

## Utilizing AI to Enhance Learning for Children with Autism Spectrum Disorders: A Case Study of a School in Eswatini

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### Abstract

The advent of artificial intelligence (AI) has become instrumental in supporting the education of children with Autism Spectrum Disorder (ASD), providing customized learning experiences that cater to their distinctive cognitive and social needs. This study investigates the effects of technology-assisted learning for children with autism in a school in Eswatini. The sample size comprised six learners from one primary school. By employing interactive applications, digital communication tools, and adaptive learning software, this research evaluates the ways in which technology contributes to increased engagement, improved communication, and academic achievement. Data were gathered through observations, teacher interviews, and tracking of students' progress. The interviews were analyzed using the grounded theory approach. The results revealed the efficacy of technology in promoting individualized learning, enhancing social interactions, and mitigating sensory overload. Additionally, the study offers recommendations for the integration of digital tools into special education curricula in Eswatini, aiming to develop inclusive and effective educational environments for children with autism.

**Keywords:** Autism Spectrum Disorder, Digital Tools, Inclusive Education, Special Education, Technology-Assisted Learning

### Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition distinguished by challenges in social interaction, communication, and behavior, alongside a spectrum of cognitive abilities and sensory sensitivities. Globally, the prevalence of ASD is increasing, highlighting the urgent need for educational strategies tailored to the unique learning profiles of affected children (Miller et al., 2015). Traditional pedagogical approaches often fail to sufficiently address these individual needs, emphasizing the importance of personalized instructional methods that consider sensory sensitivities and diverse cognitive styles (Mazurek et al., 2014).

In response to these challenges, technological advancements have increasingly been integrated into special education. Digital platforms, interactive applications, and adaptive learning systems offer personalized educational experiences by providing visual and auditory cues, pacing adjustments, and engaging interfaces aligned with students' preferences

(Kagohara et al., 2013; Davis et al., 2018). Such technologies can also help alleviate sensory overload, a common difficulty among children with ASD, by creating controlled and customizable learning environments that help reduce sensory stress and promote sustained attention (Zhou et al., 2020).

The theoretical foundation guiding this study draws primarily from Constructivist Learning Theory and Universal Design for Learning (UDL) principles. Constructivism emphasizes that learners actively construct knowledge through interaction with their environment and advocates for experiential and individualized learning experiences (Piaget, 1954; Vygotsky, 1978). For children with ASD, who often benefit from concrete, structured, and sensory-friendly learning contexts, technology offers a means of facilitating such personalized engagement. The UDL framework further supports this approach by promoting flexible educational environments that accommodate individual learner variability through multiple means of representation, expression, and

engagement (CAST, 2018). Technology aligns with UDL by providing adaptable tools that can be tailored to meet diverse needs, thereby fostering accessibility and inclusivity.

Research from international contexts demonstrates the positive impact of integrating technology into special education. Studies indicate that digital tools such as tablet applications and computer-based learning programs enhance communication, social interaction, and academic achievement among children with ASD by offering engaging and customizable learning experiences (Kagohara et al., 2013; Miller et al., 2015). Advanced adaptive technologies, including artificial intelligence (AI)-powered systems, further enhance these benefits by dynamically adjusting content based on real-time feedback, maintaining student motivation and engagement (Davis et al., 2018). Such tools facilitate practice in language, social skills, and behavioral regulation within safe, motivating environments (Mazurek et al., 2014).

Additionally, immersive technologies like virtual reality (VR) and augmented reality (AR) have emerged as promising platforms for social skills development, offering simulated experiences where children with ASD can rehearse social interactions in controlled settings, thereby reducing anxiety and unpredictability associated with real-world encounters (Zhou et al., 2020). This aligns with social learning frameworks emphasizing guided practice and scaffolding for skill acquisition (Bandura, 1977).

Despite these promising developments, the implementation of technology-based interventions in special education faces notable challenges, especially in low-resource settings such as Eswatini. Barriers include limited access to devices, unreliable internet connectivity, and insufficient teacher training, all of which impede widespread adoption (Miller et al., 2018). Cultural perceptions and local contextual factors also influence the acceptance and effective use of educational technologies, underscoring the importance of contextualized approaches.

In Eswatini, the infrastructure for special education remains underdeveloped, and resources dedicated to children with ASD are limited. Nevertheless, awareness and commitment toward inclusive education are increasing, driving initiatives to incorporate innovative teaching strategies. However, empirical evidence regarding the use of digital technologies to support children with ASD within this context remains scarce. This study aims to

address this gap by exploring the potential of artificial intelligence and other technological tools to enhance educational experiences for children with ASD in Eswatini. Specifically, it investigates how these tools influence engagement, communication, and academic outcomes, contributing valuable insights into the feasibility and effectiveness of integrating digital technologies into resource-constrained educational settings.

## Methodology

This study utilized a case study research design to investigate the effects of technology-assisted learning on children with Autism Spectrum Disorder (ASD) within a primary school in Eswatini. The research concentrated on a sample of six learners diagnosed with ASD, selected from a single educational institution to gain an in-depth understanding of the influence of digital tools in a practical learning environment (Cohen et al., 2018). To evaluate the efficacy of the interventions, a variety of technological tools were incorporated into the learning experiences of the students. These tools included interactive applications, digital communication platforms, and adaptive learning software, all customized to address the individual cognitive and social needs of each student (Mazurek et al., 2014; Davis et al., 2018). The integration of these resources aimed to promote engagement, enhance communication skills, and improve academic performance, with specific consideration given to the sensory sensitivities often associated with ASD (Zhou et al., 2020).

Data collection employed multiple methodologies. Initially, direct observations were conducted throughout the study to assess student interactions with technology, levels of engagement, and any observable changes in behavior or communication (Kagohara et al., 2013). These observations were supplemented by semi-structured interviews with teachers, offering valuable insights into their perceptions of technology's impact on student learning and development. The interviews facilitated a more comprehensive understanding of the challenges and benefits presented by the utilization of digital tools in the classroom. Furthermore, student progress was monitored through performance assessments and progress reports to gauge improvements in academic outcomes and communication as mentioned by (Mazurek et al., 2014). These assessments were conducted at various

intervals during the study to track changes over time and evaluate the overall impact of technology on students' learning achievements (Miller et al., 2015).

The qualitative data collected through teacher interviews were analyzed using the grounded theory methodology as described by Charmaz (2014). This approach facilitated a comprehensive and systematic exploration of emerging themes and patterns related to the integration of technology in classrooms for children with ASD. The analysis process began with verbatim transcription of all interviews to ensure accuracy and completeness. Initial open coding was performed on a line-by-line basis, generating a diverse set of codes that reflected teachers' experiences and perceptions.

Nvivo coding was also employed to retain participants' language and maintain close fidelity to the data. During this phase, codes such as "technology aids concentration" and "helps communication" emerged. Subsequently, focused (axial) coding was conducted to cluster related codes into broader categories, involving comparisons and refinements to identify significant concepts such as technology's role in supporting individualized learning, enhancing student engagement, and fostering peer interactions. Through continuous comparison across interviews, more abstract themes were identified. These themes were further developed during the theoretical coding stage, where core categories were integrated into a cohesive framework. Key themes included the use of technology to support personalized instruction, promote social interaction, and reduce sensory overload for students with ASD (Zhou et al., 2020). The analysis continued until theoretical saturation was reached, indicating that no new significant insights were emerging from the data. To strengthen the credibility of the findings, member checking was conducted with selected participants, and peer debriefing was utilized for validation.

### Ethical Considerations

Ethical considerations were paramount in this study, particularly given its focus on children with autism and their educational experiences. Informed consent was obtained from the parents or guardians of the participants, ensuring that they understood the study's objectives and procedures, and provided their agreement for their child's involvement (Cohen et al., 2018). Furthermore, all participants were assured of their right to withdraw from the study at any time without facing any negative repercussions. The

research maintained confidentiality and anonymity by removing all personal identifiers from data collection and reporting (Cohen et al., 2018). Additionally, the research adhered to the principles of respect, beneficence, and justice, ensuring that the welfare of the children remained a priority throughout the study (Miller et al., 2015). The implementation of technology in the classroom was carefully designed to minimize any potential harm or discomfort for the students, with ongoing monitoring of their emotional and sensory responses.

### Trustworthiness

To ensure the trustworthiness of the study, several strategies were employed. Triangulation was implemented by gathering data from various sources, including observations, interviews, and performance assessments (Merriam, 2009). This approach allowed for a more holistic understanding of the impact of technology on student learning. Member checking was also utilized, allowing teachers to review and confirm the accuracy of the data collected from interviews (Cohen et al., 2018). Moreover, the grounded theory approach provided a systematic method for analyzing qualitative data, ensuring that the emerging themes were based on actual data rather than preconceived ideas (Charmaz, 2014). This methodological rigor, along with careful adherence to ethical considerations, significantly contributed to the overall trustworthiness of the findings.

### Findings

The results of the study revealed several important findings regarding the use of technology-assisted learning tools for children with Autism Spectrum Disorder (ASD) in a primary school setting in Eswatini. Data collected through observations, teacher interviews, and tracking student progress revealed a positive impact of digital tools on promoting individualized learning, enhancing communication, and improving social interactions.

*Increased Engagement:* The integration of interactive applications and adaptive learning software resulted in elevated levels of student engagement. Observations revealed that students were more attentive and actively involved in their learning activities while utilizing digital tools compared to conventional teaching methods. The visual and auditory cues provided by these technologies helped maintain student focus, particularly for those with sensory sensitivities, by

creating a controlled and structured learning environment.

**Improved Communication:** Technology-assisted learning tools, including digital communication platforms and speech therapy applications, significantly improved the communication skills of the children. Teacher interviews indicated that many students demonstrated clear progress in expressing themselves and interacting with others, both within the classroom and during social interactions.

One teacher had this to say:

*"I am surprised how the children have improved in expressing themselves and interacting with other children"*

These digital tools facilitated the practice and reinforcement of language skills in a manner that was less intimidating than traditional methods.

**Enhanced Social Interactions:** One of the most noteworthy outcomes was the improvement in social interactions among students. The utilization of virtual reality (VR) and augmented reality (AR) tools provided simulated social scenarios, allowing children to practice appropriate social responses in a low-pressure setting. Teachers observed that these tools helped students develop improved social awareness and navigate social situations with greater confidence.

**Mitigation of Sensory Overload:** Another significant finding was the effectiveness of technology in alleviating sensory overload, a common challenge for children with ASD. Digital tools enabled personalization of sensory inputs, contributing to a more comfortable learning environment.

One teacher remarked:

*"The students appeared less agitated and more relaxed when engaged with technology, which helps in the management of their sensory sensitivities".*

Another concurred:

*"You cannot believe how wonderful it is to see these children so relaxed, these are the results of assistive technology"*

**Academic Achievement:** Tracking student progress through performance assessments demonstrated measurable advancements in academic achievement, particularly in subjects such as mathematics and language. Technology-based learning offered personalized learning paths, enabling students to progress at their own pace. This customized approach allowed students to reach academic milestones that might not have been achievable through traditional instruction.

## Discussion

The findings of this study highlight the multifaceted influence of technology-assisted learning on students with Autism Spectrum Disorder (ASD) within the Eswatini educational context. By employing a triangulated research approach comprising direct classroom observations, teacher interviews, and performance assessments a comprehensive understanding has been developed of how digital tools enhance learning, communication, and social interaction among children with ASD. This mixed-method strategy facilitated in-depth insights, revealing both commonalities and differences across data sources.

A key observation was increased student engagement, notably evidenced through classroom observations where students showed sustained attention and enthusiasm while interacting with adaptive applications and educational software. Teachers' interviews supported these observations, attributing higher engagement levels to the interactive and personalized features of digital technologies. Performance data further indicated notable improvements in task completion and responsiveness over the course of the study. These results align with existing research, such as Miller et al. (2015), which highlights the importance of personalized and visually engaging technologies in capturing the attention of students with ASD. This study additionally provides context-specific evidence from Eswatini, illustrating how technology can address challenges posed by limited educational resources.

Regarding communication development, the integration of speech-generating applications and visual supports was associated with enhancements in both verbal and non-verbal communication skills. Teachers observed improvements in expressive abilities in low-pressure digital environments, a trend supported by assessment data tracking incremental progress in language use and social interactions. These findings corroborate previous studies (Kagohara et al., 2013; Mazurek et al., 2014) that emphasize how digital tools can reduce communication anxiety and facilitate structured practice, particularly for learners struggling with traditional communication methods. An important contribution of this research is the insight shared by educators on technology's role in enabling non-verbal communication, such as the use of picture-based apps for emotional expression a perspective that emerged prominently from interview data.



Another significant outcome was the enhancement of social interactions. All data sources reflected improvements in peer engagement, especially through the use of virtual reality (VR) and augmented reality (AR) platforms that simulate social situations. Classroom observations showed students who previously demonstrated social withdrawal initiating or responding to peer interactions during technology-supported activities. These findings extend current knowledge by demonstrating the potential of immersive tools in settings with limited resources, complementing existing work by Zhou et al. (2020) and Davis et al. (2018), while also emphasizing adaptations suitable to the local context.

A less explored but vital theme was the reduction of sensory overload. Teachers reported that technological tools enabling students to regulate sensory input, such as volume-adjustable headphones, visual timers, and calming applications, significantly reduced agitation and sensory distress. Observational data supported this, indicating improved focus and fewer signs of discomfort among students using such tools. While sensory management challenges in ASD are documented in literature (e.g., Miller et al., 2015), this study highlights how real-time, technology-mediated sensory regulation can be effectively implemented within classroom environments. This insight addresses a gap in existing research by illustrating practical applications in everyday settings.

In terms of academic achievement, technology-supported interventions contributed to steady and meaningful advances, especially in literacy and numeracy skills. Diverging from studies that focus solely on standardized test scores. This research's triangulated data including teacher perceptions and assessment results demonstrates consistent progress when digital tools are integrated with pedagogical guidance. These findings support Mazurek et al. (2014), who advocate for adaptive technologies in differentiated instruction, and emphasize the importance of combining technological and teacher-led approaches rather than relying exclusively on automation.

The findings of this study closely align with the principles of Constructivist Learning Theory and Universal Design for Learning (UDL), which served as the theoretical foundation for this research. Consistent with constructivist principles, technology enabled children with ASD to actively participate in personalized learning experiences, allowing them to construct knowledge through interaction with adaptive

digital tools tailored to their cognitive and sensory needs. This individualized approach supported deeper learning and contributed to improvements in communication and social skills, aligning with Vygotsky's emphasis on scaffolding and experiential learning within the learner's zone of proximal development. Additionally, the positive role of technology in reducing sensory overload and improving accessibility aligns with the UDL framework's emphasis on creating flexible learning environments that offer multiple means of representation and engagement. The digital platforms and AI-driven applications utilized in this study exemplify the UDL principle of accommodating learner variability, thereby fostering inclusion and meeting the diverse needs of children with ASD in ways often not achievable with traditional instructional methods. These theoretical foundations not only clarify how technology facilitated learning but also emphasize the importance of adopting learner-centered, adaptable educational strategies within special education contexts.

In conclusion, while this study affirms many findings from previous research, it also offers unique insights pertinent to resource-limited settings like Eswatini. Notably, the crucial role of teacher agency and adaptability in the successful deployment of digital tools emerged prominently through interview data, a factor less emphasized elsewhere. Additionally, the study highlights that context-specific, low-cost technological solutions can significantly impact student outcomes, suggesting that educational strategies should prioritize locally appropriate and sustainable options over high-end imported systems.

### Limitations of the Study

Although this study provides valuable insights into the utilization of technology-assisted learning for children with Autism Spectrum Disorder (ASD) in Eswatini, several limitations should be acknowledged. First, the purposive sampling approach was confined to a limited number of schools and educators already engaged with technology in their teaching practices. This sampling strategy may have introduced selection bias, as participants who are more receptive to or experienced with digital tools were more likely to participate. Consequently, the results may not be fully representative of all educational settings or teachers, particularly those with limited access to technological resources.

Second, despite the use of triangulation to enhance validity, the reliance on qualitative data collection methods such as semi-structured interviews and direct observations may introduce subjective bias. The perceptions of teachers and the interpretations of researchers could be influenced by personal or contextual factors, affecting the objectivity of the findings. The lack of a control group or experimental design restricts the ability to definitively attribute observed changes in student behavior or academic achievement solely to technology interventions. Finally, the contextual factors inherent to a resource-constrained environment such as infrastructural limitations, intermittent internet connectivity, and limited staff training may have influenced the implementation and efficacy of digital tools. These factors introduce variability that may differ significantly from more resource-rich educational contexts.

## Conclusion

This study presents strong evidence regarding the positive effects of technology-assisted learning on children with Autism Spectrum Disorder (ASD) in Eswatini. The integration of interactive applications, digital communication tools, and adaptive learning software in educational settings has been shown to significantly enhance engagement, communication, social interactions, and academic performance for children with ASD. The findings contribute to the growing body of research that supports the effectiveness of digital tools in special education, particularly in resource-constrained environments. By harnessing the capabilities of digital tools, educators can create more inclusive and individualized learning environments that address the unique needs of children with ASD, ultimately improving their engagement, communication, social interactions, and academic outcomes.

## Recommendations

Based on the findings, several recommendations for integrating technology into special education curricula in Eswatini and similar environments are proposed:

**Expansion of Digital Tools in Special Education:** Educational institutions should consider broadening the use of technology-assisted learning tools to provide more tailored educational experiences for students with ASD. Incorporating adaptive learning software, communication tools, and social skills training

platforms, such as virtual reality (VR) and augmented reality (AR), could further support diverse learning needs.

**Teacher Training and Support:** To fully realize the advantages of digital tools, it is imperative to offer teachers comprehensive training on effectively integrating these technologies into the classroom. This training should encompass not only the functional use of the tools but also strategies for customizing them to meet the specific needs of students with ASD (Miller et al., 2015). Establishing professional development programs will enhance teachers' technological competencies and ensure appropriate use of digital tools.

**Improving Access to Technology:** One of the challenges in implementing technology in special education within low-resource settings like Eswatini is ensuring access to necessary devices and internet connectivity. It is essential for governments and educational authorities to invest in the infrastructure required to support the utilization of digital tools, thereby increasing the reach and effectiveness of these interventions.

**Contextual Adaptation:** As with any educational initiative, adapting technology use to the local cultural and socioeconomic context is crucial. In Eswatini, where resources may be limited and the educational system may not be fully equipped for high-tech solutions, a phased and context-sensitive approach to technology adoption is recommended. Engaging local educators, parents, and communities in the planning and implementation process will help ensure that technology applications are both practical and culturally relevant.

Future research should aim to include larger and more diverse samples, encompassing both urban and rural schools, to improve the generalizability of findings. Longitudinal studies are recommended to monitor the sustained effects of technology integration on academic performance, communication skills, and social behavior among children with ASD. Incorporating quantitative measures such as standardized assessments or behavioral rating scales alongside qualitative data could enhance objectivity and strengthen the validity of results. Additionally, exploring models of teacher training and strategies for sustainable technology integration would be valuable, especially in low-resource settings like Eswatini. Further investigations into the perspectives of students and parents could provide a more comprehensive

understanding of how technology influences the broader learning environment for children with ASD.

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