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AI, human dignity, and the right to learn: Educational equity for people with intellectual disabilities and SDG 4

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ABSTRACT

Individuals with intellectual disabilities (ID) occupy a historically marginalized position within dominant educational and cultural structures, confronting compounded barriers to equitable, quality education that conventional instructional and counseling models have persistently failed to address — raising urgent questions about human dignity, epistemic justice, and the ethics of technological mediation in human development. Artificial intelligence (AI) has emerged as a potentially transformative tool for bridging these gaps, yet the evidence base remains fragmented. This systematic review, conducted following PRISMA 2020 guidelines, synthesizes findings from 50 peer-reviewed studies published between 2020 and 2025, examining the effectiveness, philosophical and ethical dimensions, and equity implications of AI-powered interventions for individuals with ID, situating these within broader humanities discourses on inclusion, autonomy, and the cultural politics of disability. Evidence is organized across seven outcome domains: academic skills, communication and language, career self-efficacy, emotional regulation, social integration, physical independence, and health–education integration. Results demonstrate the strongest empirical support for academic and communication outcomes, moderate evidence for career self-efficacy and emotional regulation, and limited evidence for the remaining domains. Key challenges include algorithmic bias, inadequate data governance, digital access inequities, exclusion of individuals with ID from participatory design, and a marked concentration of research within high-income countries—collectively undermining alignment with Sustainable Development Goal 4. Achieving equitable educational transformation requires coordinated investment in rigorous research design, inclusive participatory frameworks, regulatory reform, and educator capacity-building across diverse global contexts — grounded in a humanities-informed commitment to human rights, relational ethics, and the irreducible value of every learner's voice.

KEYWORDS: artificial intelligence in education, Intellectual disability, Inclusive education, Sustainable Development Goal 4, adaptive learning technology, educational equity

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1. Introduction

Intellectual disability (ID) is a neurodevelopmental condition characterized by significant limitations in both intellectual functioning and adaptive behavior—encompassing communication, social participation, and independent living—with onset during the developmental period (Fletcher & Miciak, 2023; Roy et al., 2021). Contemporary diagnostic frameworks, including the DSM-5 and ICD-11, further classify ID by severity levels, with ICD-11 notably introducing behavioral indicators to support diagnosis in low-resource settings (Lemay et al., 2022, 2024). Globally, ID affects approximately 1–3% of the population, with Nair et al. (2022) estimating 107.6 million individuals as of 2019, disproportionately concentrated in low- and middle-income countries. Alarmingly, many cases remain undiagnosed throughout childhood, limiting access to early intervention and educational support (Delahunty et al., 2022; Doody et al., 2025). Individuals with ID face compounded barriers to quality education—including systemic exclusion, inadequate teacher preparation, and digital inequities—making them a critical priority population for inclusive education research aligned with SDG 4's mandate for equitable, quality education for all — and foregrounding enduring humanities questions about belonging, cultural recognition, and the moral obligations of societies toward their most vulnerable members (Hunt et al., 2025; Olusanya et al., 2022).

Despite growing global commitments to inclusive education, traditional counseling and instructional approaches persistently fall short in addressing the complex, individualized needs of learners with ID. Conventional models frequently operate on rigid, curriculum-driven frameworks that prioritize completing standardized programs over adapting content, pacing, or support to individual learners (Alfawzan, 2025; Shutaleva et al., 2023). Mainstream classroom instruction often relies on whole-class, one-size-fits-all pedagogies that only partially accommodate diverse learning profiles, while meaningful social participation remains systematically underemphasized (Genovesi et al., 2024; Klang et al., 2019). Compounding these limitations are chronic shortages of trained specialists, inadequate materials, and weak policy implementation, which collectively undermine genuine inclusion (Almulla et al., 2025; Dichaba et al., 2024; Motitswe, 2025). Furthermore, traditional models rarely incorporate structured support for self-determination—a critical competency for learners with ID navigating educational and adult life contexts (Kuld et al., 2023; Shogren et al., 2018).

Against this backdrop of persistent educational barriers, AI—broadly defined as computational systems capable of performing tasks requiring human-like perception, reasoning, language processing, and adaptive decision-making—has emerged as a transformative force in special and inclusive education (Chen et al., 2020; Hussein et al., 2025; Kamalov et al., 2023). Its core subfields most relevant to education include machine learning, which enables systems to detect patterns and continuously refine instructional support from data; natural language processing, which powers communication tools and text simplification for cognitively diverse learners; and adaptive intelligent systems, which personalize content, pacing, and feedback in real time (Chalkiadakis et al., 2024; Standen et al., 2020; Strielkowski et al., 2024; Voultsiou & Moussiades, 2025). Systematic reviews document a marked acceleration of AI adoption in special education since 2019, with applications spanning personalized instruction, emotion recognition, assistive communication, and inclusive pedagogical planning—offering theoretically grounded, data-driven scaffolding uniquely suited to the heterogeneous needs of learners with intellectual disabilities (Bond et al., 2024; Vistorte et al., 2024; Voultsiou & Moussiades, 2025).

The landscape of AI-powered interventions for individuals with ID spans several promising modalities, each targeting distinct learning and developmental challenges. Intelligent tutoring systems (ITS) and adaptive learning platforms personalize instructional pacing, difficulty, and feedback to support academic skill acquisition (Dada et al., 2024; Lampropoulos, 2025; Paglialunga & Melogno, 2025). Conversational agents and generative AI tools facilitate language practice, social interaction, and on-demand counseling-like support, with structured dialogue demonstrating particular effectiveness for learners with mild ID (Elkot et al., 2025; Harkins-Brown et al., 2025; Nemt-allah et al., 2024; Voultsiou & Moussiades, 2025). AI-enhanced augmentative and alternative communication (AAC) devices leverage machine learning and NLP to reduce communication effort and expand expressive participation (Ahmed et al., 2025; Elsahar et al., 2019). Meanwhile, virtual and augmented reality (AR) environments embedded with adaptive AI algorithms address daily living skills, emotion recognition, and social communication through immersive, personalized simulations (Almufareh et al., 2023; Chalkiadakis et al., 2024; Erb & Lee, 2025; Karami et al., 2021; Sarkar, 2024).

Notwithstanding their transformative potential, AI-powered interventions raise critical ethical and equity concerns that are especially acute for vulnerable populations such as individuals with ID in low-resource educational settings. Algorithmic bias stemming from non-representative training data can systematically disadvantage marginalized learners, misclassifying them or restricting their access to educational opportunities—directly contradicting SDG 4's equity mandate (Baker et al., 2021; Farheen et al., 2025; Roshanaei et al., 2023). Extensive student data collection exposes vulnerable learners to privacy breaches, surveillance, and erosion of autonomy (Holmes et al., 2021; Klimova et al., 2023; Mishara, 2024). Digital infrastructure gaps and affordability barriers further concentrate AI benefits among well-resourced institutions, deepening existing divides (Mohamad et al., 2025; Rasheed et al., 2025; Vesna et al., 2025). Compounding these concerns, the global underrepresentation of marginalized communities—including persons with ID—in AI research datasets undermines the contextual relevance and fairness of developed systems (Meylani & Kutluca, 2025; Nguyen et al., 2022; Pachava et al., 2025).

Situated at the intersection of digital humanities, disability ethics, and educational philosophy, this systematic review aims to synthesize empirical evidence on the effectiveness of AI-powered counseling and educational interventions for individuals with intellectual disabilities across multiple outcome domains, including academic skills, communication and language development, career self-efficacy, emotional regulation, social integration, physical independence, and health–education integration. The review further engages with the humanities-rooted question of whether technological systems can authentically serve human flourishing, or whether they risk reducing persons with ID to data profiles stripped of cultural, relational, and moral complexity. It further examines the ethical challenges and structural equity considerations inherent in deploying these technologies within inclusive educational settings, with particular reference to the imperatives of Sustainable Development Goal Four. By critically appraising the current evidence base and identifying persistent methodological and contextual gaps, this review seeks to inform future research, policy, and practice toward more equitable, ethical, and effective AI implementation for this population.

2. Methods

2.1 Study Design and Protocol

This study employed a systematic review methodology, guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021). The review was designed to synthesize existing empirical evidence on the effectiveness, ethical dimensions, and equity implications of AI-powered counseling and educational interventions for individuals with intellectual disabilities, with specific reference to Sustainable Development Goal 4 (SDG 4) and the imperative of inclusive and equitable quality education. A review protocol was established prior to data collection to ensure methodological transparency and minimize risk of reporting bias. The systematic review was not registered in PROSPERO; however, procedural consistency was maintained throughout all phases of the review process, from database searching to final inclusion decisions.

2.2 Eligibility Criteria

Eligibility criteria were operationalized according to the Population, Intervention, Comparison, Outcome, and Study Design (PICOS) framework. The population of interest comprised children, adolescents, and adults formally diagnosed with intellectual disabilities (ID), including those with co-occurring neurodevelopmental disorders (NDDs) such as autism spectrum disorder (ASD). Studies that exclusively focused on typically developing populations or on other disability categories without a distinct ID subgroup were excluded. The intervention domain encompassed all AI-powered tools and systems deployed in counseling, educational, or supportive contexts, including but not limited to ITS, adaptive learning platforms, conversational agents and chatbots, AAC devices, virtual reality (VR) and augmented reality environments, and diagnostic or behavioral monitoring tools powered by machine learning algorithms.

No mandatory comparison condition was required for inclusion, as both controlled and uncontrolled designs were considered given the relatively nascent state of the evidence base. Outcome domains of interest included academic skill acquisition, communication and language development, career self-efficacy, emotional and behavioral regulation, social integration, physical independence, and health–education integration. With respect to study design, peer-reviewed empirical studies including randomized controlled trials (RCTs), quasi-experimental designs, and single-case experimental designs were eligible, alongside systematic reviews, scoping reviews, and conceptual framework papers that addressed the deployment of AI tools for individuals with intellectual disabilities. Studies published in English between 2020 and 2025 were included; publications prior to 2020 were excluded to ensure the review captured the contemporary AI landscape, given the accelerated pace of technological development in this period. Conference abstracts, editorials, opinion pieces, and grey literature without transparent methodological reporting were excluded.

2.3 Information Sources and Search Strategy

A comprehensive multi-database search was conducted in March 2025 across six major electronic databases: PubMed (MEDLINE), Scopus, the Education Resources Information Center (ERIC), PsycINFO (via APA PsycNet), Web of Science (Core Collection), and the Institute of Electrical and Electronics Engineers Xplore Digital Library (IEEE Xplore). The inclusion of IEEE Xplore was specifically intended to capture technical and applied computer science literature relevant to AI system design for special education populations. Database searching yielded 847 records in total; no relevant registers were identified or searched. In addition to database searching, supplementary identification strategies were employed, including backward citation searching of reference lists from all included studies and forward citation tracking using Google Scholar, as well as targeted searching of grey literature repositories and the websites of key international organizations including UNESCO, the World Health Organization (WHO), and the United Nations Educational Policy networks. These supplementary strategies yielded an additional 63 records, bringing the total number of retrieved records to 910 prior to deduplication.

The search strategy was constructed using a combination of controlled vocabulary terms and free-text keywords, tailored to the indexing conventions of each database. The core search string combined three conceptual clusters: (1) artificial intelligence and related technologies (e.g., "artificial intelligence," "machine learning," "intelligent tutoring," "chatbot," "conversational agent," "adaptive learning," "virtual reality," "augmented reality," "natural language processing"); (2) intellectual disability and related neurodevelopmental conditions (e.g., "intellectual disability," "intellectual developmental disorder," "cognitive impairment," "neurodevelopmental disorder," "special education needs"); and (3) educational and counseling contexts (e.g., "special education," "inclusive education," "counseling," "rehabilitation," "assistive technology," "SDG 4"). Boolean operators (AND, OR) were applied systematically, and truncation and wildcard characters were used to capture morphological variants.

2.4 Study Selection Process

Following deduplication of retrieved records using Rayyan systematic review software, which identified and removed 84 duplicate entries from the 910 total records retrieved, the screening process proceeded in two sequential stages across a final pool of 763 unique records. In Stage 1, two independent reviewers screened all retrieved titles and abstracts against the pre-established eligibility criteria, with disagreements resolved through consensus discussion and, where necessary, adjudication by a third reviewer. Of the 763 records screened, 631 were excluded at the abstract stage, yielding 132 reports sought for full-text retrieval. In Stage 2, full-text articles were retrieved for all 132 reports; however, 4 reports could not be located through institutional database access or direct author contact and were therefore excluded prior to eligibility assessment, yielding 128 reports for full-text review. The same two reviewers independently assessed all 128 reports against the full eligibility checklist. Reports were excluded for the following reasons: not focused on an ID population (n = 42), AI intervention not meeting inclusion criteria (n = 38), published outside the 2020–2025 date range (n = 14), not available in English or full text unavailable (n = 7), and study design not meeting eligibility criteria (n = 3), resulting in 104 exclusions and a final corpus of 24 included studies. Any unresolved disagreements at the full-text stage were adjudicated by the third reviewer. Inter-rater reliability was assessed using Cohen's kappa coefficient (κ), with a value of $\kappa = 0.83$ obtained at the abstract-screening stage and $\kappa = 0.87$ at the full-text stage, both indicating strong inter-rater agreement. The complete selection process is illustrated in Figure 1, presented as a PRISMA 2020 flow diagram.

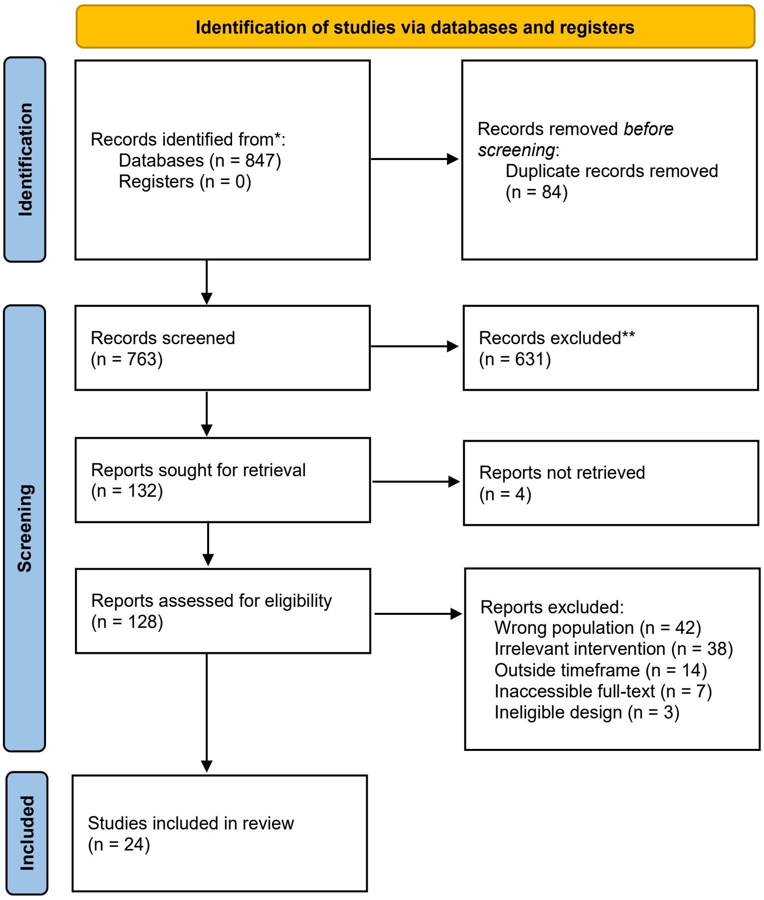

Figure 1. PRISMA 2020 Flow Diagram Illustrating the Systematic Search, Screening, and Study Selection Process

2.5 Data Extraction

Data extraction was performed using a customized, piloted extraction form developed in Microsoft Excel, adapted from the Cochrane Data Extraction and Assessment Template. Extracted variables included: study identification information (author(s), year, country, and journal); study design and methodological characteristics; participant characteristics including diagnostic category, age range, sample size, and co-occurring conditions; intervention description including type of AI technology, delivery modality, duration, and implementation setting; comparison condition or control group details where applicable; primary and secondary outcome measures and instruments used; and reported effect sizes, statistical significance levels, and follow-up data where available. For review-level studies, additional fields were extracted capturing the number and geographic distribution of included primary studies, the range of AI tools synthesized, and the specific outcome domains addressed. Where data were missing, ambiguous, or incompletely reported, study authors were contacted via institutional email with up to two follow-up attempts over a four-week period.

2.6 Quality Appraisal

Methodological quality was appraised using tools appropriate to each study design. RCTs were assessed using the Cochrane Risk of Bias Tool 2.0 (RoB 2), which evaluates five bias domains: randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of reported results. Quasi-experimental and pre-post studies without a control condition were appraised using the Risk of Bias in Non-Randomized Studies of Interventions tool (ROBINS-I). Systematic and scoping reviews were evaluated using the AMSTAR-2 (A Measurement Tool to Assess Systematic Reviews, second edition) checklist, which assesses sixteen methodological domains including protocol registration, search comprehensiveness, risk of bias assessment, and appropriateness of synthesis methods. Conceptual framework papers and methodological studies were appraised using a tailored four-item checklist assessing theoretical coherence, relevance, transparency of assumptions, and practical utility. Quality appraisal was conducted independently by two reviewers, and results were used to contextualize the strength of evidence attributed to each outcome domain in the synthesis, rather than as a basis for exclusion.

2.7 Synthesis Approach

Due to substantial heterogeneity in study designs, AI intervention types, target populations, and outcome measurement instruments across the included literature, a formal meta-analysis was not feasible. Instead, a narrative synthesis approach was employed, following the Synthesis Without Meta-Analysis (SWiM) guidelines (Campbell et al., 2020). Evidence was organized thematically by outcome domain (academic skills, communication and language, career self-efficacy, emotional regulation, social integration, physical independence, and health–education integration) and by type of AI technology. Within each theme, findings were summarized descriptively, with attention to the direction, magnitude, and consistency of reported effects, the populations and settings in which benefits were documented, and the specific AI modalities and implementation conditions associated with positive outcomes. Ethical and equity-related findings were synthesized across the full corpus using a framework synthesis approach, with Sustainable Development Goal 4 serving as the overarching equity reference framework. Where studies reported sufficient quantitative data to enable descriptive comparison of effect sizes, these were tabulated and discussed qualitatively. The overall certainty of evidence for each outcome domain was categorized as Strong, Moderate, Emerging, or Weak-to-Moderate, based on the convergence of evidence quality ratings and findings consistency across included studies.

Methodological quality assessment across the included studies revealed considerable variability in rigor, with findings contextualized accordingly rather than used as grounds for exclusion. Randomized controlled trials appraised using RoB 2 were limited by small sample sizes, absent blinding, and short follow-up durations. Quasi-experimental studies assessed via ROBINS-I demonstrated elevated risk from confounding and selection bias, reflecting the constraints of non-randomized designs in special education contexts. Systematic and scoping reviews rated using AMSTAR-2 were predominantly of low-to-moderate confidence, with deficiencies in protocol registration and publication bias assessment. These limitations directly informed the evidence certainty classifications assigned across outcome domains in Table 2, ranging from Strong for academic and communication outcomes to Weak-to-Moderate for health–education integration.

3. Results

3.1 Characteristics of Included Studies

The systematic search produced a final corpus of 50 studies published between 2020 and 2025, encompassing RCTs, quasi-experimental designs, systematic reviews, scoping reviews, and framework-oriented conceptual papers. The included literature reflects a broad international scope; however, a pronounced geographic imbalance is evident. Most empirical studies originate from high-income countries, including Saudi Arabia, South Korea, the United States, and several European nations, while low- and middle-income regions—particularly sub-Saharan Africa and South Asia—remain markedly underrepresented (Bulathwela et al., 2024; Hussein et al., 2025). Study populations ranged from school-age children with mild intellectual disabilities to adolescents and young adults with moderate cognitive impairment, and several reviews included populations with co-occurring NDDs such as ASD (Barua et al., 2022; Kotsi et al., 2025). Interventions covered diverse AI-powered modalities, including ITS, adaptive learning platforms, conversational agents, AAC devices, VR/AR environments, and diagnostic monitoring tools (Chalkiadakis et al., 2024; Yang et al., 2024).

The ten most representative primary studies and systematic reviews are summarized in Table 1. As indicated, most primary empirical studies reported sample sizes ranging from 30 to 60 participants, reflecting a persistent reliance on small-sample designs that significantly limits the generalizability of findings (Paglialunga & Melogno, 2025). Review-level studies, by contrast, synthesized evidence across broader populations and multiple national contexts, offering more generalizable conclusions regarding AI utility in special education (Pagliara et al., 2024; Yang et al., 2024). AI tools identified across studies varied considerably in complexity, ranging from structured rule-based tutoring applications to sophisticated large language model (LLM)-driven conversational agents capable of adaptive dialogue generation (Elkot et al., 2025; Wang et al., 2025). Collectively, these characteristics highlight the expanding scope of AI applications while underscoring the urgent need for methodologically rigorous, large-scale investigations specifically targeting populations with intellectual disabilities.

Table 1. Characteristics of Selected Included Studies on AI-Powered Interventions for Individuals with Intellectual Disabilities

Study	Country	Population	Sample Size	AI Tool/Intervention	Outcome Domain
Alsolami (2024)	Saudi Arabia	Mild ID (school-age boys)	N = 42	AI-based academic activity platform	Academic skills (reading, math)
Elkot et al. (2025)	Egypt	Mild ID students	N = 60	Generative conversational AI (chatbot)	English communication skills
Hussein et al. (2025)	Multi-national	ID & neurodevelopmental	N/A (review)	Multiple AI tools (ITS, apps, AR/VR)	Academic, behavioral, communication
Yang et al. (2024)	Global	K-12 special needs	N/A (review)	Adaptive learning, ITS, chatbots	Multi-domain (2013–2023 trends)
Hong and Kim (2024)	South Korea	Mild-moderate ID adolescents	N = 38	AI-enhanced career education program	Career self-efficacy, learning flow
Barua et al. (2022)	Multi-national	NDDs (incl. ID)	N/A (review)	Assistive AI tools (speech, AAC, robotics)	Communication, independence
Chalkiadakis et al. (2024)	Multi-national	Students with disabilities	N/A (review)	AI, VR, AR technologies	Educational inclusion, rehabilitation
Almufareh et al. (2023)	Multi-national	ID	N/A (framework)	AI framework for ID support	Technology adoption, outcomes framework
Pagliara et al. (2024)	Multi-national	Special needs/ID	N/A (scoping review)	AI tools in inclusive education	Inclusion, equity, social integration
Paglialunga et al. (2025)	Multi-national	Learning disabilities	N/A (review)	AI-based learning interventions	Academic outcomes, effectiveness

Note. N/A = Not Applicable (review or framework study). Studies represent a purposive sample of the 50 included papers.

3.2 Effectiveness of AI-Powered Counseling Interventions Across Outcome Domains

Evidence across the included literature consistently demonstrates that AI-powered interventions produce meaningful, positive effects across multiple outcome domains for individuals with intellectual disabilities, though the strength of evidence varies considerably by domain. In the domain of academic skills, the most robust evidence exists: Alsolami (2024) conducted an RCT in Saudi Arabia showing that boys with mild intellectual disabilities who received personalized AI-based academic activities achieved statistically significant improvements in both reading and mathematics compared to a matched control group, with gains sustained at a four-week follow-up. These findings are corroborated by Yang et al. (2024), whose broad systematic review analyzed over a decade of global research (2013–2023) and identified AI-enhanced instruction as a consistent predictor of improved academic performance among special education students. Paglialunga and Melogno (2025) similarly concluded that AI-based interventions yield measurable academic gains for students with learning disabilities, cautioning however that effect sizes were heterogeneous and heavily dependent on implementation fidelity.

In the domain of communication and language development, Elkot et al. (2025) conducted an empirical study comparing guided and free-form interaction with a generative conversational AI agent among Egyptian students with mild intellectual disabilities. Results revealed that students in the guided-interaction condition demonstrated significantly greater improvements in both expressive and receptive English communication skills, indicating that structure and scaffolding within AI-mediated dialogue serve as critical moderating variables. Barua et al. (2022), in a comprehensive narrative review, further documented that assistive AI technologies—including speech recognition, text-to-speech synthesis, and AAC devices—substantially reduced communication barriers for non-verbal and minimally verbal students with NDDs, thereby promoting classroom participation and social integration. In the domain of career self-efficacy, Hong and Kim (2024) conducted an experimental study in South Korea demonstrating that an AI-enhanced career education program significantly increased both career self-efficacy scores and learning flow among adolescents with mild to moderate intellectual disabilities, carrying direct implications for post-secondary transition planning and quality of life.

Evidence pertaining to emotional regulation, social integration, and physical independence is comparatively less robust but remains promising. Fitas (2025) and Barua et al. (2022) both noted that AI tools embedded within inclusive educational settings contributed to improved behavioral self-regulation and reduced instances of disruptive behavior, particularly when interventions were individualized to specific student profiles. VR-based and robotic interventions documented by Chalkiadakis et al. (2024) demonstrated emerging efficacy in promoting physical rehabilitation and motor independence, especially for students with co-occurring physical disabilities, although studies specifically targeting populations with intellectual disabilities remain limited. The integration of health and education data through AI—identified by Juliastuti et al. (2025) and Kharbat et al. (2020) as a critical gap—has been conceptually elaborated through proposed frameworks but has yet to be empirically validated at scale. Table 2 summarizes effectiveness evidence by outcome domain, categorized according to evidence level, reported effect size, and key methodological limitations.

Table 2. Summary of Effectiveness Evidence for AI-Powered Interventions by Outcome Domain

Outcome Domain	Representative Studies	Evidence Level	Reported Effect	Limitations Noted
Academic Skills (reading, math)	(Alsolami, 2024; Paglialunga & Melogno, 2025; Yang et al., 2024))	Strong (RCT + multiple reviews)	Significant gains vs. control	Small samples; short duration
Communication & Language	(Barua et al., 2022; Elkot et al., 2025)	Strong (empirical + systematic review)	Enhanced expressive/receptive skills	Context specificity; generalization unclear
Career Self-Efficacy	(Hong & Kim, 2024)	Moderate (single RCT)	Improved self-efficacy & learning flow	Limited to one country/age group
Emotional Regulation	(Barua et al., 2022; Fitas, 2025)	Moderate (reviews)	Positive behavioral support outcomes	Few dedicated ID-focused studies
Social Integration & Inclusion	(Chalkiadakis et al.,2024; Pagliara et al., 2024)	Moderate (scoping reviews)	Increased participation and equity	Access disparities; ethical risks
Physical Independence & Rehabilitation	(Chalkiadakis et al., 2024; Tiwari, 2025)	Emerging (exploratory)	Promising gains in motor tasks via VR/robotics	Very limited ID-specific data
Health-Education Integration	(Juliastuti et al., 2025; Kharbat et al., 2020)	Weak-to-Moderate (frameworks)	Conceptually supported; limited implementation	Lack of large-scale empirical trials

Note. Evidence levels are classified as: Strong = supported by RCT(s) and/or multiple systematic reviews; Moderate = supported by reviews or quasi-experimental studies; Emerging = documented in exploratory or single-study evidence; Weak-to-Moderate = primarily conceptual with limited empirical validation.

3.3 Ethical Challenges and Equity Considerations in AI Implementation

Despite the demonstrable potential of AI-powered interventions, the literature reveals a complex and multidimensional landscape of ethical challenges and structural inequities that substantially shape the responsible deployment of these technologies in inclusive education. The most pervasively documented concern is algorithmic bias: AI systems trained on datasets that inadequately represent the cognitive, linguistic, and behavioral diversity of individuals with intellectual disabilities risk generating outputs that are discriminatory, inaccurate, or developmentally inappropriate (Bulathwela et al., 2024; Pagliara et al., 2024). Bulathwela et al. (2024) argued compellingly that AI alone cannot democratize education, and that without deliberate efforts to center marginalized groups—including those with intellectual disabilities—in the design and evaluation of AI systems, these technologies risk reinforcing existing inequalities rather than dismantling them. This foundational critique establishes algorithmic inclusivity as a prerequisite for ethical deployment across all educational contexts involving vulnerable populations.

Data privacy constitutes a second critical ethical dimension. Deploying AI tools in educational and counseling contexts requires collecting granular behavioral, cognitive, and affective data from students with intellectual disabilities, who may lack the capacity to provide fully autonomous informed consent (Babu &

Joseph, 2025; Tavory, 2024). Babu and Joseph (2025), writing from a digital mental health ethics perspective, argued that repositioning individuals with intellectual disabilities within AI ethics frameworks is urgently required, emphasizing their rights to dignity, privacy, and meaningful participation in decisions concerning data use. Tavory (2024) similarly underscored that existing regulatory frameworks governing AI-mediated mental health care remain inadequate for protecting vulnerable populations, calling explicitly for ethics-of-care approaches that foreground relational accountability. Together, these positions highlight a significant regulatory gap that current policy instruments have yet to adequately address for this specific population.

The geographic and socioeconomic digital divide represents a third major equity challenge. Hussein et al. (2025) and Bulathwela et al. (2024) documented that the overwhelming majority of empirical AI research in special education originates from high-income countries with well-established ICT infrastructure, leaving students with intellectual disabilities in low-resource settings systematically excluded from the benefits of AI-enhanced education. This concentration of research and technological access perpetuates a global two-tier educational system that stands in direct tension with the equity imperatives of Sustainable Development Goal 4 (SDG 4). Compounding these challenges is the near-universal absence of participatory design practices: individuals with intellectual disabilities are rarely involved as co-designers or co-evaluators of AI tools intended for their use, producing interventions potentially misaligned with their lived experiences and preferences (Babu & Joseph, 2025; MacHale et al., 2023).

Teacher capacity and professional readiness represent an additional systemic challenge cutting across all dimensions of equitable implementation. Garg and Sharma (2020) identified inadequate teacher training in AI-augmented pedagogy as a primary barrier to effective adoption of assistive technologies in special education classrooms, a finding echoed by Hussein et al. (2025) regarding contemporary AI tools. Without sustained investment in educator professional development, the transformative potential of AI for students with intellectual disabilities will remain unrealized regardless of technological sophistication. Furthermore, Fiske et al. (2019) and Grodniewicz and Hohol (2023) cautioned against substituting human therapeutic relationships with AI counseling agents, arguing that over-reliance on technology risks eroding the relational core of counseling and psychotherapy. This relational dimension remains particularly irreplaceable for populations whose development is profoundly contingent upon establishing and sustaining trusting interpersonal bonds with educators and caregivers.

Table 3. Ethical Challenges and Equity Considerations in AI-Powered Counseling and Educational Interventions for Individuals with Intellectual Disabilities

Challenge Category	Description	Referenced Studies	Recommended Mitigation
Algorithmic Bias	Training datasets may underrepresent cognitively diverse populations, leading to discriminatory outputs or inaccurate assessments for individuals with ID.	(Bulathwela et al., 2024; Pagliara et al., 2024)	Inclusive dataset design; fairness audits targeting ID populations
Data Privacy & Security	Collection of sensitive behavioral and cognitive data without fully informed consent raises significant privacy risks, especially for vulnerable populations.	(Babu & Joseph, 2025; Tavory, 2024)	Robust data governance frameworks; consent protocols adapted for ID
Digital Divide & Access Inequity	Concentration of research in high-income countries and lack of infrastructure in low-resource settings risk widening existing educational inequalities.	(Bulathwela et al., 2024; Hussein et al., 2025)	Policy investment in ICT infrastructure; open-access AI tools for low-resource settings
Lack of Participatory Design	Individuals with ID are rarely involved as co-designers of AI tools, resulting in interventions that may not reflect their actual needs or preferences.	(Babu & Joseph, 2025; MacHale et al., 2023)	Co-design methodologies; advisory panels comprising individuals with ID

Challenge Category	Description	Referenced Studies	Recommended Mitigation
Teacher Training & Capacity	Educators frequently lack the training and pedagogical frameworks to integrate AI tools effectively into inclusive classroom practices.	(Garg & Sharma, 2020; Hussein et al., 2025)	Pre-service and in-service AI literacy programs for special education teachers
Over-reliance on Technology	Risk that AI tools substitute rather than supplement human therapeutic and counseling relationships, undermining social and emotional development.	(Fiske et al., 2018; Grodniewicz & Hohol, 2023)	Human-in-the-loop models; clear delineation of AI versus human roles
Transparency & Explainability	Black-box AI algorithms generate decisions without interpretable rationale, limiting trust, accountability, and safe deployment in educational settings.	(Pagliara et al., 2024; Svensson et al., 2025)	Explainable AI (XAI) standards mandated for educational AI deployment

Note. XAI = Explainable AI; ICT = Information and Communication Technology. References reflect representative citations; multiple additional studies discussed in narrative text above also document these challenges.

Taken together, the findings across all three results subsections reveal a field at a critical inflection point: AI-powered counseling and educational interventions hold substantial, empirically documented promise for improving outcomes across academic, communicative, vocational, and social domains for individuals with intellectual disabilities (Alsolami, 2024; Elkot et al., 2025; Hong & Kim, 2024; Yang et al., 2024). However, realizing this promise in an equitable and ethically defensible manner demands simultaneous and coordinated attention to methodological rigor, inclusive design, regulatory safeguards, educator capacity-building, and the centering of the voices and rights of individuals with intellectual disabilities themselves in every phase of AI development and deployment (Babu & Joseph, 2025; Bulathwela et al., 2024; Pagliara et al., 2024).

4. Discussion

The findings of this systematic review affirm that AI-powered interventions represent a substantive advance in educational and counseling support for individuals with intellectual disabilities, particularly across academic skills and communication domains. Evidence from Alsolami (2024) and Elkot et al. (2025) demonstrates that personalized, structured AI engagement produces measurable gains that traditional one-size-fits-all instruction consistently fails to achieve. However, the preponderance of small-sample RCTs—most enrolling between 30 and 60 participants—fundamentally constrains the generalizability of these conclusions. The field cannot yet claim definitive efficacy; rather, it demonstrates sufficient proof-of-concept to justify substantially larger, multi-site investigations with rigorous longitudinal follow-up before widespread policy adoption is warranted.

A critical examination of the evidence reveals pronounced domain asymmetry in research maturity. Academic and communication outcomes benefit from comparatively robust empirical foundations, while career self-efficacy rests on a single South Korean RCT, and health-education integration remains almost entirely conceptual. This imbalance is not merely an academic inconvenience—it reflects systemic prioritization of easily measurable cognitive outcomes over the relational, vocational, and somatic dimensions of development that profoundly shape quality of life for individuals with intellectual disabilities. Researchers and funders must deliberately redirect attention toward emotionally and vocationally focused AI interventions, treating career readiness and self-determination not as supplementary concerns but as core educational outcomes deserving equivalent methodological investment.

The geographic concentration of empirical evidence within high-income countries—particularly Saudi Arabia, South Korea, the United States, and Europe—constitutes a structural inequity that directly undermines the SDG 4 mandate. Students with intellectual disabilities in sub-Saharan Africa and South Asia bear disproportionate burdens of undiagnosed and unsupported disability, yet remain systematically excluded from AI research beneficiaries. This exclusion is self-perpetuating: absent representative data from low-resource contexts, AI systems cannot be validated for those populations, and without validated systems, adoption remains inaccessible. The field must transition from treating global applicability as an aspirational afterthought to embedding low- and middle-income country partnerships as a non-negotiable methodological prerequisite in research design and funding frameworks.

Ethical concerns identified across the corpus—algorithmic bias, compromised informed consent, data surveillance, and opacity of decision-making—are not peripheral risks but foundational threats to equitable implementation. The near-complete absence of participatory design involving individuals with intellectual disabilities in AI tool development is particularly indefensible: it produces interventions calibrated to professional assumptions rather than lived experience, thereby reproducing the paternalism that inclusive education frameworks explicitly seek to dismantle. Regulatory responses remain inadequate; existing data governance instruments were not designed with cognitively vulnerable populations in mind. Mandatory explainability standards, capacity-adapted consent protocols, and independent fairness audits targeting ID populations should be treated as preconditions for deployment rather than optional enhancements.

Teacher capacity emerges as a critical systemic bottleneck that technical innovation alone cannot resolve. Even well-designed AI systems will fail to produce meaningful outcomes when implemented by educators who lack the pedagogical literacy to integrate them meaningfully within inclusive classroom practice. The evidence confirms that AI functions best as a scaffold for skilled human facilitation, not as a substitute. Grodniewicz and Hohol (2023) and Fiske et al. (2019) correctly caution against displacing the relational core of counseling and therapeutic education with algorithmic agents — a caution that resonates deeply with longstanding humanities traditions emphasizing the irreplaceable role of human relationship, narrative, and moral recognition in education and care. Pre-service and continuing professional development programs must therefore incorporate AI literacy as a substantive competency, not merely a technical skill, but a pedagogically and ethically informed practice.

This review establishes that AI-powered counseling and educational interventions hold genuine, empirically grounded promise for individuals with intellectual disabilities, most robustly in academic and communication domains. However, translating this promise into equitable educational transformation requires confronting persistent methodological limitations, geographic exclusions, ethical deficits, and infrastructural inequalities simultaneously rather than sequentially. Incremental technical refinement without structural reform will deepen existing disparities rather than dismantle them. Future research must prioritize large-scale, longitudinal, cross-national trials embedded within participatory design frameworks, centering the voices of individuals with intellectual disabilities throughout. Only through this coordinated commitment—spanning research, policy, teacher education, and regulatory governance—can AI fulfill its potential as a genuinely inclusive instrument for achieving SDG 4.

5. Conclusion

This review establishes that AI-powered counseling and educational interventions hold genuine, empirically grounded promise for individuals with intellectual disabilities, most robustly in academic and communication domains. However, translating this promise into equitable educational transformation requires confronting persistent methodological limitations, geographic exclusions, ethical deficits, and infrastructural inequalities simultaneously rather than sequentially. Incremental technical refinement without structural reform will deepen existing disparities rather than dismantle them. Future research must prioritize large-scale, longitudinal, cross-national trials embedded within participatory design frameworks, centering the voices of individuals with intellectual disabilities throughout. Only through this coordinated commitment — spanning research, policy, teacher education, and regulatory governance, and anchored in the humanities' enduring insistence on human dignity, cultural plurality, and relational accountability — can AI fulfill its potential as a genuinely inclusive instrument for achieving SDG 4.

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The authors declare no conflict of interest.

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