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Assistive Technologies for Learning Disabilities: A Systematic Review of Trends and Impact

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ABSTRACT

This review aims to explore how Artificial Intelligence has been employed in the field of special education and how it supports the students with learning disabilities. 6 studies were analyzed for this review, 2 of which focused primarily on dyslexia, 1 focused on speech therapy for students with dyslalia, and the rest aimed to support learning disabilities in general. AI technologies and techniques such as interactive tutors, face-expression recognition using computer vision, and machine learning models that recommend learning content based on individual strengths and weaknesses are some of the technologies explored in the review. The findings reveal a positive impact created by the AI technologies on the learning of the SWLDs and potential to develop and expand to provide better education for the students.

INTRODUCTION

In the United States, about **10%** of adolescents and children are affected by learning disabilities such as dyslexia, dyscalculia, autism, and dyslalia. This maps to around 1 in 10 children having some form of learning disability. It is important to understand how education can be effectively made available for these children to help them thrive in society. Special education programs provide tailored educational services for students with learning disabilities (SWLD) and support their academic and social growth. Understanding the unique needs and weaknesses of SWLDs makes special education challenging; this is where Artificial Intelligence steps in.

AI has revolutionized several industries with applications sometimes unachievable by manpower, including **Healthcare**, **Construction**, **Entertainment**, **Computer Vision, and Deep Learning**. Similarly, AI provides a unique way to supplement traditional teaching practices and enhance content to better suit students' individual needs. Students engaged with an AI tutor have shown significant academic improvement, averaging up to **15 percentile points higher** than a parallel course without AI assistance. AI will also play a crucial role in educating SWLDs by taking a micro-analytic approach that caters content to each student's specific needs.

This review will explore **AI technologies** and **approaches** supplementing special education and their impact on SWLDs. Examples include face detection using AI-assisted computer vision and machine learning models that analyze student weaknesses and develop personalized learning schedules aimed at growth and performance.

METHOD

The review uses an inclusion criteria to select relevant studies on AI in special education. The following are the steps use to determine relevant data.

Step 1 includes Defining inclusion criteria to ensure the studies are up-to-date, relevant, and of high quality. **(A)** Study must follow DSM 5 in 2013 to prevent variation in result generalizability. Prioritizing DSM 5 as it is the latest. DSM is the Diagnostic and Statistical Manual of Mental Disorders which provides a comprehensive and authoritative classification system and descriptive criteria for mental disorders. **(B)** Study and Publication in the last 15 years. **(C)** The source is a journal article or conference proceeding. **(D)** The AI model must attempt to positively impact learning and engagement among SWLD. **(E)** Study must be published in English. **(F)** The study provides information on supporting or instructing SWLD. Studies like Orefice (2022) and Draffan et al. (2007) were excluded due to language and publication date issues. while Zingoni et al. (2021) met the criteria perfectly, providing substantial intent to support SWLD and aligning with the DSM-5 standards.

Step 2 involves collecting relevant studies using databases like Web of Science and Google Scholar. Key terms such as "AI," "Artificial Intelligence," "AI-Assisted Technology," and "special education" or "learning disabilities" were used to identify appropriate research. Studies were selected based on their publication date, relevance to the topic, and clarity.

Step 3 entails thoroughly analyzing the literature to extract key information and evaluate the impact of each study. The focus is on assessing how meaningful the AI technology is in achieving its intended goals, ensuring that the technology provides significant and positive contributions to the learning outcomes of SWLD.

LITERATURE

The keyword search of **Google Scholar** and **Web of Science** yielded over an aggregate of 500 studies that responded to the search terms. Out of all the studies, 6 were shortlisted to undergo analysis and evaluation

Research Literature	Learning Disability
Machine Learning-based approach to support SWLD (Sharif & Elmedany, 2022)	Learning Disabilities in General
LOGOMON (Schipor et al., 2010)	Speech Disorder (such as Dyslalia)
ALEXZA (Rajapakse et al., 2018)	Dyslexia
Computer Vision Assisted Facial Expression Analysis for Student Engagement Prediction (Abdul Hamid et al., 2018)	Learning Disabilities in General
BESPECIAL (Zingoni et al., 2021)	Dyslexia
NAO (Papakostas et al., 2021)	Learning Disabilities in General

RESULTS

Rajapakse et al. (2018) developed **ALEXZA**, an AI-based application that adapts learning content to students with dyslexia. It employs a pre-processing algorithm to enhance text and image quality, allowing for text manipulation, including color changes, formatting, highlighting, and word replacement. A Smart AI assistant further supports students, making learning more accessible. When combined with other technologies, **ALEXZA** could **significantly** enhance learning outcomes for dyslexic students. Similarly, **Schipor et al. (2010)** developed **LOGOMON**, a computer-based speech therapy model for children with speech disorders such as dyslalia. It uses a fuzzy expert system to create personalized pronunciation training paths based on defect categories, prior experiences, and therapy progress. **LOGOMON** generates individualized training schedules to aid sound acquisition, consolidation, and automation. The AI Model **did not aim to replace** the SLPs (Speech and Learning Pathologists, colloquially referred as Speech Therapists), but had a goal to "facilitate their assessment of speech by helping them target therapeutic intervention, augment their efforts in highly repetitive articulation drill and training and assist in record keeping and reporting". **ALEXZA** and **LOGOMON** illustrate AI-driven technologies that provide tailored learning materials and improve student engagement. However, a comprehensive approach is required to support students with learning disabilities effectively.

Papakostas et al. (2021) engaged ten elementary students with learning disabilities using the social chat robot, **NAO**. The study designed real-life interaction scenarios, successfully predicting student engagement with 93% accuracy. Similarly, **Abdul Hamid et al. (2018)** explored engagement prediction using AI-assisted facial expression detection. Their model used the **Bag of Features (BoF)** method and frontal face detection to analyze students aged 7 to 12, offering valuable insights for educators to enhance lesson plans and engagement. Beyond supporting traditional teaching, some AI technologies reshape pedagogy by tailoring content. **Zingoni et al. (2021)** introduced the **BESPECIAL platform**, which utilizes clinical reports and self-evaluation forms to personalize learning for students with disabilities, providing teachers with actionable insights. **Sharif and Elmedany (2022)** proposed a dynamic machine learning model that identifies learning difficulties and recommends personalized strategies. Like professional athletes receiving customized training, AI-driven education enables students with disabilities to access more efficient, engaging learning experiences, ultimately benefiting them long-term.

CONCLUSIONS

The review puts light on the **growing role of AI** in supporting students with learning disabilities (SWLD) by improving engagement and growth. It emphasizes AI's potential to identify learning challenges and provide personalized strategies, enhancing traditional teaching methods. AI applications like computer vision and facial expression analysis further help **increase student engagement and tailor learning strategies** that uniquely benefit a student. The studies reviewed span various countries, including the United States, Malaysia, India, and others, showing a growing interest in use of AI for assisting SWLDs.

Despite concerns over AI replacing human teachers, the review **stresses** that AI is meant to **supplement, and not replace**, traditional teaching. It assists educators by offering better content and advice, helping to create more effective learning environments for SWLD. AI's integration into education has the potential to significantly enhance the system, and awareness of its variety of benefits is crucial for its wider adoption. It is also now evident through this review that AI in special education is still in its **early stages**, with much potential yet to be realized.

Future research should aim to **expand the scope of AI applications** in special education, exploring new studies and combining different technologies to improve outcomes. As AI continues to gain attention, its integration into the classroom will unlock opportunities for more equitable and effective educational practices for students with learning disabilities.

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