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Assistive technology in special education: Current practices and emerging trends

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Abstract

The use of technology in special education has been a topic of interest for educators, researchers, and policymakers. Integrating technology in special education classrooms can significantly enhance the learning experience for students with special needs by providing differentiation, varied content representations, enhanced motivation, engagement, formative assessment, and fostering life skills. The model of providing assistive technology to students with disabilities in special education schools comprises collaboration, a holistic perspective, independent management, learning systems, and the development of an assistive technology centre. However, there is a need to address the positive and negative impact of technologies on service delivery and personnel preparation, as well as educators' attitudes and reactions toward emerging technologies, to determine the future of teacher education in special education. The integration of technology in inclusive education has significantly influenced the shift towards inclusive education. Technology promotes greater access and flexibility for disabled students and adults, contributing to sustainable, inclusive education. The use of technology in inclusive education is not without challenges, as it has been blamed for potential social exclusion. However, it is essential to recognise that technologies have the potential to improve inclusion and should be leveraged as a tool for enhancing the educational experience of students with disabilities. Assistive technology has emerged as a potential aid for compensating for the educational needs of students with disabilities, providing them with the necessary support to access education and participate actively and independently in the learning process.

Keywords: Assistive technology, inclusive education, learning systems, special education

Introduction

The utilisation of technology in educating students with special needs has great importance, as it can significantly enhance the learning experience and bring about transformative changes for these learners. Technology in special education classrooms provides differentiation, varied content representations, enhanced motivation, engagement, and formative assessment, and fosters life skills (Anderson & Putman, 2020) [6]. In addition, technology plays a pivotal role in enhancing the overall well-being of individuals with special needs and fostering conducive learning environments. The literature on special education technology focuses on testing, implementation, accountability, and access to assistive technology and AAC (Courduff & Maktari, 2021) [16]. Additionally, mobile technology has become ubiquitous in society, leading to a surge in its use in special education (Cumming & Rodríguez, 2017) [18]. With the rapid advancement of technology, tablets and iPads have become valuable tools in special education classrooms. These devices offer an array of functionalities that can greatly benefit students with special needs (Alimi *et al.*, 2021) [4].

Collaboration, a holistic approach, independent management, learning systems, and establishing an assistive technology centre are essential in providing assistive technology to students in special education schools. (Lersilp *et al.*, 2015) [53]. It is disheartening to know that there is a lack of technologies that cater to individual needs, leaving many possibilities unrealised. However, it is inspiring to see initiatives like the Technologies for Children with Individual Needs Project (Kärnä-Lin *et al.*, 2007) [46] stepping up to address this issue. The infusion of technology instruction into content-area instruction has been proposed to prepare teachers for transition services through web-based cases (Smith & Jones, 1999) [78]. The historical evolution of the use of technology in special education over the last three decades has been traced, highlighting its evolving nature (Haines & Sanche, 2000) [33]. The role of games and educational computer games in special education, particularly in the field of

special preschool education, has been emphasised (Kokkalia *et al.*, 2016) ^[49].

Overall, technology plays a crucial role in special education, offering diverse tools and resources to support the learning and development of students with special needs. Additionally, teachers' perceptions of students with visual impairments regarding assistive technology have evolved, with amendments to the Individuals with Disabilities Education Act (IDEA) mandating the consideration and assessment of assistive technology needs for every child in special education (Kamei-Hannan *et al.*, 2012) ^[45]. However, the evolving landscape of assistive technology in special education has also raised concerns. There is a need to address the positive and negative impact of technologies on service delivery and personnel preparation, as well as educators' attitudes and reactions toward emerging technologies, to determine the future of teacher education in special education (Ludlow, 2001) ^[56].

The shift towards inclusive education and technology's role

The integration of technology in the education of persons with special needs has been a game-changer, leading to a significant shift towards inclusive education. Technology has created a world of possibilities, providing greater access and flexibility for students and adults with disabilities. This, in turn, has contributed to the development of sustainable and inclusive education. (Foley & Ferri, 2012) ^[27]. Inclusive education aims to strengthen the capacity of education systems to reach out to all learners and support them in learning, contributing, and participating in all aspects of school life (Hamburg & Lütgen, 2019) ^[34]. The use of technology in inclusive education is not without challenges, as it has been blamed for potential social exclusion.

However, it is essential to recognise that technologies have the potential to improve inclusion and should be leveraged as a tool for enhancing the educational experience of students with disabilities (Orecchio, 2022) ^[65]. Assistive technology has emerged as a potential aid for compensating for the educational needs of students with disabilities, providing them with the necessary support to access education and participate actively and independently in the learning process (Alkahtani, 2013; Reddy *et al.*, 2021) ^[5, 71]. Undoubtedly, technology plays an integral role in enhancing the quality of life for individuals with special needs and fosters a productive learning environment for them (Genc *et al.*, 2021) ^[28]. The effectiveness of assistive technologies in supporting students with special needs has been widely recognised, as these technologies are promoted to schools, parents, and educators to assist students by providing compensatory value, remediating learning problems, and promoting personal independence (Maor *et al.*, 2011) ^[57].

Technology integration in inclusive education has also been a subject of study, with research focusing on stakeholders' views, including educational leaders and teachers, on technology integration for sustainable, inclusive education (Uygun *et al.*, 2020) ^[84]. Additionally, special education teachers' attitudes towards using technology in inclusive classrooms have been explored, highlighting the importance of understanding educators' perspectives on technology integration in inclusive education (Mohamed, 2018) ^[59]. Moreover, the role of technology as a tool for assisting students with special educational needs in learning subjects such as mathematics and science has been emphasised,

indicating the potential of technology to support diverse learning needs (Iyamuremye *et al.*, 2023) ^[43].

Current Practices in Assistive Technology Augmentative and alternative communication (AAC) devices

Research has shown that Augmentative and alternative communication (AAC) intervention positively impacts the communication skills of children and adults with complex communication needs (Light & McNaughton, 2015) ^[55]. Students with complex communication needs, such as those with autism, have been found to benefit from AAC systems, which include picture symbols, communication boards, and speech-generating devices (Biggs, 2022) ^[9]. It is imperative to implement effective strategies that foster communication skills and facilitate interactions among students using AAC in an inclusive classroom (Biggs *et al.*, 2018) ^[10]. Inclusive education is a promising practice for teaching students with AAC needs. It is essential to provide systematic in-service training to teachers to improve the quality of inclusive education (Soto *et al.*, 2001; Rajaguru, 2023) ^[79, 70].

Identifying access and opportunity barriers early in the inclusion experience is crucial to planning for students with AAC needs' desired academic and social participation (Pufpaff, 2008) ^[68]. Chung *et al.* (2012) ^[14] studied the social interactions of students with disabilities who use AAC in inclusive classrooms to explore their naturally occurring social interactions. The study clearly establishes a direct correlation between the extent of access to regular education settings and the academic skills and communication of students with significant cognitive disabilities. The data suggests that those students who have greater access to regular education settings demonstrate better expressive communication, make effective use of AAC systems, and exhibit higher levels of proficiency in reading and mathematics. Moreover, AAC training provision for professionals is essential, and questions remain regarding the extent to which AAC supports inclusive education and the experience of inclusion by students who use AAC (Iacono *et al.*, 2022; Wallis *et al.*, 2017) ^[38, 29].

Learning management systems and educational software

Inclusive education aims to provide equal educational opportunities for all students, including those with diverse learning needs. Technology, particularly learning management systems (LMS) and educational software, is crucial in facilitating inclusive education. Research has shown that LMS, such as Google Classroom and Moodle, are effective tools for delivering, tracking, and managing educational courses (Etfita *et al.*, 2022) ^[85]. These systems enable the distribution of learning materials, collaboration between educators and students, and support for the learning process. Furthermore, online educational technologies, including support software like (Word processors), systems (Such as learning management systems), services (Such as YouTube or Google Docs), and environments (Such as virtual worlds), benefit learners with disabilities. Inclusive education also involves evaluating and analysing educational software to ensure its effectiveness for special education.

Educational software engineering has been identified as a significant contributor to addressing critical educational challenges, particularly in the context of massive open online courses (MOOCs). The incorporation of digital

technologies, particularly e-learning, has been shown to significantly improve access to education and promote social inclusion. This is based on research conducted by which highlights the profound impact of digital technologies on education. Creating a more inclusive and accessible learning environment by embracing technology ultimately benefits society. It is crucial to consider the perspectives of all stakeholders, including teachers, school administrative staff, and educational leaders, when deciding how to effectively incorporate technology into sustainable and inclusive education (Uygun *et al.*, 2020) [84]. Positive perceptions of inclusive education among school principals and teachers have been reported, indicating a favourable attitude towards implementing inclusive practices. However, it is crucial to ensure that educational tools and technologies are experienced as inclusive and engaging by all students.

Adaptive hardware and software

Adaptive hardware and software are essential in creating an inclusive learning environment for students with special educational needs. Integrating technology-enhanced tools and media has been highlighted as a seamless approach to fostering inclusive education. This integration has been shown to improve the functional capabilities of students and increase their participation in learning opportunities (Alkahtani, 2013) [5]. Furthermore, the use of information and communication technologies, along with adapted educational content, has been emphasised as a means to meet the educational needs of students with psycho-physical disorders. Digital technologies have also been recognised for their potential to integrate individuals with special needs into active social and economic life, promoting inclusivity. In addition to hardware and software, e-learning opportunities have been identified as significantly influencing the development of inclusive education, particularly in higher education settings. The use of technological innovation, such as Mentimeter, has been highlighted for its potential to ensure inclusive and equitable education for all, allowing diverse audiences to participate in the learning process. Moreover, stakeholders have expressed positive views on integrating technology into sustainable, inclusive education, emphasising its role in facilitating quick and easy learning for students (Uygun *et al.*, 2020) [84].

Assistive technologies have also been recognised as effective tools for supporting students with special needs, ranging from simple spellcheckers to more complex speech recognition systems and educational software (Maor *et al.*, 2011) [57]. Furthermore, universal design and assistive technologies have been shown to remove barriers in educational environments for individuals with special needs, promoting inclusivity for all students (Genc *et al.*, 2021) [28]. According to Alimi *et al.* (2021) [4], the availability and utilisation of assistive technology for learning among students with special needs have been identified as crucial factors in promoting inclusivity in educational settings.

Assistive listening and visual aids

Genc *et al.* (2021) [28] argued that using assistive listening and visual aids is crucial in educating learners with special needs, as it enhances their learning, self-confidence, and independence. However, the effectiveness of high-tech assistive technologies depends on how teachers and students utilise them as teaching and learning tools (Chukwuemeka

& Dominic, 2019) [13]. Teachers' attitudes and competence in assistive technologies are essential for effective implementation in special needs schools (Adams *et al.*, 2017) [2]. Additionally, the use of audio-visual aids has been found to reduce test anxiety and enhance listening comprehension scores for learners of English as a foreign language (Lee *et al.*, 2015) [52]. Alkahtani (2013) [5] highlighted the significance of teachers' knowledge and attitudes in effectively using assistive technology in for teaching students with special needs.

Metacognitive learning activities are also crucial for second language (L2) listening development, as they deepen learners' understanding of themselves as listeners and the process of listening and teach them how to manage their comprehension and learning (Goh, 2008) [32]. The availability and utilisation of functional assistive technologies are vital for the teaching-learning process for students with special needs (Alimi *et al.*, 2021) [4]. Moreover, assistive technology can promote independence for individuals with disabilities and special needs (Omar & Ali, 2022) [64]. Historically, assistive technology has been associated with individuals with physical and sensory impairments, but its application for students with mild disabilities is also essential (Edyburn, 2017) [22]. Additionally, students with visual disabilities may require assistive technologies more than those with physical disabilities (Lersilp *et al.*, 2015) [53].

In special education, individualised interventions such as flexible seating arrangement and personal FM systems are effective for children with special listening needs (Johnson, 2012) [42]. The use of audio-visual aids in listening learning has been shown to positively impact student learning, motivation, and scores (Febriani *et al.*, 2022) [25]. Furthermore, assistive technology is defined as tools used to minimise restrictions on the interaction of individuals with special needs and to provide an accessible environment for them (Tulepova *et al.*, 2022) [82]. Metacognitive strategy-based instruction using audio-visual aids has been modified and applied to improve listening comprehension (Salasiah *et al.*, 2018) [75]. However, there is insufficient empirical evidence regarding the role of visual support in assessing L2 learners' listening comprehension (Suvorov, n.d.).

The attitudes of special education students towards assistive technologies are essential, as these technologies are used within a general framework in special education (Uluyol & Aslan, 2022) [83]. Multimedia annotations have been suggested to support listening comprehension and vocabulary acquisition (Jones, 2013) [43]. Additionally, practice-oriented technologies are essential for supporting families raising children with special needs, addressing issues such as socialisation and obtaining comprehensive education (Reznikova, 2021) [72]. The development of audio-visual learning media has improved learning outcomes and student enthusiasm in mathematics education (Sholikah *et al.*, 2023) [76]. Help options in multimedia listening environments have been reviewed for their potential to aid listening comprehension and improve vocabulary learning (Mohsen, 2015) [60]. Assisted listening devices, including extra loud, vibrating, or visual-alerting devices, are essential for individuals with hearing impairment (Smith *et al.*, 2005) [77].

Emerging Trends in Assistive Technology

The use of assistive technology in special education has

evolved considerably, with a growing emphasis on the importance of teachers' knowledge and attitudes in effectively utilising these technologies (Alkahtani, 2013) [5]. There is a changing trend in how students perceive assistive technology, focusing on improving access to the curriculum and the quality of learning experiences for students with special educational needs (Lersilp, 2016) [54]. Furthermore, the inclusion of learners with disabilities extensively relies on digital and Artificial Intelligence (AI) enabled Assistive Technologies (AT) as enablers for Persons Living with Disabilities (PWD) (Kirongo *et al.*, 2022) [48]. The availability and utilisation of assistive technology for learning among students with special needs have been studied, showing that these devices are available for the assimilation of students with special needs, with no significant influence based on the student's gender (Alimi *et al.*, 2021) [4]. Additionally, the development of assistive technologies is related to new service delivery mechanisms, changes to public policy, and coordination among consumers, policymakers, manufacturers, researchers, and service providers (Lersilp *et al.*, 2015) [53].

The legal and policy landscape surrounding assistive technology in special education has also been a focus, with federal policy and legislation emphasising the importance of assistive technology for students with disabilities (Day & Huefner, 2003; Bowser & Reed, 1995) [19, 11]. It is imperative for special educators to possess the necessary assistive technology competencies to effectively integrate these technologies into the learning environment. This has been highlighted by research (Lahm & Niekels, 1999; Lahm, 2003) [51, 52], indicating the urgency for educators to acquire the required skills. Assistive technology has transformed the pedagogical environment in social skills training for children with intellectual difficulties (Hashim *et al.*, 2016) [35].

Virtual reality (VR) and augmented reality (AR) for immersive learning

Virtual reality (VR) and augmented reality (AR) are technologies that are being increasingly used in immersive learning. These technologies allow learners to engage in realistic and interactive learning experiences by immersing themselves in a simulated environment. This provides learners with a more hands-on approach to learning, which has the potential to be more effective than traditional methods (Moro *et al.*, 2017) [61]. These technologies have been proven effective in enhancing language learning (Huang *et al.*, 2021) [36]. VR and AR can also be used to improve the learning motivation and performance of elementary school students (Hung *et al.*, 2023) [37] and aid experiential learning by allowing students to interact and immerse in simulated environments (Asad *et al.*, 2022) [7]. VR technology not only expands the physical learning environment but also offers learners with richer learning experiences and resources (Wang, 2021) [30]. Immersive 3D VR mediums have the potential to significantly increase the learning effect, although the development of learning content in this area is still minimal (Kim & Ahn, 2021) [47]. Moreover, VR and AR offer new ways to deliver educational content by simulating real-world experiences and using immersive and interactive formats for learning (Ebinger *et al.*, 2022) [21]. These technologies have also been applied in various educational contexts, such as mathematics education (Rahmawati *et al.*, 2022) [69],

electrical circuit simulation (Nuanmeesri & Poomhiran, 2019) [63], and history education (Challenor & Ma, 2019) [2]. The immersive nature of VR and AR technologies allows students to apply their knowledge in realistic settings and increases the transfer of learning to the real world (Pang, 2021) [66]. Additionally, VR has been used to create immersive learning experiences in fields such as agriculture (Wang, 2021) [30], astronomy (Mukhtar *et al.*, 2019) [62], and history education (Challenor & Ma, 2019) [2].

Artificial Intelligence (AI) and machine learning in special education

AI in education is a rapidly emerging field, potentially enhancing teaching and learning for students with special needs (Marino *et al.*, 2023) [58]. AI technologies, such as intelligent tutoring systems and educational robots, can facilitate personalised learning experiences for students with special educational needs (Rios-Campos *et al.*, 2023) [73]. Additionally, AI has the potential to address various challenges in special education, including assisting disabled children with cutting-edge communication and learning assistive technologies (Zdravkova *et al.*, 2022) [31]. It is essential to incorporate AI in education to enhance the learning experience and provide personalised education to students with special needs (Abdellatif *et al.*, 2022) [1].

AI offers numerous benefits, such as remote teaching capabilities, innovative assessment methods, and in-depth learning, making it a crucial component of modern education. Bah and Artaria (2020) [8] found that AI technologies in special education can address written language, reading, listening, memory, and arithmetic problems faced by students with special needs. However, using AI in special education poses ethical challenges in ensuring fairness and addressing the needs of students with special needs (Fenu, 2022) [26]. It is essential to consider AI's ethical implications in education and address the potential risks and benefits for learners with special needs (Akgün & Greenhow, 2021) [3].

Addressing the digital divide in special education

The digital divide in special education is a critical issue that requires attention to ensure equitable access to educational resources and opportunities. Several studies have highlighted the challenges and implications of the digital divide in the context of special education. For instance, research has emphasised the importance of addressing the digital divide to ensure that students with special needs have access to assistive devices and technologies (Eliuteri & Lema, 2022) [23]. Additionally, the impact of the COVID-19 pandemic has exacerbated the digital divide, particularly for special education students, leading to challenges in accessing online education and specialised educational software and hardware (Sabeghi *et al.*, 2021) [74]. Furthermore, the role of technology in special education has been underscored, focusing on the potential of educational technology to support students with special needs in leading independent lives (Elverici, 2022) [24]. Efforts to bridge the digital divide in education have been explored in various contexts, including deploying technology initiatives such as the One Laptop per Child (OLPC) program (Thapa & Sein, 2018) [81]. However, it has been noted that simply providing access to technology is insufficient, and there is a need for a comprehensive approach that includes media education to address the

digital divide effectively (Pietraß, 2007) ^[67]. Moreover, a study on university students in Pakistan highlighted the challenges faced in acquiring online education, emphasising the theoretical background of the digital divide and the need for policy interventions to bridge this gap (Iftikhar *et al.*, 2023) ^[39].

Distance support services have been proposed in special education as a model to assist special education students in accessing educational and behavioural support, particularly during school closures (Jk *et al.*, 2020) ^[41]. Additionally, assistive technology, such as graphic haptic electronic boards, has been suggested to facilitate the education of students with visual impairment and low vision in special education environments (Jungil *et al.*, 2015) ^[44].

Ethical Considerations in using technology for students with special needs

Teachers' knowledge and attitudes are pivotal in successfully implementing assistive technology for students with special educational needs (Alkahtani, 2013) ^[5]. The potential of high-tech assistive technologies lies not only in the technologies themselves but also in how teachers and students use them as teaching and learning tools (Chukwuemeka & Dominic, 2019) ^[13]. Every developing technology, including assistive technology, has unique ethical considerations that must be carefully addressed. Assistive technology has been found to enable students with special educational needs to improve their access to the curriculum and the quality of their learning experience (Iyamuremye *et al.*, 2023) ^[43]. Additionally, the availability and utilisation of assistive technology for learning among students with special needs have been studied, showing that these devices are available for assimilating students with special needs, with no significant influence based on the student's gender (Alimi *et al.*, 2021) ^[4].

In higher education, challenges faced by students with special needs in online distance learning have been identified, emphasising the importance of providing technology support to these students and their parent. Furthermore, the ethical development of students through educational technology has been explored, highlighting the theoretical and practical modules that, when combined, effectively foster students' mastery of ethical competencies. Moreover, the design of technological ecosystems that support people with disabilities, including special-needs-education technology, should anticipate various factors such as the person, task, context, environment, inclusion, technological tools, and desired outcomes. Transition considerations and the use of technology for students with special needs have also been discussed, emphasising how technology may be used to address transition issues for these students.

In special education, the articulation and application of ethical theory are critical to support practice and policy development, underlining the significance of ethical considerations. Additionally, the role of school principals in ensuring ethical technology use while promoting the use of advanced technologies in instruction has been examined, shedding light on the ethical responsibilities of educational leaders. Moreover, a set of principles for an ethical-constructive technology assessment approach has been proposed to connect technology ethics more closely with technology development processes, emphasising the ethical considerations in technology assessment. The impact of

ethical approaches and the intersection of internal student data usage and application have been explored, providing a working typology of ethical approaches in educational technologies (Parsons, 2020).

Conclusion

In conclusion, the role of technology in special education is undeniably significant and transformative, with the potential to enhance learning, differentiate instruction, motivate and engage students, and foster life skills. It increases the quality of life for individuals with special needs and creates productive learning environments. The literature on special education technology has evolved to encompass testing, implementation, accountability, and access to assistive technology and augmentative and alternative communication (AAC) devices. The widespread use of mobile technology, including tablets and iPads, has become a hallmark of modern special education classrooms, offering diverse functionalities and educational applications.

Additionally, the model of providing assistive technology to students with disabilities in special education schools involves collaboration, a holistic perspective, independent management, learning systems, and the development of assistive technology centres. Efforts to bridge the digital divide in special education are essential, especially considering the challenges posed by the COVID-19 pandemic. Ensuring equitable access to technology and addressing the digital divide are crucial steps toward promoting inclusive education for all students. The ethical considerations surrounding the use of technology in special education are paramount. Teachers' knowledge, attitudes, and responsible application of assistive technologies are vital for successful implementation. Ethical development and the careful articulation of ethical theory are crucial in supporting practice and policy development in special education technology.

Technology has a transformative impact on special education, offering diverse tools and resources to support the learning and development of students with special needs. While it presents numerous benefits, it also requires careful consideration of ethical concerns and efforts to bridge the digital divide to ensure equitable access. The evolving landscape of assistive technology continues to shape the future of special education, promising new possibilities and challenges to address in the years to come.

Limitations

The conclusions regarding assistive technology in special education have several challenges and limitations. These include resource constraints in terms of funding and training, varying levels of teacher readiness for technology integration, ethical considerations related to data privacy and student well-being, challenges in policy implementation, persistent inequities in access to technology, the rapidly evolving technological landscape, difficulties in assessing technology's impact, and the need for ongoing advocacy efforts. Despite these challenges, stakeholders need to acknowledge and address these limitations to enhance special education through responsible technology use and create more inclusive learning environments for students with disabilities.

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