering adaptive feedback based on learner performance (Nouri, 2023). At the same time, coding enables learners to understand the logic behind AI-based systems, fostering critical digital literacy and learner agency.

Several studies emphasize that integrating AI and coding supports the principles of Universal Design for Learning by enabling flexible learning pathways and learner-centered instruction (Al-Azawei, Serenelli, & Lundqvist, 2020; CAST, 2018). For example, students can be guided to design simple AI-assisted applications, such as chatbots or interactive learning tools, that address real-world accessibility challenges. Such activities not only enhance technical competence but also promote empathy and ethical awareness regarding the use of technology in education.

This integrated approach aligns with contemporary educational goals that emphasize creativity, problem-solving, and inclusivity. However, the literature suggests that successful

integration requires careful instructional design and adequate teacher support to ensure that technology serves pedagogical rather than purely technical purposes.

Pedagogical and Policy Implications

The findings of this review carry important pedagogical and policy implications for inclusive education. From a pedagogical perspective, teachers are encouraged to integrate artificial intelligence and coding not merely as technological tools but as instructional strategies that support differentiated and learner-centered instruction. AI-driven feedback systems and adaptive coding tasks can help teachers address individual learner needs while maintaining inclusive classroom dynamics.

From a policy perspective, educational stakeholders should prioritize the development of inclusive digital education frameworks that explicitly incorporate artificial intelligence and coding. This includes providing adequate infrastructure, establishing ethical guidelines for AI use, and ensuring continuous professional development for teachers. In the Indonesian context, these implications align with the objectives of the Merdeka Curriculum, which emphasizes flexibility, autonomy, and inclusivity in learning. Without clear policy direction and institutional support, however, the potential of AI and coding to transform inclusive education may remain underutilized.

Comparison Across Educational Contexts

The reviewed studies reveal notable differences in the implementation of artificial intelligence and coding across educational contexts. In developed countries, AI-based inclusive learning systems are commonly supported by stable digital infrastructure, continuous teacher training, and clear policy frameworks. These conditions allow technologies such as adaptive learning platforms and intelligent tutoring systems to be implemented more systematically and evaluated through large-scale empirical studies (Holmes et al., 2023; Kim & Lim, 2024).

In contrast, studies conducted in developing countries often report fragmented implementation and

limited empirical evidence. Challenges related to infrastructure availability, teacher digital literacy, and institutional readiness frequently constrain the adoption of AI and coding in inclusive classrooms (Suryani, 2022; Hidayat & Sari, 2024). As a result, many initiatives remain at the pilot or exploratory stage, with limited scalability.

These contextual differences highlight the importance of adapting AI- and coding-based inclusive education to local conditions rather than adopting technological solutions wholesale. In the Indonesian context, inclusive technology integration must consider regional disparities, school readiness, and teacher capacity. This finding reinforces the argument that inclusive digital innovation should be grounded in contextual analysis and supported by long-term policy commitment (Selwyn, 2022; UNESCO, 2023).

Future Directions for Inclusive Digital Education

The findings of this systematic literature review also point toward several important future directions for inclusive digital education. First, there is a growing need for empirical research that examines the long-term impact of artificial intelligence and coding on learning outcomes among students with special educational needs. Many existing studies focus on short-term interventions or pilot projects, making it difficult to assess sustainability and scalability. Longitudinal studies and mixed-method research designs are therefore recommended to provide deeper insights into how inclusive digital technologies influence cognitive, social, and emotional development over time.

Second, future research should explore the role of teachers as key mediators in the successful implementation of AI- and coding-based inclusive education. While technology offers adaptive and personalized learning opportunities, its effectiveness largely depends on teachers' pedagogical competence, digital literacy, and attitudes toward inclusion. Professional development programs that integrate inclusive pedagogy, artificial intelligence literacy, and coding instruction are essential to ensure that technology supports, rather than replaces,

meaningful teacher–student interaction (Bennett et al., 2018; Hadi, 2024).

Third, collaboration between policymakers, researchers, and educational technology developers should be strengthened to ensure that inclusive digital innovations are aligned with educational goals and ethical standards. Issues related to data privacy, algorithmic transparency, and equitable access must be addressed systematically to prevent new forms of exclusion. International organizations emphasize that inclusive digital education should prioritize fairness, accountability, and learner protection, particularly for vulnerable student populations (Bulger & Davison, 2021; UNESCO, 2023).

Finally, in the Indonesian context, future initiatives should focus on developing locally grounded models of AI- and coding-based inclusive education that consider regional diversity, school readiness, and cultural factors. Rather than adopting technological solutions developed in different contexts, inclusive digital education in Indonesia should be informed by local needs assessments and participatory approaches involving teachers, students, and communities. Such context-sensitive innovation has the potential to support sustainable educational transformation while ensuring that no learner is left behind.

Challenges and Opportunities in the Indonesian Context

The literature review reveals a significant imbalance in the geographical distribution of research on AI and coding in inclusive education. Most empirical studies originate from developed countries, such as the United States, the United Kingdom, and South Korea (Holmes, Bialik, Fadel, & Tuomi, 2023). In contrast, studies focusing on developing countries, including Indonesia, remain limited (Hidayat & Sari, 2024).

Despite this gap, Indonesia presents considerable opportunities for implementing inclusive technology-based education. The Merdeka Curriculum emphasizes differentiated instruction, learner autonomy, and inclusive practices, which align closely with the principles underlying AI and coding-based learning

(Kemendikbudristek, 2023). Moreover, the growing number of local educational technology initiatives provides a foundation for innovation.

Nevertheless, several challenges must be addressed. These include limited infrastructure, insufficient teacher training, and the absence of locally grounded empirical research. Addressing these challenges requires coordinated efforts involving policy development, professional teacher training, and sustained research initiatives. Strengthening AI literacy among teachers is particularly critical to ensure that technology integration supports inclusive learning goals rather than exacerbating existing inequalities (Selwyn, 2022; Hadi, 2024).

In addition, ethical considerations related to artificial intelligence in inclusive education deserve attention. Issues such as data privacy, algorithmic bias, and unequal access to technology may disproportionately affect students with special needs. Several scholars emphasize that inclusive AI implementation must prioritize fairness, transparency, and learner protection to avoid reinforcing existing educational inequalities (Selwyn, 2022; UNESCO, 2023). Addressing these ethical dimensions is essential to ensure that AI-based educational innovations genuinely support inclusive and equitable learning.

D. Conclusion

This systematic literature review highlights the substantial potential of artificial intelligence and coding to support inclusive education by enhancing accessibility, personalization, and learner engagement. The reviewed studies demonstrate that AI-based technologies such as adaptive learning systems, speech-to-text tools, and intelligent feedback mechanisms can reduce learning barriers for students with diverse needs, while coding activities contribute to the development of computational thinking, creativity, collaboration, and learner autonomy.

The findings also indicate that the integration of AI and coding, when aligned with the Universal Design for Learning (UDL) framework, enables flexible and learner-centered instructional practices that accommodate individual differences.

This integrated approach positions technology not merely as a support tool, but as an inclusive pedagogical strategy that promotes equitable participation in learning.

Despite these benefits, the review identifies several challenges, particularly in the Indonesian context, including limited digital infrastructure, uneven access to technology, and insufficient teacher readiness in applying AI- and coding-based instruction. These challenges underscore the importance of strengthening teacher professional development, improving digital infrastructure, and developing inclusive curricula that explicitly integrate AI and coding.

This study is limited by its reliance on secondary data and the absence of empirical classroom implementation. Future research should focus on empirical studies in inclusive school settings, the design of adaptive coding curricula, and policy-oriented research that supports sustainable and ethical integration of artificial intelligence in inclusive education, particularly in developing countries such as Indonesia.

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