Review Article

Integrating artificial intelligence in supporting students with disabilities in higher education: An integrative review

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Abstract

Artificial intelligence has the potential to significantly enhance accessibility, inclusivity, and academic performance for students with disabilities. This review investigates how AI-driven assistive technologies can support students with disabilities in higher education. Using an integrative review methodology, this study synthesizes peer-reviewed research published between 2020 and 2024 to assess the impact of AI-powered assistive technologies on the academic performance, engagement, and accessibility of students with disabilities in higher education. Thematic synthesis was used to categorize and analyze the data from 27 papers, identifying five major themes: personalized learning, the benefits of AI-driven assistive technology, adoption challenges, institutional barriers, and best practices for AI implementation. The analysis identifies gaps in the current research, including the insufficient evaluation of underrepresented disabilities and the ethical considerations regarding AI usage.

Keywords

artificial intelligence, disability, higher education, integrative review, inclusion, personalized learning

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Introduction

Education is a powerful tool for promoting social inclusion and long-term financial independence. Inclusive education enables students with diverse needs to learn together in the same environment. Higher education can significantly impact on the lives of individuals with disabilities by improving their access to the labor market,[1] which is a critical step toward enhancing their socioeconomic status and preventing economic marginalization.[2] However, despite growing efforts to make education more inclusive, students with disabilities remain underrepresented in higher education, even as enrolment trends overall increase. According to Hauschildt et al.,[3] approximately 15% of European students report having a disability that impacts their ability to study. Unfortunately, consistent support and accommodations for these students are still lacking in higher education institutions.[2] Without the necessary support and adjustments, their academic performance can be severely impacted, often resulting in poor outcomes[4] and, in some cases, even leading to dropping out.[5]

The successful implementation of inclusive education has been greatly supported by technological and strategic developments aimed at improving accessibility, enhancing the learning experience, and ensuring that students with diverse needs receive the necessary accommodations and support throughout their studies. By incorporating AI and other technological advancements, higher education can transform into a truly inclusive space where all students, regardless of their abilities, can thrive. Emerging technologies, particularly artificial intelligence (AI), have significant potential to make education more accessible and customized to individual needs.[6] AI can enable personalized learning pathways for every student, thereby improving both the learning process and outcomes.[7]

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Although AI-driven educational technologies have demonstrated their potential to enhance inclusivity, there are still significant gaps in our understanding of their impact on students with disabilities.[8] Prior research highlights the role of AI in adaptive learning environments, where systems adjust instructional content based on individual performance.[7] Furthermore, AI-powered assistive technologies, including speech-to-text tools and real-time captioning systems, have been shown to enhance accessibility for students with hearing and visual impairments.[9] However, concerns regarding algorithmic bias and the ethical implications of AI decision-making in education persist.[10] By democratizing education, AI presents promising solutions to overcome barriers to accessibility and inclusion, enabling every learner to reach their full potential.[11] As AI technologies continue to evolve, they are expected to contribute significantly to creating more inclusive learning environments that address the unique needs of diverse learners. These technologies can help personalize education, ensuring that all students, regardless of their abilities, have access to the same opportunities and can realize their full potential. However, despite this optimistic outlook, there is a noticeable lack of research exploring the specific needs of students in actual special educational contexts.[12] Given the inevitable integration of AI into education,[13] it makes sense to better understand its implications and explores how it can be used effectively, without compromising students' privacy, autonomy, or emotional well-being, ensuring that AI enhances, rather than undermines, the core values of inclusive and ethical education.

The concept of AI in education is still evolving, and there is no universally agreed-upon definition. Much like broader discussions surrounding natural and artificial intelligence, debates persist about the nature of AI and its broader implications. However, there are certain characteristics of AI systems that are particularly relevant when considering their application in education. Typically, AI technologies involve software solutions capable of analyzing their environment and executing algorithms with a degree of autonomy. Key features include the ability to learn independently and display anthropomorphic traits of intelligence, such as "rationality" or "awareness," at least in specific contexts.

This review explores the potential of AI-driven assistive technologies to promote accessibility, inclusivity, and academic success for students with disabilities in higher education. In contrast to previous reviews that have examined general AI applications, this study delves into the specific impact of AI across various disability types, including sensory, cognitive, and physical disabilities. Additionally, it addresses the ethical considerations associated with the adoption of AI technologies.

Inclusive education and artificial intelligence

Higher education institutions are aiming to make education more accessible, and AI offers significant potential to support this goal. The Universal Design for Learning (UDL) framework recognizes the unique ways in which individuals process information, stay motivated, and express knowledge.[14] As a result, higher education is moving toward a more flexible and personalized learning environment to accommodate the diverse needs of students. Despite the potential of AI to assist students with disabilities, there is a lack of comprehensive analysis on this topic in existing literature.[9] Few studies address the impact of AI on students with disabilities in depth. For instance, while some reviews briefly mention adaptive learning platforms for students with disabilities, they fail to provide a thorough analysis.[9,15] Furthermore, AI-based proctoring systems, which monitor students during exams, may increase anxiety, particularly for students with mental health conditions. However, this concern is often overlooked in research.[16]

While previous reviews[6,10] have explored the role of AI in education, they predominantly focus on general student populations rather than addressing the specific needs of students with disabilities. These reviews primarily explore AI's potential to increase engagement, automate assessments, and improve personalized learning for all students, but lack a detailed analysis of how AI technologies specifically impact accessibility and inclusivity for learners with disabilities.

Our findings are consistent with existing literature on AI-driven personalized learning[17] and reinforce evidence that AI-powered adaptive systems can tailor educational experiences to individual needs. However, this study extends previous research by highlighting key gaps in AI accessibility, ethical concerns, and institutional barriers that have been largely overlooked. Specifically, while AI tools are widely recognized for their ability to personalize learning experiences, few studies have critically examined their effectiveness for students with disabilities, particularly those with cognitive or neurodevelopmental differences.

Several previous reviews[9,18] discuss AI-powered tools such as adaptive learning systems and chatbots. However, these studies do not critically examine whether these tools effectively accommodate students with different disabilities. Furthermore, there is limited research on the potential biases in AI models and how these biases may inadvertently disadvantage students with disabilities. Our review highlights these gaps and highlights the need for more targeted research on AI accessibility and ethical AI design.

Unlike previous studies that broadly assess the role of AI in higher education, our review specifically examines its impact on students with disabilities, making it one of the few studies to systematically evaluate AI-driven accessibility tools in this context. Our findings provide practical insights for institutions seeking to implement AI in an inclusive way.

AI is increasingly being used in education to perform students learning analytics, which involves measuring, collecting, analyzing, and presenting data about learners and their learning environments to better understand and improve educational outcomes. AI technology can apply all four types of learning analytics (1) descriptive analytics to

describe what has already occurred, (2) diagnostic analytics to analyze the reasons behind certain outcomes, (3) predictive analytics to forecast what is likely to happen in the future, and (4) prescriptive analytics to provide recommendations on how to achieve desired results.[19] Unlike traditional methods, AI-driven analytics can process the full range of available data and learn from it autonomously. This allows AI to gain deeper insights and offer personalized learning pathways. Another key advantage is that AI operates in real-time, enabling the immediate detection of challenges that students may encounter during the learning process.[19] This dynamic and adaptive approach makes AI a powerful tool for enhancing educational environments and improving outcomes.

Recent literature reviews highlight that knowledge of inclusiveness in AI-powered learning tools remains limited.[6,9,10,18] Ethical concerns regarding the use of AI in education, particularly discrimination, are becoming increasingly urgent. These concerns encompass issues such as inclusivity, bias, privacy, error, and social acceptability. For example, bias in machine learning algorithms can lead to discriminatory practices that hinder access to education, while natural language processing (NLP) models may reinforce negative stereotypes about certain disabilities.[9] A primary goal of educational technology is the shift toward personalized learning.[7] To achieve this, large-scale computer adaptive learning (CAL) systems have been developed. These systems automatically adjust the type or difficulty of instructional materials and practice based on an individual learner's performance. They also provide diagnostic feedback on areas that need improvement, offer guidance on which skills to prioritize, and recommend resources for skill enhancement.[7] Educational chatbots, or conversational agents, have significant potential for delivering personalized and interactive learning experiences to students.[13] In the context of AI, these technologies can help students with disabilities in higher education by enhancing accessibility, inclusivity, and academic performance. Additionally, these tools can streamline administrative tasks, allowing instructors to focus on more meaningful aspects of instruction and mentorship.[20]

In our review we focused on investigating how AI can enhance existing assistive technologies (e.g., speech-to-text, AI-powered screen readers, predictive text, etc.) to improve accessibility for students with physical, visual, auditory, or learning disabilities in higher education. The aim of this research was to determine the impact of AI-powered assistive technologies on academic performance, engagement, and accessibility for students with disabilities in higher education. To explore the role of AI in supporting students with disabilities in higher education, we developed the following research question.

RQ1: How can AI-driven assistive technologies create a personalized learning environment for students with disabilities in higher education?

RQ2: What are the benefits and challenges associated with integrating AI-driven assistive technologies to support students with disabilities in higher education?

RQ3: What are the best practices or design considerations for creating AI-powered tools that effectively address the needs of students with different types of disabilities?

Methods and procedures

This study employs an integrative review methodology, following the framework outlined by Whittemore and Knafl.[21] The integrative review was selected over a systematic or scoping review due to its ability to synthesize diverse research methods (qualitative, quantitative, and mixed methods) into a cohesive thematic analysis. The heterogeneity of research approaches and disciplines involved in the study of AI in higher education, which is still in its infancy, necessitates an appropriate review method that can accommodate such diversity. A scoping review differs from a systematic review in that the former allows for a broader scope by incorporating findings from qualitative case studies, experimental research, and theoretical frameworks, as opposed to the typical focus of a systematic review on a well-defined research question with strict inclusion criteria for quantitative studies. While scoping reviews are often used to map the literature and identify research gaps, they do not provide the critical synthesis required to derive practical and theoretical implications. Consequently, the present study employs an integrative approach, a strategy that has been demonstrated to facilitate a more profound comprehension of the way AI-powered assistive technologies influence accessibility, academic performance, and engagement for students with disabilities in higher education.

This approach allows for the inclusion of diverse research methods (qualitative, quantitative, and mixed methods) and integrates theoretical, empirical, and practical insights. This review followed the six-phase approach outlined by Whittemore and Knafl.[21] First, the theme of integrating AI to support students with disabilities in higher education was identified, as discussed in the introduction, and three key research questions were formulated. Second, inclusion and exclusion criteria were established, focusing on the time frame, research status, and language to ensure the relevance of selected studies. Third, key information to be extracted from the studies, including AI-powered assistive technologies, AI tools, AI's impact on students' learning, and best practices, was determined. Fourth, the selected studies were thoroughly evaluated. Fifth, the results were interpreted, offering insights into the role of AI in supporting students with disabilities in higher education. Finally, the body of knowledge was synthesized and presented in this review.

In order to integrate the findings derived from a variety of methodologies, a thematic synthesis approach was

employed. A thematic synthesis approach was used to analyze and categorize the extracted data. The themes in this study were not predefined but rather emerged inductively from the data analysis. To identify these emergent themes, we followed an iterative coding process, wherein each selected study was systematically reviewed to extract key concepts related to AI-powered assistive technologies and their impact on students with disabilities. Initial open coding was performed to highlight recurring ideas and concepts. The studies were coded based on their methodological approach (qualitative, quantitative, or mixed methods) and categorized into key themes, namely. The present study employed inductive thematic synthesis, allowing key themes to emerge from the data. These codes were then grouped into broader thematic categories based on patterns observed across the studies. Thematic clusters were refined through multiple rounds of review and discussion among the researchers to ensure accuracy and coherence in theme development. The studies were analyzed in three stages: (I) initial coding: two reviewers independently extracted recurring concepts related to AI implementation; (II) category formation: codes were grouped into broader themes based on AI's role in education; and (III) final thematic clusters: the most frequent and relevant patterns were synthesized into four major themes: (1) AI-driven accessibility tools, (2) personalized learning experiences, (3) institutional barriers to adoption, and (4) best practices for inclusive AI integration. This structured synthesis ensures that insights from different research paradigms contribute to a coherent understanding of AI's role in inclusive higher education. The synthesis process followed three key criteria.

- *Thematic frequency* by identifying recurring themes across studies through keyword analysis.
- *AI technology used* by examining specific AI tools (e.g., speech-to-text, predictive analytics, adaptive learning).
- *Results integration* by compared study findings to assess AI's impact on accessibility, engagement, and learning outcomes. In order to guarantee coding consistency, the coding of a subset of studies was carried out by two independent reviewers. The Cohen's Kappa coefficient ($\kappa = 0.82$) was calculated, indicating a high level of agreement in theme identification. Discrepancies were resolved through discussion and consensus.

Search strategy: A comprehensive literature search was conducted in PubMed, IEEE Xplore, Web of Science, and Scopus on September 23, 2024. Search terms included "AI-powered assistive technology," "disability," "higher education," "accessibility," "academic performance," "inclusivity," "learning tools," "speech-to-text," "screen readers," and "adaptive learning tools." A manual search of reference lists in selected studies was also performed to identify any relevant articles not captured in the initial search. To capture relevant studies on the role of AI-powered assistive technologies in supporting students with disabilities in higher education, the following search string was used:

> ("AI-powered assistive technology" OR "artificial intelligence") AND ("disability" OR "students with disabilities" OR "special needs") AND ("higher education" OR "university" OR "college") AND ("accessibility" OR "academic accessibility" OR "inclusion") AND ("academic performance" OR "learning outcomes" OR "student achievement") AND ("inclusivity" OR "inclusive education" OR "inclusive learning") AND ("learning tools" OR "adaptive learning tools" OR "assistive technology tools") AND ("speech-to-text" OR "screen readers" OR "text-to-speech" OR "assistive devices") AND ("adaptive learning systems" OR "personalized learning tools").

This search string included a broad range of terms related to the key areas of interest in our research and helped capture studies addressing AI-powered assistive technologies in higher education. The search was conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines.[22] As illustrated in Figure 1, our search strategy included: (1) Initial identification of 1200 studies across four databases (PubMed, IEEE Xplore, Web of Science, Scopus); (2) Screening based on title and abstract, leading to 250 articles for full-text review; and (3) Final inclusion of 27 studies, selected based on predefined eligibility criteria (AI application, assistive technology focus, higher education context). Of the 89 reports sought for retrieval, 56 were excluded at the full-text screening stage. Among these, 51 articles were excluded due to not meeting the inclusion criteria (e.g., irrelevant outcomes, inappropriate study design, lack of focus on AI tools and inclusion), and five were excluded due to lack of access to full text despite repeated attempts through institutional and interlibrary resources.

We included both quantitative and qualitative studies (peer-reviewed journal articles, conference proceedings, dissertations, and reports) published in English between 2020 and 2024. A search strategy was employed to identify relevant studies, including both quantitative and qualitative research methodologies. This approach included reviewing peer-reviewed journal articles, conference proceedings, and institutional reports. The term "reports" in this context refers to institutional white papers, government publications, and conference findings that offer critical insights into the application of AI in the domain of assistive technologies in education. While some of these reports have undergone a peer-review process, others constitute grey literature, which has been critically assessed for credibility. The adoption of AI in accessibility and education represents a nascent field of study, with various observations documented in institutional reports as opposed to the conventional format of academic journals. These reports offer real-time data on the

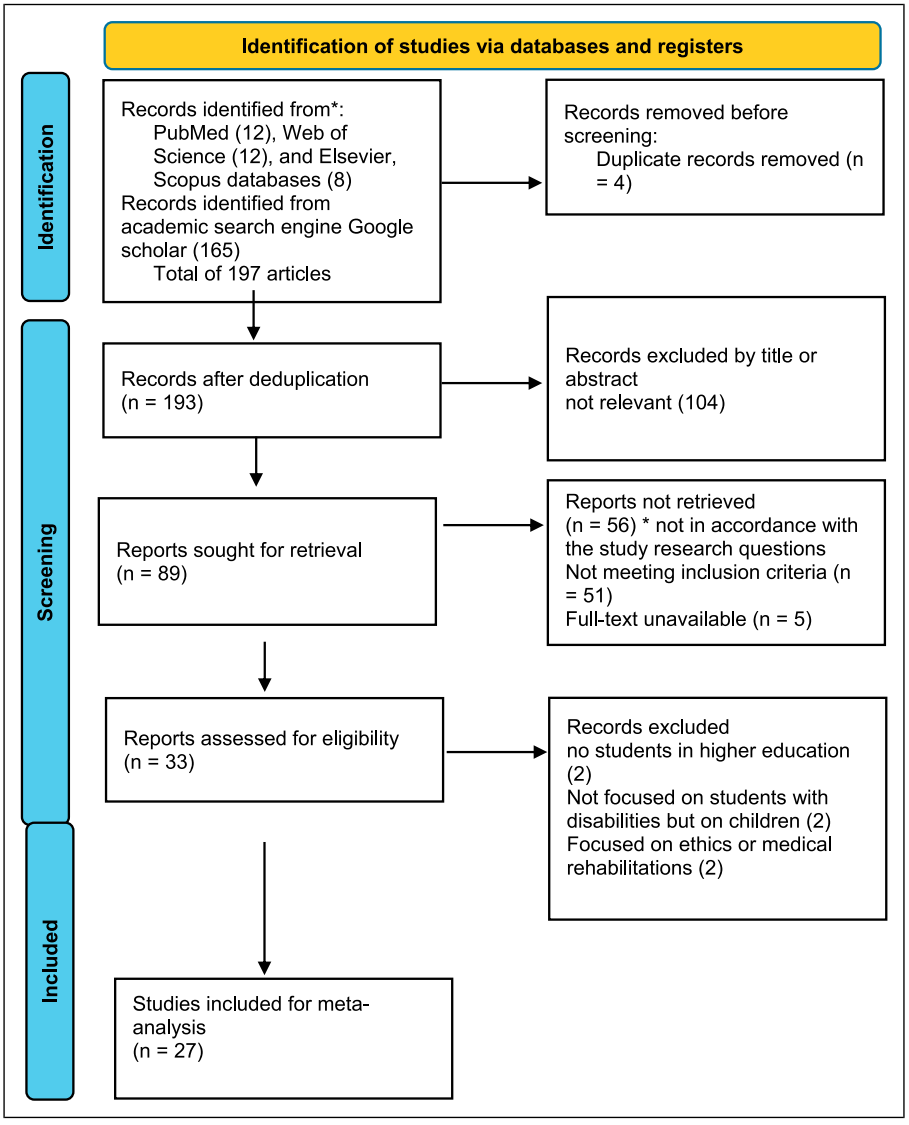

Figure 1. PRISMA flow chart.

implementation challenges and emergent solutions pertaining to AI, thereby serving as invaluable resources for analyzing practical applications that have not yet been adequately addressed in academic literature.

Although the primary inclusion criterion focused on empirical studies reporting measurable impacts on student learning, accessibility, or engagement, the review also included select conceptual papers and systematic reviews. These were incorporated when they contributed critical theoretical perspectives, synthesized empirical findings, or offered valuable insights that informed understanding of AI tools and digital literacy in educational contexts.

While the review prioritized empirical studies with clearly reported methodologies and measurable outcomes, a small number of non-empirical sources were included. These were selected based on their conceptual relevance, clarity of argumentation, and potential to enrich the thematic synthesis—particularly in areas where empirical data was sparse or emerging. For example, brief reflective contributions[23] were included when they offered practitioner insights or contextual interpretations that aligned with identified themes. These sources were treated as supplementary and were coded using the same thematic framework as empirical studies, with caution taken to distinguish between opinion-based content and substantiated claims.

In addition to empirical studies, we included a small number of systematic literature reviews (n = 5), selected based on their comprehensive synthesis of relevant research and their alignment with the review's thematic focus. These reviews were analyzed separately to avoid inflating thematic

frequency counts, with only their explicitly stated thematic conclusions coded. This allowed us to use systematic reviews as triangulating sources, supporting or challenging themes that emerged from empirical data, while maintaining methodological rigor in the frequency analysis.

The present review focuses on studies published between 2020 and 2024, due to the rapid advancements in AI technologies during this period. While the use of AI in education has been a subject of study for many years, studies prior to 2020 often employed AI models that are now considered outdated (e.g., rule-based systems as opposed to deep learning or neural networks). However, key studies providing foundational insights from before 2020 were manually screened and referenced where relevant.

The existence of selection bias is a possibility, given the presence of language limitations and the exclusion of certain grey literature. However, this focus ensures the inclusion of high-quality, peer-reviewed research. Moreover, it is important to note that AI technologies are subject to rapid evolution; therefore, the 2020–2024 time frame encompasses the most recent advancements in deep learning, natural language processing (NLP), and AI-driven accessibility tools.

The selected studies specifically addressed the use of AI-powered assistive technologies (e.g., speech recognition, text-to-speech, AI-based predictive text, AI tutors, etc.) by students with physical, sensory, cognitive, or learning disabilities in higher education. Studies were excluded based on the following criteria: (1) they were not directly related to applications in higher education, (2) they involved non-AI assistive technologies (e.g., traditional or non-AI assistive devices), and (3) they lacked sufficient methodological detail (see Table 1). Additionally, studies focused on K-12 education or special needs programs outside the higher education context were excluded, although their reference lists were reviewed for potential articles.

Following the application of the inclusion and exclusion criteria, a total of 27 studies were selected for this review. The selection process was guided by several key criteria to ensure the relevance, methodological rigor, and empirical value of the included studies. Empirical studies in this review are those that use qualitative, quantitative, or mixed-methods approaches to systematically collect and analyze data related to AI-powered assistive technologies in higher education. This includes experimental research, case studies, surveys, and ethnographic studies. Firstly, relevance was a primary consideration, meaning that only studies explicitly focused on AI-powered assistive technologies in higher education were included. Research that did not specifically address AI-driven tools, or that examined general educational technology without an assistive focus, was excluded.

Secondly, methodological rigor played a crucial role in the selection process. Priority was given to studies that demonstrated a transparent research design, provided clear details about their sample populations, and used replicable methods. This criterion ensured that the findings were reliable and could contribute meaningfully to the broader discourse on AI in education. Additionally, direct AI application was an essential requirement. Articles that examined non-AI assistive technologies, such as traditional screen readers or basic accessibility tools without AI-driven functionalities, were excluded. The present review concentrated on technologies that used artificial intelligence to enhance accessibility, learning experiences, or student engagement.

Studies presenting empirical evidence were considered, with the inclusion criterion being the reporting of measurable impacts on student learning, accessibility, or engagement. The incorporation of empirical data ensured that the findings were based on observed outcomes rather than theoretical discussions or speculative analyses.

Data extraction and analysis

Data from selected studies were extracted using a standardized extraction sheet, covering: (1) AI tool type (e.g., speech-to-text and adaptive learning systems); (2) disability type addressed (e.g., visual, auditory, and cognitive); (3) methodology used (qualitative, quantitative, and mixed methods); (4) outcome measures (academic performance, accessibility, and engagement); and (5) key findings (challenges, benefits, and recommendations). Data were analyzed using a thematic synthesis approach. Codes were

Table 1. Inclusion criteria and exclusion criteria.

Inclusion criteria:
Peer-reviewed journal articles, conference papers, reports, or dissertations
Published between 2020 and 2024
Written in English
Examined AI-powered assistive technologies (e.g., speech recognition, AI screen readers, predictive text, adaptive learning platforms)
Targeted students with physical, sensory, cognitive, or learning disabilities in higher education
Exclusion criteria:
They focused on K-12 education or non-higher education settings
They assessed traditional (non-AI) assistive technologies
They lacked sufficient methodological details on AI tools and outcomes

assigned to recurring concepts, and coherent thematic clusters were developed by grouping similar themes related to AI integration in higher education (Table 2).

Based on the inclusion and exclusion criteria, 27 papers were selected for this integrative review (see Figure 1). Key data were extracted from the selected studies, including recurring concepts, applied AI technologies, contexts, results, and conclusions. The extracted information was analyzed to identify and organize recurring themes related to AI integration in higher education. For each identified theme or pattern, a code was assigned. Coherent thematic clusters were created by grouping similar codes based on their relationships and aspects of AI integration.

A thematic synthesis was conducted to categorize and analyze the data into major themes: (1) personalized learning, (2) benefits of AI-driven assistive technology, (3) adoption challenges and institutional barriers, and (4) best practices for AI implementation. This synthesis process involved analyzing and summarizing studies on the integration of AI into inclusive higher education, guided by three key criteria:

Thematic frequency. This criterion focuses on identifying prevalence of themes or concepts across studies through key term analysis of titles, abstracts, and keywords.

AI technology used. This involved examining the specific AI tools, techniques, and algorithms employed to support students with disabilities in higher education.

Results. The findings from each study were reviewed, with particular attention to the integration of AI in supporting students with disabilities and its implications for educational practice.

Given the diversity of study designs (empirical, conceptual, and systematic reviews), a quality appraisal was conducted. Critical appraisal tools, such as CASP for qualitative studies[24] and PRISMA for systematic reviews,[22] were used to assess the quality of the included studies. We evaluated each empirical study for clarity of research aims, methodological transparency, appropriateness of data collection tools, and rigor in analysis. Conceptual and review papers were assessed for relevance, depth of analysis, and theoretical contribution. While formal scoring was not applied, notes on methodological strengths and limitations were taken to inform thematic synthesis. As this integrative review did not involve primary data collection from human participants, ethical approval was not required. However, ethical considerations were carefully observed in the interpretation and reporting of the research data.

Results

This integrative review aimed to explore current AI-powered assistive technologies available and their applications in supporting students with disabilities in higher education. As research on AI and its integration into education continues to grow at an exponential rate, this review specifically focused on studies that addressed AI-powered assistive technologies for students with disabilities in higher education, ultimately selecting 27 relevant studies. The primary goal was to examine how AI is being used to enhance accessibility, personalize learning experiences, and improve academic outcomes for students with various disabilities. Although there is a wealth of studies on AI in education, a significant gap remains in understanding how these technologies are specifically tailored to meet the needs of students with disabilities. This includes areas such as adaptive learning, real-time feedback systems, and AI-driven accommodations for cognitive and physical challenges. Notably, Toyokawa et al.[19] found it challenging to identify studies that explore AI applications for students with disabilities in Japan, highlighting a broader lack of research in this crucial area. The thematic analysis of the selected papers identified four key categories in the applications of AI to support students with disabilities in higher education. The first theme, "AI and personalized learning," explored how AI can customize educational experiences to meet the unique needs of individual students, promoting more effective and engaging learning for students with disabilities. The second theme, "Benefits of AI-driven assistive technology," was highlighted in six studies that specifically examined various technologies used to support students with disabilities in higher education. The third theme, "AI challenges and barriers," addressed the obstacles faced in the adoption of AI-powered assistive technologies in higher education. Finally, "Best practices" theme focused on examples of AI-powered tools that have successfully addressed the needs of students with different types of disabilities.

The analysis of the 27 studies revealed several critical areas where AI can be effectively applied to enhance the inclusion of students with disabilities in higher education. As demonstrated in recent studies,[20,25] artificial intelligence (AI)-powered tools have been used in various domains to support students with disabilities. Table 3 presents a comparative summary of key AI applications in higher education, categorizing their functionalities based on accessibility improvements, personalized learning, and institutional integration. Table 3 provides a summary of these areas highlighting how AI tools can offer valuable insights and practical solutions for improving learning outcomes and student engagement.

When integrating AI into education, the student or learner should be placed at the core of the process, surrounded by various educational technologies and systems designed to enhance learning outcomes. Ahmad et al.[26] highlighted several AI applications in education that address student diversity and foster inclusive universities. These include: (1) *e-Resources* with *cloud computing and*

Table 2. List and description of selected studies.

Study	Study Type	AI Tool	Disability Type	Key Findings
Parashar et al., 2023	Conceptual review	AI animation tools, AI-powered tutors, and AI-powered grading software for personalized learning, feedback, and assessment.	Diverse linguistic needs of students	The study highlights that AI technologies, particularly animation tools, can improve accessibility and individualize instruction, helping students with disabilities learn at their own pace and receive personalized feedback, thus improving their educational outcomes.
Hofman et al., 2020	Comparative analysis	Computerized adaptive learning (CAL)	Students with diverse learning needs.	The study concludes that the Urnings algorithm overcomes the drawbacks of the ERS by providing known standard errors, allowing statistical inference, and addressing issues such as score variance inflation, thus providing a more reliable approach to tracking student progress in adaptive learning systems.
Panjwani-Charani and Zhai, 2023	Systematic Literature Review	BESPECIAL, Elo Rating System, "Sammy" Chatbot, LEAF Learning Environment Framework, SAMCares	Students with Specific Learning Disorders	AI-driven adaptive learning algorithm dynamically adjusts difficulty levels based on student performance. This system benefits students with general learning disabilities by ensuring they engage with educational content which enhances retention and motivation.
Ristad et al., 2024	Qualitative exploration	The Collaboration Forum Workshops	Students of disabilities	The study finds that professionals often lack the knowledge and cooperation needed to include students with disabilities in higher education, with unclear responsibilities and ignorance hindering effective decision-making and leading to avoidance of inclusive actions.
Hadi Mogavi et al., 2021	Qualitative study (content analysis of social media)	ChatGPT	Students with diverse learning needs	The study finds a dichotomy of opinions about ChatGPT: some users see it as a tool to increase students' self-efficacy and motivation to learn, while others express concerns about potential over-dependence, superficial learning and the erosion of critical thinking skills.

(continued)

Table 2. (continued)

Study	Study Type	AI Tool	Disability Type	Key Findings
Song and Xie, 2024	Literature review	Assistive technology	Students with disabilities	Students with disabilities face significant challenges in accessing complex, scholarly non-text content, even when alternative text formats are provided. The most persistent barrier identified is the lack of understandability, which, despite being a core principle of accessibility, remains largely unaddressed in many academic and policy contexts.
Nacheva and Czaplewski, 2024	Comparative analysis	Intelligent Tutoring Systems, AI-powered visual tools	Students with disabilities	Studies indicate ITS improve engagement, knowledge retention, and skill acquisition
Addy et al., 2023	Review	Generative AI (e.g., ChatGPT, Bard, Claude, Copilot); AI-Powered Writing Assistants	Multi-language learners, students from marginalized linguistic communities, students with disabilities, and low-income students	These tools help to improve written communication by suggesting grammar, restructuring sentences and generating content, thus promoting equality in academic participation.
Mulaudzi and Hamilton, 2024	Qualitative explanatory case study	AI tools for personalized learning, including AI-assisted teaching methods	Not explicitly stated, but relevant to students requiring personalized learning, including those with learning disabilities	Successful adoption of AI in higher education depends on user acceptance, perceived usefulness and ease of use. Both students and faculty need training to balance AI tools with traditional teaching. Institutions need to develop ethical AI policies and implement AI literacy programs.
Faruqui et al., 2024	Applied research with controlled trials	AI-powered chatbot and virtual assistant (SAMCares) using Large Language Models (LLaMa-2 70B) and Retriever-Augmented Generation (RAG)	Students with learning disabilities, cognitive impairments, and students needing personalized learning support	SAMCares provides real-time, contextual and adaptive learning support by interacting in a chat-like environment and retrieving course-specific knowledge. The system improves accessibility by allowing students to upload additional study materials for personalized support. Its effectiveness will be tested through controlled trials and feedback.
Yunusov et al., 2024	Mixed methodology (quantitative and qualitative)	AI-driven learning analytics, Adaptive Learning, Predictive Analytics, and Automated Assessment	Multiple Disabilities	AI is improving personalized education, adaptive learning and automated assessment. However, challenges such as privacy, ethical concerns and the digital divide need to be addressed to ensure inclusiveness and accessibility in higher education.

(continued)

Table 2. (continued)

Study	Study Type	AI Tool	Disability Type	Key Findings
Zhang and Zhang, 2024	Quantitative research study	AI for teaching support, classroom management, personalized learning, and digital skill enhancement	College students	AI improves classroom management, enhances digital literacy, creates inclusive learning environments, personalizes teaching methods and strengthens teacher-student relationships. However, challenges such as digital literacy gaps and effective integration of AI into teacher training need to be addressed.
Abid et al., 2024	Quantitative research study	Various AI technologies	The research does not specifically focus on types of disabilities but rather investigates the broader category of students with disabilities.	Encourage AI developers to consider accessibility and transition to employment.
Toyokawa et al., 2023	Case study	LEAF (LA-enhanced AR learning) learning analytics system	Students with ADHD	The study identified specific learning behaviors from students' learning logs and highlighted both the challenges and potential of integrating AI into inclusive education, emphasizing the importance of human involvement in guiding educational practice.
Zingoni et al., 2021	Usability study	BESPECIAL	Students with dyslexia	Preliminary results from around 700 dyslexic students reveal the key challenges they face, which will inform the final implementation of BESPECIAL, an AI and VR-based platform designed to alleviate these difficulties.
Gupta and Chen, 2022	Experimental investigation	Sammy chatbot	Disadvantaged students	The study found that chatbots offer opportunities to support students in an accessible, interactive and confidential way, particularly benefiting those who are disadvantaged and have different learning needs.

(continued)

Table 2. (continued)

Study	Study Type	AI Tool	Disability Type	Key Findings
Ghulam et al., 2024	Qualitative (faculty perception study)	Machine Learning and Natural Language Processing to develop adaptive learning environments and enhance educational tasks	The study does not specifically address any disability types but focuses on faculty perception.	The study finds that AI can enhance personalized learning, automate administrative tasks and create interactive learning experiences. It also highlights concerns about data confidentiality and ethical issues and stresses the importance of balancing technological innovation with human principles such as equity and inclusivity in education.
Lister et al., 2021	Case study (participatory research)	Virtual assistant	Students with disabilities	The study highlights the importance of participatory design in creating AI solutions that address the specific needs and concerns of disabled students, with the aim of reducing barriers and improving equity in education.
Xiao et al., 2021	Design-based research	Artificial intelligence is used to create personalized training models, predict student development, and analyze student information for personalized education	The study does not specifically address any disability types but focuses on personalized education for a diverse range of students, which could be applied to students with disabilities as part of individualized learning approaches	The study finds that AI can enhance personalized learning, automate administrative tasks and create interactive learning experiences. It also highlights concerns about data confidentiality and ethical issues and stresses the importance of balancing technological innovation with human principles such as equity and inclusivity in education.
Šumak et al., 2024	Analytical review	Intelligent tutoring systems, chatbots, robotics, learning analytics dashboards, adaptive learning systems, and automated assessments	Students with various disabilities	The study identifies both the challenges and benefits associated with AI-based educational tools, emphasizing their potential to enhance inclusive education by supporting diverse learners.
Pierrès et al., 2024	Systematic literature review	AI educational technologies (EdTech) such as AI tools that provide personalized learning and feedback	Students with disabilities	The review identifies a lack of ethical consideration in AI EdTech for students with disabilities and highlights eight potential risks, concluding that ethical reflection, greater involvement of disabled people in AI development and careful adoption are needed to mitigate these risks.

(continued)

Table 2. (continued)

Study	Study Type	AI Tool	Disability Type	Key Findings
Halkiopoulos and Gkintoni, 2024	Systematic literature review	AI-powered tools designed for Personalized Learning (PL) and Adaptive Assessment (AA)	Students with diverse learning needs	The review highlights that AI can improve student performance, engagement and motivation, but also points to challenges such as bias and discrimination. It emphasizes the need for empirical validation, bias reduction in algorithms, and careful consideration of ethical issues such as privacy in AI-based education systems.
Babo et al., 2024	Quantitative research study	Generative Artificial Intelligence (GAI) tools used for personalized learning, content creation, and individualized assessment	Students with disabilities	The study finds that students value the personalized learning, efficient content creation and individualized assessment offered by GAI, but are concerned about ethical considerations, lack of control over content, over-reliance on AI and reduced interpersonal engagement. Students agree that GAI is likely to disrupt the educational process in higher education.
Ahmad et al., 2024	Exploratory investigation	Augmented Reality, Big Data, and Virtual Reality	The study addresses students with diverse learning needs, including differences in learning styles, talents, interests, and cultural backgrounds, without specifying a particular disability type.	The study highlights that the integration of Industry 4.0 technologies can provide personalized learning experiences that cater to diverse student profiles, promoting inclusivity and equity in education by adapting to the diverse needs of students.
Denisova and Lekhanova, 2018	Experience-based case study	The study does not specifically focus on AI tools but discusses a support algorithm used to coordinate activities for disabled students in higher education.	Students with disabilities	The study highlights the effectiveness of a coordinated support system that facilitates career guidance, education and employment for students with disabilities, and emphasizes the importance of creating tailored conditions to enhance their success and integration into society.

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Table 2. (continued)

Study	Study Type	AI Tool	Disability Type	Key Findings
Chang et al., 2023	Conceptual paper	AI Chatbots such as ChatGPT	Students with disabilities	The study proposes three key pedagogical principles for the use of AI chatbots in education: goal setting (prompting), self-assessment and feedback, and personalization. It argues for the role of AI in promoting student self-regulation through data-driven learning analytics, with the aim of improving SRL and the ethical use of AI tools in education.
Alshahrani et al., 2024	Semi-systematic literature review	Application of AI tools within the higher education	The review does not specifically address a particular disability type	The review highlights the lack of empirical evaluation of the added value of AI and institutional readiness and emphasizes the need for a socio-technical approach that balances the benefits and social considerations of AI in education.

big data: These technologies help manage vast amounts of educational content, making resources more accessible to students. They enable the storage, processing, and dissemination of educational materials through digital platforms; (2) *Feedback systems:* These systems connect multiple components of the education system by processing feedback from various sources. This real-time feedback improves the learning experience for both students and educators; (3) *Personalized learning:* AI can customize educational content and learning paths to meet individual student needs. Cloud computing and big data further support personalized learning by ensuring that students receive the right materials and instructions; (4) *Secure and reliable system*: These systems ensure the safe and reliable management of data, protecting student information while maintaining the integrity of the education system; and (5) *Educational robots:* They can assist in learning activities, particularly in personalized and interactive education. These robots may support students by providing guidance, feedback, and even teaching assistance. The

Table 3. Comparative summary of key AI applications in higher education for students with disabilities.

AI application	Primary functionality	Impact on accessibility, personalization, or integration
Text-to-Speech (TTS) Tools	Converts written text into spoken audio	Enhances access for students with visual or print disabilities (Accessibility)
Speech Recognition	Converts speech into written text	Assists students with motor disabilities or dyslexia in note-taking (Accessibility)
Chatbots & Virtual Assistants	Provides on-demand academic support and information	Supports real-time help and information access (Institutional Integration)
AI-Powered Learning Analytics	Monitors engagement and performance trends	Enables personalized feedback and early intervention (Personalized Learning)
Adaptive Learning Platforms	Adjusts learning content to student pace and needs	Offers differentiated instruction for diverse learners (Personalized Learning)
Computer Vision-Based Tools	Enables gesture or gaze-based interaction	Supports non-verbal communication or control (Accessibility)
AI Proctoring Systems	Monitors student behaviour during exams	Raises equity concerns; needs careful adaptation for mental health conditions
Natural Language Processing (NLP)	Analyses written content for tone, clarity, comprehension	Helps design better alternative texts and summaries (Accessibility)

potential of AI in helping students with disabilities is enhanced by the introduction of educational robots, which act as assistants to support, guide and assist students throughout their learning process. Additionally, Virtual Reality (VR) and Augmented Reality (AR) are being explored as educational tools that can create immersive and interactive learning experiences, making educational content more engaging and accessible.[26] Gamification techniques are also incorporated to encourage learning through game-based environments, enhancing creativity and motivation.[26–28] Ahmad et al.[26] further suggest the potential of the Metaverse as an evolving space where learners can engage in virtual learning environments. Building on this, Ahmad et al.[26] argue that the integration of these technologies—AI, Cloud Computing, and Blockchain—can create a feedback-driven, secure, and highly adaptive educational environment, fostering a more inclusive and equitable learning experience for students with disabilities in higher education.

The reviewed papers suggest several AI-based assistive technologies that have significantly enhanced the learning experience for students with disabilities in higher education: (1) *text-to-speech tools* that convert written text into spoken words, offering essential support for students with visual impairments, reading difficulties, or dyslexia.[25] These tools allow students to listen to textbooks, articles, and other educational materials at their own pace and as often as necessary, empowering them to engage with content without feeling self-conscious or less capable than their peers; (2) *speech recognition software* that uses natural language processing to convert spoken words into text. This technology can be particularly beneficial for students with physical disabilities, enabling them to write essays, take notes, and navigate digital environments using only their voice[25]; (3) *AI-powered note-taking tools* that transcribe lectures in real time using speech recognition. These tools help students with hearing impairments or learning disabilities by providing accessible notes and transcripts, which can be reviewed and studied at their convenience; and (4) *adaptive learning platforms* that create personalized learning paths, by analyzing each student's learning pace and difficulties. These platforms adjust the content, complexity, and instructional style, allowing students with cognitive disabilities or attention disorders to progress at a comfortable pace.[25] These AI-based tools represent a valuable step forward in making higher education more accessible to, and more supportive of, students with disabilities.[29]

The review of the selected articles revealed several key findings regarding the impact of AI on higher education, particularly in areas such as personalization, efficiency, accessibility, and early intervention, while also addressing associated challenges. Among the empirical studies included the study by Yunusov et al.[30] offers one of the most detailed quantitative analyses of AI-driven adaptive learning systems, reporting an 85% improvement in student learning outcomes Furthermore, educators reported a 70% increase in student engagement when AI tools were integrated into the curriculum.

Other studies suggested that AI-driven assessments helped reduce grading time by an average of 50%, while maintaining accuracy levels comparable to traditional methods.[30] However, educators raised concerns about AI's ability to effectively assess complex, creative assignments.[31–33] AI was also found to strengthen stronger teacher-student relationships by enhancing daily interactions, allowing teachers to focus more on meaningful engagement with students while administrative tasks were streamlined by AI.[20] Additionally, AI positively impacted the digital literacy and computer skills of teachers, promoting increased access to digital teaching resources.[20] AI also played a key role in helping teachers create a more inclusive and accessible learning environment.[34,35]

A broad range of methodological rigors was observed across the 27 included studies. Most empirical studies (e.g., Refs. 18 and 20) clearly articulated their research questions and presented data collection and analysis procedures transparently. However, several others (e.g., Ref. 30) lacked detail on sampling or validation strategies, limiting replicability. Non-empirical studies showed variability in depth and analytical richness. For example, while Song and Xie[23] provided reflective insights relevant to ITS design, their brevity and lack of methodological structure limit their generalizability. Similarly, the systematic reviews (e.g., Ref. 20) offered synthesized findings but varied in reporting the included studies' characteristics, complicating our ability to assess thematic frequency precisely. These limitations were considered during synthesis, with greater interpretive weight given to well-documented empirical studies. Nonetheless, all studies contributed conceptual or contextual value to understanding ITS in inclusive education.

Discussion

This review systematically explored the role of AI in higher education, focusing specifically on its impact in supporting students with disabilities. The evidence presented across 27 studies highlights the significant potential of AI to enhance inclusivity, accessibility, and learning outcomes for students with disabilities. By integrating AI into higher education, universities can create more personalized, engaging, and effective learning environments, ultimately fostering inclusiveness. These findings not only align with existing theories of accessibility and inclusive education but also expand upon them. This section discusses the key areas in which AI influences accessibility and inclusivity, as well as its broader implications for both education theory and practice.

Our findings are aligned with those of preceding studies, which have emphasized the role of AI in supporting personalized learning (see Ref. 13). However, the present study also reveals critical challenges that have not been widely

discussed in previous literature, such as the lack of AI tools designed specifically for students with cognitive disabilities. While existing research has focused on AI's potential for improving accessibility, the present study highlights the necessity of incorporating universal design principles into AI-based assistive technologies to ensure equitable learning opportunities for all students.

AI-powered technologies have been increasingly contributed to the creation of personalized learning experiences for students with disabilities. A substantial body of research has been published on this topic, including studies by Panjwani-Charani and Zhai,[36] Song and Xie,[23] and Babo et al.[1] These studies have highlighted the importance of AI-driven adaptive learning systems in tailoring educational content to the individual needs of students, thereby enhancing both engagement and accessibility. For instance, Yunusov et al.[30] found that students using AI-driven adaptive learning tools demonstrated an 85% improvement in learning outcomes compared to traditional methods. Moreover, AI-based tutoring systems, such as MetaTutor, have been observed to enhance students' metacognitive skills by providing real-time feedback on their learning strategies.[18]

Personalized learning

A major theme emerging across the included studies is the capacity of AI-ATs to adapt to learners' cognitive, sensory, and behavioral needs through personalization features such as adaptive learning pathways (e.g., Ref. 13), predictive content delivery (e.g., Ref. 37), and voice or gesture-based interfaces (e.g., Refs. 6 and 38), which answer our RQ 1. Personalization in education has been a topic of ongoing discussion for several decades, not only in relation to students with disabilities but also as a core element of a student-centered approach.[17,39,40] AI's ability to tailor educational content and adapt to individual needs makes it a powerful tool in promoting inclusivity and enhancing overall learning outcomes.[36] Consequently, AI fosters a more positive and engaging learning environment where students feel valued and recognized.[20] By assessing student behavior, learning patterns, and preferences, AI enables the creation of customized learning pathways that cater to specific disabilities.

AI uses computational methods, algorithms, data analytics, and automation to extract meaningful insights from the vast amount of data generated in educational settings. These insights, referred to as learning analytics, hold the potential to create personalized learning experiences and personalized learning experiences and environments tailored to students' unique needs and preferences.[26] AI-powered personalized learning systems employ algorithms that make data-driven decisions to optimize the educational experience, offering customized recommendations based on collected learning data.

AI technologies facilitate continuous monitoring of student progress, enabling real-time adjustments to learning environments and course content based on individual preferences and prior experiences.[13,41] One of the key challenges in developing personalized learning systems is the creation of diverse educational content that considers the various ways students perceive and process information. For teachers, it is nearly impossible to account for all the factors influencing students' performance. However, with the support of AI tools in co-teaching, higher education can move closer to offering personalized learning experiences. These AI tools not only tailor educational content to each students' abilities but also adjust the presentation methods, complexity, and volume to better align with individual learning needs.

Tapalova and Zhiyenbayeva[34] highlight the popular language-learning application, Duolingo, as an example of how AI can create personalized learning experience. This app uses machine learning and natural language processing to tailor the learning process. It starts with an adaptive entry test, tracks user errors, and offers various forms of content interaction, all supported by instant feedback. AI-powered chatbots simulate real-life conversations, immersing learners in situational scenarios that enhance the learning experience. This approach can be especially beneficial for students with disabilities, as they can access the platform as often as needed, ensuring flexible and personalized practice.

In addition to the studies by Johnson et al.,[42] several other papers reported adaptive instructional systems as a key feature of ITS. These studies emphasized dynamic content tailoring in response to learner profiles. For instance, Song and Xie[23] discussed reflective design strategies that indirectly supported personalization through teacher involvement.

Benefits of AI-driven assistive technology in supporting students with disabilities

All the selected studies emphasize that AI-driven assistive technologies can significantly improve learning outcomes for both students with and without disabilities (RQ 2). These technologies enhance accessibility and offer diverse learning experiences, presenting a valuable alternative to traditional assistive devices.[18] This approach allows students with disabilities, but not exclusively, to participate in a more flexible and personalized learning environment.[34] In a study conducted at Spanish universities, students with disabilities recognized the potential of educational technologies, praising the wide range of opportunities these tools provide for enhancing their learning experiences.[43]

The selection of AI-powered assistive technologies was informed by the prevalence of literature on the subject, empirical evidence of their effectiveness, and their adoption in higher education settings. The review incorporated only tools for which there was peer-reviewed evidence supporting their impact on students with disabilities. The effectiveness of AI-

powered assistive technologies in improving accessibility for students with disabilities is highlighted by several studies. For example, Neha et al.[25] found that speech-to-text software significantly improved academic performance among students with hearing impairments. Similarly, Vistorte et al.[18] demonstrated how screen readers enhance accessibility for visually impaired learners, improving content comprehension and engagement.

AI tools are changing how students are trained by providing real-time feedback and valuable insights.[13] However, many educators lack the necessary training to effectively integrate these tools, resulting in a knowledge gap.[20] To ensure successful AI integration in supporting students with disabilities in higher education, prioritizing the professional development of teachers is essential.[20] Research shows that AI can play a crucial role in various aspects of training, such as managing knowledge, assessing needs, organizing training sessions, and giving feedback on outcomes. For example, Intelligent Tutoring Systems like MetaTutor offer feedback on how students' emotions influence their learning and provide guidance on managing those emotions for improved results. MetaTutor goes further by assessing not only students' cognitive abilities but also their metacognitive skills, making it a comprehensive tool for enhancing both learning and emotional regulation.[18]

Chatbots are another valuable tool, serving as interactive tutors available 24/7. Students appreciate having chatbots to answer questions, provide learning resources, and offer emotional support while preserving their privacy.[44] These chatbots are designed to cater to different learning styles, including visual, auditory, and kinesthetic learners, by providing personalized resources and engaging activities.[45,46] While chatbots offer substantial support, they cannot fully replace teachers.[44] As illustrated in Table 4, an overview of AI-driven assistive technologies is provided, synthesizing empirical findings on their impact on learning outcomes, accessibility, and engagement.[44,45] These results demonstrate how AI contributes to personalized education for students with disabilities.

AI-powered assistive technologies have been shown to significantly enhance accessibility and personalized learning for students with disabilities.[8] These tools, including speech-to-text software and adaptive learning platforms, provide tailored support, thereby reducing learning barriers and fostering academic success.[46,47]

Reported benefits include increased autonomy, reduced reliance on human assistance, and enhanced access to learning materials (e.g., Ref. 23). Challenges, however, were equally prevalent, particularly in terms of data privacy, user trust, and the need for institutional readiness. Systematic reviews in the sample (e.g., Refs. 14, 16, and 17) also noted that technical barriers, such as limited language or gesture recognition accuracy, disproportionately affect users with complex or multiple disabilities. These insights underscore the importance of embedding ethical and usability considerations into AI-AT development.

Challenges in adopting AI-driven assistive technology to support students with disabilities

The theme "Challenges in AI Adoption" has been consolidated into a single section in order to prevent redundancy. This section highlights key issues such as data privacy concerns, teacher preparedness, and AI bias, all of which impact the successful integration of AI-powered assistive technologies in higher education.

Our review identified several challenges in integrating AI technology into higher education to support students with disabilities. As noted in recent studies, Zhang J and Zhang Z[20] emphasize that AI have yet to significantly reduce educational disparities. Other studies point to major obstacles in the successful implementation of AI in supporting students with disabilities. One key challenge is gaining user acceptance and finding an effective balance between AI-assisted learning and traditional teaching methods.[48] Additionally, ensuring robust data privacy and security measures is critical to protect sensitive student information.[20] Another concern is the potential over-reliance on technology, which may undermine the importance of human interaction and mentorship, particularly in teacher training.[20,49] Furthermore, excessive dependence on AI could disadvantage individuals with disabilities in the job market, as highlighted by Samuel & Kolawole.[50]

Whilst the implementation of AI applications has the potential to enhance accessibility, it must be noted that there are significant challenges associated with this process. These challenges primarily concern the necessity of ensuring equitable access and the minimization of bias. It is therefore vital to understand these barriers if effective adaptive learning environments are to be designed.

AI-generated data may also lead to unequal and discriminatory outcomes. Numerous studies have shown that AI tools, such as ChatGPT, can produce biased outputs that reflect political, religious, racial, gender, or fairness-related biases.[10] According to Alshahrani et al.,[10] AI-generated information must be balanced and accurate for all users to prevent the amplification of existing societal inequalities. Despite the accessibility advantages AI brings to education, there is growing concern that it could inadvertently exacerbate existing biases, further disadvantaging certain groups.[51] To address this risk, AI tools must be developed and implemented within an ethical framework that promotes inclusivity and fairness. Ensuring that AI has a positive and equitable impact on all student groups is essential for its successful integration into higher education.[10,5,52]

AI bias remains a critical concern in education, as machine learning algorithms have the potential to unintentionally reinforce societal inequalities. Research has

Table 4. AI-driven assistive technology benefits in supporting students with disabilities.

AI tool	Function	Example implementation	Most effective for disabilities	Impacts/Benefits	Limitations	Studies
Speech-to-Text Software	Converts spoken language to text	AI-powered note-taking (e.g., Otter.ai, Google Live Transcribe)	Hearing impairments, physical disabilities	Supports students with hearing impairments by providing real-time lecture transcription	Struggles with background noise & accents	Neha et al., 2024
Screen Readers	Reads text aloud for visually impaired users	JAWS, NVDA, VoiceOver	Visual impairments, dyslexia	Enhances accessibility for students with low vision or blindness	Limited interpretation of complex layouts	Vistorte et al., 2024
AI-Driven Assessment Tools	Automated grading, adaptive feedback	AI-based essay scoring & plagiarism detection	All disabilities	Reduces grading bias and provides personalized feedback	Potential bias in grading creativity	Yunusov et al., 2024
Computerized adaptive learning: Elo Rating System	Adjusts difficulty levels dynamically based on student performance, ensuring a personalized learning experience.	AI-driven adaptive learning platforms in higher education that modify content in real-time according to learner progress.	Learning disabilities (e.g., dyslexia, ADHD), cognitive impairments, students with varied learning paces, and neurodivergent learners	Provides personalized learning paths based on individual performance, enhancing engagement and effectiveness.	May not account for emotional or motivational factors in learning; effectiveness depends on the quality of the AI model and dataset diversity	Hofman et al., 2020
Intelligent Tutoring Systems and AI-powered virtual tutors, as well as AI-driven chatbots and virtual assistants	Personalized learning assistance	Chatbot tutors (e.g., Sammy, Duolingo AI)	Cognitive disabilities, ADHD	Serve as 24/7 tutors answering questions and providing resources. Offers immediate help and encourages social interaction without revealing personal identities. Chatbots can provide additional materials like video tutorials, images, or audio instructions.	Can lack emotional understanding	Nacheva and Czaplewski, 2024; Deng and Lin, 2023; Gupta and Chen, 2022; Hadi Mogavi et al., 2024; Rane, 2023; Tlili et al., 2023

(continued)

Table 4. (continued)

AI tool	Function	Example implementation	Most effective for disabilities	Impacts/Benefits	Limitations	Studies
SAMCares t	AI-powered adaptive learning hub that personalizes educational experiences based on cognitive and emotional needs.	Integrates AI-driven analytics to assess learning patterns and provide tailored educational support.	All disabilities	This tool can address and adapt to the varied educational needs of students, reflecting our commitment to enhancing the quality and accessibility of learning experiences in higher education	Requires continuous AI training and refinement to ensure accurate personalized support; potential data privacy concerns	Faruqui et al., 2024
LEAF	Learning environment framework that provides e-learning tools and analytics.	Includes BookRoll, a digital learning material browsing system, and LogPalette, a group of learning analytics (LA) dashboard modules that analyze and visualize learning behavior.	All disabilities	LEAF is a learning environment framework that includes BookRoll, an e-learning material browsing system that allows learners to view digital learning materials anytime and anywhere, and a group of LA dashboard modules (LogPalette) that analyze and visualize the logs learned using BookRoll.	Effectiveness depends on student engagement with the platform; requires training for optimal use	Toyokawa et al., 2023
BESPECIAL	Machine learning-based classification model to assist students with dyslexia.	Provides personalized tools and strategies to enhance learning accessibility for students with dyslexia in higher education.	Students with Specific Learning Disorders	A machine learning-based classification model to support university students with dyslexia with personalized tools and strategies	May not fully accommodate variations in dyslexia severity; AI-based classifications require regular accuracy validation	Zingoni et al., 2024
"Sammy"	AI chatbot designed as an intelligent and inclusive tutor.	Experimental chatbot platform that assists students by providing academic support and guidance	All disabilities	It is a chatbot, an experimental platform to investigate the design opportunities of using chatbots as an intelligent and inclusive tutor	Limited to pre-programmed responses; may struggle with complex queries or nuanced learning needs	Gupta and Chen, 2022

demonstrated that AI-powered educational tools may disproportionately disadvantage students from underrepresented backgrounds if the training data lacks diversity.[10] Moreover, natural language processing (NLP) models employed in AI tutoring systems have been observed to perpetuate negative stereotypes about disabilities, which raise concerns about their fairness and inclusivity.

AI bias remains a significant ethical challenge in education. For example, speech-to-text AI tools often misinterpret the speech patterns of people with disabilities, resulting in inaccurate transcriptions.[6] Similarly, AI proctoring tools have been found to disproportionately flag students with disabilities for "suspicious behavior," particularly those with involuntary movements or assistive technologies.[16] These biases risk exacerbating, rather than reducing educational inequalities.

The integration of AI in education raises significant privacy concerns. AI-powered proctoring systems, for example, use facial recognition and keystroke monitoring to prevent cheating, but these methods have been criticized for violating student privacy and disproportionately misidentifying certain demographic groups.[51] Furthermore, AI-driven learning analytics collect vast amounts of student data, often without explicit consent, leading to concerns over data security and potential misuse. In order to minimize risks to student data, AI developers should adopt transparent data collection policies and prioritize privacy-preserving AI techniques, such as differential privacy and federate learning.

While AI can make educational processes more efficient, there is growing concern that excessive reliance on technology could diminish personal interactions between teachers and students.[53] This shift may also hinder the development of essential skills such as critical thinking, creativity, and problem-solving.[10] Additionally, the risk of students using AI tools to cheat presents a significant challenge, potentially allowing them to receive academic recognition without genuinely engaging in learning. This raises important questions about academic integrity and how educational institutions should address these evolving challenges. To maintain high educational standards, it is crucial that AI be used responsibly enhancing learning rather than replacing meaningful engagement.

Another concern revolves around the mental health of both students and teachers. "AI anxiety" refers to the fear and uncertainty surrounding the rapid development of AI, particularly regarding job displacement and its unpredictable effects.[42] Educators are concerned that AI might replace their roles, prompting questions about the future of employment in education and other sectors.[10] Additionally, the high cost and complexity of scaling AI, coupled with the lack of clear guidelines and specialized expertise, pose significant barriers to its effective implementation in education.[10] Addressing these challenges is crucial for ensuring that AI has a sustainable and positive impact on education.

Best practices

To answer to our RQ3, several studies highlighted the value of participatory design and user-centered development (e.g., Refs. 20 and 37). Best practices include multimodal interfaces, customizable settings, explainable AI features, and interoperability with existing learning management systems. Conceptual contributions emphasized the alignment with Universal Design for Learning (UDL) frameworks and iterative prototyping with feedback from diverse disability groups. While the evidence on implementation quality varies, the studies collectively suggest that inclusive design principles must be embedded from the early stages of AI tool development.

While the number of studies on AI applications in education is growing rapidly, there remains a relatively small body of research specifically focused on AI's role in promoting inclusive education. This gap may be attributed to factors such as "AI anxiety" and teachers' lack of preparedness to integrate AI in their daily teaching practices. Despite these challenges, our review uncovered several studies that provide valuable insights into the use of AI-driven assistive technologies to support students with disabilities in higher education. For example, Zingoni et al.[41] explore how BESPECIAL, a supporting software platform, helps dyslexic students navigate the challenges they encounter in university settings. Preliminary results indicate the platform's effectiveness as proof of concept for personalized learning approaches.[41] Another example is the chatbot Sammy, which was tested among 215 undergraduate students to assess its potential as an inclusive tutor.[45] The findings suggest that chatbots can create supportive environments for disadvantaged students by answering questions, connecting them with resources, and accommodating various learning styles through personalized interactions.[45] These examples identify key features that enhance AI usability, such as accessibility, interactivity, and immediate feedback, underscoring the importance of design considerations that prioritize inclusivity.

The integration of AI tools within higher education to support students with disabilities must be approached with a structured and best-practice approach to ensure the equitable, effective and sustainable use of these technologies. The following key principles can be generalized across diverse educational contexts.

Teacher training and AI literacy. The fundamental requirement for effective AI adoption is to equip educators with the necessary skills and knowledge to use AI tools effectively. A significant proportion of educators are not familiar with AI-powered assistive technologies, resulting in underutilization or improper implementation. Training programs should be developed to assist educators in integrating AI into their teaching strategies, thereby making learning more inclusive and adaptive for students with disabilities.

Ethical AI design. AI models must be designed with fairness, transparency, and inclusivity at their core. The presence of biases in AI algorithms can disproportionately affect students with disabilities, limiting accessibility or reinforcing inequalities. It is therefore essential that developers ensure that AI-based assistive tools undergo rigorous bias testing and adhere to ethical AI guidelines to provide equitable opportunities for all students. Clear and explainable AI decision-making processes should be implemented to build trust among users.

User-centered development. It is crucial that AI tools are not designed in isolation; rather, they should be co-developed with direct input from students with disabilities. Engaging users in the design process is essential to ensure that AI-powered solutions align with real-world accessibility needs, preferences, and learning styles. Inclusive design frameworks, such as participatory design and usability testing with diverse student groups, should guide AI development in educational settings.

By prioritizing these fundamental principles, educational institutions have the potential to transcend the mere adoption of AI-powered assistive technologies and instead foster a more inclusive, student-centered learning environment. In this paradigm, AI functions not as a hindrance but as an empowering tool, enabling a more equitable and conducive learning environment for all students.[54]

Recent studies have indicated the efficacy of AI-powered assistive technologies in enhancing accessibility for students with disabilities.[54] For instance, Neha et al.[25] discovered that speech-to-text software substantially improved academic performance among students with hearing impairments. In a similar vein, Vistorte et al.[18] demonstrated how screen readers can augment accessibility for visually impaired learners, thereby enhancing content comprehension and engagement.

Ethical AI solutions

To ensure that the benefits of AI-powered tools are maximized and potential risks mitigated, several ethical AI solutions are necessary. A major concern in education is the lack of transparency in AI decision-making processes. Many AI-driven tools, such as automated grading systems and adaptive learning platforms, function as "black boxes," which makes it difficult for students and educators to understand how decisions are made. Explainable AI (XAI) addresses this issue by enhancing transparency and trust. By rendering the decision-making processes of AI more interpretable, XAI enables users to comprehend the rationale behind specific recommendations or actions. This is of particular significance for students with disabilities, as it ensures that assistive technologies provide clear, justifiable adaptations tailored to their individual needs. Furthermore, XAI can contribute to the alleviation of concerns regarding fairness in grading and learning assessments by offering insights into the generation of automated feedback. Future advancements in XAI should prioritize user-friendly explanations that accommodate diverse cognitive and learning abilities, ensuring accessibility for all students.

Students with disabilities are particularly at risks of AI bias, due to the lack of diverse user input in the training of most models. A notable example of this bias is the tendency of AI-generated captions to misinterpret dysarthric speech, creating accessibility barriers in online learning environments. Furthermore, AI-based essay grading systems may penalize students with cognitive disabilities unfairly if they structure their arguments differently to their neurotypical peers.[9] These findings emphasize the urgent need for inclusive AI training datasets and bias audits in educational AI tools.

Limitations

This review has several limitations in exploring available AI-powered assistive technologies and their applications in supporting students with disabilities in higher education. First, it is clear that very few peer-reviewed studies directly address the intersection of AI, accessibility, and student learning for individuals with disabilities in higher education. Second, by excluding studies focused on primary or secondary education, we may have overlooked valuable research that could offer transferable insights. However, the primary aim of this review was to focus specifically on the unique challenges and opportunities AI presents in supporting students with disabilities in higher education, particularly in fostering more inclusive learning environments. Additionally, this review highlights a lack of understanding of the impact of AI on academic research within higher education institutions. While some studies provide robust methodologies for assessing AI's influence on student academic outcomes, there is a clear lack of research specifically targeting students with disabilities. To address this, future studies should be funded and conducted to assess the impact of AI on academic performance within the educational context, with a particular focus on higher education settings. This would help to deepen our understanding of how AI can enhance both accessibility and academic success for students with disabilities.

Conclusions

This integrative review explored the potential of integrating AI into higher education to support students with disabilities. The findings show that AI has the potential to significantly enhance student assessment and foster inclusive education. Inclusive technologies can improve learning outcomes for all students. AI-driven technologies offer a wide range of opportunities to innovate and improve higher education practices, particularly in terms of personalization

and individualization. AI-based services contribute to the personalization and individualization of the learning process by utilizing educational analytics and data engineering methods. However, it is important to recognize and address challenges and limitations that may arise when implementing these tools.

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