Transforming Special Education: The Role of Technology, Especially AI, in Enhancing Inclusivity and Learning Outcomes

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Abstract: This paper explores the transformative role of Information and Communication Technologies (ICTs) and Artificial Intelligence (AI) in special education, focusing particularly on their potential to foster inclusivity and equity in education for disabled individuals. Globally, over one billion people experience some form of disability, often facing social exclusion and discrimination, which can be mitigated through targeted educational strategies. The integration of advanced technologies like AI and VR in educational systems offers unprecedented, personalized learning experiences, addresses the diverse needs of disabled students, and supports their integration into society. This study delves into the applications of these technologies globally and in China, highlighting the challenges and potential solutions to ensuring quality education for all. Through the analysis of current technological applications and their impact, the paper discusses how digital tools and AI-driven solutions not only enhance learning outcomes but also promote social and cognitive inclusion.

1 INTRODUCTION

According to data from the UNESCO Asia Pacific Education Bureau and the World Health Organization (WHO), more than one billion people worldwide experience some form of disability, and this figure continues to rise as the global population increases (World Health Organization, 2018). Due to the unique behavioral and cognitive characteristics of individuals with disabilities, they often face various degrees of discrimination and marginalization in society. This societal exclusion not only threatens social stability but also infringes upon the equal rights of citizens (Ditchman et al., 2016). Therefore, using educational measures to support and advocate for this group is increasingly important for both national and societal well-being. Developing specialized education for disabled children is a crucial strategy for promoting equal educational opportunities (Miles, 2012). Assisting disabled children in integrating into their peer groups through special education and fostering their holistic development is a societal issue that warrants attention.

China has the largest population of disabled individuals in the world (Guo, 2014). The Chinese government has highlighted a focus on ensuring the enrollment rate of individuals with disabilities in its development plans for special education. However, amidst high enrollment rates in inclusive education settings, ensuring high-quality, effective education and adequate educational resources remains a challenge (Deng & Harris, 2008). Additionally, given the unique needs and educational goals of each disabled child, particularly in the context of a shortage of qualified special education teachers and limited professional training, meeting current special education needs is difficult. Thus, the development of information technology in special education and the expansion of resources are critically important. These advances not only help integrate individuals into social life but also provide personalized learning experiences that support individualized learning. This article will detail the potential and applications of technology and AI in the field of special education.

2 THE IMPACT OF INFORMATION TECHNOLOGY ON SPECIAL EDUCATION

The rapid development of ICTs has significantly altered the living conditions of many individuals. The application of ICTs in the field of education has also amassed substantial evidence to date. These

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technologies provide relatively personalized and timely feedback. The introduction of multimedia technologies has greatly enriched teaching methods, enhancing students' learning motivation and classroom engagement. For students with autism and attention deficits, modern technological devices like tablets with touchscreen capabilities significantly aid their understanding and interaction.

Dating back to the early 1980s, ICT specifically designed for students with learning disabilities had already emerged. The application of this technology heavily depended on the exceptionality it was designed for, leading to considerable variability. For students requiring special education, the predominant technology used comprised computer-assisted instruction (CAI) (Jeffs et al., 2003). The primary purpose of this instruction was to develop specific skills through repetitive practice, viewing the computer as a teacher's role and providing timely feedback to students. Nevertheless, Hummel et al. (1985) critiqued that CAI also had its limitations, lacking significant interaction and serving merely as an aid. This aspect was particularly unfriendly to the learning process of students with learning disabilities, as their attention could easily be diverted. Without supportive, interactive content, there tends to be a gradual reduction in students' motivation and engagement, fostering a traditional 'computer-centred' passive learning environment.

As technology progressed in the late 1980s and early 1990s, researchers in the field of learning disabilities started investigating the use of graphics and multimedia in education. Multimedia, which combines elements like graphics, videos, animations, images, and sound, provides a variety of instructional approaches. The Cognition and Technology Group at Vanderbilt (CTGV) carried out extensive research on multimedia teaching methods, with a particular emphasis on videodisc environments. These contextualized settings provided learners with valuable opportunities to actively build knowledge within a realistic learning context (Cognition and Technology Group at Vanderbilt, 1993). It is regarded as a method that allows students to connect their unique perspectives and expressive methods with the common curriculum (Najjar, 1996). Increasingly, multimedia applications have transitioned to computer-based platforms, shifting from passive reception to more interactive modes. The research conducted by Daiute and Morse (1994) involved the use of multimedia writing tools to assist low-achieving and reluctant writers, of whom five-sixths required special education services. The study found that multimedia learning materials attract learners through various forms of presentation, thereby supporting the positive benefits of multimedia instruction for students with learning disabilities or those lacking prior knowledge in specific academic areas.

Furthermore, an educational support centre in Western Australia has also enhanced practical and perceptual learning by incorporating iPads into teaching. By equipping each classroom with two iPads and frequently using the devices in teaching, personalized educational plans incorporating iPad applications were developed based on teachers' understanding of individual student needs. According to classroom teachers' feedback, the large touchscreens and swipe functions of the iPads are particularly beneficial for children with motor control issues (Johnson, 2013). The educational trials have shown promising results in enhancing student motivation, especially among students with autism and attention deficit disorders (Johnson, 2013).

3 CHALLENGES AND LIMITATIONS: THE APPLICATION OF TECHNOLOGY IN EDUCATION AND ITS SOCIO-ECONOMIC IMPACTS

However, while this instructional method has enhanced teaching outcomes, it also faces challenges such as insufficient device availability and potential social isolation (Johnson, 2013). Interactions with machines do not improve students' social skills in real life; instead, prolonged use may lead to increased seclusion, exclusion, and isolation in interpersonal interactions. Additionally, although these devices provide a certain level of personalization, the teaching process still largely depends on the teacher's knowledge of each student and long-term surveys of volunteers. This could lead to problems of self-presentation bias and delays in information availability (Kopcha & Sullivan, 2006).

Additionally, the financial burden required to support these devices is not something every school can afford. The reliance on technological resources may also exacerbate educational inequalities (Rafalow & Puckett, 2022), particularly in economically disadvantaged areas where students may be unable to access necessary technological devices, thus missing out on the benefits of multimedia education. These issues indicate that

technology must undergo further innovation to address the existing challenges in education.

4 THE ROLE OF AI TECHNOLOGY IN THE DIAGNOSIS AND EDUCATION OF CHILDREN WITH SPECIAL NEEDS

The integration of AI with education offers a new perspective on these issues and has now become a core technological domain supporting formal education and lifelong learning (Luckin & Holmes, 2016). AI in education represents a new field that emerges from the intersection of artificial intelligence and educational theory. It aims to merge AI with education, employing advanced technological means to enhance teaching quality, ensure greater equity in education, and diversify educational support (Han et al., 2022). Currently, AI is predominantly applied in the diagnostic and screening processes to evaluate children with autism and learning disabilities and to send reports to doctors and parents. The objectivity and accuracy of these assessments are enhanced by their deep-learning capabilities and machine-learning algorithms (Lu & Perkowski, 2021). These applications demonstrate that AI now has the capacity to distinguish between children who require special education and those who are suitable for mainstream education. This ability signifies that AI has mastered the characteristics of the special education demographic. Identifying these needs lays the foundation for providing appropriate support in aspects of life, social interaction, and personalized teaching strategies for this group of students.

5 GLOBALLY & CHINA'S AI AND SPECIAL EDUCATION RESEARCH

5.1 Support in Social Life

In the area of enhancing social skills and intervening in the social behaviour disorders of individuals with autism spectrum disorder (ASD), numerous studies have found that children with ASD often show a greater interest in robots or other forms of AI. Simut et al. (2015) found that children with autism often made more eye contact with AI robots and preferred interacting with AI rather than caregivers and peers. Shi (2019) suggests that this phenomenon is due to AI being less intrusive and simpler compared to human interactions. These characteristics make AI an ideal tool for improving the social skills of children with autism. Numerous studies indicate that interactions between AI robots and children with autism can enhance their joint attention skills, which are considered one of the most crucial aspects of social abilities. Additionally, AI can enhance ASD children's ability to be oriented to prompts and attention (Warren et al., 2013).

In a study conducted in China, AI was utilized as a reinforcement tool within Applied Behaviour Analysis (ABA) interventions. The research focused on the intervention combining a humanoid robot named Wukong with ABA training for a 7-year-old child with autism. The results demonstrated that through interaction with this AI robot, Wukong quickly became the most effective reinforcer during the study, not only enhancing the creativity and interaction of the autistic children but also serving as a bridge for communication between them and their neurotypical peers. For instance, the study noted that the familiarity of autistic children with Wukong's functions earned the admiration of their peers for their ability to control the robot. This represents the first step in integrating ASD children into the mainstream educational system. It acts as a link between them and typically developing children, thereby providing more opportunities and possibilities within an inclusive educational environment (Shi, 2019).

Despite these benefits, the research also highlighted some limitations and potential risks associated with Wukong. For example, due to the limited interactive modes of the AI robot, it struggles to capture the emotional fluctuations of children with autism. Moreover, a two-month trial study revealed that children with autism might develop a dependency on the AI robot, consequently neglecting communication with their parents. This dependency, coupled with a fixed pattern of communication, may lead to self-stimulating behaviors such as echolalia and avoiding interactions with others. However, Shi (2019) points out that compared to evidence-based interventions, AI is seen as an effective tool for reducing high costs, particularly in enhancing the social skills of children with autism. Given that AI robots like Wukong currently cannot autonomously adjust and mitigate these negative impacts, the research suggests that AI robots can only serve as an effective reinforcer under manual control. Future

research and practice will need to focus on how to harness the potential of AI for children with autism while avoiding negative impacts.

5.2 Support in Personalized Learning

Children with special needs exhibit significant learning differences based on the type and severity of their disabilities. However, in the present one-to-many educational environment, personalized tutoring is often limited, causing teachers to neglect the specific learning support needs of individual students, which leads to an unequal allocation of educational resources (Deng & Pei, 2009). The integration of artificial intelligence and neural networks provides an unprecedented, personalized learning solution for education. AI-based intelligent teaching systems employ algorithms and data, integrating computational intelligence, learning analytics, and data mining techniques (Han et al., 2022). These systems can track students' learning dynamics in real-time, collecting and analyzing past learning states and progress. Based on this information, the systems comprehensively understand each student's learning level and needs, tailoring adaptive learning plans accordingly. Moreover, throughout the teaching process, the system can automatically generate appropriate questions and answers based on the learning goals and individual student levels, adjusting the content and pace dynamically by assessing the accuracy of student responses. This approach aims to enhance educational efficiency and ultimately supports student learning and assists teachers in their instructional roles (Han et al., 2022).

For students with visual impairments who are unable to acquire knowledge through sight, learning must rely on tactile or auditory methods. The incorporation of artificial intelligence and neural networks supports the collection, processing, and analysis of individual learning data, allowing for the creation of customized instructional programs (Tan & Wang, 2020). This approach also involves the use of brain-computer interface (BCI) technology to reconstruct neural signals in the visual cortex, assisting in their learning process. Additionally, for students with expressive disorders, developed BCI technology can directly collect and analyze brain signals to assess whether the students are focused or if their emotional states are stable (Jiang et al., 2018). Teachers can use this real-time information to adjust teaching strategies and provide targeted instruction.

Students with specific learning disabilities or language disorders require assistance in reading, writing, pronunciation, and comprehension (Sarisahin, 2020). The BeeSpecial software platform uses artificial intelligence to deliver personalized digital tools that help students with dyslexia, reducing the challenges they usually face and supporting their academic success (Zingoni et al., 2021). The platform's implementation occurs in stages. Initially, clinical reports on dyslexia, self-assessment questionnaire responses, and results from a series of psychometric tests are entered into the system. AI processes this data to extract crucial information regarding student needs and challenges, forming an initial predictive model. This model forecasts the most suitable support methods for each student, outlining best practices for teachers and educational institutions and ways to make learning materials more accessible through digital tools. In the second phase, each student tests the digital support tools, and their responses, improvements, and remaining challenges are evaluated. These assessment results are fed back to the AI, transforming the predictive model from category-specific to student-specific.

Additionally, virtual reality (VR) technology will be applied in the assessment module, as it can present materials in a more engaging manner and easily collect the necessary information. This approach not only helps mitigate issues of dyslexia and attention deficits but also simulates the challenges faced by students with reading difficulties, enabling teachers to understand these phenomena better and intervene appropriately (Zingoni et al., 2021). The platform has already collected data from approximately 700 students with dyslexia and carried out preliminary analyses, yielding initial results about the most significant challenges and the most effective support tools and strategies.

Attention problems and memory impairments are the main difficulties faced by these students (Zingoni et al., 2021). To address these issues, the platform emphasizes the need for proper support and has identified that using highlighted keywords, clear layouts, along with images, summaries, concept maps, and diagrams are the most effective tools. Furthermore, strategies such as pausing during classes, hosting online sessions, repeating learning materials, and providing course programs and slideshows are considered most appropriate, significantly enhancing learning efficiency. The platform also advocates utilizing auditory channels, such as recording lessons, using audiobooks, and preferring oral exams, to cater to specific student needs. These results will serve as valuable guides for refining the concept and technological choices of the BeeSpecial platform. The next steps in implementation will involve training the AI module

to automatically predict the most useful tools and strategies, as well as incorporating VR capabilities to administer psychometric tests and assess digital tools.

6 CONCLUSIONS

The deployment of Technology and AI in special education presents a vital opportunity to revolutionize how educational services are delivered to disabled students. As demonstrated in the various case studies and literature reviewed, these technologies provide critical support in personalizing learning experiences, enhancing student engagement, and facilitating the social integration of students with disabilities. However, the effective implementation of such technologies requires overcoming significant challenges, including the equitable distribution of educational resources, professional training for educators, and the development of infrastructure to support technology-driven teaching methods. Moreover, future research should focus on refining AI models to better address the nuanced needs of disabled students and expanding the use of VR to simulate complex learning environments. By advancing these technologies, educators can significantly improve the educational landscape for students with disabilities, making it more inclusive and effective. The continued evolution of AI and VR in special education holds the promise of creating more equitable educational opportunities and fostering a more inclusive society.

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