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Original Research

Intelligent Tutoring Systems and Inclusive Higher Education: Implications for Students With Disabilities

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ABSTRACT

The pursuit of inclusive higher education has intensified the need for instructional approaches that effectively address learner diversity, particularly for students with disabilities. Intelligent Tutoring Systems (ITS), as applications of artificial intelligence in education, offer adaptive, personalized, and interactive learning support that can enhance accessibility and equity. This study adopts a conceptual research design supported by illustrative empirical evidence drawn from a doctoral study on awareness, readiness, accessibility, and interactivity of ITS adoption among pre-service teachers in Nigerian Colleges of Education. Grounded in cognitive theory, adaptive learning theory, and mastery learning theory, the paper synthesizes relevant literature to examine how ITS can support inclusive higher education. Empirical insights reveal low levels of awareness and readiness, alongside significant accessibility challenges within the Nigerian context. The paper further explores the implications of ITS across different disability categories and critically examines its limitations, particularly in addressing socio-emotional learning needs. It concludes that while ITS holds significant potential, its effectiveness depends on institutional readiness, accessible design, and integration with human support systems.

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1. INTRODUCTION

Higher education systems across the globe are experiencing increasing pressure to respond to learner diversity, expand access, and ensure equity for all students, including those with disabilities. Inclusive higher education has therefore become a central goal of educational policy and practice, emphasizing the removal of physical, pedagogical, technological, and attitudinal barriers that hinder full participation in learning (UNESCO, 2017; Ainscow, 2020). Students with disabilities in higher education include individuals with physical, sensory, cognitive, learning, emotional, and developmental disabilities who often face persistent challenges related to accessibility, instructional delivery, assessment, and social participation (Moriña, 2017).

Despite global commitments to inclusive education, many higher education institutions, particularly in developing contexts, continue to struggle with large class sizes, limited instructional time, inadequate support services, and insufficient assistive technologies (WHO & World Bank, 2019). Conventional lecture-based teaching methods often fail to accommodate individual differences in learning pace, prior knowledge,

and cognitive processing, thereby disadvantaging students with disabilities (Florian & Black-Hawkins, 2018). These challenges necessitate the adoption of innovative, technology-driven approaches that can personalize learning and support diverse learners within mainstream higher education environments.

The rapid advancement of Information and Communication Technology (ICT) and Artificial Intelligence (AI) has opened new possibilities for addressing inclusivity challenges in education. Artificial Intelligence in Education (AIEd) has gained prominence for its capacity to provide adaptive, data-driven, and learner-centered instructional support (Luckin et al., 2016; Holmes et al., 2019). Among AIEd applications, Intelligent Tutoring Systems (ITS) stand out as powerful tools capable of simulating one-on-one human tutoring through personalized instruction, continuous assessment, and immediate feedback (VanLehn, 2011). ITS dynamically adapts content, pacing, and instructional strategies based on individual learner performance, making them particularly suitable for students with disabilities who require differentiated support (Alam, 2023).

Empirical studies have demonstrated that ITS can enhance learner engagement, improve academic performance, and foster self-regulated learning across various educational levels (Ma et al., 2014; Koedinger et al., 2015). In inclusive higher education contexts, ITS have been shown to support students with learning disabilities through adaptive scaffolding, students with visual or auditory impairments through multimodal content delivery, and students with attention-related difficulties through structured and interactive learning environments (Williams, 2017; Smith et al., 2018). These features align strongly with the principles of Universal Design for Learning (UDL), which advocates for flexible approaches to content representation, learner engagement, and assessment (CAST, 2018).

The potential of ITS for inclusive education is widely acknowledged; effective adoption depends largely on human and institutional factors such as awareness, readiness, accessibility, and interactivity. Awareness refers to stakeholders' understanding of ITS capabilities and relevance, while readiness encompasses the skills, attitudes, and institutional support necessary for effective integration (Teo, 2013; Ertmer, 2015). Accessibility extends beyond physical access to include system design features that accommodate diverse learners, and interactivity reflects the quality of learner-system engagement that promotes deep and meaningful learning (Clark & Mayer, 2016).

Building on a doctoral study that examined awareness, readiness, accessibility, and interactivity levels of Intelligent Tutoring Systems adoption among pre-service teachers in Nigerian Colleges of Education, this paper extends the discussion to inclusive higher education and students with disabilities. Pre-service teachers play a pivotal role in shaping future inclusive classroom practices; therefore, their exposure to and understanding of ITS has significant implications for how technology will be used to support learners with disabilities in higher education and beyond (Florian, 2019). By situating ITS within inclusive higher education discourse, this paper contributes to the growing body of literature on AI-enabled learning and equity, highlighting how intelligent systems can support institutional efforts to provide inclusive, accessible, and high-quality education for all learners.

However, existing literature largely focuses on the technical capabilities of ITS, with limited attention to contextual factors such as institutional readiness, awareness, accessibility, and interactivity, particularly in developing countries. Furthermore, studies often treat students with disabilities as a homogeneous group, without accounting for differences across disability categories.

This paper addresses these gaps by proposing a multidimensional conceptual analysis of ITS adoption, integrating awareness, readiness, accessibility, and interactivity as key mediating factors in inclusive higher education. This article aims to answer the following questions.

1) How can Intelligent Tutoring Systems support inclusive higher education for students with disabilities?
2) What roles do awareness, readiness, accessibility, and interactivity play in ITS adoption?
3) What are the implications of ITS for policy, practice, and research in resource-constrained contexts?

2. METHODOLOGY

The study adopts a conceptual research design aimed at synthesizing and critically analyzing existing theoretical and empirical literature on Intelligent Tutoring Systems (ITS) and inclusive higher education. This approach does not involve primary data collection; rather, it enables a comprehensive examination of established knowledge to identify patterns, gaps, and emerging insights. It is particularly suitable for exploring the role of ITS in inclusive learning environments, where both theoretical grounding and existing empirical evidence are essential for meaningful interpretation.

The study is anchored on three key theoretical frameworks: Cognitive Theory, Adaptive Learning Theory, and Mastery Learning Theory. Cognitive Theory explains how learners process and retain information, thereby informing the design of ITS to support meaningful learning experiences. Adaptive Learning Theory emphasizes the personalization of instruction based on learners' needs and progress, which aligns with the core functionality of ITS. Mastery Learning Theory highlights the importance of ensuring learners achieve a high

level of understanding before advancing, a process that ITS can facilitate through continuous assessment and feedback. These frameworks collectively guide the interpretation of how ITS can enhance inclusivity by accommodating diverse learning needs.

Relevant literature was systematically sourced from peer-reviewed journals and academic databases, guided by criteria such as studies on ITS and artificial intelligence in education, inclusive higher education, and accessibility for learners with disabilities. A thematic synthesis approach was employed to analyze the literature, focusing on awareness, readiness, accessibility, and interactivity. To strengthen the conceptual analysis, the study integrates empirical insights from a doctoral study conducted among pre-service teachers in Nigerian Colleges of Education, thereby providing contextual relevance and enriching the discussion on ITS adoption in inclusive educational settings.

3. EMPIRICAL INSIGHTS FROM DOCTORAL STUDY

Findings from the doctoral study indicate that a significant proportion of respondents demonstrated limited familiarity with Intelligent Tutoring Systems (ITS), with approximately 62% exhibiting low levels of awareness of ITS applications in education. This low level of awareness appears to influence their preparedness for adoption, as only 38% of the respondents expressed readiness to integrate ITS into their teaching practices. The results suggest a substantial gap between the potential of ITS and the current level of engagement among pre-service teachers, highlighting the need for increased exposure and capacity-building initiatives within teacher education programmes.

The study further revealed several critical barriers hindering the effective adoption of ITS, including limited technological infrastructure, inadequate training opportunities, and insufficient access to assistive technologies. These challenges were found to disproportionately affect inclusive education efforts, particularly for students with visual and learning disabilities, who face additional accessibility constraints. Overall, the findings underscore that both institutional limitations and human capacity gaps remain significant obstacles to the successful implementation of ITS, thereby necessitating strategic interventions to improve readiness, accessibility, and support systems within educational institutions.

4. CONCEPTUAL FRAMEWORK

The conceptual framework of this paper is anchored on the interaction between Intelligent Tutoring Systems (ITS) and inclusive higher education, with particular emphasis on students with disabilities. The framework conceptualizes ITS as an AI-driven instructional intervention whose effectiveness in inclusive higher education is mediated by four critical adoption dimensions: awareness, readiness, accessibility, and interactivity. These dimensions, originally examined among pre-service teachers, are extended in this paper to explain how ITS can support equitable learning experiences for students with disabilities in higher education contexts.

At the core of the framework is the assumption that inclusive learning outcomes are not determined by technology alone, but by the alignment between system design, institutional capacity, educator competence, and learner characteristics (Ertmer & Ottenbreit-Leftwich, 2013; Holmes et al., 2019). ITS serves as the independent construct, while inclusive learning outcomes such as engagement, academic achievement, self-regulation, and participation of students with disabilities constitute the dependent outcomes. Awareness, readiness, accessibility, and interactivity function as mediating variables that influence the extent to which ITS can deliver inclusive educational benefits.

5 DISCUSSIONS

5.1 Awareness of Intelligent Tutoring Systems

Awareness refers to stakeholders' knowledge and understanding of the existence, functionality, and pedagogical potential of Intelligent Tutoring Systems. In inclusive higher education, awareness extends beyond basic familiarity to include understanding how ITS can support learners with diverse needs, including students with physical, sensory, cognitive, and learning disabilities (Moriña, 2017; Florian, 2019). Studies have shown that limited awareness of assistive and intelligent technologies among educators and students significantly constrains adoption and effective use (Teo, 2013; Erdemir & Kandil-İngeç, 2016).

Awareness is viewed as a foundational condition that shapes attitudes and beliefs about ITS. When lecturers, pre-service teachers, and students are aware of ITS capabilities such as adaptive feedback, multimodal content, and personalized pacing, they are more likely to perceive the systems as useful and relevant for inclusive teaching and learning (Davis, 1989; Venkatesh et al., 2003). Conversely, low awareness contributes to underutilization and reinforces reliance on traditional instructional approaches that often marginalize students with disabilities.

5.2 Readiness for Its Adoption in Inclusive Higher Education

Readiness encompasses the psychological, technical, and institutional preparedness to adopt and integrate ITS into teaching and learning processes. This includes educators' digital competence, positive attitudes toward technology, institutional support structures, and policy alignment (Ertmer, 2015; Cuhadar, 2018). For inclusive higher education, readiness also involves the capacity to align ITS use with inclusive pedagogical practices and disability support services.

Readiness is strongly linked to the Technology Acceptance Model, which emphasizes perceived usefulness and perceived ease of use as predictors of technology adoption (Davis, 1989). In the context of students with disabilities, readiness determines whether ITS will be used proactively to scaffold learning, provide remediation, and support mastery learning (Bloom, 1968; Guskey, 2007). Institutions lacking readiness, such as insufficient training, weak technical support, or the absence of inclusive policies, are less likely to realize the full inclusive potential of ITS.

5.3 Accessibility of Intelligent Tutoring Systems

Accessibility is a central pillar of the conceptual framework and a defining principle of inclusive higher education. It refers to the extent to which ITS can be accessed and used effectively by learners with diverse abilities and needs. Accessibility goes beyond physical access to include system compatibility with assistive technologies, flexible interface design, multimodal content delivery, and compliance with universal design standards (Smith et al., 2018; CAST, 2018).

ITS offers unique opportunities to enhance accessibility through adaptive interfaces, text-to-speech and speech-to-text functions, adjustable presentation formats, and personalized learning pathways (Williams, 2017; Jones & Brown, 2019). Within the framework, accessibility mediates the relationship between ITS and inclusive learning outcomes by determining whether students with disabilities can meaningfully engage with instructional content. Without accessible design, ITS risks reproducing existing inequities rather than mitigating them (WHO & World Bank, 2019).

5.4 Interactivity and Learner Engagement

Interactivity refers to the dynamic and reciprocal interaction between the learner and the ITS, including real-time feedback, adaptive dialogue, simulations, and collaborative features. High levels of interactivity are associated with increased learner engagement, motivation, and deeper cognitive processing (Clark & Mayer, 2016; Aleven & Koedinger, 2022). For students with disabilities, interactive learning environments can reduce anxiety, promote autonomy, and support sustained attention.

Interactivity functions as a mechanism through which ITS translates accessibility and readiness into actual learning gains. Adaptive feedback and continuous assessment enable mastery learning by allowing learners to progress at their own pace while receiving targeted support (Bloom, 1968; VanLehn, 2016). Interactive ITS environments also facilitate social inclusion by supporting peer collaboration and communication, which are critical for the holistic development of students with disabilities in higher education (Xu & Zhao, 2019).

5.5 Integrative View of the Conceptual Framework

The conceptual framework posits that awareness and readiness are prerequisite conditions that enable the effective deployment of accessible and interactive ITS. Accessibility ensures equitable entry and participation, while interactivity drives engagement and learning effectiveness. Together, these constructs influence inclusive learning outcomes for students with disabilities, including improved academic performance, self-regulation, confidence, and retention in higher education.

Grounded in cognitive theory, adaptive learning theory, and mastery learning theory, this framework provides a holistic lens for understanding how Intelligent Tutoring Systems can function as catalysts for inclusive higher education. By explicitly linking ITS adoption dimensions to the needs of students with disabilities, the framework offers a guiding structure for research, system design, teacher preparation, and policy development aimed at promoting equity and inclusion through AI-driven educational technologies.

6 INTELLIGENT TUTORING SYSTEMS IN INCLUSIVE HIGHER EDUCATION

Intelligent Tutoring Systems (ITS) represent one of the most influential applications of artificial intelligence in education due to their ability to deliver personalized, adaptive, and scalable instruction that responds to individual learner differences. ITS are computer-based instructional systems designed to emulate aspects of one-to-one human tutoring by continuously diagnosing learner understanding, providing immediate feedback, and adjusting instructional content and sequencing in real time (VanLehn, 2011). Unlike conventional lecture-based approaches that often adopt a uniform pace and mode of instruction, ITS tailors learning

experiences to individual needs, making them particularly suitable for inclusive higher education environments where learner diversity is pronounced.

In inclusive higher education, students with disabilities, including those with physical, sensory, cognitive, and learning disabilities, frequently encounter barriers such as inaccessible instructional materials, limited individualized support, and rigid assessment structures (Moriña, 2017; Florian & Black-Hawkins, 2018). It addresses these challenges by enabling adaptive learning pathways that accommodate differences in learning pace, prior knowledge, and cognitive processing abilities. Through adaptive algorithms, ITS can modify task difficulty, provide additional scaffolding, or revisit prerequisite concepts until mastery is achieved, thereby aligning with mastery learning principles (Bloom, 1968; Guskey, 2007).

A major contribution of ITS to inclusive higher education lies in its capacity to support accessibility and Universal Design for Learning (UDL). ITS can present content in multiple formats such as text, audio, visuals, and interactive simulations, allowing students to engage with learning materials in ways that best suit their abilities and preferences (CAST, 2018; Williams, 2017). For example, students with visual impairments can benefit from text-to-speech functions, while students with hearing impairments can rely on text-based explanations and visual cues. Similarly, students with learning disabilities or attention-related difficulties benefit from structured, step-by-step guidance and immediate feedback that reduces cognitive overload (Clark & Mayer, 2016).

Empirical research indicates that ITS enhance learner engagement, motivation, and academic performance across higher education contexts (Ma et al., 2014; Koedinger et al., 2015). In inclusive settings, these benefits extend to students with disabilities by promoting self-regulated learning, confidence, and sustained participation. Adaptive feedback mechanisms allow learners to monitor their progress, identify errors, and receive targeted remediation without the stigma sometimes associated with seeking help in traditional classroom environments (VanLehn, 2016). This autonomy-supportive feature is particularly important for students with disabilities, as it fosters independence and persistence in learning.

Furthermore, ITS contribute to equity in higher education by scaling individualized support in contexts where human tutoring resources are limited. In many institutions, especially in developing countries, large class sizes and limited specialist staff make it difficult to provide personalized instruction for students with disabilities (WHO & World Bank, 2019). ITS help bridge this gap by offering continuous, individualized instructional support that complements lecturers' efforts and institutional disability services. However, the effectiveness of ITS in inclusive higher education depends on thoughtful system design, adequate institutional readiness, and ethical considerations such as data privacy, transparency, and avoidance of algorithmic bias (Holmes et al., 2019; Zawacki-Richter et al., 2019).

Intelligent Tutoring Systems serve as a critical technological enabler for inclusive higher education by aligning adaptive instruction, accessibility, and interactivity with the diverse needs of students with disabilities. When embedded within inclusive policies and supported by trained educators, ITS can significantly enhance participation, learning outcomes, and retention of students with disabilities in higher education.

6.1 ITS and Different Disability Categories

Intelligent Tutoring Systems (ITS) provide significant support for learners with physical disabilities by enabling flexible participation through remote access and self-paced learning. This flexibility reduces the need for constant physical presence in traditional classroom settings and allows learners to engage with instructional materials at their own convenience and comfort level. For students with visual impairments, ITS can incorporate features such as text-to-speech functionality, audio-based navigation, and compatibility with screen readers, thereby enhancing access to digital content. These tools help transform visual information into accessible formats, ensuring that visually impaired learners can interact meaningfully with learning materials.

For learners with hearing impairments, ITS can support inclusive learning through captioned instructional content, visual simulations, and text-based feedback mechanisms that reduce reliance on auditory input. In the case of students with cognitive and learning disabilities, ITS offers structured scaffolding, repeated exposure to content, and simplified instructions, all of which facilitate better understanding and retention. Additionally, learners with attention disorders benefit from the interactive nature of ITS, which includes engaging tasks, immediate feedback, and short learning cycles designed to sustain focus and improve concentration. Overall, these features demonstrate how ITS can be tailored to accommodate diverse learning needs, thereby promoting inclusivity and enhancing educational outcomes.

7 LIMITATIONS OF ITS

Intelligent Tutoring Systems (ITS) offer numerous advantages for enhancing teaching and learning, but they are not without significant limitations. One of the primary concerns is their lack of socio-emotional intelligence, which restricts their ability to understand and respond to learners' emotional states. Unlike human

teachers, ITS cannot effectively interpret non-verbal cues such as frustration, anxiety, or motivation levels, nor can they provide the kind of empathy and emotional support that many learners, particularly those with disabilities, require. This limitation reduces their effectiveness in addressing the holistic needs of students, especially in inclusive learning environments where emotional encouragement and interpersonal connection play a crucial role in learning.

In addition, the use of ITS may increase the risk of learner isolation, as students may engage more with digital systems than with peers and instructors, thereby limiting opportunities for social interaction and collaborative learning. There is also the concern of over-dependence on technology, where both learners and educators may rely excessively on ITS at the expense of developing critical thinking, creativity, and interpersonal skills. Furthermore, infrastructural challenges and unequal access to technology can exacerbate existing educational inequalities. Ultimately, while ITS can significantly support learning processes, it cannot replace human interaction, which remains essential for fostering inclusion, providing emotional support, and ensuring a well-rounded educational experience for students with diverse needs.

8 AWARENESS, READINESS, ACCESSIBILITY, AND INTERACTIVITY: IMPLICATIONS FOR STUDENTS WITH DISABILITIES

=The effective use of Intelligent Tutoring Systems (ITS) in inclusive higher education is shaped not only by the technical capabilities of the systems but also by critical human and institutional factors. Awareness, readiness, accessibility, and interactivity constitute interrelated dimensions that determine whether ITS can meaningfully support students with disabilities. This section expands on these dimensions and discusses their implications for inclusive teaching and learning in higher education.

9. AWARENESS, READINESS, ACCESSIBILITY AND INTERACTIVITY

9.1 Awareness: Understanding for Inclusive Learning

Awareness refers to the extent to which educators, students, and institutional leaders understand the purpose, functionality, and inclusive potential of Intelligent Tutoring Systems. In the context of students with disabilities, awareness must go beyond general familiarity with educational technology to include explicit knowledge of how ITS can address diverse learning challenges and support inclusive pedagogical goals (Florian, 2019; Moriña, 2017). Low awareness among lecturers and students has been identified as a major barrier to the adoption of assistive and intelligent technologies in higher education (Teo, 2013; Erdemir & Kandil-İngeç, 2016). When educators are unaware of the adaptive and accessibility features embedded in ITS, they are less likely to integrate these systems intentionally to support students with disabilities. Similarly, students with disabilities who lack awareness of available intelligent learning supports may underutilize tools that could significantly enhance their academic performance and independence.

Increased awareness has important implications for inclusion. Awareness programs, professional development workshops, and orientation sessions that highlight the role of ITS in inclusive education can foster positive attitudes, reduce resistance to technology adoption, and encourage equitable use of intelligent systems (Ertmer & Ottenbreit-Leftwich, 2013). For students with disabilities, awareness empowers them to advocate for appropriate learning supports and to engage more confidently with technology-enhanced learning environments.

9.2 Readiness: Institutional and Human Capacity For Inclusive Its Adoption

Readiness encompasses the preparedness of higher education institutions, educators, and learners to adopt and effectively use Intelligent Tutoring Systems. This includes technological infrastructure, digital competence, institutional support, policy alignment, and positive attitudes toward inclusive technology use (Ertmer, 2015; Cuhadar, 2018). For students with disabilities, readiness also involves the availability of disability support services and the integration of ITS into inclusive teaching practices. Educator readiness is particularly critical, as lecturers play a central role in selecting, implementing, and facilitating ITS-based learning activities. Studies suggest that educators who possess strong digital skills and inclusive pedagogical knowledge are more likely to use adaptive technologies to support diverse learners (Florian & Black-Hawkins, 2018). In contrast, limited training and a lack of confidence in using AI-driven systems can result in superficial or ineffective ITS integration, thereby limiting benefits for students with disabilities.

At the institutional level, readiness includes policy frameworks that promote inclusive education, funding for accessible technologies, and technical support structures. Institutions that lack readiness may deploy ITS without adequate consideration for accessibility or inclusion, leading to uneven learning experiences (Holmes et al., 2019). Conversely, institutions with high readiness can leverage ITS to complement human support services, extend individualized instruction, and enhance mastery learning opportunities for students with disabilities (Bloom, 1968; Guskey, 2007).

9.3 Accessibility: Removing Barriers for Students with Disabilities

Accessibility is a core principle of inclusive higher education and a critical determinant of ITS effectiveness for students with disabilities. Accessibility refers to the extent to which ITS can be accessed, navigated, and used effectively by learners with diverse abilities, including those with visual, auditory, motor, and cognitive impairments (WHO & World Bank, 2019). ITS can significantly enhance accessibility when designed in line with Universal Design for Learning (UDL) principles. Features such as multimodal content presentation, adjustable interfaces, compatibility with assistive technologies, and flexible assessment options enable students with disabilities to engage with learning materials in ways that suit their individual requirements (CAST, 2018; Williams, 2017). For example, adaptive text-to-speech tools support students with visual impairments, while structured step-by-step guidance benefits students with learning disabilities.

Accessibility is not automatically guaranteed by the presence of advanced technology. Poorly designed ITS may inadvertently exclude learners by relying on inaccessible interfaces or rigid interaction patterns (Smith et al., 2018). The implication for inclusive higher education is that accessibility must be treated as a foundational design requirement rather than an optional add-on. Institutions must therefore prioritize accessibility standards, continuous evaluation, and user feedback to ensure that ITS truly reduce rather than reinforces educational inequities.

9.4 Interactivity: Engagement and Meaningful Learning for Students with Disabilities

Interactivity refers to the quality and depth of learner engagement with Intelligent Tutoring Systems through adaptive feedback, dialogue, simulations, and collaborative features. High levels of interactivity are associated with increased motivation, sustained attention, and deeper learning outcomes (Clark & Mayer, 2016; Aleven & Koedinger, 2022). For students with disabilities, interactivity has significant inclusive implications. Interactive ITS environments provide immediate, non-judgmental feedback that allows learners to make mistakes and learn at their own pace, reducing anxiety and dependence on instructor intervention (VanLehn, 2016). Adaptive dialogue systems can guide learners through complex problem-solving processes, while interactive simulations help concretize abstract concepts, particularly for students with cognitive or learning difficulties.

Interactive ITS can support social inclusion by facilitating peer interaction and collaborative learning in digital spaces. Such opportunities are crucial for students with disabilities, who may otherwise experience isolation in higher education settings (Xu & Zhao, 2019). By promoting active participation and learner autonomy, interactivity serves as the mechanism through which awareness, readiness, and accessibility translate into meaningful, inclusive learning outcomes.

9.5 Integrated Implications for Inclusive Higher Education

Awareness and readiness function as enabling conditions for the successful deployment of accessible and interactive ITS. Accessibility ensures equitable participation, while interactivity drives engagement, mastery, and self-regulated learning. For students with disabilities, the alignment of these dimensions determines whether ITS serve as tools for empowerment or simply replicate existing barriers.

The implication for higher education institutions is clear: inclusive adoption of Intelligent Tutoring Systems requires a holistic approach that combines stakeholder awareness, institutional readiness, accessible system design, and meaningful interactivity. When these conditions are met, ITS can significantly enhance learning experiences, academic success, and retention of students with disabilities, contributing to more equitable and inclusive higher education systems.

10. LESSONS FROM INCLUSIVE HIGHER EDUCATION PRACTICES

Inclusive higher education practices across different global contexts provide important lessons for the effective integration of Intelligent Tutoring Systems (ITS) to support students with disabilities. These practices demonstrate that inclusion is not achieved through technology alone, but through deliberate institutional commitment, inclusive pedagogy, supportive policies, and learner-centered system design. Drawing from international experiences, this section highlights key lessons relevant to the adoption of ITS in inclusive higher education.

10.1 Institutional Commitment to Inclusion

One of the most consistent lessons from inclusive higher education practices is the importance of strong institutional commitment. Universities that have made significant progress in supporting students with disabilities typically embed inclusion within their mission statements, policies, and strategic plans (UNESCO, 2017; Moriña, 2017). Such institutions recognize disability as a dimension of diversity and prioritize equitable access to learning opportunities.

In these contexts, ITS are adopted not as isolated technological tools but as part of a broader inclusive education strategy. Institutional commitment ensures that ITS implementation is aligned with accessibility standards, supported by funding, and integrated into mainstream teaching and learning processes rather than relegated to specialized units (Ainscow, 2020). This lesson underscores that for ITS to effectively support students with disabilities, higher education institutions must first establish a culture of inclusion.

10.2 Integration of Technology with Inclusive Pedagogy

Inclusive higher education practices reveal that technology is most effective when integrated with inclusive pedagogy. Studies indicate that institutions that combine adaptive technologies with learner-centered teaching approaches achieve better outcomes for students with disabilities (Florian & Black-Hawkins, 2018). ITS, when aligned with inclusive pedagogical principles, supports differentiated instruction, formative assessment, and mastery learning, key components of effective inclusive teaching. For example, inclusive universities encourage lecturers to use ITS-generated learning analytics to identify students who require additional support and to adjust instructional strategies accordingly (Koedinger et al., 2015; Aleven & Koedinger, 2022). This practice shifts the focus from remediation to proactive support, benefiting students with disabilities by addressing learning difficulties early and reducing the risk of academic failure.

10.3 Accessibility and Universal Design for Learning

A central lesson from inclusive higher education is the critical role of accessibility and Universal Design for Learning (UDL). Institutions that prioritize UDL principles design learning environments that are flexible and responsive to learner variability from the outset (CAST, 2018). Rather than retrofitting accommodations, inclusive universities embed accessibility into curricula, assessments, and digital platforms. ITS align well with UDL by offering multiple means of representation, engagement, and expression. Inclusive institutions ensure that ITS platforms are compatible with assistive technologies, offer customizable interfaces, and provide alternative assessment pathways for students with disabilities (Williams, 2017; Smith et al., 2018). This lesson emphasizes that accessibility must be a foundational requirement in ITS adoption to prevent the exclusion of learners with disabilities.

10.4 Capacity Building and Professional Development

Another critical lesson from inclusive higher education practices is the importance of continuous capacity building. Inclusive institutions invest in ongoing professional development for academic staff, instructional designers, and support personnel to enhance their competence in inclusive teaching and educational technology use (Ertmer, 2015; Cuhadar, 2018).

Training programs that focus on inclusive pedagogy, assistive technologies, and ITS functionality enable educators to design learning experiences that effectively support students with disabilities. Without such capacity building, even well-designed ITS may be underutilized or used in ways that do not fully address learner diversity (Holmes et al., 2019). This lesson highlights that human capacity is as critical as technological infrastructure in achieving inclusive higher education.

10.5 Student Support and Participation

Inclusive higher education practices also demonstrate the importance of involving students with disabilities as active participants in the design and evaluation of learning systems. Institutions that engage students in decision-making processes gain valuable insights into accessibility challenges and learning preferences (Moriña, 2017). In the context of ITS, student feedback helps institutions refine system design, improve usability, and ensure that adaptive features genuinely support learning. Inclusive practices further emphasize holistic student support services, including academic advising, counseling, and peer mentoring, which complement ITS-based instruction and promote retention and success among students with disabilities (WHO & World Bank, 2019).

10.6 Policy Alignment and Ethical Considerations

Inclusive higher education practices highlight the need for policy alignment and ethical oversight. Institutions operating within clear regulatory frameworks that mandate accessibility, data protection, and equity are better positioned to deploy ITS responsibly (Zawacki-Richter et al., 2019). Ethical considerations such as learner data privacy, transparency of AI decision-making, and avoidance of algorithmic bias are particularly important for protecting vulnerable student populations. The lesson for inclusive higher education is that ITS adoption must be guided by ethical principles and inclusive policies to ensure that intelligent systems enhance, rather than undermine, equity and social justice in education.

10.7 Implications for ITS Adoption in Inclusive Higher Education

Collectively, lessons from inclusive higher-education practices suggest that the successful use of Intelligent Tutoring Systems for students with disabilities depends on a holistic approach. Institutional commitment, inclusive pedagogy, accessibility, capacity building, student participation, and ethical governance must work in synergy. When these conditions are met, ITS can function as powerful enablers of inclusive higher education, supporting personalized learning, reducing barriers to participation, and enhancing academic success for students with disabilities. These lessons provide a valuable foundation for policymakers, institutional leaders, and educators seeking to leverage intelligent technologies to advance equity and inclusion in higher education.

11. CHALLENGES AND ETHICAL CONSIDERATIONS

Despite the significant potential of Intelligent Tutoring Systems (ITS) to advance inclusive higher education, their adoption and implementation are accompanied by several challenges and ethical considerations. These issues are particularly salient when ITS are deployed to support students with disabilities, as this population may be more vulnerable to exclusion, misuse of data, and unintended consequences of poorly designed technologies. This section discusses the major technical, institutional, pedagogical, and ethical challenges associated with ITS in inclusive higher education.

11.1 Infrastructure and Resource Constraints

One of the foremost challenges to ITS adoption in inclusive higher education is inadequate technological infrastructure. Many higher education institutions, particularly in developing contexts, face limitations related to unreliable internet connectivity, insufficient hardware, and lack of technical support (WHO & World Bank, 2019). These constraints can disproportionately affect students with disabilities who rely heavily on consistent access to digital and assistive technologies.

The cost of acquiring, customizing, and maintaining ITS platforms may be prohibitive for institutions with limited funding. Without sustained investment, ITS initiatives risk being short-lived or unevenly implemented, resulting in fragmented learning experiences and further marginalization of students with disabilities (Ainscow, 2020).

11.2 Digital Divide and Unequal Access

The digital divide remains a critical barrier to inclusive technology adoption. Differences in students' access to devices, connectivity, and digital literacy skills can significantly influence the effectiveness of ITS (Van Dijk, 2020). Students with disabilities may experience compounded disadvantages due to socioeconomic factors, limited prior exposure to technology, or additional costs associated with assistive devices. If unaddressed, these disparities may result in unequal benefits from ITS, thereby reinforcing rather than reducing educational inequalities. This challenge highlights the need for institutional policies that ensure equitable access to digital resources and targeted support for students with disabilities.

11.3 Limited Educator Preparedness and Resistance To Change

Another major challenge relates to educator preparedness and attitudes toward AI-driven instructional systems. While ITS are designed to complement teaching, some educators perceive them as complex, time-consuming, or threatening to conventional instructional roles (Ertmer, 2015; Holmes et al., 2019). Limited training in both inclusive pedagogy and educational technology can further hinder effective integration. For students with disabilities, inadequate educator preparedness may result in inappropriate use of ITS, superficial integration, or failure to leverage adaptive features that support inclusion. This challenge underscores the importance of sustained professional development and institutional support to build confidence and competence among educators.

11.4 Accessibility and Design Limitations

ITS have the potential to enhance accessibility, poorly designed systems may introduce new barriers. Inaccessible user interfaces, rigid interaction patterns, or lack of compatibility with assistive technologies can exclude students with visual, auditory, motor, or cognitive impairments (Smith et al., 2018; Williams, 2017). From an ethical standpoint, deploying ITS that do not adhere to accessibility standards contradicts the principles of inclusive education and Universal Design for Learning (CAST, 2018). Institutions, therefore, face the challenge of ensuring that accessibility is embedded in system design, evaluation, and continuous improvement processes.

11.5 Data Privacy, Security, and Consent

ITS rely heavily on learner data to personalize instruction, raising significant concerns about data privacy, security, and informed consent. Students with disabilities may be particularly vulnerable if sensitive data related to disabilities, learning difficulties, or behavioral patterns are collected and analyzed without adequate safeguards (Zawacki-Richter et al., 2019).

Ethical use of ITS requires transparent data governance policies that clearly define how learner data are collected, stored, analyzed, and shared. Institutions must ensure compliance with data protection regulations and obtain informed consent while safeguarding students from surveillance, misuse of data, or unintended profiling (Holmes et al., 2019).

11.6 Algorithmic Bias and Fairness

Algorithmic bias represents a critical ethical challenge in AI-driven systems. ITS algorithms trained on limited or non-representative datasets may produce biased instructional decisions that disadvantage certain learner groups, including students with disabilities (O'Neil, 2016; Zawacki-Richter et al., 2019). For example, adaptive systems may misinterpret atypical learning patterns as low ability, leading to inappropriate content sequencing or reduced learning opportunities. Addressing algorithmic bias requires inclusive data practices, continuous system evaluation, and human oversight to ensure fairness and equity in instructional decision-making.

11.7 Over-Reliance on Technology and Human Agency

Another concern is the potential over-reliance on ITS at the expense of human interaction and professional judgment. While ITS can provide individualized support, it cannot fully replace the empathy, contextual understanding, and holistic support offered by educators and support staff (Selwyn, 2019). For students with disabilities, human relationships and social interaction play a crucial role in academic success and well-being. Ethical implementation of ITS therefore requires a balanced approach in which intelligent systems augment rather than replace human support structures.

11.8 Ethical Implications for Inclusive Higher Education

Collectively, these challenges highlight the ethical responsibility of higher education institutions to deploy ITS in ways that promote equity, dignity, and social justice. Ethical ITS adoption requires inclusive design, stakeholder involvement, transparency, accountability, and continuous monitoring of system impact on students with disabilities.

The implication for inclusive higher education is that ITS must be governed by clear ethical frameworks and inclusive policies that prioritize learner well-being and rights. When these considerations are addressed, ITS can be leveraged responsibly to enhance inclusive learning while minimizing risks and unintended consequences.

12. IMPLICATIONS FOR POLICY, PRACTICE, AND RESEARCH

Based on the findings of this research, several key implications emerge across policy, practice, and future study. At the policy level, governments and regulatory bodies should actively promote AI-inclusive education policies and allocate funding for accessible educational technologies to ensure equitable access for all learners. In terms of practice, teacher education programs must embed training on Intelligent Tutoring Systems (ITS) with a strong emphasis on inclusive pedagogy, enabling educators to effectively support diverse student needs. Finally, future research should empirically examine the effectiveness of ITS for specific disability categories and varied learning contexts, as such evidence is essential for guiding targeted interventions and maximizing the benefits of AI in special education.

13. CONCLUSION

Intelligent Tutoring Systems represent a transformative tool for advancing inclusive higher education. By leveraging adaptive, cognitive, and mastery-based learning principles, ITS can address the diverse needs of students with disabilities, enhance accessibility, and promote meaningful engagement. When supported by informed policy, institutional readiness, and ethical design, ITS can contribute significantly to equitable and sustainable higher education systems.

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ETHICAL STATEMENT

Not applicable.

AI USE STATEMENT

The authors declare that no generative artificial intelligence (AI) tools were used in the preparation, analysis, or writing of this manuscript.

REFERENCES

Ainscow, M. (2020). Promoting inclusion and equity in education: Lessons from international experiences. *Nordic Journal of Studies in Educational Policy, 6(1), 7–16.* https://doi.org/10.1080/20020317.2020.1729587

Alam, A. (2023). Harnessing the power of AI to create intelligent tutoring systems for enhanced classroom experience and improved learning outcomes. In *Lecture notes on data engineering and communications technologies* (pp. 571–591). https://doi.org/10.1007/978-981-99-1767-9_42

Aleven, V., & Koedinger, K. R. (2022). An effective metacognitive strategy: Learning by doing and explaining with a computer-based cognitive tutor. *Cognitive Science, 46(3)*, e13054. https://doi.org/10.1111/cogs.13054

Bloom, B. S. (1968). Learning for mastery. Instruction and curriculum. Regional Education Laboratory for the Carolines and Virginia, *Topical Papers and Reprints*, 1(2), 1–12. http://www.scirp.org/reference/referencepapers?referenceid=1223917

CAST. (2018). Universal design for learning guidelines version 2.2. Center for Applied Special Technology. https://udlguidelines.cast.org

Clark, R. C., & Mayer, R. E. (2016). E-learning and the science of instruction (4th ed.). Wiley.

Cuhadar, C. (2018). Investigation of pre-service teachers' levels of readiness for technology integration in education. *Contemporary Educational Technology, 9(1), 61–80.* https://doi.org/10.30935/cet.41480

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13(3), 319–340.* https://doi.org/10.2307/249008

Erdemir, N., & Kandil-İngeç, Ş. (2016). Teacher educators' beliefs about the use of educational technologies in teacher education. Journal of Education and Training Studies, 4(12), 97–104. https://doi.org/10.11114/jets.v4i12.1890

Ertmer, P. A. (2015). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? Educational Technology Research and Development, 63(2), 255–268. https://doi.org/10.1007/s11423-015-9371-3

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2013). Removing obstacles to the pedagogical changes required by Jonassen's vision of authentic technology-enabled learning. *Computers & Education, 64, 175–182.* https://doi.org/10.1016/j.compedu.2012.10.008

Florian, L. (2019). On the necessary co-existence of special and inclusive education. *International Journal of Inclusive Education, 23(7–8), 691–704.* https://doi.org/10.1080/13603116.2019.1622801

Florian, L., & Black-Hawkins, K. (2018). Achievement and inclusion in schools. Routledge.

Guskey, T. R. (2007). Closing achievement gaps: Revisiting Benjamin S. Bloom's "learning for mastery." Journal of Advanced Academics, 19(1), 8–31. https://doi.org/10.4219/jaa-2007-704

Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. Center for Curriculum Redesign.

Jones, A., & Brown, C. (2019). Assistive technologies and inclusive higher education. *Journal of Special Education Technology, 34(3), 145–157.* https://doi.org/10.1177/0162643418821598

Koedinger, K. R., Anderson, J. R., Hadley, W. H., & Mark, M. A. (2015). Intelligent tutoring goes to school in the big city. *International Journal of Artificial Intelligence in Education, 25(1), 1–26.* https://doi.org/10.1007/s40593-014-0023-4

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). Intelligence unleashed: An argument for AI in education. Pearson.

Ma, W., Adesope, O. O., Nesbit, J. C., & Liu, Q. (2014). Intelligent tutoring systems and learning outcomes: A meta-analysis. *Journal of Educational Psychology, 106(4), 901–918.* https://doi.org/10.1037/a0037123

Moriña, A. (2017). Inclusive education in higher education: Challenges and opportunities. *European Journal of Disabilities Education, 32(1), 3–17.* https://doi.org/10.1080/08856257.2016.1254964

O'Neil, C. (2016). Weapons of math destruction: How big data increases inequality and threatens democracy. Crown.

Selwyn, N. (2019). Should robots replace teachers? AI and the future of education. Polity Press.

Smith, F., Davies, P., & Heindel, T. (2018). Accessibility and digital learning in higher education. *Computers & Education, 121, 1–14.* https://doi.org/10.1016/j.compedu.2018.02.007

Teo, T. (2013). Modelling technology acceptance in education: A study of pre-service teachers. *Computers & Education, 52(2), 302–312.* https://doi.org/10.1016/j.compedu.2008.08.006

VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist, 46(4), 197–221.* https://doi.org/10.1080/00461520.2011.611369

VanLehn, K. (2016). Intelligent tutoring systems for problem-solving and beyond. *Journal of Educational Psychology, 108(1), 1–17.* https://doi.org/10.1037/edu0000060

Williams, P. (2017). Learning analytics and inclusive education in higher education. *British Journal of Educational Technology, 48(4), 1120–1132*. https://doi.org/10.1111/bjet.12466

Xu, B., & Zhao, J. (2019). Digital collaboration and inclusive higher education. *Educational Technology Research and Development, 67(6), 1385–1404*. https://doi.org/10.1007/s11423-019-09677-3

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. *International Journal of Educational Technology in Higher Education, 16(1), 39.* https://doi.org/10.1186/s41239-019-0171-0