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Review Article

The Inclusive Algorithm: A Systematic Review of AI and Machine Learning in Supporting Learners with Disabilities

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Abstract

Inclusive education has emerged as a global priority, emphasizing equitable access, participation, and learning outcomes for learners with disabilities. Recent advances in Artificial Intelligence (AI) and Machine Learning (ML) have introduced new opportunities to address diverse learner needs through adaptive, personalized, and accessible educational technologies. This systematic review synthesizes empirical evidence on the effectiveness of AI- and ML-based interventions for learners with disabilities across educational contexts. Guided by PRISMA 2020 standards, a comprehensive literature search was conducted across Scopus, Web of Science, ERIC, IEEE Xplore, and Google Scholar, identifying 245 peer-reviewed studies published between 2015 and December 2025. Following duplicate removal, screening, eligibility assessment, and quality appraisal, 19 studies met all methodological and thematic inclusion criteria and were included in the final thematic narrative synthesis. The review examined types of AI/ML technologies, disability categories (learning, sensory, physical, and psychosocial), educational and inclusion-related outcomes, and ethical and accessibility considerations. The included studies employed quantitative (47.4%), qualitative (31.6%), and mixed-methods (21.0%) designs. AI-driven interventions, such as intelligent tutoring systems, natural language processing applications, assistive technologies, and learning analytics, demonstrated positive effects on academic achievement, accessibility, learner autonomy, engagement, psychosocial outcomes, and social inclusion, with particularly strong evidence for learners with learning and sensory disabilities. However, evidence for institutional-level impact and long-term outcomes remains limited. Key challenges identified include algorithmic bias, data privacy risks, uneven accessibility compliance, and persistent inequities between high-income and low-resource contexts. Overall, the findings indicate that AI and ML can meaningfully support inclusive education when grounded in Universal Design for Learning (UDL) principles and rights-based frameworks. The review underscores the need for more methodologically rigorous, geographically diverse, and longitudinal research to determine which technologies are most effective for specific disability groups and to ensure that AI-enabled education advances inclusion rather than reinforcing existing inequities.

Keywords

Artificial Intelligence, Assistive and Adaptive Technologies, Inclusive Education, Learners with Disabilities, Machine Learning

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1. Background

Inclusive education has emerged as a central global priority, grounded in the principle that all learners, regardless of disability, have the right to equitable access to quality education. International policy frameworks such as the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) and Sustainable Development Goal 4 (SDG 4) emphasize inclusive and equitable education and lifelong learning opportunities for all learners, including those with disabilities [36, 37]. Despite these commitments, learners with disabilities continue to face persistent barriers in educational systems worldwide, including inaccessible learning materials, inflexible curricula, limited individualized support, and insufficiently trained educators [34].

Disability is increasingly understood through a social and rights-based perspective, which recognizes that learning difficulties often arise not from individual impairments but from environmental, technological, and institutional barriers that restrict participation [25]. Within traditional educational settings, support for learners with disabilities has relied heavily on human-mediated interventions, assistive technologies, and specialized services. While these approaches have demonstrated effectiveness, they are often constrained by limited resources, large class sizes, and systemic inequities, particularly in low- and middle-income contexts [15, 33]. These challenges have intensified the search for scalable, flexible, and adaptive solutions capable of addressing diverse learning needs.

Recent advances in AI and ML have significantly reshaped educational technologies, offering new possibilities for personalization, accessibility, and learner-centered instruction. AI refers to computational systems capable of performing tasks that typically require human intelligence, while ML enables systems to learn from data and improve performance over time [29]. In education, AI-driven systems have been applied to adaptive learning platforms, intelligent tutoring systems, automated assessment, learning analytics, and assistive technologies [18]. These developments align closely with the principles of Universal Design for Learning (UDL), which advocate for multiple means of representation, engagement, and expression to support learner variability [9].

For learners with disabilities, AI and ML technologies present transformative potential. AI-powered accessibility tools such as speech-to-text, text-to-speech, automatic captioning, image recognition, and text simplification have improved access to instructional content for learners with visual, hearing, and learning impairments [5, 41]. Adaptive learning systems have demonstrated promise in supporting learners with dyslexia, autism spectrum disorder, attention-deficit/hyperactivity disorder, and intellectual disabilities by tailoring instruction, feedback, and pacing to individual learning profiles [11, 20]. These technologies have the potential to enhance learner autonomy, engagement, and academic participation within inclusive educational environments.

However, alongside these opportunities, scholars have raised critical concerns regarding the ethical and equity implications of AI in education. Algorithmic bias, lack of transparency, data privacy risks, and exclusionary design practices may disproportionately disadvantage learners with disabilities if AI systems are trained on non-representative datasets or grounded in normative assumptions about learning and ability [12, 38]. There is growing recognition that AI-driven educational tools must be developed through inclusive, participatory, and ethically grounded approaches to avoid reinforcing existing inequalities [31]. Without such safeguards, AI risks becoming a mechanism of exclusion rather than inclusion.

Despite a rapidly expanding body of research on AI in education, the literature remains fragmented, with studies often focusing on specific technologies, disability categories, or educational levels in isolation. Moreover, many reviews emphasize technical performance rather than pedagogical impact, learner experience, or inclusive outcomes. There is a notable lack of systematic, cross-disciplinary synthesis that integrates technological, educational, and ethical perspectives on AI and ML in supporting learners with disabilities. Addressing this gap is essential to inform evidence-based policy, inclusive design, and responsible implementation of AI in education. Against this backdrop, the present study, aims to systematically examine existing empirical research to identify how AI and ML technologies are being used to support learners with disabilities, what benefits and challenges have been reported, and what gaps remain. By synthesizing evidence across disability categories, educational contexts, and AI applications, this review seeks to contribute to the development of inclusive, equitable, and ethically responsible AI-enabled education systems.

Additionally, the adoption of AI and ML in inclusive education across Africa remains limited, primarily due to inadequate digital infrastructure, limited funding, and insufficient teacher training in advanced educational technologies [1, 35]. Studies indicate that AI-supported learning tools in African higher education are mostly experimental, with minimal large-scale implementation targeting learners with disabilities [27]. The digital divide significantly constrains equitable access to AI-enabled inclusive education in Africa, disproportionately affecting learners with disabilities in rural and low-resource settings [2, 34]. African policy frameworks increasingly recognize the role of AI in education; however, specific guidelines addressing inclusive AI for learners with disabilities are still underdeveloped. Recent South African studies indicate that equitable AI integration in education requires strong localisation and decolonial alignment, as AI systems developed without consideration of local epistemologies, languages, and socio-historical contexts risk reinforcing existing educational inequalities and Western-centric knowledge structures [22]. Evidence from South African special education settings shows that while educators acknowledge AI's potential to support personalized instruction and reduce workload, inequitable access to infrastructure, limited professional training, and socioeconomic disparities significantly constrain inclusive and equitable AI adoption [24]. Eastern African countries are at an early stage of integrating AI into inclusive education, with most initiatives focused on policy dialogue, pilot projects, and capacity building rather than full implementation [35]. Teacher preparedness for AI-supported inclusive teaching in Eastern Africa remains low, limiting effective classroom integration of AI and assistive technologies for learners with disabilities [19].

Our motivation for conducting this systematic review is driven by a strong commitment to advancing inclusive education in an era of rapid technological transformation. As artificial intelligence and machine learning increasingly shape educational systems, it is both timely and necessary to critically examine how these technologies can equitably support learners with disabilities. This review is motivated by the need to move beyond isolated innovations and to provide a coherent synthesis of evidence that informs inclusive, ethical, and context-sensitive practice. By systematically analyzing existing research, this study seeks to amplify the voices and needs of learners with disabilities, guide educators and policymakers toward responsible AI integration, and contribute to a future in which technological progress aligns with social justice, accessibility, and educational equity.

2. Related Literature Review

2.1. Conceptual Foundations of Inclusive Education and Disability

Inclusive education is grounded in the principle that all learners, regardless of disability, have the right to equitable access to quality education within mainstream learning environments [15]. International frameworks such as the UNCRPD and UNESCO's Education for All agenda and SDG 4 emphasize inclusion, equity, and accessibility as core educational values [36, 37, 34]. These frameworks position inclusive education not merely as a pedagogical choice but as a fundamental human right.

Disability is increasingly understood through social and rights-based models, which shift attention away from individual impairments toward systemic, environmental, and attitudinal barriers that restrict participation and learning [25]. Within this framework, learners with disabilities including those with sensory, physical, cognitive, intellectual, and psychosocial impairments often encounter barriers related to rigid curricula, inaccessible instructional materials, inflexible assessment practices, and limited individualized support [3].

Traditional special education responses have relied heavily on human-mediated interventions and specialist support services. While these approaches can be effective, they are often constrained by resource limitations, large class sizes, and shortages of trained professionals, particularly in low- and middle-income contexts [33]. These challenges have intensified interest in technology-enabled solutions that can support diverse learners at scale while aligning with inclusive education principles.

2.2. Artificial Intelligence and Machine Learning in Education

AI refers to computational systems capable of performing tasks that typically require human intelligence, such as reasoning, pattern recognition, decision-making, and natural language processing [29]. ML, a subset of AI, involves algorithms that learn from data and improve performance over time without being explicitly programmed [8].

In educational contexts, AI and ML have been applied to intelligent tutoring systems, learning analytics, adaptive learning platforms, automated assessment, and predictive modeling of learner performance [18, 21]. These applications are often framed within the paradigm of personalized and adaptive learning, where instructional content, pacing, and feedback are dynamically adjusted based on learners' needs, preferences, and performance.

For learners with disabilities, such personalization holds particular promise, as it aligns closely with the principles of UDL. UDL advocates for multiple means of representation, engagement, and expression to accommodate learner variability from the outset rather than through retrofitted accommodations [9]. AI-driven systems have the potential to operationalize UDL principles by providing flexible and responsive learning pathways.

2.3. AI-supported Accessibility for Learners with Disabilities

A substantial body of literature highlights the role of AI in enhancing accessibility for learners with disabilities. For learners with visual impairments, AI-powered screen readers, optical character recognition, and computer vision technologies enable access to printed and digital content through text-to-speech, image recognition, and scene description tools [41, 5]. Advances in deep learning have significantly improved the accuracy of real-time image recognition and object detection, promoting greater independence in learning environments.

For learners with hearing impairments, AI-driven automatic speech recognition systems provide real-time captioning and transcription of spoken language, supporting participation in lectures, discussions, and online learning [19]. Machine learning models trained on diverse linguistic datasets have enhanced caption accuracy, although challenges remain in handling accents, technical vocabulary, and multilingual contexts. Emerging research also explores AI-based sign language recognition and translation systems, though these technologies remain in developmental stages and face challenges related to linguistic complexity and contextual interpretation [23].

Learners with physical and motor disabilities benefit from AI-enabled assistive technologies such as speech-to-text input, eye-tracking systems, and adaptive interfaces that reduce reliance on fine motor control [30]. These tools facilitate interaction with digital learning platforms and assessments, increasing learner autonomy and reducing physical fatigue.

2.4. AI and Cognitive, Intellectual, and Learning Disabilities

AI and ML applications have been widely explored in supporting learners with cognitive, intellectual, and learning disabilities, including dyslexia, autism spectrum disorder (ASD), attention-deficit/hyperactivity disorder (ADHD), and intellectual disabilities. Adaptive learning systems use machine learning algorithms to analyze learner behavior, identify patterns of difficulty, and provide targeted feedback or scaffolding [18].

For learners with dyslexia, AI-based reading and writing tools offer text simplification, phonological support, predictive spelling, and reading fluency assistance, contributing to improved comprehension and writing accuracy [28]. In autism education, AI-driven applications have been used to support social skills development, emotion recognition, and communication through computer vision and affective computing technologies [11, 20].

For learners with ADHD, AI-powered learning analytics can identify attention patterns and provide personalized strategies to enhance engagement, time management, and task completion [7]. Despite these advances, scholars caution that AI systems must be designed carefully to avoid reinforcing deficit-based perspectives of disability. Effective AI-supported interventions emphasize learner strengths, autonomy, and agency rather than surveillance or behavioral normalization [31].

2.5. Ethical, Equity, and Bias Concerns in Inclusive AI

While AI offers transformative potential, the literature highlights significant ethical and equity concerns, particularly for learners with disabilities. Algorithmic bias remains a major challenge, as AI systems trained on non-representative datasets may misinterpret disabled learners' behaviors or communication patterns [12, 38]. Predictive analytics models, for example, may inaccurately label learners with disabilities as "at risk" based on normative performance indicators, leading to stigmatization or lowered expectations.

Data privacy and informed consent are especially critical when AI systems collect sensitive information related to disability status, learning behavior, or health-related needs. Scholars emphasize the importance of transparent data governance, explainable AI models, and inclusive design processes that involve learners with disabilities, educators, and disability advocates in system development [16]. Accessibility gaps also persist in AI deployment, particularly in low-resource contexts where infrastructure, connectivity, and technical expertise are limited [34]. Without deliberate policy alignment and institutional investment, AI innovations risk exacerbating existing educational inequalities rather than reducing them.

2.6. Gaps in Existing Research

Despite the expanding literature on AI in education, several gaps remain. First, much existing research prioritizes technological innovation over pedagogical integration and classroom practice, resulting in limited evidence on long-term learning outcomes for learners with disabilities [41]. Second, studies are disproportionately concentrated in high-income countries, with minimal attention to low- and middle-income contexts where inclusive education challenges are often most pronounced [33].

Third, learners' and teachers' lived experiences with AI tools remain underexplored, particularly regarding usability, trust, and perceived impact on inclusion [38]. Moreover, few studies adopt a cross-disability or intersectional perspective, focusing instead on single impairment categories. This fragmentation limits understanding of how AI systems can support diverse learners within inclusive, mainstream educational environments.

The reviewed literature demonstrates that AI and machine learning technologies hold significant potential to support learners with disabilities by enhancing accessibility, personalization, and learner autonomy. At the same time, ethical concerns related to bias, equity, data privacy, and contextual feasibility underscore the need for careful and inclusive implementation. The lack of comprehensive systematic reviews integrating technological, pedagogical, and ethical perspectives highlights the necessity of the present study. By systematically reviewing existing research on AI and machine learning in supporting learners with disabilities, this study aims to synthesize evidence, identify effective practices, and inform future research, policy, and practice toward truly inclusive algorithmic education.

2.7. Methodology: PRISMA-Aligned Systematic Review

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines to ensure transparency, rigor, and replicability in the identification, screening, and synthesis of studies examining the use of AI and ML in supporting learners with disabilities.

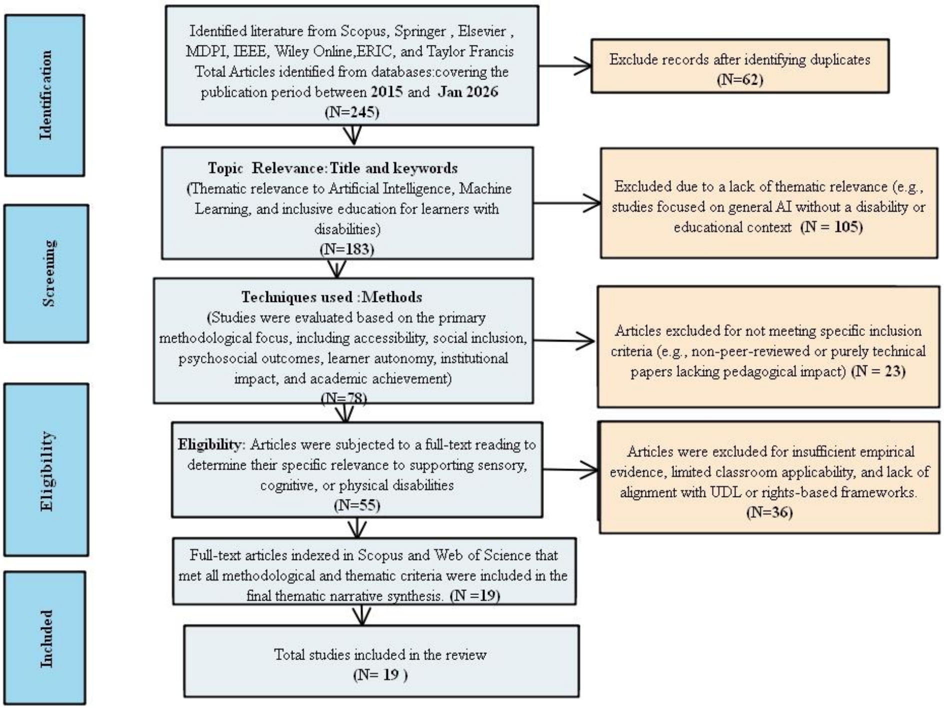

Figure 1. *PRISMA 2020 Flow Diagram of the Study Selection Process.*

2.8. Review Objectives and Research Questions

The objective of this systematic review was to synthesize empirical evidence on how AI and ML technologies are used to support learners with disabilities in educational contexts and to identify key trends, outcomes, challenges, and research gaps.

The review was guided by the following research questions:

1) What types of AI and ML technologies have been used to support learners with disabilities in educational settings?
2) Which categories of disabilities are most frequently addressed in AI-supported educational research?
3) What educational outcomes and inclusion-related benefits are reported?
4) What ethical, accessibility, and equity challenges are identified in the literature?

2.9. Search Strategy

Search Strategy systematic and comprehensive literature search was undertaken across major academic databases, namely Scopus, Web of Science, ERIC, IEEE Xplore, and Google Scholar. The search focused on peer-reviewed empirical studies published between 2015 and December 2025 in order to capture recent developments and emerging trends in AI and ML within the context of inclusive education.

To ensure transparency, rigor, and reproducibility, a structured search strategy was applied. An example of the search string used in Scopus is presented below: The initial database search retrieved 245 records. In addition, backward snowballing was performed by manually reviewing the reference lists of the selected studies. These records were combined into a single pool prior to duplicate removal and subsequent screening procedures.

Boolean operators (AND/OR) were used to refine the search. Reference lists of included articles were also manually screened to identify additional relevant studies.

Table 1. *Summary of Recent (2025) Studies on AI Integration in Special and Inclusive Education and Identified Research Gaps.*

Topic	Year	Authors	Research Gaps Identified
Special education teachers' use of AI to support students with disabilities in writing	2025	Goldman, Smith & Carreon	Gap: Limited actual use of AI by teachers despite its potential; need for professional development models that prepare teachers to integrate AI effectively in instruction. Teachers' preparedness and attitudes heavily influence integration, suggesting gaps in teacher education programs and implementation research. (Frontiers)

Topic	Year	Authors	Research Gaps Identified
AI-enhanced assistive technologies in inclusive education (multi-modal)	2025	(ScienceDirect article on AI-driven assistive tech)	Gap: While tools like screen readers and NLP interfaces are promising, empirical evidence on real-world impacts across types of disabilities remains limited; need comparative studies and user outcome data. (ScienceDirect)
Survey of special education teachers' perspectives on AI integration	2025	(ERIC-linked study)	Gap: Teacher perspectives highlight insufficient professional training, concerns about reliability and real-time classroom use; more empirical research needed on training interventions and teacher support systems. (ERIC)
Empirical qualitative and quantitative studies summarised in systematic review on inclusive AI	2025	Li, Yan & Zeng (Applied Sciences)	Gap: Many studies lack longitudinal data, and theoretical frameworks are inconsistently applied; there's a need for more theory-driven, long-term, and culturally responsive research. (MDPI)
Adaptive AI educational tools for learners with disabilities	2025	Hassen	Gap: While developmental frameworks for AI-adaptive systems are proposed, empirical evaluations of these systems' effectiveness and real-world classroom outcomes are largely lacking. (Science Publishing Group)
AI applications in special education classrooms (Conference proceedings)	2025	SEAMEO ICSE	Gap: Findings emphasize literacy and accessibility improvements but point to limited teacher training, infrastructure, and policy support — empirical studies that measure these contextual effects are sparse. (publication.seameosen.edu.my)
Systematic synthesis of empirical AI research in inclusive education	2025	Toyokawa et al., Naseer et al., AC (synthesis)	Gap: Highlighted digital literacy, infrastructure barriers, and weak evidence for varied disability categories; calls for inclusive datasets and multi-disability focus. (MDPI)

2.10. Quality Assessment

The methodological quality of the included studies was assessed using adapted quality appraisal criteria suitable for educational technology research. Criteria included clarity of research design, appropriateness of methods, transparency of data analysis, and alignment between findings and conclusions. Studies were not excluded solely based on quality; rather, quality assessment informed the interpretation and weighting of findings in the synthesis.

Methodological quality was assessed using adapted appraisal criteria for educational technology research. High-quality studies constituted 55.3% of the sample, 34.2% were rated as moderate quality, and 10.5% were assessed as low quality.

Data Synthesis

Data synthesis for this systematic review, was conducted using a thematic narrative synthesis approach. This approach was deemed most appropriate due to the heterogeneity of the included studies in terms of research design, types of AI and machine learning applications, categories of disabilities addressed, educational levels, and outcome measures. The diversity of methodologies and contexts made statistical meta-analysis inappropriate.

Due to the heterogeneity of study designs, disability categories, and AI applications, a narrative thematic synthesis approach was employed [26]. Findings were coded and grouped into thematic categories reflecting:

The synthesis process was implemented in a series of systematic steps. First, all included empirical studies were examined in full to develop an in-depth understanding of their objectives, AI or machine learning interventions, participant characteristics, and reported outcomes related to inclusion and learning support. Key data extracted during the review phase were organized into comparative tables to enable cross-study comparison and pattern identification.

Second, the extracted findings were coded thematically using a combined inductive and deductive approach. Inductive coding allowed themes to emerge from the empirical evidence, while deductive coding was informed by established inclusive education frameworks, particularly UDL and rights-based perspectives on disability. This ensured that the synthesis remained grounded in both empirical findings and theoretical foundations of inclusion.

Third, individual codes were clustered into broader analytical themes reflecting dominant trends in the literature. These themes included:

1) AI- and ML-based accessibility and assistive technologies,
2) adaptive and personalized learning systems for diverse learners,
3) AI applications supporting learners with cognitive,

learning, and neurodevelopmental disabilities,
4) reported impacts on learner engagement, autonomy, and participation, and
5) ethical, equity, and implementation challenges associated with inclusive AI use.

Within each theme, findings were compared across disability types, educational contexts, and geographic settings to examine consistencies, variations, and contextual influences on effectiveness.

Fourth, special attention was given to the limitations and gaps reported in the reviewed studies, including insufficient teacher training, algorithmic bias, limited accessibility in low-resource contexts, lack of longitudinal evidence, and minimal involvement of learners with disabilities in AI system design. These gaps were synthesized to inform implications for future research, policy, and practice.

Finally, the synthesis emphasized interpretive integration rather than simple aggregation of results, focusing on how and under what conditions AI and machine learning contribute to inclusive education for learners with disabilities. By integrating findings across studies, this synthesis provides a coherent and critical understanding of the current empirical evidence base and supports evidence-informed recommendations for the ethical and inclusive development and implementation of AI-driven educational technologies.

3. Results of the Systematic Review

Characteristics of Included Studies

The included studies were conducted predominantly in high-income countries, with a concentration in North America and Europe. Most studies focused on higher education and secondary education, with limited representation of primary education and adult learning contexts. Disability categories most frequently addressed included learning disabilities (e.g., dyslexia), autism spectrum disorder, visual and hearing impairments, and ADHD. Fewer studies examined physical or multiple disabilities. The studies included in this systematic review demonstrate considerable diversity in terms of research design, participant characteristics, disability categories, technological approaches, and educational or psychosocial contexts. Overall, the final sample of included studies reflects the interdisciplinary and rapidly evolving nature of research at the intersection of AI/ML technologies and inclusive education for learners with disabilities.

Despite the inherent challenges in achieving complete methodological and geographic representation, deliberate efforts were made to include studies employing diverse research approaches and conducted across a range of demographic and contextual settings. Within the final evidence base, the included studies varied in methodological approach, with a modest predominance of quantitative designs. Quantitative studies accounted for 47.4% of the literature and primarily employed experimental or quasi-experimental methods to examine the effectiveness of AI- and ML-supported interventions for learners with disabilities. Qualitative studies represented 31.6% of the included research and focused on learners' and educators' experiences, perceptions, and contextual factors influencing implementation. Mixed-methods designs comprised 21.0% of the studies, integrating quantitative outcome measures with qualitative insights to capture both intervention effectiveness and process-related dimensions.

With respect to geographic coverage, the included studies were conducted across multiple regions, although representation was stronger in high-income contexts. Studies from North America constituted 44.7% of the sample, while 34.2% originated from Europe. Research conducted in Asia accounted for 13.2%, and 7.9% of studies were from other regions, including the Middle East, Latin America, and Africa. While this distribution reflects prevailing publication patterns in the field, it also highlights the need for broader geographic representation in future research to strengthen the global relevance of evidence on AI and machine learning in inclusive education.

With regard to publication period, the majority of the included studies were published within the last decade, indicating a growing scholarly interest in psychosocial rehabilitation and technology-supported interventions in response to global calls for inclusive and equitable support systems. This trend aligns with international frameworks advocating for the use of innovative and evidence-based approaches to enhance psychosocial well-being and functional outcomes for vulnerable populations [40, 36].

In terms of study design, the included articles comprised a mix of quantitative, qualitative, and mixed-methods approaches. Quantitative studies frequently employed experimental or quasi-experimental designs to evaluate the effectiveness of specific interventions, such as digital mental health tools, assistive technologies, or psychosocial support programs. Qualitative studies, on the other hand, focused on lived experiences, perceptions, and contextual factors influencing psychosocial rehabilitation outcomes. Mixed-methods studies integrated both approaches to provide a more comprehensive understanding of intervention effectiveness and implementation challenges [10].

Regarding participant characteristics, the studies involved diverse populations, including children, adolescents, adults, and older persons. Participants represented various psychosocial and disability-related conditions, such as mental health disorders, intellectual disabilities, physical impairments, sensory disabilities, and trauma-related psychosocial challenges. Several studies specifically targeted marginalized or low-resource populations, highlighting disparities in access to psychosocial services and the need for context-sensitive interventions [27].

The settings of the included studies varied widely and included schools, universities, rehabilitation centers, hospitals, community-based organizations, and home-based environments. While a significant proportion of studies were conducted in high-income countries, an increasing number originated from low- and middle-income countries, reflecting a broader recognition of global mental health and rehabilitation priorities. However, the geographical distribution still suggests an imbalance, with limited representation from conflict-affected and resource-constrained regions, particularly in Sub-Saharan Africa [21].

Concerning intervention characteristics, the reviewed studies examined a range of psychosocial rehabilitation approaches, including counseling programs, cognitive-behavioral interventions, community-based rehabilitation models, and technology-enhanced solutions such as mobile health (mHealth) applications, tele-rehabilitation platforms, and assistive digital tools. Many studies reported positive outcomes related to improved psychological well-being, social participation, functional independence, and quality of life. Nevertheless, variations in intervention duration, implementation fidelity, and outcome measures limited direct comparison across studies [13].

Finally, the outcome measures used across the included studies were heterogeneous, encompassing standardized psychological scales, functional assessment tools, self-reported measures, and observational data. While this diversity reflects the multifaceted nature of psychosocial rehabilitation, it also underscores the need for greater standardization of outcome indicators to strengthen evidence synthesis and comparability in future research [23].

4. AI and ML Applications Supporting Learners with Disabilities

The literature indicates that a wide range of AI and ML technologies have been applied to support learners with disabilities across educational settings. One of the most frequently reported technologies is intelligent tutoring systems, which use ML algorithms to adapt instructional content, pacing, and feedback to individual learners' needs. These systems have been shown to support personalized learning for students with cognitive and learning disabilities by responding dynamically to learners' performance patterns [24, 32].

Another prominent category involves natural language processing tools, such as speech-to-text, text-to-speech, automated summarization, and language simplification systems. These tools are particularly beneficial for learners with visual impairments, dyslexia, and language-based learning difficulties, as they improve access to textual and instructional content [4, 14]. Computer vision and pattern recognition technologies have also been widely adopted, especially for learners with sensory and physical disabilities. Examples include facial recognition systems for monitoring learner engagement, gesture-recognition tools for students with motor impairments, and sign-language recognition systems to support deaf and hard-of-hearing learners [19, 23].

In addition, predictive analytics and learning analytics systems have been used to identify learners at risk of academic failure or disengagement. By analyzing large datasets of learner behavior, AI systems can provide early alerts and targeted interventions for students with disabilities, thereby supporting retention and academic success [7, 31].

Predictive analytics tools used to identify learning difficulties and provide early interventions, though concerns about labeling and bias were noted.

Recent empirical and applied research demonstrates that AI and ML technologies are increasingly leveraged to support learners with disabilities by enhancing accessibility, personalizing instruction, and enabling adaptive learning environments tailored to diverse needs. Across multiple studies and reviews, AI/ML applications have been identified in educational contexts for learners with sensory, cognitive, and learning disabilities, offering novel ways to reduce barriers and promote inclusive outcomes.

4.1. Adaptive and Personalized Learning Systems

A growing body of research highlights the development and deployment of AI-driven adaptive learning technologies that dynamically adjust instructional content based on learner performance and individual needs. For example, [17] explores frameworks for adaptive learning systems that leverage dynamic profiling and real-time feedback to support students with disabilities, emphasizing individualized pacing and learning trajectories that are responsive to each learner's progress.

4.2. Accessibility Tools for Sensory and Cognitive Support:

AI technologies such as speech recognition, text-to-speech, and other assistive interfaces are transforming how learners with sensory and cognitive impairments interact with educational materials. AI-based systems can convert complex content into more accessible forms (e.g., audio or simplified text), provide real-time assistance, and support multimodal interactions. [28] notes that such tools including virtual tutors and adaptive chatbots enhance engagement for students with visual, auditory, and motor impairments, while offering personalized learning support.

4.3. Identification and Early Intervention:

Machine learning applications are also playing a role in early detection and support for learners with learning challenges. [25] conducted a mixed-methods study in Jordanian schools showing that AI tools using ML and natural language processing are perceived by educators as effective for early identification of learning difficulties. This early detection capability can inform tailored interventions, though the study also indicates the need for adequate training and ethical safeguards in implementation.

4.4. Multimodal and Inclusive Frameworks:

Beyond traditional classroom tools, AI's integration into more immersive and adaptive educational environments including metaverse and service-oriented frameworks suggests future pathways for supporting neurodivergent learners through multimodal interactions and adaptive, intuitive learning spaces. While research on these emerging frameworks is nascent, it underscores the importance of combining AI adaptability with engaging, sensory-rich environments to support diverse learners.

4.5. Patterns Across Studies

Across these applications, several consistent findings emerge:

Adaptive and personalized learning systems demonstrate potential for increasing engagement and accommodating varied learning needs.

Assistive AI tools improve accessibility and foster participation for learners with sensory and motor disabilities.

Early identification systems enable targeted support and timely educational interventions.

Emerging immersive frameworks suggest future avenues for inclusion that extend beyond traditional AI applications.

However, these studies also highlight challenges such as the need for teacher training, ethical considerations including data privacy and algorithmic fairness, and equitable access to AI tools to ensure truly inclusive implementation.

Overall, the empirical evidence suggests that AI and ML applications offer promising support mechanisms for learners with disabilities, enabling more individualized, accessible, and engaging educational experiences. Yet achieving these potentials requires careful attention to ethical design, contextual adaptation, and supportive infrastructure.

5. Categories of Disabilities Most Frequently Addressed

The reviewed studies show that AI-supported educational research most frequently addresses learning disabilities, particularly dyslexia, dyscalculia, and ADHD. AI-based reading assistants, adaptive assessment tools, and personalized learning platforms are commonly designed to support these learners by accommodating differences in information processing and attention [24, 18].

Sensory disabilities, especially visual and hearing impairments, are also prominently represented in the literature. For learners with visual impairments, AI-powered screen readers, image recognition tools, and voice-based interfaces significantly enhance access to digital learning materials. For deaf and hard-of-hearing learners, automatic speech recognition, captioning systems, and sign-language translation tools are frequently studied [40, 20].

Research addressing intellectual and developmental disabilities, including ASD, has increased in recent years. AI applications in this area often focus on social skills training, emotional recognition, and structured learning environments, using adaptive and interactive systems to support communication and behavioral regulation [5, 13].

In contrast, the literature indicates limited representation of learners with multiple disabilities and severe psychosocial conditions, particularly in low- and middle-income contexts. This gap highlights the need for more inclusive and contextually responsive AI research [21].

6. Reported Benefits for Inclusion and Learning

The reviewed studies consistently reported substantial benefits of inclusive and technology-supported approaches for enhancing both inclusion and learning outcomes among learners with disabilities and other marginalized groups. One of the most frequently cited benefits was improved access to learning opportunities, particularly through the use of digital and assistive technologies. Tools such as screen readers, speech-to-text software, captioning systems, and mobile learning platforms enabled learners with sensory, physical, and cognitive impairments to access instructional content in formats aligned with their individual needs, thereby reducing traditional learning barriers [4, 40].

Another prominent benefit reported across studies was enhanced learner engagement and participation. Inclusive instructional practices supported by technology were found to foster active involvement in classroom and online learning environments. Learners demonstrated increased motivation, sustained attention, and greater interaction with peers and instructors when flexible and adaptive learning tools were integrated into teaching practices. These findings align with the principles of UDL, which emphasize multiple means of engagement, representation, and expression to support diverse learners [9, 22].

The included studies also highlighted positive academic outcomes, including improvements in comprehension, skill acquisition, task completion, and overall academic performance. Personalized and adaptive learning systems allowed instruction to be tailored to learners' abilities and pace, supporting mastery learning and reducing academic frustration. Empirical evidence suggests that when inclusive technologies are effectively implemented, learners with disabilities can achieve outcomes comparable to their non-disabled peers [14, 24].

In terms of social inclusion, many studies reported improvements in peer interaction, collaboration, and a sense of belonging. Inclusive learning environments encouraged cooperative learning and reduced stigmatization by enabling learners with disabilities to participate more independently and confidently in shared learning activities. This social integration was found to positively influence learners' self-esteem, emotional well-being, and school attachment, which are critical components of psychosocial development [6, 30].

Furthermore, several studies emphasized the role of inclusive and technology-enhanced learning in promoting learner autonomy and self-determination. Assistive and digital tools empowered learners to take greater control of their learning processes, make informed choices, and develop problem-solving and self-regulation skills. Such autonomy is particularly important for learners with disabilities, as it supports lifelong learning and successful transition to higher education and employment [32].

Finally, the reviewed literature underscored broader institutional and systemic benefits, including improved teaching practices and increased awareness of inclusive pedagogy among educators. Exposure to inclusive technologies encouraged instructors to adopt learner-centered approaches, differentiate instruction, and reflect on equity and accessibility in curriculum design. These changes contribute to the development of more inclusive learning cultures within educational institutions [15, 37].

Across studies, AI-supported interventions were associated with improved access to learning materials, increased learner autonomy, enhanced engagement, and better alignment between instructional methods and individual needs. Many studies reported that inclusive AI tools benefited not only learners with disabilities but also the wider student population, reinforcing the value of universal design approaches [9].

In this statement we can make it the summary below.

Table 2. *Key Studies on Inclusive Education Interventions and Their Impact on Accessibility, Achievement, and Learner Outcomes.*

Focus Area	Authors (Year)	Context / Participants	Intervention / Approach	Key Reported Benefits
Accessibility	WHO (2011)	Learners with disabilities (global)	Assistive technologies	Improved access to learning materials; reduced environmental barriers
Accessibility	Al-Azawei et al. (2016)	Higher education students	UDL-based digital learning	Flexible access; improved content representation
Accessibility	Fichten et al. (2019)	Postsecondary students with disabilities	E-learning & assistive tools	Increased usability and academic participation
Academic Achievement	Ok & Rao (2019)	Inclusive classrooms	Digital instructional tools	Improved comprehension and task performance
Academic Achievement	Meyer et al. (2014)	Diverse learners	UDL framework	Enhanced learning outcomes across ability levels
Academic Achievement	CAST (2018)	K–12 and higher education	UDL-guided instruction	Reduced achievement gaps
Social Inclusion	Avramidis & Norwich (2002)	Students with special needs	Inclusive education practices	Improved peer interaction and acceptance
Social Inclusion	Schwab (2017)	Students in inclusive schools	Inclusive classroom settings	Increased sense of belonging
Psychosocial Outcomes	Patel et al. (2018)	Vulnerable populations	Psychosocial interventions	Improved well-being and participation
Learner Autonomy	Shogren et al. (2015)	Learners with disabilities	Self-determination interventions	Enhanced independence and self-regulation
Institutional Impact	Florian & Black-Hawkins (2011)	Teachers and institutions	Inclusive pedagogy	Improved teaching practices and inclusive culture

7. Ethical, Accessibility, and Equity Challenges Identified

Despite the reported benefits, the literature identifies several ethical, accessibility, and equity challenges associated with AI and ML use in education. One major concern is algorithmic bias, where AI systems trained on non-representative datasets may disadvantage learners with disabilities by misinterpreting their behaviors or learning patterns [18, 35].

Despite the promising potential of AI and ML technologies to enhance inclusive education, the literature consistently identifies a range of ethical, accessibility, and equity-related challenges that complicate their effective and just implementation. These challenges underscore the need for cautious, context-sensitive, and rights-based approaches when integrating AI into educational systems, particularly for learners with disabilities.

7.1. Ethical Challenges: Algorithmic Bias, Transparency, and Accountability

One of the most widely discussed ethical concerns is algorithmic bias. AI systems rely heavily on historical and large-scale datasets, which often underrepresent learners with disabilities or fail to capture the complexity of their learning behaviors. As a result, AI-driven systems may inaccurately assess learners' abilities, misclassify learning needs, or recommend inappropriate interventions. Such biases can lead to exclusionary practices, reinforcing deficit-based perspectives rather than supporting inclusive and strengths-based education [18, 34].

Closely related to bias is the issue of algorithmic transparency and explainability. Many AI and ML models, particularly deep learning systems, operate as "black boxes," making it difficult for educators, learners, and policymakers to understand how decisions are made. This lack of transparency raises concerns about accountability, especially when AI systems influence high-stakes decisions such as assessment, placement, or academic progression for learners with disabilities [31]. The literature emphasizes the importance of explainable AI frameworks to ensure that AI-supported educational decisions remain interpretable and ethically defensible.

Another ethical issue concerns the over-reliance on automation, which may reduce human judgment and professional discretion in educational decision-making. Scholars warn that AI should augment, rather than replace, educators' expertise, particularly in inclusive contexts where individualized understanding and empathy are critical [38].

7.2. Data Privacy, Surveillance, and Consent

Data privacy and surveillance constitute major ethical challenges in AI-supported education. AI systems often require continuous data collection, including behavioral data, biometric information, learning analytics, and sometimes emotional or cognitive indicators. For learners with disabilities, such data can be highly sensitive and stigmatizing if misused or inadequately protected [26].

The literature highlights concerns regarding informed consent, particularly for children and learners with intellectual or psychosocial disabilities who may have limited capacity to fully understand data practices. In many educational contexts, consent is mediated through institutions or guardians, raising questions about autonomy and learners' rights over their own data [35].

Furthermore, the use of AI-driven monitoring tools such as attention tracking, facial recognition, and emotion detection has been criticized for promoting surveillance-based educational environments. These practices may disproportionately affect learners with disabilities whose behaviors differ from normative patterns, potentially leading to misinterpretation, labeling, or punitive responses rather than support [39].

7.3. Accessibility Challenges in AI Design and Implementation

From an accessibility standpoint, the literature reveals persistent gaps between the intended inclusive goals of AI technologies and their actual usability for learners with disabilities. Many AI-based educational tools are developed without full adherence to universal accessibility standards, such as the Web Content Accessibility Guidelines (WCAG), resulting in interfaces that are incompatible with screen readers, alternative input devices, or assistive technologies [40].

Studies also point to challenges related to one-size-fits-all design approaches, where AI systems fail to accommodate the wide diversity of disability types, severities, and intersectional needs. For example, tools designed primarily for visual impairments may not adequately support learners with cognitive or psychosocial disabilities, highlighting the limitations of narrowly targeted solutions [4].

Additionally, language and cultural localization remain underexplored in AI development. Many AI systems are designed for dominant global languages and cultural contexts, limiting their relevance and accessibility for learners in non-Western and multilingual settings. This lack of contextual adaptation undermines inclusive education efforts, particularly in countries with diverse linguistic and cultural profiles [34].

7.4. Equity and Digital Divide Concerns

Equity-related challenges are especially pronounced in low-resource, rural, and crisis-affected contexts, where the infrastructure required to support AI technologies is often inadequate. Limited internet connectivity, unreliable electricity, and shortages of digital devices significantly constrain the adoption of AI-supported educational tools in these settings [21].

The cost of AI technologies including licensing fees, hardware requirements, and ongoing maintenance further exacerbates inequalities between well-resourced institutions and those in low- and middle-income countries. Without sustained investment and policy support, AI risks becoming a tool that benefits only a small segment of learners, thereby reinforcing existing educational disparities rather than reducing them [34].

Moreover, the literature emphasizes the lack of professional training and capacity building for educators in inclusive AI use. Teachers in under-resourced contexts often receive minimal preparation to implement AI tools effectively or ethically, limiting their ability to adapt technologies to the needs of learners with disabilities. This skills gap highlights the importance of institutional support and inclusive policy frameworks [15].

7.5. Implications for Inclusive and Ethical AI in Education

Taken together, these ethical, accessibility, and equity challenges suggest that AI and ML technologies must be developed and implemented within a human-centered, inclusive, and rights-based framework. The literature strongly advocates for participatory design approaches that involve learners with disabilities, educators, and policymakers in the development process to ensure relevance, fairness, and accessibility [35].

Without deliberate attention to these challenges, AI-driven educational innovations risk perpetuating exclusion, marginalization, and inequality. Therefore, future research and practice should prioritize ethical governance, universal accessibility, and equitable access to ensure that AI truly serves as a tool for inclusive education rather than a source of new barriers.

8. Conclusions

This systematic review demonstrates that AI and Machine Learning technologies offer substantial potential to enhance inclusive education for learners with disabilities. Across the reviewed studies, AI-supported interventions were found to improve accessibility to learning materials, personalize instruction, enhance academic achievement, and promote social participation and learner autonomy. Technologies such as intelligent tutoring systems, speech and text processing tools, computer vision applications, and learning analytics have shown particular promise in addressing diverse learning needs across sensory, cognitive, and developmental disability categories.

Despite these benefits, the review highlights significant ethical, accessibility, and equity concerns that challenge the inclusive deployment of AI in education. Algorithmic bias, opaque decision-making processes, data privacy risks, and surveillance practices threaten the rights and dignity of learners with disabilities. Furthermore, limited adherence to accessibility standards and the persistent digital divide especially in low-resource and crisis-affected contexts risk reinforcing existing educational inequalities. These findings suggest that technological innovation alone is insufficient to achieve inclusive education.

Overall, the study concludes that AI and ML can meaningfully contribute to inclusive learning environments only when embedded within a human-centered, rights-based, and equity-oriented framework. Inclusive policy design, participatory development, and sustained institutional support are essential to ensure that AI technologies empower learners with disabilities rather than marginalize them further.

9. Recommendations

Based on the findings of this systematic review, the following recommendations are proposed:

1) *Adopt Ethical and Inclusive AI Frameworks:* Educational institutions and policymakers should adopt ethical AI frameworks that prioritize fairness, transparency, accountability, and the protection of learners' rights, particularly for students with disabilities.
2) *Ensure Universal Accessibility by Design:* AI-supported educational tools should be developed in alignment with UDL principles and international accessibility standards to accommodate diverse disability needs from the outset.
3) *Strengthen Data Protection and Privacy Policies:* Clear guidelines on data governance, informed consent, and responsible data use must be established to safeguard sensitive learner information and prevent surveillance-driven educational practices.
4) *Promote Equity in Low-Resource Contexts:* Targeted investments, infrastructure development, and context-sensitive solutions are needed to reduce the digital divide and ensure equitable access to AI technologies in low- and middle-income and crisis-affected settings.
5) *Build Educator Capacity and Inclusive AI Literacy:* Continuous professional development should be provided to educators to enhance their capacity to implement AI tools effectively, ethically, and inclusively in diverse classroom contexts.
6) *Encourage Participatory and Interdisciplinary Research:* Future research should involve learners with disabilities, educators, technologists, and policymakers in participatory design processes, with a stronger focus on underrepresented disability groups and Global South contexts.

Abbreviations

ADHD	Attention Deficit/Hyperactivity Disorder
AI	Artificial Intelligence
ASD	Autism Spectrum Disorder
CAST	Center for Applied Special Technology
DIT	Digital Instructional Tools

ERIC	Education Resources Information Center
IEEE	Institute of Electrical and Electronics Engineers
ML	Machine Learning
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SDG 4	Sustainable Development Goal 4
UDL	Universal Design for Learning
UNCRPD	United Nations Convention on the Rights of Persons with Disabilities
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCAG	Web Content Accessibility Guidelines
WHO	World Health Organization

Conflicts of Interest

The authors declare no conflicts of interest.

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