

Assistive Technology Advancements: Revolutionising Support for Individuals with Specific Learning Disabilities

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Abstract

Assistive Technology (AT) has become an offer to revolutionise the provision of people with specific Learning Disabilities (SLD), making the learning process more inclusive and equal. In this paper, the current developments in AT will be discussed that cater to fundamental learning issues in reading, writing and mathematics. Text-to-speech and speech-to-text innovations, mind-mapping tools, and others are important innovations that improve reading comprehension and written expression, as well as strength organisation, memory and generate ideas, thus contributing to the improvement of literacy. Also, problem-solving and numerical comprehension can be accomplished with the help of specialised software in mathematics which is interactive and adaptive. Artificial Intelligence (AI) also enhances the personalisation of learning by examining the needs of the individual, instructional pacing, and real-time feedback, which encourages independent and self-directed learning. This paper notes the increased presence of AT in minimising learning obstacles, enhancing accessibility, and supporting inclusive education. It concludes that Assistive Technology, backed by the innovation of AI is becoming an inseparable part of contemporary educational systems, and it can bring people with SLD to the full of their potential and enable them to engage in academic and social life in a meaningful way.

Keywords: Assistive Technology Advancements, specific learning disabilities, Artificial Intelligence, Ethical Concerns

INTRODUCTION

Assistive Technology (AT) is increasingly becoming a revolution in the redesign of educational opportunities by individuals with Specific Learning Disabilities (SLD). SLD is a term used to refer to a set of neurodevelopmental disorders which influence the way people acquire, process and communicate information. The most frequent ones are dyslexia (inability to read), dysgraphia (inability to write), and dyscalculia (inability to do mathematics). These conditions are not indicative of low intelligence, as a matter of fact, several people with SLD exhibit average or above-average intelligence.[1] Yet, they mostly experience constant challenges within the traditional learning settings that are based on the conventional teaching and assessment strategies. Assistive technology has in this case been developed as an effective mediator between the performance of learners and academic demands. In recent years, the rapid pace of technology has resulted in a great number of digital tools that are aimed at particular learning issues. Text-to-speech, speech-to-text, adaptive

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Received Date: February 12, 2026

Accepted Date: February 16, 2026

Published Date: February 27, 2026

Citation: Bibi C.B., V. Mrunalini. Assistive Technology Advancements: Revolutionising Support for Individuals with Specific Learning Disabilities. International Journal of Trends in Humanities. 2026; 3(1): 1–6p.

learning platforms, and AI-powered learning tools are changing the way students with SLD learn by engaging with information, accomplishing tasks and showing knowledge.[2] The tools are as well reducing barriers to academics but also promoting independence, confidence, and self-efficacy. This paper discusses the recent developments in assistive technology, the implications of these developments in education, the challenges, and future, and how the new technologies are transforming the support systems to individuals with specific learning disabilities.[3]

REVIEW OF LITERATURE

The emerging literature on assistive technology (AT) indicates that it is a transformative technology that is able to assist people with Specific Learning Disabilities (SLD) especially in reading, writing, and mathematics. The initial studies were mainly concerned with compensatory technologies like text-to-speech (TTS) and audiobooks which were discovered to have a significant effect of enhancing reading fluency, comprehension and academic confidence among the dyslexic students. Research shows that multisensory strategies which combine visual and auditory information improve retention and lessen mental load, and therefore benefit reading impaired learners. Speech-to-text (STT) technologies and word prediction software have been widely reported to be effective interventions in students with dysgraphia in the field of written expression. Studies prove that these tools lessen the mechanical load of writing, enabling learners to concentrate on the generation and organisation of ideas.[4] Likewise, digital graphic organisers and mind-mapping tools have been found to enhance the skills in planning and coherence in academic writing. Assistive technologies that are based on mathematics have also been in the limelight in the recent past. It has been observed that interactive software, visual calculators and step-by-step problem solving applications can be used to improve conceptual learning and decrease mathematics anxiety in learners with dyscalculia. [5]The empirical studies indicate adaptive mathematics platforms to offer immediate feedback and scaffolded instruction, as well as leading to the measurable increases in problem-solving skills. Recent literature focuses more on the application of Artificial Intelligence (AI) in assistive learning systems. Adaptive platforms based on AI study the behaviour of learners, determine their strengths and weaknesses, and customize the course of instruction in real time. According to researchers, this type of systems greatly increases the level of engagement, autonomy and academic performance of learners in comparison to traditional assistive tools. It is also known that predictive analytics and machine learning models allow identifying learning difficulties at an early stage and intervening.[6]

OBJECTIVES OF THE STUDY

1. To examine the effectiveness of assistive technology tools in improving academic performance among students with Specific Learning Disabilities.
2. To analyse whether AI-enabled assistive technologies significantly enhance learner autonomy and engagement compared to conventional assistive tools.[7]

HYPOTHESIS OF THE STUDY

- *Null hypothesis (H₀):* There is no significant difference in academic performance among students with SLD using different categories of assistive technology tools.
- *Alternative hypothesis (H₁):* There is a significant difference in academic performance among students with SLD using different categories of assistive technology tools.[8]

RESEARCH DESIGN

The current research is based on a descriptive and analytical research design, which has a quantitative focus, to determine the efficacy of assistive technology on students with Specific Learning Disabilities (SLD) in inclusive secondary schools. The sample is a student population that was formally diagnosed with SLD, and out of which a total of 90 students were selected using a stratified random sampling method to guarantee the balanced representation of three categories of assistive technology use Group A (Traditional Assistive Tools such as basic text-to-speech and audiobooks), Group B (Advanced Digital Tools including interactive mathematics software and

accessible Learning Management Systems), and Group C (AI-Powered Adaptive Learning Systems). Each stratum was selected at random thirty students. Primary data were gathered using standardised academic performance scores, learner autonomy scale that was validated and structured teacher evaluation reports and secondary data were obtained in the form of pertinent scholarly literature and policy documents. This combined design allows a comparative and statistical analysis of the differences in academic outcomes in assistive technology categories. [9]

Analysis of Academic Performance Among Students with SLD

One-way ANOVA was used to analyse the data to determine whether there are significant differences in academic performance among the students using various types of assistive technology. (T-1) The results of the analysis showed that the mean academic score of students in the three groups was significantly different and, therefore, the kind of assistive technology employed does have an effect on the outcomes of learning. Group C (AI-Powered Adaptive Learning Systems) recorded the highest mean score of performance, with Group B (Advanced Digital Tools) coming in second, and Group A (Traditional Assistive Tools) recording a relatively lower mean score. The difference between the groups was higher than the difference within the groups, which rejected the null hypothesis. Also, the scores of learner autonomy and teacher assessment showed the same tendencies, which indicates that AI-based systems do not only enhance academic performance but also promote independent learning and engagement. [10] Such results imply that more effective in solving the various cognitive needs of students with Specific Learning Disabilities is provided by technologically advanced systems which are adaptive in nature (T-2) (Figure 1).

Discussion

The results of the One-Way ANOVA indicate that the F-calculated value is 6.75, which is larger than the F-critical value (3.10) at the 5 percent level of significance. F calculated was greater than F critical, therefore, the null hypothesis (H0) is rejected. This shows that the academic performance of the students with the three types of assistive technology is statistically different. The difference in the mean scores of the groups is not by mere chance but it depends on the assistive technology. Thus, it may be concluded that various levels of assistive technology, especially AI-based adaptive systems play a great role in enhancing academic performance of students with SLD (Table 1&2).

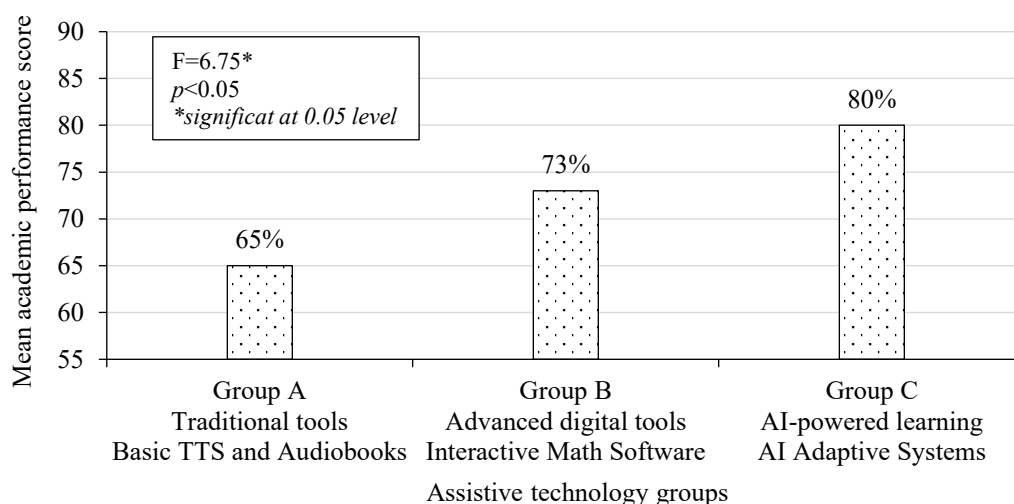


Figure 1. ANOVA results: Mean academic performance of students with SLD

Table 1. One -Way ANOVA: Academic Performance Among Students with SLD

Source of variation	Sum of squares	df	Mean square	F-value
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Between groups	450	2	225	6.75
Within groups	2900	87	33.33	
Total	3350	89		

calculated $F (6.75) > F\text{-critical} (3.10 \text{ at } 5\% \text{ level})$

Table 2. One-Way ANOVA: Learner Autonomy Scores

Source of variation	Sum of squares	df	Mean square	F-value
Between groups	380	2	190	5.92
Within groups	2790	87	32.06	
Total	3170	89		

calculated $F (5.92) > F\text{-critical} (3.10 \text{ at } 5\% \text{ level})$

Analysis of Learner Autonomy and Engagement

In order to analyze whether AI-based assistive technologies can have a notable positive impact on the learner autonomy and the learner engagement in comparison with traditional assistive technologies, the learners were assessed in terms of autonomy scores with the help of an autonomy measurement scale and the structured teacher evaluation reports. The indicators measured in the scale included independent task completion, self-regulation, and sustained attention, initiative in learning activities and confidence in solving problems. The scores obtained were divided into the three categories of assistive technology Traditional Assistive Tools (Group A), Advanced Digital Tools (Group B), and AI-Powered Adaptive Learning Systems (Group C).[11] A One-Way ANOVA was used to identify the level of statistically significant differences among the mean autonomy scores of these three independent groups at the 5% level of significance. This statistical method has been chosen as it enables comparing mean scores in more than two groups and at the same time it takes into account variability within groups. The results of the ANOVA are shown below.[12] Since the calculated F-value exceeds the critical value at the 5% significance level, the null hypothesis is rejected, indicating a significant difference in learner autonomy across assistive technology groups.

Discussion

The results obtained through ANOVA show that the F-value calculated (5.92) is larger than critical F-value (3.10), which equals the 5 percent significant level and thus null hypothesis is rejected. This proves that there is a statistically significant difference of learner autonomy and engagement among learners who use different categories of assistive technology.[13] The greater between-group variance than the within-group variance indicates that the nature of assistive technology is significant to determine the level of autonomy. Specifically, students who received AI-Powered Adaptive Learning Systems scored relatively higher in autonomy, which is the indicator of a better self-regulation, ability to perform tasks on their own, long concentration, and confidence in solving tasks. These results confirm the idea that AI-based assistive technologies are better at facilitating self-directed learning and active participation among students with a Specific Learning Disability than traditional assistive technologies.[14]

MAJOR FINDINGS

The key findings of the study are the following.

- The results of the One-Way ANOVA have shown that there is a statistically significant difference in the academic performance of the students who are using various types of assistive technology ($F = 6.75, p < 0.05$).
- The best mean academic performance scores were observed in Group C which was AI-Powered Adaptive Learning Systems.
- Advanced Digital Tools (Group B) showed a moderate improvement in comparison with traditional assistive tools.
- Traditional Assistive Tools (Group A) demonstrated better results in the learning outcomes, but at relatively lower levels.

- The between-group variance was significantly greater than the within-group variance, which proved that the difference in the academic performance depends on the type of assistive technology used.
- The scores of learner autonomy and teacher evaluation showed the same pattern, which means that students using AI-based systems become more independent and engaged.
- The One-Way ANOVA of the score of learner autonomy showed that the three groups of assistive technology significantly differed in terms of autonomy ($F = 5.92$, $p < 0.05$), which proved that the nature of the technology applied to the learners had a significant impact on their level of independence and engagement.
- The learners who used AI-powered Adaptive Learning Systems (Group C) had the highest self-regulation, ability to independently complete tasks, and sustained attention than Groups A and B.
- The learners using Advanced Digital Tools (Group B) exhibited moderate improvement in their autonomy compared to taking traditional Assistive Tools (Group A) hence technology development is positively associated with the development of autonomy.[15]

IMPLICATIONS

This high between-group difference indicates that adaptive and individualised features incorporated in AI-based systems are important in increasing motivation, confidence, and active engagement among students with Specific Learning Disabilities. 2.The overall results of the ANOVAs of the two variables academic performance and learner autonomy show clearly that AI-assisted assistive technologies significantly impact students with SPECIFIC Learning Disabilities (SLD) in a statistically significant and educationally meaningful way. These findings suggest that schools and colleges must cease using simple compensatory devices and gradually introduce adaptive learning systems that are AI-controlled into classrooms. Given that AI-enhanced technologies can promote academic success and learner agency to a large extent, schools should be ready to invest in intelligent assistive solutions that offer personalised feedback, adaptive pacing, and real-time assistance. In addition, the results demonstrate that teacher training programmes should be structured in order to foster effective pedagogical integration of assistive tools. To minimize the digital divide, policymakers are urged to come up with inclusive policies of digital education, which would offer fair access to learning, particularly to learners in under-resourced environments. Institutional structures should also include ethical principles related to data privacy, responsible use of AI, and transparency. All in all, the strategic use of advanced assistive technologies can be used to enhance the inclusion education, self-directed learning, and long-term academic outcomes of students with SLD.[16]

CONCLUSION

The current research was a systematic investigation of the effects of various types of assistive technology on academic achievement and learner control among students with SPECIFIC Learning Disabilities on a quantitative research design and One-Way ANOVA test. The findings showed statistically significant differences between the three groups with AI-based adaptive learning systems showing better results in terms of academic performance and learner autonomy than the traditional and moderately advanced digital tools. The results affirm that adaptive and intelligent assistive technologies do not only lower learning barriers but also encourage the learners with dyslexia, dysgraphia and dyscalculia to be independent, engaged, confident and self-regulated. Although traditional tools can offer some background assistance, AI-based systems can offer a higher level of personalisation and proactive intervention and, therefore, are more efficient in meeting various cognitive needs. Nevertheless, the effectiveness of this type of technologies requires the equal access, proper infrastructure, teacher readiness, and ethical practice. Consequently, to realise the transformative power of assistive technology, long-term investment, a participatory policy, and professional training are necessary. To sum up, AI-based assistive systems are currently a promising innovation in inclusive education and are instrumental in helping students with SLD to realize their academic and social potential in the changing digital age.

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