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Artificial Intelligence as a Virtual Assistant Teacher for Personalized Inclusive Learning: A Systematic Literature Review and Human AI Collaboration Framework for Indonesia

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Abstract

Artificial Intelligence (AI) offers significant potential to support personalized and inclusive learning for students with special educational needs. However, its role as a Virtual Assistant Teacher, particularly in the Indonesian context, remains insufficiently explored. This study examines the role of AI in personalized inclusive learning, its educational impacts, implementation challenges, and potential for human–AI collaboration. A Systematic Literature Review (SLR) was conducted using the PRISMA 2020 framework, analyzing relevant literature published between 2021 and 2026 through Google Scholar and Publish or Perish. Qualitative thematic synthesis was applied to identify major patterns across the selected studies. The findings indicate that AI supports inclusive learning through adaptive learning systems, assistive technologies, intelligent tutors, educational robots, and learning analytics. These applications can improve learning motivation, participation, accessibility, communication, autonomy, and academic support. However, challenges remain regarding data privacy, algorithmic bias, digital infrastructure, teacher competence, and technological dependence. The study proposes a human-in-the-loop approach in which AI provides adaptive instructional support while teachers retain primary pedagogical decision-making authority. The findings provide a conceptual foundation for developing ethical, equitable, and human-centered AI integration in Indonesian inclusive education.

Keywords: artificial intelligence, virtual assistant teacher, inclusive education, personalized learning, adaptive learning, assistive technology, human–ai collaboration.

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Introduction

Advancements in Artificial Intelligence (AI) have increasingly transformed various sectors, including education, by enabling data-driven, adaptive, and personalized approaches to teaching and learning. The growing adoption of digital technologies requires educational institutions to reconsider conventional instructional practices and develop more responsive learning environments [1]. Within this transformation, inclusive education has become an important educational and social agenda, emphasizing the right of every learner to access high-quality education regardless of individual differences, including students with special educational needs [2]. AI offers considerable potential to support this agenda because its capacity to process learner data, recognize learning patterns, provide adaptive feedback, and personalize instructional content can help address the diverse cognitive, behavioral, and learning needs of students. The rapid expansion of AI in education further demonstrates its technological and economic significance. However, the adoption of AI in inclusive education remains uneven, particularly in developing contexts such as Indonesia, where access to adaptive technologies and supporting infrastructure is still limited [3]. This condition highlights the need for systematic investigation into how AI can function as a virtual assistant teacher to support personalized and inclusive learning.

Despite its potential, the implementation of AI as a virtual assistant teacher presents substantial pedagogical, technological, ethical, and infrastructural challenges. Among the most prominent concerns are data security and privacy, the limited availability of representative datasets for students with special needs, algorithmic bias, and unequal access to digital infrastructure [4]. These challenges are particularly relevant in Indonesia, where disparities in technological infrastructure between urban and rural areas may restrict the effective implementation of AI-supported learning. In addition, excessive dependence on automated systems may reduce opportunities for direct teacher–student interaction and potentially weaken the development of critical thinking, social interaction, and other competencies that require meaningful human engagement. Thus, AI should not be conceptualized as a replacement for teachers but rather as an assistive technology that complements teachers' pedagogical roles. The limited preparedness of educators also remains a significant concern, as only approximately 40% of educators have received formal training related to AI utilization [5]. Consequently, successful implementation requires not only technological availability but also teacher competence, ethical governance, appropriate pedagogical design, and sustained human oversight.

Previous studies have demonstrated the potential of AI to facilitate more inclusive learning experiences. AI-supported educational systems can accommodate individual differences by adapting learning materials, instructional strategies, and feedback according to students' needs. For example, adaptive AI robots have been developed to provide learning assistance to students with learning disabilities. Other research has reported that AI-based STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning can improve numeracy literacy among children with intellectual disabilities [6]. These findings indicate that AI can provide meaningful instructional support for learners who may require differentiated learning approaches. Nevertheless, existing studies have predominantly emphasized the technical capabilities and general educational benefits of AI, while the specific role of AI as a virtual assistant teacher in inclusive educational settings remains insufficiently examined [7]. In particular, limited attention has been given to how AI can continuously adapt instructional content to individual learner characteristics while simultaneously supporting teachers in managing diverse learning needs.

This limitation becomes more pronounced in the Indonesian context. Existing literature has identified infrastructure limitations, algorithmic bias, data privacy, and digital inequality as major barriers to AI adoption [8]. However, the interaction between AI-driven personalization, local educational conditions, teacher involvement, and the learning engagement of students with special needs remains relatively underexplored. Rural and resource-constrained inclusive schools represent an especially important context because the effectiveness of AI-based interventions may depend on the availability of appropriate local data, technological infrastructure, teacher competencies, and mechanisms for human–AI collaboration. Therefore, there is a need for a more focused examination of AI not merely as a digital learning medium but as a virtual assistant teacher capable of supporting differentiated instruction and personalized learning.

Although previous research has explored AI as a virtual learning medium in general educational contexts [9], studies specifically addressing the roles, personalization mechanisms, implementation challenges, and contextual requirements of AI in inclusive education remain limited [10]. This study addresses this gap by conceptualizing AI as a Virtual Assistant Teacher that can support real-time curriculum adaptation, deliver instructional materials according to individual learning characteristics, provide personalized feedback, and promote learner autonomy [11]. Such a role positions AI as a complementary instructional agent rather than a substitute for human teachers. This distinction is particularly important in inclusive education, where effective learning requires both technological adaptability and human-centered pedagogical intervention.

Accordingly, this study aims to analyze the role of AI as a virtual assistant teacher in personalizing inclusive learning through a systematic literature review. Specifically, the study seeks to: (1) identify the roles of AI in supporting students with special needs; (2) analyze mechanisms of AI-driven learning personalization for students with special needs; (3) evaluate the impact of AI-assisted teaching on student engagement; (4) identify the challenges and opportunities associated with AI implementation in Indonesian inclusive education; and (5) formulate recommendations for a virtual AI teacher framework appropriate to the Indonesian educational context. By synthesizing findings from existing research, this study is expected to contribute theoretically to the growing discourse on AI-enabled inclusive education, particularly regarding personalized curriculum adaptation and human–AI collaboration. Practically, the findings may provide a conceptual foundation for educators, policymakers, and educational technology developers to design and implement AI-assisted learning environments that are more adaptive, autonomous, inclusive, and responsive to the diverse needs of students with special educational needs.

Method

This study employed a Systematic Literature Review (SLR) using a qualitative approach to systematically identify, evaluate, and synthesize previous studies concerning the role of Artificial Intelligence (AI) as a virtual assistant teacher in personalizing inclusive learning. The review was designed to provide a comprehensive understanding of the application of AI in supporting students with special educational needs, particularly in relation to learning personalization, student engagement, teacher assistance, implementation challenges, and opportunities within the Indonesian educational context.

The review process consisted of several stages, including literature identification, screening, eligibility assessment, data extraction, and qualitative synthesis. The study selection procedure was structured based on the principles of the PRISMA 2020 framework to improve transparency and reproducibility in the identification and selection of relevant literature. The review focused on recent scientific publications to capture developments in AI technologies and their applications in inclusive and special education.

a. Search Strategy

The literature search was conducted using Google Scholar as the primary academic search engine and Publish or Perish as a supporting tool for retrieving and organizing bibliographic records. The search was conducted using combinations of keywords representing the main concepts of the study. The keywords included "Artificial Intelligence," "Artificial Intelligence in Special Education," "Inclusive Education," "Pendidikan Inklusi," "Students with Special Needs," and "Anak Berkebutuhan Khusus."

Keyword combinations were developed to capture studies addressing AI applications in education, inclusive learning, special education, adaptive learning, personalized learning, and AI-supported teaching. The search focused on publications issued between 2021 and 2026 to ensure that the evidence reflected recent developments in AI-enabled educational technologies. In addition to database searches, the reference lists of relevant publications were examined to identify potentially relevant studies that might not have been retrieved through the initial keyword search.

The literature search and selection process followed four principal stages: identification, screening, eligibility, and inclusion. During the identification stage, potentially relevant records were collected from the selected sources. Duplicate records and clearly irrelevant records were subsequently removed. During screening, titles and abstracts were examined to determine their relevance to the research objectives. Articles that potentially met the criteria were retrieved in full text and assessed during the eligibility stage. Finally, studies satisfying all predefined criteria were included in the qualitative synthesis.

b. Inclusion and Exclusion Criteria

Predefined inclusion and exclusion criteria were established to ensure that the selected literature was relevant to the research questions and sufficiently comparable for qualitative synthesis. The criteria considered publication year, relevance to AI and education, population or educational context, research focus, and availability of substantive information.

Table 1. Inclusion and Exclusion Criteria for Study Selection

Criteria	Inclusion	Exclusion
Publication period	Studies published between 2021 and 2026	Studies published before 2021
Research focus	Studies examining AI applications in education, inclusive education, or special education	Studies focusing on AI applications unrelated to education
Target learners	Students with special educational needs, disabilities, learning difficulties, or learners in inclusive educational settings	Studies with populations unrelated to the educational context of the review
AI application	AI used for learning personalization, adaptive learning, instructional assistance, assessment, feedback, engagement, or teacher support	Studies focusing exclusively on AI algorithms or technical development without an educational application
Educational context	Inclusive education, special education, primary education, or contexts relevant to students with special educational needs	Studies conducted exclusively in unrelated professional or industrial contexts
Research relevance	Studies addressing at least one of the research objectives concerning AI-assisted inclusive learning	Studies with no substantive relationship to the research objectives
Publication type	Peer-reviewed journal articles and relevant scholarly publications with sufficient methodological or substantive information	Duplicate records, incomplete records, editorials, non-scholarly materials, and publications without sufficient information
Language	Publications available in English or Indonesian	Publications that could not be adequately interpreted because the full text was inaccessible or unavailable in an interpretable language

c. Study Selection and PRISMA Procedure

The study selection procedure followed the PRISMA 2020 framework. The process began with the identification of records through the specified literature sources. All retrieved records were compiled and examined for duplication. Duplicate records were removed before the screening process. The remaining records were screened based on their titles and abstracts, with studies that were clearly unrelated to the research topic being excluded.

The potentially relevant studies were then assessed through full-text examination. At this stage, studies were excluded when they did not satisfy the predefined inclusion criteria, did not address AI applications in inclusive or special education, did not focus on relevant forms of personalization or instructional assistance, or lacked sufficient information for qualitative analysis. The final set of eligible studies constituted the evidence base for the qualitative synthesis.

The complete identification, screening, eligibility, and inclusion process is presented in Figure 1, which provides the PRISMA 2020 flow diagram of the literature search and study selection process. The numbers reported in the diagram correspond to the actual results obtained during the literature search and screening process.

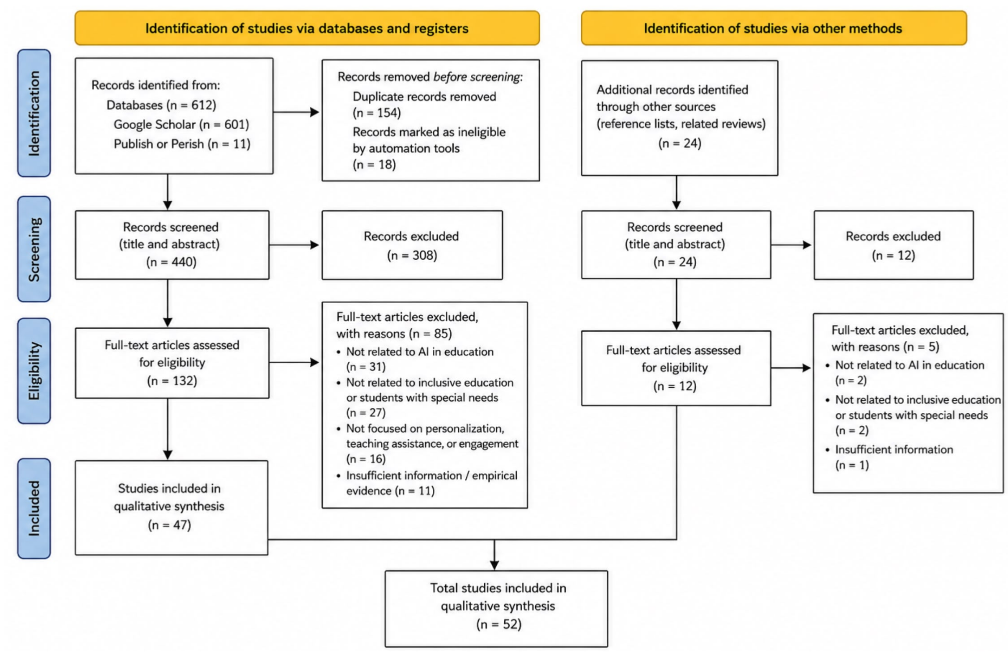

Figure 1. PRISMA 2020 Flow Diagram of the Literature Search and Study Selection Process

d. Data Extraction

Data extraction was conducted systematically using a predefined extraction framework. Information relevant to the research objectives was extracted from each included study to facilitate comparison across publications. The extracted information included bibliographic characteristics, research objectives, methodological approaches, educational contexts, target populations, AI technologies, personalization mechanisms, reported outcomes, and implementation challenges.

The extracted data were organized into a structured matrix to identify similarities, differences, and recurring patterns among the reviewed studies. Particular attention was given to evidence concerning the capacity of AI to provide individualized learning support, adapt instructional materials, generate personalized feedback, facilitate student engagement, and assist teachers in managing diverse learning needs.

Table 2. Data Extraction Framework for the Included Studies

No	Data Category	Information Extracted	Analytical Purpose
1	Bibliographic information	Author(s), publication year, and publication source	Identify the characteristics and recency of the evidence
2	Research objective	Main objective or research question	Determine the primary focus of each study
3	Research methodology	Research design, methods, and analytical approach	Compare methodological characteristics across studies

No	Data Category	Information Extracted	Analytical Purpose
4	Educational context	Primary school, secondary school, special education, inclusive education, or other contexts	Identify the contexts in which AI has been implemented
5	Target population	Students with special educational needs, disabilities, learning difficulties, or other learner groups	Identify the populations benefiting from AI-supported learning
6	AI technology/application	AI system, intelligent tutoring system, adaptive technology, AI robot, generative AI, machine learning, or other applications	Identify the technological approaches used
7	Personalization mechanism	Adaptive content, individualized feedback, learning recommendations, differentiated instruction, or learner profiling	Examine how AI supports personalized learning
8	Role of AI	Virtual assistant, learning assistant, instructional support, assessment support, or teacher support	Determine the functional role of AI in the learning process
9	Learning outcomes	Engagement, learning achievement, numeracy, literacy, autonomy, motivation, or other outcomes	Evaluate the reported educational effects
10	Teacher involvement	Teacher supervision, collaboration, intervention, or pedagogical decision-making	Examine human–AI collaboration
11	Challenges	Data privacy, algorithmic bias, infrastructure, digital divide, teacher competence, and ethical issues	Identify barriers to AI implementation
12	Opportunities	Personalization, accessibility, scalability, adaptive instruction, and learner autonomy	Identify potential benefits and future opportunities
13	Relevance to Indonesia	Findings applicable to Indonesian inclusive education	Determine contextual implications for Indonesia
14	Key findings	Principal findings and conclusions of the study	Support cross-study comparison and synthesis

e. Data Analysis and Qualitative Synthesis

The extracted data were analyzed using qualitative thematic synthesis. The analysis involved three principal stages. First, relevant findings from each included study were identified and coded according to concepts associated with AI-supported inclusive learning. Second, similar codes were grouped into broader themes. Third, the themes were compared across studies to identify common findings, differences, research gaps, and contextual considerations.

The synthesis was organized around five major analytical themes: (1) the role of AI as an assistant for teachers and students; (2) AI-driven personalization of learning; (3) student engagement and learning autonomy; (4) technological, pedagogical, ethical, and infrastructural challenges; and (5) opportunities and contextual requirements for AI implementation in Indonesian inclusive education.

Particular emphasis was placed on the relationship between AI capabilities and the diverse learning needs of students with special educational needs. The analysis also considered the extent to which AI can complement teachers through adaptive instructional support while maintaining human supervision and pedagogical decision-making. This approach recognizes that AI should function as a complementary instructional technology rather than a replacement for teachers.

f. Framework Development

The findings synthesized from the selected studies were subsequently used to formulate recommendations for a conceptual framework of AI as a Virtual Assistant Teacher in inclusive education. The framework considers five interconnected components: learner characteristics, AI enabled personalization, teacher AI collaboration, technological and ethical infrastructure, and learning outcomes.

The proposed framework is intended to explain how AI can support the delivery of differentiated learning while maintaining teacher involvement and learner-centered pedagogical principles. Particular consideration is given to data privacy, algorithmic fairness, teacher competency, accessibility, and the technological conditions required for sustainable implementation. The resulting framework provides a conceptual basis for understanding how AI can be integrated into Indonesian inclusive education and identifies areas requiring further empirical investigation.

Result and Discussion

a. AI as a Virtual Assistant Teacher for Personalized Inclusive Learning

The literature indicates that Artificial Intelligence (AI) has increasingly emerged as a complementary instructional technology capable of supporting inclusive and personalized learning at the elementary school level. Rather than replacing teachers, AI can function as a virtual assistant teacher or co-teacher that supports instructional adaptation, accessibility, feedback, and learner autonomy [12]. The analysis of the reviewed literature demonstrates that AI applications in inclusive education encompass adaptive learning systems, assistive technologies, educational robots, intelligent tutoring systems, and learning analytics [13]. These applications are particularly relevant to students with special educational needs because conventional standardized instructional approaches may not adequately accommodate differences in cognitive abilities, communication needs, learning pace, and individual learning characteristics.

One of the most important contributions of AI is its ability to support teachers in adapting learning activities according to individual student characteristics. AI-based systems can process learning data, including student responses, task completion, interaction patterns, and learning progress, to identify strengths and difficulties. Based on these data, the system can recommend or provide learning materials that correspond to the student's current level of understanding. Consequently, learning can become more responsive and individualized rather than following a uniform instructional sequence [14]. This capability is particularly important in inclusive classrooms, where teachers must accommodate students with diverse abilities and learning requirements.

The main applications of AI identified in the literature are summarized in Table 3.

Table 3. Major AI Applications Supporting Inclusive and Personalized Learning

AI Application	Primary Function	Targeted Learning Need	Contribution to Inclusive Learning	Role as Virtual Assistant
Adaptive learning systems	Adjust learning content according to student performance	Different cognitive abilities and learning pace	Provides differentiated learning pathways	Recommends and modifies learning materials
Assistive technologies	Support communication, reading, and information access	Visual, auditory, speech, and communication difficulties	Improves accessibility and participation	Provides real-time instructional and communication support
AI-powered educational robots	Provide interactive and repetitive learning activities	Intellectual disabilities and autism-related learning needs	Supports structured and engaging learning experiences	Provides consistent interaction and guided practice
Intelligent chatbots/tutors	Provide answers, explanations, and feedback	Students requiring immediate instructional assistance	Extends access to learning support	Provides on-demand academic assistance
Learning analytics	Analyze learning behavior and performance	Students requiring early identification of difficulties	Supports data-informed intervention	Helps teachers identify learning progress and difficulties
Speech and image recognition	Interpret, convert, or communicate information	Visual, speech, and communication impairments	Enhances interaction with learning environments	Supports classroom communication and participation

Table 3 demonstrates that AI's role in inclusive learning extends beyond simply delivering digital learning materials. Its functions encompass instructional adaptation, accessibility enhancement, communication support, interaction, and learning analytics. Adaptive learning systems are particularly important because they allow the level and sequence of instructional materials to be adjusted according to student performance [15]. Assistive technologies address accessibility barriers experienced by students with sensory or communication difficulties. Meanwhile, AI-powered educational robots can provide structured and repetitive interactions that may be particularly useful for students who benefit from consistent learning routines [16].

Intelligent chatbots and AI tutors provide another form of instructional assistance by enabling students to obtain immediate responses to questions and receive feedback during learning activities. Learning analytics further strengthens the teacher's capacity to identify students who experience difficulties by processing learning-related data. Thus, AI can be conceptualized as a distributed instructional support system rather than a single technological intervention. Its value lies in its capacity to perform complementary functions that enable teachers to respond more effectively to diverse learner needs.

The second important dimension concerns the mechanisms through which AI facilitates learning personalization. Traditional instructional models commonly apply similar learning materials, activities, and assessment procedures to students within the same class. Such approaches may create difficulties when students have substantially different levels of prior knowledge, cognitive abilities, communication capacities, and learning speeds. AI provides an opportunity to shift from this standardized model toward a more individualized and adaptive learning paradigm [17].

The mechanisms through which AI supports personalization are presented in Table 4.

Table 4. Mechanisms of AI-Driven Personalization in Inclusive Learning

Personalization Mechanism	Data/Information Used	AI-Supported Action	Expected Educational Benefit	Relevance to Special Educational Needs
Learner profiling	Performance, interaction, and progress data	Identifies individual learning characteristics	Supports more accurate instructional planning	Recognizes diverse learner profiles
Adaptive content	Responses, task accuracy, and mastery level	Adjusts material difficulty and sequence	Reduces cognitive overload and frustration	Accommodates different levels of cognitive readiness
Personalized feedback	Student responses and task performance	Generates immediate and targeted feedback	Supports faster correction and understanding	Provides additional assistance during learning
Learning pace adjustment	Completion time and learning progress	Modifies instructional tempo	Reduces boredom and learning pressure	Supports students requiring additional learning time
Multimodal presentation	Accessibility requirements and interaction patterns	Provides text, audio, visual, or interactive content	Improves accessibility and comprehension	Accommodates sensory and communication differences
Intelligent recommendation	Learning history and identified difficulties	Recommends exercises, resources, or interventions	Promotes independent learning	Creates individualized learning pathways

Table 4 demonstrates that AI-driven personalization involves substantially more than simply increasing or decreasing the difficulty of instructional materials. It incorporates learner profiling, adaptive content, personalized feedback, learning pace adjustment, multimodal presentation, and intelligent recommendations [18]. This broader conceptualization is important for inclusive education because students with special educational needs may require different forms of support even when they are learning the same curriculum.

For example, a student experiencing reading difficulties may benefit from audio-based instructional materials, whereas another student may require simplified textual instructions, additional examples, or repeated practice. Similarly, students with communication difficulties may require alternative forms of interaction through speech recognition, visual interfaces, or augmentative communication technologies. AI can facilitate these adaptations dynamically when sufficient learner data and appropriate pedagogical parameters are available [19].

The personalization process generally begins with the collection and analysis of learner data. Machine learning algorithms and learning analytics can monitor learning patterns, interaction frequency, assessment performance, and progress over time. These data can be used to identify learning strengths and difficulties and subsequently inform appropriate instructional interventions [20]. The continuous nature of this process represents an important advantage over conventional assessment practices, in which instructional adjustments may only occur after periodic examinations.

AI can subsequently adjust learning materials according to the learner's current level of comprehension. For students who have not yet mastered a prerequisite concept, the system can provide reinforcement activities, additional explanations, or lower-level exercises before progressing to more complex content. Conversely, students demonstrating higher levels of mastery can be provided with more challenging materials. This adaptive mechanism allows students to progress at different rates while remaining within the same broader curriculum framework [21].

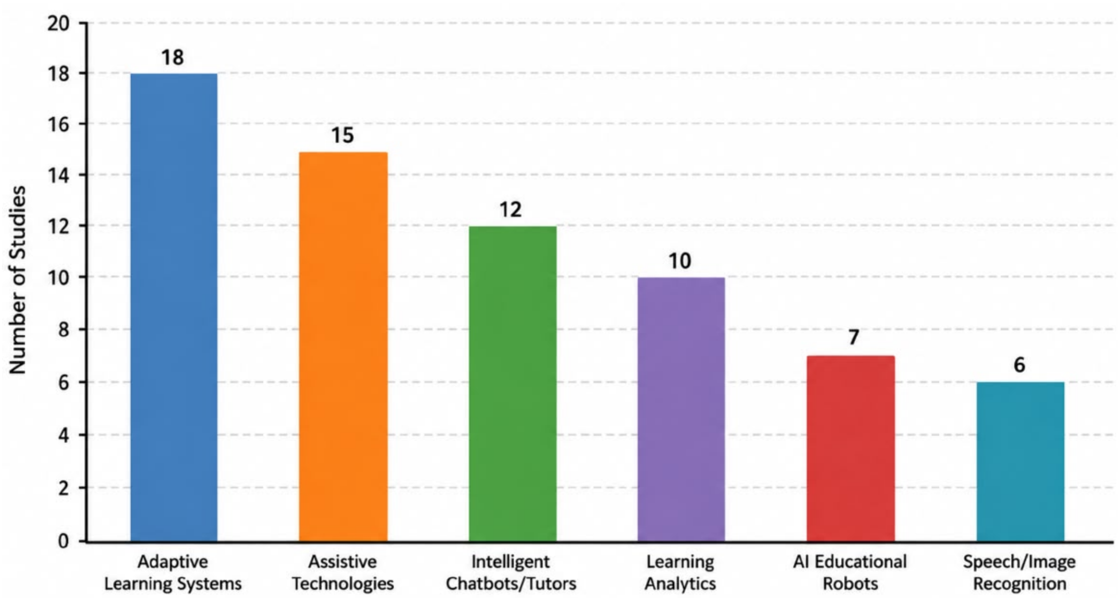

Figure 2. Illustrative Distribution of AI Applications in Inclusive and Personalized Learning

Figure 2 illustrates the distribution of AI applications identified thematically in the reviewed literature. The illustrative distribution suggests that adaptive learning systems represent a particularly important application because they directly support differentiated instruction and individualized learning pathways. Assistive technologies constitute another major area because they address accessibility barriers experienced by students with visual, auditory, speech, and communication difficulties [22]. Intelligent chatbots and tutors provide immediate instructional assistance, while learning analytics support teachers in identifying learning patterns and potential difficulties. Educational robots and speech/image recognition systems represent more specialized applications that can address particular learning and communication needs.

However, these applications should not be interpreted as autonomous instructional agents. The effectiveness of AI-based personalization depends substantially on the quality, completeness, and representativeness of learner data. If the available data do not adequately reflect students with special educational needs, AI systems may generate inappropriate recommendations or fail to recognize important learning characteristics [23]. This issue is particularly relevant in inclusive education because learner populations are highly heterogeneous. Therefore, teachers need to remain actively involved in monitoring AI-generated recommendations and determining whether they are pedagogically appropriate [24].

Another important finding is that AI-driven personalization can potentially strengthen learner autonomy. Immediate feedback from intelligent tutors and chatbots allows students to identify errors and attempt alternative solutions without always waiting for direct teacher assistance [25]. Students can also access learning support at different times and progress according to their individual learning pace. These characteristics can reduce frustration and encourage students to become more actively involved in their learning process.

Nevertheless, personalization should not be interpreted as individualization that isolates students from their peers. In inclusive education, differentiated learning should remain connected to opportunities for collaboration, communication, and social interaction [26]. AI should therefore provide individualized support while teachers maintain responsibility for designing collaborative activities and ensuring that students with special educational needs remain actively integrated into the classroom community.

From a pedagogical perspective, the findings support the conceptualization of AI as a Virtual Assistant Teacher rather than an autonomous teacher. AI can perform computationally intensive and repetitive functions, including analyzing learning data, adapting materials, generating feedback, and recommending learning activities. Teachers, however, remain responsible for interpreting student conditions, establishing learning objectives, managing classroom relationships, providing emotional support, and making pedagogical decisions. This distinction is especially important in inclusive education because many dimensions of learning, such as empathy, social interaction, emotional development, and contextual understanding, cannot be fully represented through quantitative learning data.

Overall, the literature demonstrates that AI has considerable potential to transform inclusive learning from a predominantly standardized model into a more adaptive, individualized, and responsive learning environment. Its strongest contribution lies in its ability to continuously process learner information and translate these data into differentiated instructional support. Adaptive learning systems, assistive technologies, intelligent tutors, educational robots, and learning analytics provide complementary mechanisms for addressing diverse learning needs [27]. However, the successful implementation of these technologies requires reliable data, appropriate pedagogical design, teacher competence, and continuous human supervision. Therefore, AI should be positioned as an intelligent instructional assistant that augments teachers' capacity to personalize learning rather than replacing the central pedagogical role of human educators.

b. Educational Impacts, Benefits, and Challenges of AI in Inclusive Education

The literature synthesis indicates that Artificial Intelligence (AI) has the potential to generate substantial educational impacts for students with special educational needs, particularly in relation to learning motivation, participation, accessibility, communication, and learning autonomy. The reviewed studies suggest that AI-supported learning environments can provide more interactive and responsive learning experiences by adapting instructional content and feedback to individual learner characteristics. This finding is consistent with Kugurakova et al. [28], who reported that technologies such as Augmented Reality (AR) and Virtual Reality (VR) can stimulate learning motivation among students with hearing, intellectual, and physical disabilities. Similarly, AI-driven adaptive learning systems and gamified learning activities have been associated with increased motivation and engagement because students receive individualized feedback and interactive learning experiences [29].

The impact of AI is particularly evident in its ability to improve students' participation in classroom activities. For students with special educational needs, participation may be constrained by communication difficulties, sensory limitations, or a lack of confidence in conventional classroom environments. Assistive technologies, audiovisual media, communication systems, and interactive applications can reduce these barriers by providing alternative channels through which students can access information and express their ideas. Şahin et al. [30], for example, identified the use of TalkBack systems, audiovisual technologies, and specialized learning media for students with hearing and speech impairments as mechanisms for improving comprehension and participation. Similarly, communication tablets and visual applications can facilitate classroom interaction for students who experience speech or hearing difficulties [31].

The major educational impacts identified in the literature can be summarized as follows.

Table 5. Educational Impacts of AI on Students with Special Educational Needs

Impact Dimension	AI-Supported Mechanism	Expected/Reported Outcome	Relevance to Inclusive Education	Supporting Studies
Learning motivation	Interactive content, gamification, adaptive feedback	Increased interest and willingness to learn	Creates more engaging learning experiences	[2], [17], [21]
Classroom participation	Assistive communication and interactive applications	Greater participation in discussions and activities	Reduces barriers to active involvement	[18], [19], [20]
Accessibility	Text-to-speech, speech recognition, visual and audiovisual tools	Improved access to instructional information	Supports learners with sensory and communication difficulties	[18], [22], [23]

Impact Dimension	AI-Supported Mechanism	Expected/Reported Outcome	Relevance to Inclusive Education	Supporting Studies
Learning achievement	Adaptive materials, individualized practice, immediate feedback	Improved academic performance	Supports differentiated learning pathways	[11], [21]
Communication	Augmentative communication and AI-based recognition	Improved ability to express ideas	Facilitates interaction between students and teachers	[19], [20], [22]
Learning autonomy	On-demand assistance and self-paced learning	Greater independence in completing learning activities	Encourages self-regulated learning	[12], [14], [15]

Table 5 demonstrates that the impact of AI extends across both academic and non-academic dimensions of inclusive learning. Learning motivation and classroom participation represent particularly important outcomes because students with special educational needs may encounter barriers that extend beyond academic comprehension. AI-supported environments can provide interactive interfaces and immediate feedback that make learning activities less intimidating and more responsive to individual needs [32]. The accessibility dimension is equally significant because technologies such as text-to-speech, speech recognition, and visual interfaces can enable students with sensory or communication difficulties to access information and participate in classroom interactions [33]. Moreover, AI can contribute to learning autonomy by allowing students to obtain assistance without continuously depending on direct teacher intervention [34]. However, these benefits should be interpreted as complementary educational support rather than evidence that AI independently produces improved learning outcomes. The effectiveness of AI remains dependent on pedagogical implementation, learner characteristics, teacher supervision, and technological accessibility.

Beyond motivation and participation, AI can contribute to the development of more learner-centered educational environments. By adjusting learning activities according to individual performance, AI can reduce the mismatch between instructional difficulty and student capability. Students who require additional support can receive supplementary materials and repeated practice, whereas students who demonstrate stronger mastery can progress toward more complex tasks [35]. This adaptive mechanism is particularly important in inclusive classrooms because differences among learners may be substantial even when students follow the same curriculum.

AI can also provide continuous assistance outside conventional instructional interactions. Intelligent chatbots and virtual tutors can respond to students' academic questions and provide feedback without requiring the teacher to be physically available at every moment. In this context, AI may extend the temporal accessibility of learning support. Chin et al [36] explored AI-supported applications for children with disabilities, including systems incorporating speech and image recognition to support reading and communication. Such applications illustrate how AI can be integrated into learning environments to facilitate communication and literacy while simultaneously assisting teachers [37].

Another important benefit concerns the reduction of teachers' administrative workload. AI can support repetitive activities such as grading, attendance monitoring, preparation of learning materials, documentation, and analysis of student performance [38]. Reducing these administrative demands may allow teachers to allocate more time to direct instructional interaction, individualized guidance, emotional support, and classroom management. In inclusive education, this redistribution of teacher effort is particularly valuable because students with special educational needs frequently require more intensive individual attention.

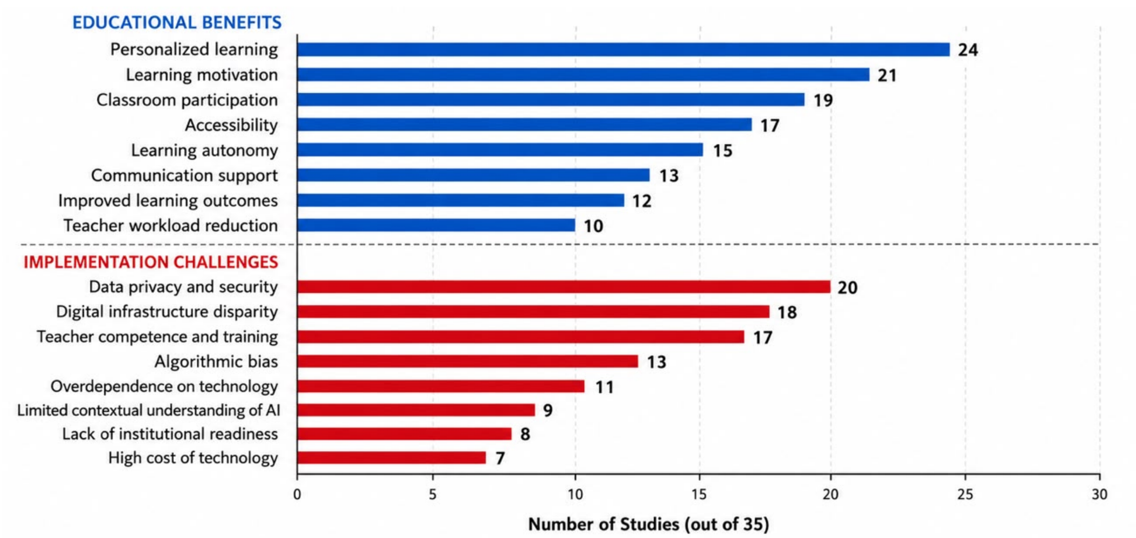

Figure 3. Educational Benefits and Implementation Challenges of AI in Inclusive Education

Figure 3 illustrates the balance between the potential benefits and implementation challenges of AI in inclusive education. The illustrative distribution indicates that personalized learning represents one of the most frequently emphasized benefits, followed by learning motivation, classroom participation, and accessibility. At the same time, data privacy, digital infrastructure, and teacher competence emerge as substantial implementation challenges. This pattern suggests that the success of AI in inclusive education cannot be evaluated solely according to technological functionality. The educational value of AI is determined by the interaction between technological capability and the institutional, pedagogical, ethical, and infrastructural conditions in which the technology is implemented [39].

Despite these benefits, the literature identifies several challenges that may constrain the effectiveness and sustainability of AI-based inclusive education. The first major challenge concerns ethical and privacy issues. AI-based educational systems require access to student information, including learning performance, behavioral patterns, communication data, and potentially sensitive personal characteristics [40]. The collection and processing of such information create risks related to unauthorized access, inappropriate data use, and privacy violations. Algorithmic bias represents another concern because AI systems trained using incomplete or non-representative datasets may generate recommendations that are inappropriate for particular groups of students [41].

The major challenges identified in the literature are presented in Table 6.

Table 6. Major Challenges in Implementing AI for Inclusive Education

Challenge	Underlying Issue	Potential Educational Consequence	Required Mitigation	Supporting Studies
Data privacy and security	Collection of sensitive learner data	Privacy violations and loss of trust	Data governance, security protocols, and informed consent	[42], [43]
Algorithmic bias	Non-representative or biased training data	Unequal or inappropriate recommendations	Bias auditing and representative datasets	[44], [45], [46]
Digital infrastructure	Unequal access to devices, connectivity, and systems	Limited adoption, particularly in remote areas	Infrastructure investment and equitable access	[4], [47]
Teacher competence	Limited AI and digital literacy	Ineffective technology integration	Continuous professional development and training	[48], [49]
Overdependence on technology	Excessive reliance on automated assistance	Reduced critical thinking and independence	Balanced human–AI learning strategies	[50]
Limited contextual understanding	AI lacks comprehensive human common sense and contextual interpretation	Inappropriate or insensitive recommendations	Continuous teacher supervision	[51]
Institutional readiness	Limited school management and support	Fragmented and unsustainable implementation	Institutional planning and implementation guidelines	[38], [52]

Table 6 shows that the challenges associated with AI are multidimensional and cannot be addressed solely through improvements in software or computational performance. Data privacy and algorithmic bias are particularly important because students with special educational needs may be vulnerable to inappropriate classification or recommendations when datasets do not adequately represent their characteristics [53]. Infrastructure represents another structural challenge, especially for schools located in areas with limited connectivity or access to digital devices [4]. Meanwhile, limited teacher competence may prevent schools from obtaining the full pedagogical benefits of AI even when the necessary technological infrastructure is available [47]. These findings indicate that technological adoption must be accompanied by teacher professional development, institutional support, data governance, and continuous evaluation.

Another concern is the potential for overdependence on AI. Excessive reliance on automated systems may reduce opportunities for students to develop critical thinking, problem-solving abilities, and interpersonal competencies [54]. This concern is particularly relevant when AI is positioned as a virtual teacher because students may interpret automated feedback as universally correct. In reality, AI-generated recommendations can contain errors or fail to account for contextual factors. As emphasized by Dahito et al [55], AI remains fundamentally limited in its capacity to understand human common sense, intentions, emotions, and contextual meaning in the same manner as human educators.

Therefore, the educational benefits of AI must be considered alongside the principle of human-centered implementation. AI can provide rapid data processing, individualized feedback, adaptive content, and assistive functions, but teachers remain responsible for evaluating whether these outputs are appropriate for particular students. This human oversight is especially important in inclusive classrooms, where pedagogical decisions may depend on emotional, social, behavioral, and contextual factors that cannot be adequately represented through learning analytics alone.

The literature also suggests that AI implementation should be viewed as a process of institutional transformation rather than merely the adoption of a new educational technology. Schools require appropriate infrastructure, teacher training, ethical guidelines, data protection mechanisms, and management support to ensure sustainable implementation [56]. Teacher attitudes toward inclusive education are also important because positive attitudes can facilitate the integration of technological tools into differentiated instructional practices [57].

Overall, the findings demonstrate that AI has substantial potential to improve inclusive education through personalized learning, increased motivation, enhanced participation, improved accessibility, communication support, and greater learner autonomy. Nevertheless, these benefits are accompanied by significant challenges involving data privacy, algorithmic bias, infrastructure disparities, teacher competence, technological dependence, and limitations in contextual understanding [58]. The evidence therefore supports a balanced perspective: AI should be understood as a capacity-enhancing technology for inclusive education, rather than an autonomous replacement for teachers. Its successful implementation depends on the integration of technological innovation with pedagogical expertise, ethical governance, institutional readiness, and sustained human oversight [59]. This balance provides an essential foundation for developing a human–AI collaboration model that is both technologically effective and consistent with the principles of inclusive education.

c. Human AI Collaboration and Policy Implications for Indonesian Inclusive Education

The findings of the literature review indicate that the sustainable implementation of Artificial Intelligence (AI) in inclusive education depends not only on technological capability but also on the quality of collaboration between AI systems and human teachers. In inclusive classrooms, teachers remain central to the learning process because they are responsible for understanding students' emotional, social, behavioral, and educational needs. AI, in contrast, can perform computational, analytical, and repetitive tasks that complement teachers' pedagogical responsibilities [60]. Therefore, the appropriate implementation model is not one in which AI replaces teachers, but one in which AI functions as an intelligent instructional assistant under continuous human supervision.

This relationship can be conceptualized through the human-in-the-loop approach, in which teachers remain the primary decision-makers while AI provides recommendations, adaptive learning support, feedback, and analytical information [3]. Such an arrangement is particularly important in inclusive education because learning outcomes cannot be determined solely through academic performance data. Students with special educational needs may experience changes in motivation, emotional state, communication ability, and social interaction that require contextual interpretation by teachers. Consequently, AI-generated recommendations should be regarded as decision-support information rather than definitive pedagogical decisions.

The distribution of responsibilities between AI and teachers identified from the literature is presented in Table 7.

Table 7. Complementary Roles of AI and Human Teachers in Inclusive Education

Educational Function	Role of AI	Role of Human Teacher	Expected Outcome	Human Oversight
Learner profiling	Analyzes learning performance and interaction data	Interprets learner characteristics in context	More comprehensive learner profiles	High
Content personalization	Recommends materials and adjusts difficulty	Validates suitability of materials	Differentiated instruction	High
Feedback	Provides immediate automated feedback	Provides contextual and developmental feedback	Faster and more meaningful learning support	Moderate–High
Assessment	Supports automated assessment and performance analysis	Interprets results and makes pedagogical decisions	More efficient assessment	High
Communication support	Provides assistive and alternative communication tools	Facilitates social and interpersonal communication	Improved participation	High
Learning monitoring	Tracks progress and identifies potential difficulties	Determines appropriate interventions	Earlier instructional intervention	High
Administrative tasks	Automates repetitive documentation and data processing	Reviews and verifies outputs	Reduced administrative workload	Moderate
Emotional and social support	Detects selected behavioral or interaction patterns	Provides empathy, counseling, and direct social support	Holistic learner development	Very high

Table 7 demonstrates that AI and human teachers possess complementary rather than competing capabilities. AI is particularly effective in activities involving large-scale data processing, pattern recognition, adaptive content generation, automated feedback, and routine administrative tasks. Teachers, however, remain indispensable for interpreting those outputs within the social and emotional context of individual learners. For example, an AI system may detect a decline in a student's task performance, but it cannot reliably determine whether the decline is caused by conceptual difficulty, emotional distress, family circumstances, social conflict, fatigue, or another contextual factor. The teacher is therefore required to interpret the information and determine an appropriate intervention. This reinforces the human-in-the-loop model as a particularly suitable approach for inclusive education [61].

The collaborative model also requires clear boundaries regarding decision authority. AI may recommend a learning pathway, identify potential difficulties, or generate instructional materials, but teachers should retain authority over curriculum interpretation, intervention decisions, assessment judgments, and student welfare [62]. This arrangement minimizes the risk of inappropriate automation while allowing educators to benefit from AI's computational capabilities. In this respect, AI should be viewed as a decision-support system rather than an autonomous educational decision-maker.

The effectiveness of human–AI collaboration is further influenced by teacher competence and institutional readiness. AI technology cannot generate meaningful educational transformation when teachers lack the knowledge and confidence required to evaluate and integrate its outputs. The literature indicates that teacher attitudes, digital competencies, and understanding of inclusive education play important roles in determining the success of technology integration [63]. Consequently, professional development should not focus exclusively on the technical operation of AI tools. Teachers should also be trained in AI literacy, data interpretation, ethical decision-making, prompt formulation where relevant, bias awareness, privacy protection, and the pedagogical integration of AI [64].

The main requirements for effective implementation are summarized in Table 8.

Table 8. Requirements for Human-AI Collaboration in Inclusive Education

Implementation Dimension	Current/Identified Issue	Required Intervention	Responsible Stakeholders	Expected Contribution
Teacher competence	Limited knowledge of AI and adaptive technologies	Continuous AI and digital pedagogy training	Schools, universities, government	Increased teacher readiness
Digital infrastructure	Unequal access to devices and connectivity	Infrastructure development and equitable access	Government and schools	Improved technological accessibility
Data governance	Risks related to collection and processing of student data	Data protection standards and governance mechanisms	Government, schools, technology providers	Safer AI implementatio n
AI literacy	Limited understanding of AI limitations and bias	AI literacy and critical evaluation training	Teacher education institutions and schools	More responsible AI use

Implementation Dimension	Current/Identified Issue	Required Intervention	Responsible Stakeholders	Expected Contribution
Pedagogical integration	Technology may be adopted without clear instructional objectives	Development of AI-integrated pedagogical guidelines	Schools and teachers	More meaningful technology use
Institutional support	Limited management capacity for AI adoption	Institutional planning, technical support, and evaluation	School management	Sustainable implementatio n
Accessibility	AI systems may not accommodate diverse disabilities	Universal and accessible AI interface design	Technology developers and schools	Greater inclusion
Ethical governance	Lack of clear ethical standards	Guidelines for transparency, accountability, and human oversight	Government and institutions	Responsible AI deployment

Table 8 indicates that the implementation of AI requires a multidimensional readiness framework. Teacher competence is particularly important because educators serve as the primary interface between AI systems and classroom practice. Training should therefore move beyond basic digital skills toward the ability to critically evaluate AI-generated outputs and determine their pedagogical suitability. Infrastructure is another fundamental requirement because AI-supported learning depends on reliable devices, connectivity, software, and technical support [65]. These requirements become particularly significant in rural and resource-constrained schools, where unequal access to digital technologies may reinforce rather than reduce educational disparities.

Data governance also represents a critical component of implementation. Because AI systems may process sensitive information concerning students with special educational needs, schools must establish clear procedures for data collection, storage, access, and use. Ethical governance should additionally address algorithmic bias, transparency, accountability, and the right to human review [66]. Thus, technological adoption must be accompanied by institutional mechanisms that ensure AI remains safe, equitable, and accountable.

At the policy level, inclusive education requires coordination among government institutions, schools, teachers, technology developers, parents, and local communities. The literature indicates that inclusive education continues to face challenges associated with limited facilities, insufficient teacher training, and suboptimal institutional management [67]. These structural constraints imply that AI implementation should be conducted progressively according to institutional readiness rather than through uniform technology deployment. Schools with limited infrastructure, for example, may initially prioritize low-bandwidth AI applications or assistive technologies before adopting more computationally intensive systems.

The policy implications identified through the literature can be further organized into four major domains, as shown in Table 9.

Table 9. Policy Priorities for AI Implementation in Indonesian Inclusive Education

Policy Domain	Priority Policy Action	Key Objective	Potential Indicator
Human capacity	Establish continuous AI literacy and inclusive pedagogy training	Strengthen teacher readiness	Percentage of trained teachers
Technology and infrastructure	Improve connectivity, devices, accessibility, and technical support	Reduce the digital divide	School-level infrastructure readiness
Data and ethics	Establish student data protection, transparency, and AI accountability standards	Protect learners and reduce algorithmic risks	Compliance with data governance standards
Pedagogical governance	Develop guidelines for human-in-the-loop AI implementation	Ensure teachers remain decision-makers	Availability and implementation of institutional guidelines
Institutional readiness	Establish school-level AI implementation plans and evaluation mechanisms	Ensure sustainable adoption	Institutional AI readiness assessment
Equity and inclusion	Require accessible and disability-responsive AI design	Prevent technology-driven exclusion	Accessibility compliance and learner participation

Table 9 demonstrates that AI policy in inclusive education should not be reduced to the procurement of technological systems. A comprehensive policy framework must simultaneously address human capacity, infrastructure, data governance, pedagogy, institutional readiness, and educational equity. Teacher training should constitute a central policy priority because technology can only produce meaningful educational outcomes when teachers understand how to integrate it into instructional practice [68]. Similarly, infrastructure policies should prioritize equitable access so that AI does not widen the gap between well-resourced and resource-constrained schools.

Data protection and ethical governance are equally important because students with special educational needs may be particularly vulnerable to inappropriate data classification or automated decision-making. Policies should therefore require transparency regarding how student data are collected and processed and establish mechanisms through which teachers can review or override AI-generated recommendations [69]. Such safeguards reinforce the principle that educational decisions affecting students should remain subject to meaningful human judgment.

Based on the synthesis of the reviewed literature, the proposed relationship among students, AI, teachers, and the supporting policy environment is illustrated in Figure 4.

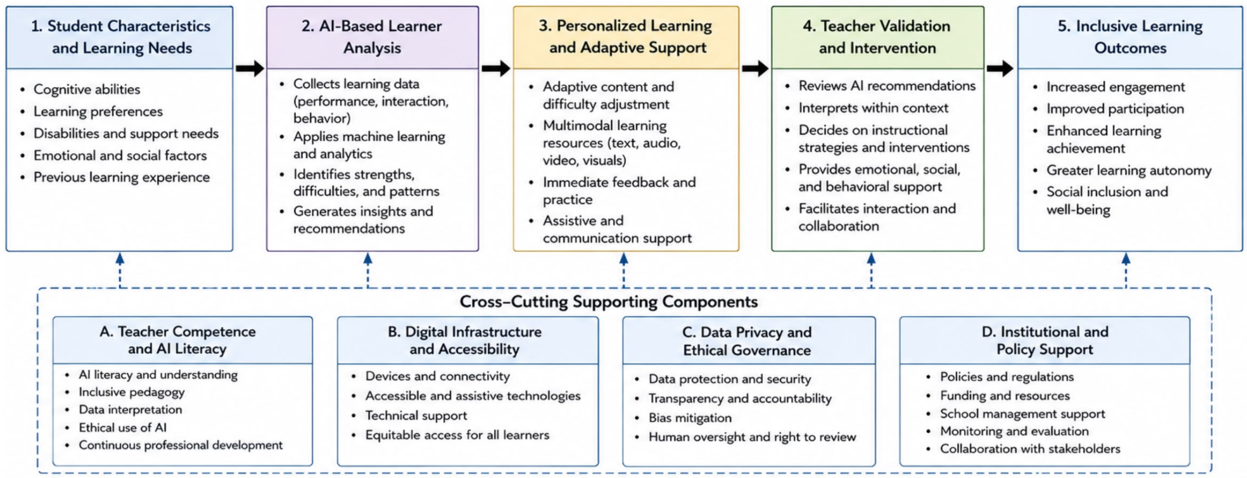

Figure 4. Conceptual Framework of Human AI Collaboration for Personalized Inclusive Education in Indonesia

Figure 4 conceptualizes AI as an intermediate technological layer connecting learner needs with teacher-supported instructional decisions. The process begins with the identification of student characteristics and learning needs. AI subsequently analyzes relevant learning data and generates adaptive recommendations, personalized materials, or feedback [70]. These outputs are then evaluated by the teacher before being implemented in the learning process. The teacher can accept, modify, or reject AI-generated recommendations depending on the student's contextual condition. The resulting learning process is expected to improve engagement, accessibility, learning autonomy, and academic development while maintaining the principles of inclusive education.

The framework also emphasizes that human–AI collaboration does not operate independently of the broader educational ecosystem. Teacher competence determines the ability to interpret and supervise AI outputs, while digital infrastructure determines whether AI services can be accessed reliably. Data privacy and ethical governance establish boundaries for responsible AI use, and institutional policies provide the regulatory and organizational foundation for implementation [71]. These components function as enabling conditions rather than supplementary elements. Without them, the technical capabilities of AI may not translate into meaningful educational benefits.

The findings therefore support a human-centered AI model for inclusive education, in which technological intelligence and human pedagogical intelligence operate synergistically. AI contributes computational scalability, adaptive processing, and continuous instructional assistance, while teachers contribute contextual understanding, empathy, ethical judgment, social interaction, and pedagogical expertise [72]. Such a model is particularly appropriate for inclusive elementary education because the diversity of student needs requires both technological adaptability and human sensitivity.

For the Indonesian context, the implementation of this model should be gradual and context-sensitive. Schools should first assess teacher readiness, infrastructure availability, accessibility requirements, and data governance capacity before adopting AI systems at scale. Government policies should subsequently provide standards and resources that enable schools to develop AI-supported inclusive learning without compromising equity, privacy, or teacher autonomy [73]. The ultimate objective should therefore not be technological substitution, but the development of an educational ecosystem in which AI expands teachers' capacity to provide differentiated and responsive learning.

Overall, the literature demonstrates that the future implementation of AI in inclusive education depends on establishing a balanced relationship between technological capabilities and human educational expertise. AI can provide valuable assistance in learner analysis, personalization, assessment, feedback, and administrative support, but teachers must remain central to pedagogical decision-making. The proposed human–AI collaboration framework consequently positions the teacher as the primary educational decision-maker and AI as a supportive, adaptive, and data-informed instructional assistant [74]. This approach provides a practical foundation for developing inclusive education policies and implementation strategies that are technologically innovative while remaining human-centered, ethical, equitable, and responsive to the diverse needs of students with special educational needs.

Conclusion

This systematic literature review demonstrates that Artificial Intelligence (AI) has substantial potential to function as a Virtual Assistant Teacher in supporting personalized and inclusive learning for students with special educational needs. The findings indicate that AI can complement human teachers through adaptive learning systems, assistive technologies, intelligent tutors, educational robots, learning analytics, and multimodal communication tools. These applications enable learning materials, instructional difficulty, feedback, learning pace, and modes of interaction to be adjusted according to individual learner characteristics. Consequently, AI can contribute to more adaptive, accessible, and learner-centered educational environments.

The review further indicates that AI-supported inclusive learning can generate positive educational impacts, particularly in learning motivation, classroom participation, accessibility, communication, learning autonomy, and academic achievement. AI can also reduce teachers' administrative workload by supporting activities such as learning monitoring, assessment, content preparation, and data analysis. However, these benefits are accompanied by significant challenges, including student data privacy and security, algorithmic bias, unequal digital infrastructure, limited teacher competence, potential overdependence on technology, and the limited contextual understanding of AI systems. These challenges demonstrate that technological capability alone is insufficient to guarantee effective and equitable implementation.

A key finding of this review is that the most appropriate model for AI integration in inclusive education is human–AI collaboration based on a human-in-the-loop approach. AI should serve as a supportive and data-informed instructional technology, while teachers remain the primary decision-makers responsible for pedagogical judgment, emotional and social support, contextual interpretation, and student welfare. The proposed conceptual framework emphasizes a continuous process beginning with the identification of student characteristics and learning needs, followed by AI-based learner analysis, personalized and adaptive learning support, teacher validation and intervention, and the achievement of inclusive learning outcomes. This process must be supported by teacher competence and AI literacy, accessible digital infrastructure, data privacy and ethical governance, and institutional and policy support.

Within the Indonesian context, the implementation of AI in inclusive education should therefore be progressive, context-sensitive, ethical, and human-centered. Schools require adequate technological infrastructure and teacher professional development, while policymakers need to establish clear standards for data protection, algorithmic accountability, accessibility, and human oversight. Such measures are essential to ensure that AI reduces rather than reinforces existing educational inequalities, particularly between well-resourced and resource-constrained schools.

Overall, AI should not be positioned as a replacement for teachers but as an intelligent instructional assistant that extends teachers' capacity to provide differentiated and responsive learning. The integration of AI and human pedagogical expertise offers a promising pathway toward more personalized, accessible, equitable, and inclusive education. Future research should move beyond conceptual and literature-based evidence toward empirical investigations that evaluate the proposed human–AI collaboration framework in diverse Indonesian inclusive schools, particularly in rural and resource-constrained settings. Such research is necessary to validate the effectiveness, scalability, ethical implications, and long-term educational impact of AI-supported inclusive learning.

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