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EFFECTIVENESS OF THE LINGOKIDS AI-POWERED EDUCATIONAL INTERVENTION ON ACADEMIC, BEHAVIORAL, AND AI ENGAGEMENT OF STUDENTS WITH AUTISM SPECTRUM DISORDER: A SINGLE-SUBJECT STUDY

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ABSTRACT

Children with Autism Spectrum Disorder (ASD) often have persistent challenges with the sustenance of academic and behavioral interest in traditional classroom contexts. Although the applications of artificial intelligence in education are claimed to offer adaptive and personalized learning opportunities, there is limited empirical research on how it affects the engagement levels to increase the school participation of students with ASD. The current study analyzed the effectiveness of the Lingokids AI-based learning intervention in improving the academic engagement, behavioral engagement, and AI engagement in a student with ASD with a single-subject experimental design. An experimental study based on a multiple-baseline across-behaviors study design was carried out on a single subject (a nine-year-old) with a mild case of ASD. Measurements of engagement were collected at the baseline, intervention, and maintenance (38 instructional days). In addition to the constant observation records, a Structured Observation-based Rating Scale for School Participation was conducted to assess the performance of the tasks in the Lingokids application. Academic engagement was measured by the performance on the Alphabet Tracing tasks, and the behavioral interaction was measured through the Calm Down Yoga exercise. AI interaction was measured throughout the interaction with AI-generated prompts and feedback from the participant. Visual analysis, effect-size analysis, inter-rater reliability, fidelity, and pre-posttest with confirmatory factor analysis were incorporated into the data analyses. The results indicated significant positive shifts in academic and behavioral engagement intervention with Lingokids. These findings suggusts that AI-based educational programs such as Lingokids can effectively play a supplementary role in school participation by engaging with students with ASD in motivational ways, with implications for inclusive classroom education and AI-driven educational design.

Keywords: *Artificial Intelligence, Lingokids, Academic engagement, Behavioral engagement, Autism Spectrum Disorder, School participation, Intervention, Single subject design*

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder whereby the individual has continual challenges in social interaction and communication, accompanied by limited, repetitive patterns of behavior, interests,

or activities (American Psychiatric Association [APA], 2013). These fundamental traits occur in the educational environment, such as difficulties in maintaining attention, academic participation, and behavioral control in the classroom, and hinder substantive involvement in the learning process. As a result, the improvement of Academic and behavioral activities is taking a central role as one of the goals of interventions focusing on ASD students.

Academic participation has been generally considered as one of the most important measures of academic success and performance among students with disabilities. It entails some observable behaviors, which include paying attention to instructional resources, responding to teacher cues, and engaging in given tasks (Fredricks, Blunden, and Paris, 2004). Frequently, sensory sensitivities, communication challenges, and a deficiency of intrinsic drive to conventional instructional patterns are among the students with autism spectrum disorder as factors that interfere with academic involvement (Odom et al., 2010). Similarly, behavioral engagement operationalized as on-task behavior, resistance to in-classroom expectations, and persistence in learning activities has a residual role in supporting instruction and favorable learning trajectories (Lane et al., 2006). Meanwhile, interventions that can be used to effectively support the academic as well as behavioral engagement of students with ASD are thus necessary to help them in an inclusive classroom environment.

Technology-enhanced and digitally mediated interventions are gaining attention in the field of special education as they offer an opportunity to individualize instruction, provide immediate feedback, and increase student motivation (Bouck, 2016; Knight, McKissick, and Saunders, 2013). Structured, visually abundant, and predictable online learning environments must have a positive effect on students with ASD, calming them down and promoting the process of long-term learning (Odom et al., 2015). Adaptive content, interactive, and game-based learning technologies, which combine these three aspects, are now being explored to improve engagement and learning in this population.

Educational artificial intelligence (AI) applications are a recent development in the field of educational technology that allow dynamic presentation of content according to the learners 'pace and performance. The support of AI in terms of task difficulty, immediate reinforcement, and maintaining consistent instructional routines can be offered by the systems and characteristics that can be adapted to suit the learning profile of many students with ASD (Holmes, Bialik, and Fadel, 2019). Although many empirical studies on AI in education have a positive impact on student engagement and self-regulated learning, studies on students with ASD remain limited and fragmented.

Lingokids is an application that delivers early education with its interactive and game-based approach, focusing on the basic academic skills by using AI. The platform combines adaptive learning pathways, visual aids, and instant feedback, especially applicable when working with students with ASD because they prefer structured and predictable learning conditions. Although it is increasingly being used in the educational life of students, there is a dearth of empirical research that can be used to establish the effectiveness of Lingokids as an intervention module in improving the academic and behavioral interests of students with ASD. The technology-based interventions for ASD focus on assistive communication-based interventions, video modeling, and computer-assisted instruction, rather than AI-based educational applications (Knight et al., 2013; Wong et al., 2015).

The other gap in the literature that is of critical concern is the methodological approaches that are used to assess the AI-based interventions on students with ASD. Single-subject experimental methods are commonly regarded as methodologically suitable for intervention studies in special education, as they allow repeated measurements, visual analysis, and functional relationship analysis on the individual level (Horner et al., 2005). SSEDs are especially effective in assessing engagement-related, context-dependent, and can be affected by changes in instructions. SSEDs can give strong evidence on the effectiveness and replicability of interventions

when augmented with the use of effect size indices and procedural fidelity measures. However, there is still a gap in the domain of high-quality single-subject research, which methodically investigates AI-driven educational interventions and their effectiveness on the studies of academic and behavioral engagement in students with ASD in real classroom environments.

The current research fills these gaps by assessing the effectiveness of the AI application Lingokids on academic and behavioral involvement of students with autism spectrum disorder based on a single-subject research design. Engagement-related behaviors and strict visual and quantitative analysis substantiate the current body of research concerning the use of technology to improve interventions in special education. To be more specific, it will attempt to offer empirical evidence as to whether an AI-based learning tool can potentially contribute to the active engagement of students in the learning processes to facilitate inclusive and efficient teaching methods with ASD learners.

Literature Review

2.1 Autism Spectrum Disorder and Educational Engagement

Autism spectrum disorder is a neurodevelopmental disorder that is marked by lifelong problems with social communication and interaction, and limited, repetitive patterns of behavior, interests, or activity with a significant degree of heterogeneity (American Psychiatric Association, 2022). In education, these features often manifest as the inability to focus attention together, social reciprocity, communication with peers, communication with a teacher, behavioral flexibility, and adaptability to the routine in a classroom. Also, a significant percentage of the students with ASD have sensory hypersensitivity, difficulties in attentional control, and overreaction to environmental stimuli, all of which may interfere with sustained participation in instructional tasks (May-Benson, T. A., & Koomar, J. A., 2010). This means that students with ASD always demonstrate lower measures of academic and behavioral activity as compared to their normally developing peers. The results of empirical classroom-based studies show that ASD students dedicate significantly less percentage of the instructional time to active participation in learning activities, have increased off-task behavior, reduced task persistence, and are less likely to comply with instructional requirements (Keen et al., 2016; Wong and Kasari, 2012). The concept of engagement is widely regarded as one of the essential preconditions of the learning process and presented as a proximal variable that demonstrates access to academic competencies and instructional advantages on the part of students. In particular, behavioral engagement has already identified as a strong predictor of Academic and classroom success, which mediates between the instructional input and learning outcomes (Fredricks et al., 2004).

2.2 Academic and Behavioral involvement of students with ASD

Academic engagement refers to the observable behaviors that express students' active involvement in the instructional process: on-task behavior, persistence in an activity, responsiveness to teacher instructions, and general classroom engagement (Fredricks et al., 2004; Zhang, Y., Zheng, T., & Liu, C., 2025). For students with autism spectrum disorder, academic engagement is the prompt initiation of tasks, concentrating on learning material, and evidence of effort in meeting instructional demands. Although these actions are often supported by cognitive and affective investment in learning processes, they can be weakened in students with ASD due to the difficulties in attentional control and differences in motivation to tasks (Zhang, Y., Zheng, T., & Liu, C., 2025).

Behavioral engagement involves compliance with classroom expectations, reduced cases of disruptive or non-task behavior, self-control, and positive interaction with instructional requirements (Fredricks et al., 2004; Wang, M. T., & Eccles, J. S., 2012). In practice, high behavioral involvement is manifested in terms of compliance with rules, cooperation with peers and instructors, and longer-term participation in behavioral patterns associated with tasks, which, in turn, leads to more effectively engaged classroom

behaviors. Empirical studies of ASD populations have repeatedly shown that there is a positive association between engagement, academic and behavioral, and more extensive measures of classroom participation. For example, an observational study indicates that ASD students often spend less than half of the time engaged with instruction, and on-task behavior is limited, with limited interaction with instructional content (Shapiro et al., 2015). Positive student-teacher relationships and instigated supports have been shown lead to engagement and social functioning (McCurdy, E. E., & Cole, C. L., 2014). Peer support and interventions planned to reduce off-task behavior and increase engagement in inclusive settings (McCurdy, E. E., & Cole, C. L., 2014).

2.3 Educational Interventions of ASD based on technology and AI.

The role of digital and technology-based interventions in special education has taken up a more central platform that allows new avenues of personalized teaching, interaction, and learning among students with ASD. Traditional teaching approaches often prove to be ineffective in meeting the highly heterogeneous needs of learners with ASD and the other hand, technology-based solutions, such as the interactive software, mobile apps, and online platforms, can be used to customize the learning experience to the personal strengths, preferences, and speed, which will result in a more inclusive and accessible environment (Smith, S. J., Mosher, M. A., & Lowrey, K. A., 2022). AI-based learning systems build on this paradigm by offering real-time adaptation, personalized feedback, and adjustments of content according to learner inputs, pacing, and performance with advanced machine-learning algorithms. Adaptive learning platforms, AI frequently assess students' performance and adjust the levels of difficulty, courses of instruction, and support to maximize engagement and learning (Melo-López, V. A. et al., 2023). The affordances of such systems, personalization, adaptivity, immediate feedback, and predictability, are particularly salient to students with ASD as they are responsive to their learning profile, alleviate cognitive overload, and maintain their engagement by adjusting the instructional strategy to individual requirements. Systematic reviews show that AI-based interventions can improve motivation, attention, and enable students with ASD to engage in a task more effectively, which suggests the use of individualized AI-based instructional support as a more efficient means to resolve the issue of core engagement compared to traditional ones (Hussein, E., Hussein, M., & Al-Hendawi, M., 2025; Li, G., Zarei, M. A., Alibakhshi, G., & Labbafi, A., 2024).

2.4 Empirical Studies on App-Based and AI-Powered Interventions Targeting Engagement

The effect of experimental interventions based on apps and AI on the engagement outcomes of students with ASD was studied in empirical research. Meta-analytic research indicates that computer- and tablet-based interventions, namely the digital ones, have medium to large overall effects on salient developmental and social outcomes. Interactive applications especially prove to be promising in terms of improvement of engagement and communicative behavior in ASD populations (Xu, F. et al., 2024). Mobile applications that guide instructional techniques, video modeling, and interactive tasks have shown considerable changes in the deliberate communication and receptive language abilities, demonstrating an increased level of academic engagement in specific areas (Leung, P. W. S. et al., 2021). The two main elements of academic engagement are immediate feedback and interactive material, which maintain attention and task engagement. In addition to mobile apps, AI-enhanced augmented reality and adaptive learning platforms have recorded remarkable enhancements in engagement and behavioral outcomes. The evaluation of augmented reality platforms with AI features brought better engagement scores, good social interaction, and behavioral engagement among learners with ASD, which implies that immersive and customized technologies could contribute to longer-term engagement in activities during the learning process (Elegbeleye et al., 2025). Longitudinal

observational study of AI platforms also indicates improved development and social outcome measures with prolonged use, showing interest, minimal disruptive behavior, and more developed developmental outcome measures, which are also correlated with behavioral involvement (Atturu et al., 2025).

2.5 Lingokids as an Artificial Intelligence Educational Intervention

Lingokids is an early learning platform designed for interactive play and systematic learning of a unique Playlearning™ approach, which makes learning content enjoyable and developmentally significant (Lingokids Help Center, 2025). The platform gives an inclusive collection of game-based activities, narratives, movies, and workouts that introduce the theoretical spheres of foundational learning, including literacy, numeracy, science, and language, structured into flexible learning journeys that react to how each student operates (Marketplace Daidu, 2025; Lingokids Help Center, 2025). Gamified features of Lingokids: rewards, levels, and interactive challenges to maintain motivation and help learners master skills with constant practice, with instant feedback. Its curriculum is defined by principles of child-centered learning, which values motivational engineering practices, adaptive sequencing of personalization, and balanced instructional stretching to keep learners in the optimal challenge zone (Lingokids Methodology and Curriculum, 2025). These design characteristics are correlated with engagement-promoting procedures reported in educational psychology: positive reinforcement to foster intrinsic motivation; adaptive pacing to accommodate learner differences in learning pace; the self-pacing process enables learners to be autonomous and have learner control, which is related to increasing persistence in completing tasks and enduring on-task attention. Further, the research on Lingokids shows that the foundational skills of the system, including literacy and socio-emotional capabilities, have shown measurable improvement in the wake of its systematic use, which is why its interactive and adaptive structure can cause cognitive and behavioral aspects of engagement (University of California Davis efficacy results, 2024; Lingokids Research, 2025). The personalization and responsiveness inherent in Lingokids provide a conceptual and practical foundation for its effectiveness in promoting academic and behavioral interest, especially for students who are enthusiasts of orderly, inspiring, and visual learning contexts.

2.6 Research Gaps and Reasons behind the Current Study.

Although there is increasing attention to the use of technology-based learning interventions to support the education of learners with ASD, empirical findings identifying and assessing the use of platforms like Lingokids among learners with ASD are scarce. As of now, the majority of the studies on AI-based interventions helping to treat ASD have focused on social robots, AR and assistive technologies helping to engage in social interaction or even sense emotions, but not on academic interaction or learning engagement; not many studies have incorporated educational content and engagement outcomes (Mukhtarkyzy et al., 2025). Additionally, the literature reviews indicate that the number of studies utilizing a rigorous experimental design is extremely low. Instead, they rely on a group-based comparison rather than an individual-level control (Paglialunga, A., & Melogno, S., 2025). This is especially noticeable in the field of single-subject experimental studies, which investigate the outcomes of engagement in single-subject-based research. This methodological tradition in special education allowed in-depth analysis of individual response patterns over time and is also best suited to heterogeneous ASD respondent profiles (Horner et al., 2005).

Problem Statement

Students with Autism Spectrum Disorder (ASD) are often faced with the challenge of maintaining an academic interest and classroom behavioral control, thus limiting their involvement and access to the content of the curriculum. The lack of attention, motivation, and self-regulation leads to a decrease in on-task performance and an increase in off-task or disruptive behaviors that may hinder

the learning process even in inclusive classrooms. The recent development in artificial intelligence (AI) has produced adaptive educational tools to personalize the learning process and provide immediate feedback and create structured learning settings, which are especially sensitive to the needs of students with ASD in instruction. However, empirical data on the effectiveness of AI-based interventions in improving academic and behavioral engagement remains limited. Existing research has largely focused on the concept of communication, social interaction, or achievement outcomes, and often uses group designs that conceal individual differences.

To fill this gap, the current research employs a single-subject experimental design to evaluate the efficacy of the Lingokids AI-based intervention on academic achievement, behavioral involvement, and AI involvement, thereby capturing an individualized pattern of response over time.

Objectives of the Study

The main aims of the present research were to:

1. Examine the impact of Lingokids AI-based intervention on the academic engagement of students with autism spectrum disorder.
2. Identify the degree to which the Lingokids intervention affects the behavioral engagements in classroom learning activities.
3. Measure the AI engagement of the students with the adaptive features of the Lingokids application.

Research Questions of the Study

1. What is the impact of Lingokids AI-based intervention on the academic engagement of students with autism spectrum disorder?
2. What is the degree to which the Lingokids intervention affects the behavioral engagements in classroom learning activities?
3. How does the AI engagement of the students with the adaptive features of the Lingokids application?

Significance of the Study

The proposed study contributes significantly to the theory, methodology, and practice of special education as it will help broaden the knowledge about AI-based educational interventions that can be adopted by people with ASD. Theoretically, it applies an existing engagement framework by theorizing AI engagement as a discrete construct in relation to academic and behavioral engagement, providing a more precise explanation of the interaction mechanisms between students with ASD and adaptive, intelligent learning systems. The experimental design, single-subject experimental design, systematic visual analysis, effect size indices, and previously tested measures of engagement, methodologically, meet the demands of functionally sensitive research, which can be used to capture patterns of responses of individuals. In practice, the results give evidence-based support on how Lingokids can be used as an AI-aided instructional tool and task-relevant activities to improve academic interactions and behavioral control in teachers and professionals. Policy-wise and research-wise, the study informs the decision-making regarding the integration of AI-based technologies in inclusive classrooms and the necessity of additional research investigating the engagement of AI as one of the most important outcomes for learners with ASD.

Target Constructs and Operational Definitions

There were three engagement-related constructs as dependent variables.

Academic Engagement

Academic engagement was based on observable participation of a student in learning tasks, which include sustained attention, correct task completion, and attentiveness to instructional cues.

Behavioral Engagement

Behavioral engagement refers to classroom behaviors, including compliance with instructions of tasks, continued participation in activities, and minimal disruptive behavior during learning activities.

AI Engagement

The definition of AI engagement assumed active use of the Lingokids application by the learner, namely, the ability to start tasks, react to prompts

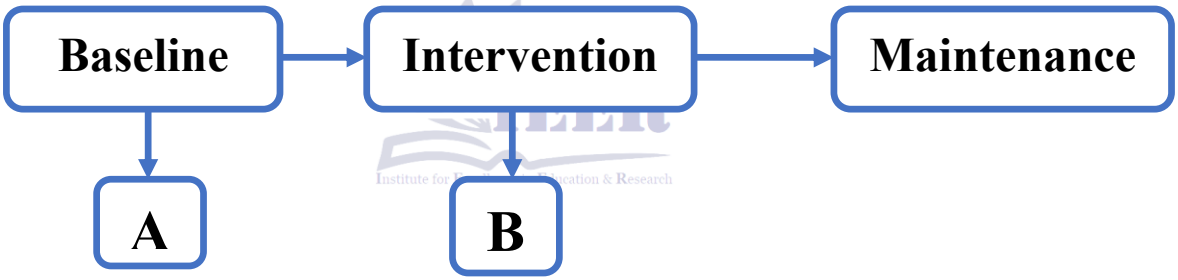
created by an AI and remain engaged in adaptive digital material.

Research Design

This paper utilized a Single Subject Experimental Design (SSED) with a multiple-baseline across behaviors design to investigate the efficacy of the Lingokids AI-based educational tool in the academic engagement, behavioral engagement, and artificial intelligence (AI) engagement of students with Autism Spectrum Disorder (ASD). The single-subject intervention study is especially applicable in special education, because it is sensitive to individual variance and allows revealing the working relationships between interventions and the identified behavioral change (Horner et al., 2005; Kratochwill et al., 2013).

A multiple-baseline design was chosen to allow the staggered implementation of the intervention in target engagement behaviors, which would help to enhance causal inference and eliminate threats to internal validity, including maturation, history, and external classroom events. The design helps attribute observed effects to the Lingokids intervention by showing that behavioral changes occurred only with the introduction of the intervention and at different time points at which the changes occurred in each behavior.

Figure 1 illustrates the general design of the AB single-subject experimental design with maintenance phase, which includes Baseline (A), Intervention (B), and Maintenance. The engagement indicators were followed in a preliminary period where no intervention based on AI was provided. Lingokids activities were subsequently introduced during a structured intervention stage, and a maintenance stage was later measured after the effects of the interventions had stabilized. The research design was adapted from Morgan and Morgan (2008) and Kazdin (2011).



***Adapted from* Morgan and Morgan (2008), Single-Case Research Methods for the Behavioral and Health Sciences, *and* Kazdin (2011), Single-Case Research Designs: Methods for Clinical and Applied Settings**

Participants and Setting

The sample was a group of students with the formal diagnosis of Autism Spectrum Disorder, which was confirmed through school records and the professional evaluation conducted according to the DSM-5 criteria (American Psychiatric Association, 2013). The participants were registered in an ordinary special education school and their failures to engage academically and behaviorally were persistent before the intervention

The intervention was carried out in a natural classroom environment and within the usual learning time so as to assure the ecological validity and as a way of limiting the interference with the teaching practices. The data on engagement was gathered in normal classroom activities to mirror the true engagement patterns. Due to space limitations in the journal, the article provides the graphical information of a single representative participant. Similar interaction patterns were also found in other participants and mentioned in detail in doctoral theses.

Participant Characteristics

Participant	Age	Section	Gender	CARS Score	ASD Severity	Strengths	Challenges
Student 1	9	Junior	Male	32.0	Mild ASD	Visual learning, receptive language	Limited expressive communication, inconsistent behavioral engagement, and minimal group participation

Target Behaviors and Multiple Baseline Structure

Three engagement-related target behaviors were checked, namely Academic Engagement (AE), Behavioral Engagement (BE), and Artificial Intelligence Engagement (AIE). The multiple-baseline across behaviors design was based on the staggered introduction of the intervention to academic and behavioral engagement, whereas AI engagement was tracked throughout all the stages.

Indicators	Day 1–7	Day 8–13	Day 14–19	Day 20–25	Day 26–31	Day 32–38
Academic Engagement	Baseline	Intervention	Intervention	Intervention	Intervention	Follow-Up
Behavioral Engagement	Baseline	Baseline	Baseline	Intervention	Intervention	Follow-Up
AI Engagement	Recorded Daily	Recorded Daily	Recorded Daily	Recorded Daily	Recorded Daily	Recorded Daily

This sequencing allowed for differential demonstration of intervention effects across behaviors while maintaining methodological rigor consistent with single-case design standards.

Task-Specific Intervention Activities

Each target behavior was operationalized through specific Lingokids instructional activities, selected to align with the theoretical dimensions of engagement.

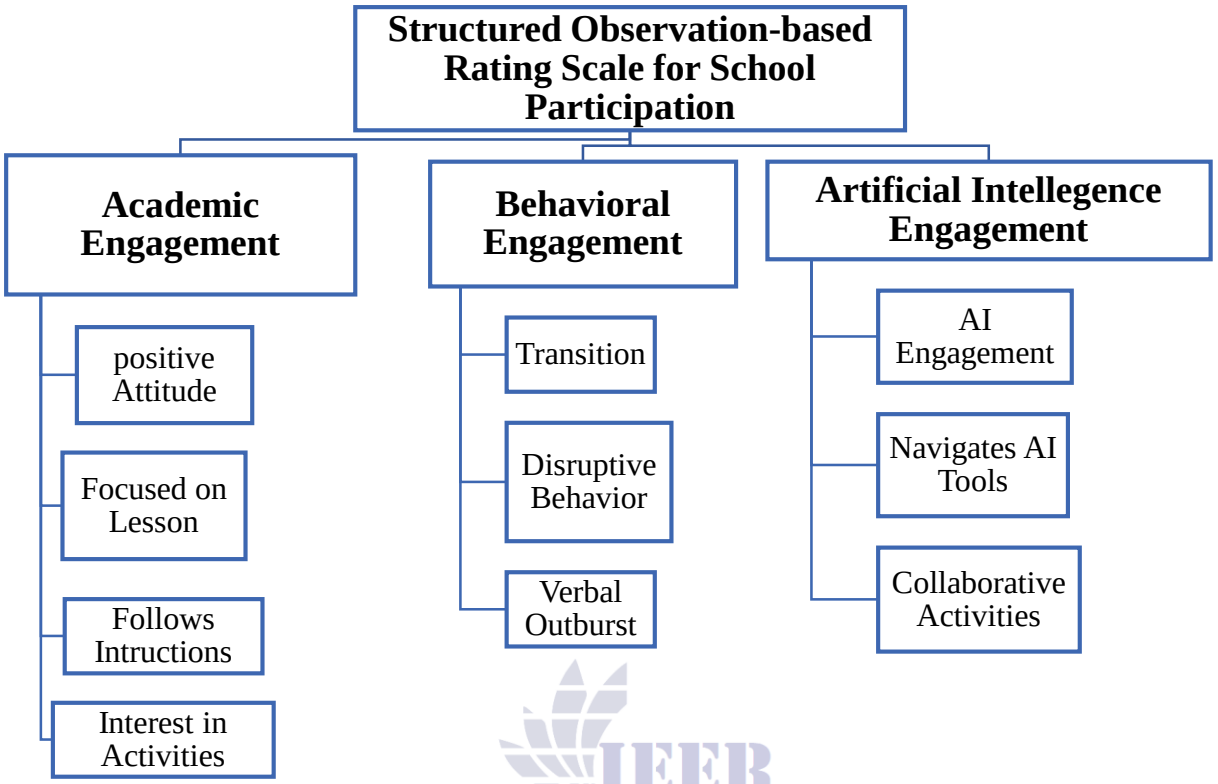
Target Behavior	Lingokids Tasks
Academic Engagement (AE)	Alphabet Tracing
Behavioral Engagement (BE)	Calm Down Yoga
Artificial Intelligence Engagement (AIE)	Continuous interaction with AI-generated prompts, feedback, and adaptive task progression

The academic attention was a subject of academic involvement, characterized by long-term attention, precision in task performance, and responsiveness to instructions. Behavioral involvement was based on self-control, adherence, and perseverance with the organized calming procedures. The use of AI also depicted the interaction patterns with adaptive AI elements offered on the Lingokids platform.

Structured Observation-based Rating Scale for School Participation Framework

A school participation rating scale was made in a structured form of observation to supplement the session-by-session observational data that are inherent to the single-subject design. This framework was based on student engagement and participation models (Reschly and Christenson, 2022; Imms et al., 2017) and on recent AI-mediated engagements (Ma and Chen, 2024). The framework was also created to be adaptable to

single-subject approach to interpreting results of engagement at the construct level.



Adapted from *Handbook of Research on Student Engagement* (Reschly & Christenson, 2022); *Participation, Both a Means and an End: A Conceptual Analysis of Processes and Outcomes in Childhood Disability* (Imms et al., 2017); and *AI-Empowered Applications Effects on EFL Learners' Engagement in the Classroom and Academic Procrastination* (Ma & Chen, 2024).

Measurement Validation and Reliability

A panel of five professionals from diverse fields of knowledge engaged in the Structured Observation-based Rating Scale for School Participation for content validity. The panel consisted of: (a) senior psychologist specializing in assessment and intervention of students with Autism Spectrum Disorder (ASD) who offered information on the behavioral and cognitive components of the disorder; (b) senior special education teacher with long time experience in classroom who tested the practical clarity and applicability of the instruments; (c) two specialists in ASD related research and inclusive education who tested the theoretical consistency, scientific integrity, and the suitability of the instruments; (d) an expert in artificial intelligence and educational technology who was able to determine the capability of the instruments to capture meaningful interactions among students. According to their responses, the researcher made additional adjustments to clarify the language, structure, and relevance of the content for the content validity of the scale. Also, it was confirmed through Confirmatory Factor Analysis (CFA) of the engagement measures. Fit to the model was also excellent (Chi-square = 109, 104, p =. 002; CFI =. 996; TLI =. 994; RMSEA=. 022, 90% confidence interval [. 004, 055]). There were strong to very strong standardized factor loadings in all indicators, indicative of factorial integrity of the measurement model.

Cronbach's alpha was used to evaluate the internal consistency reliability and delivered excellent reliability for all the constructs.

Construct	Cronbach's Alpha	Number of Items	Interpretation
Behavioral Engagement	0.955	3	Excellent
Academic Engagement	0.907	4	Excellent
AI Engagement	0.897	3	Excellent

Integration with Phase Structure

The results of the Structured Observation-based Rating Scale for School Participation were applied to session-by-session observational data, which were recorded during the baseline, intervention, and maintenance phases. Academic engagement also underwent the intervention phase at an earlier stage, and then behavioral engagement received delayed intervention, which was consistent with the multiple-baseline across behaviors design. To capture ongoing interactive patterns with the AI-based system, the use of AI was monitored daily at each phase. The integrated methodology helped in triangulating the visual analysis, effect-size estimation and construct-level change, which increased the internal validity without compromising logical coherence of single-subject research.

Data Collection Procedures

Engagement data were collected during each session using the Structured Observation-based Rating Scale for School Participation. Academic and behavioral involvement was noted on a session-by-session basis during the baseline period, intervention, and maintenance phase. The AI engagement was observed daily in all sessions.

Fidelity to Treatment Monitoring Plan

Fidelity treatment was also adhered to the intervention provided as planned (Borrelli, 2011). Fidelity was assessed in terms of the NIH Behavior Change Consortium framework, which included five domains: study design, provider training, treatment delivery, participant receipt, and enactment (Bellg et al., 2004).

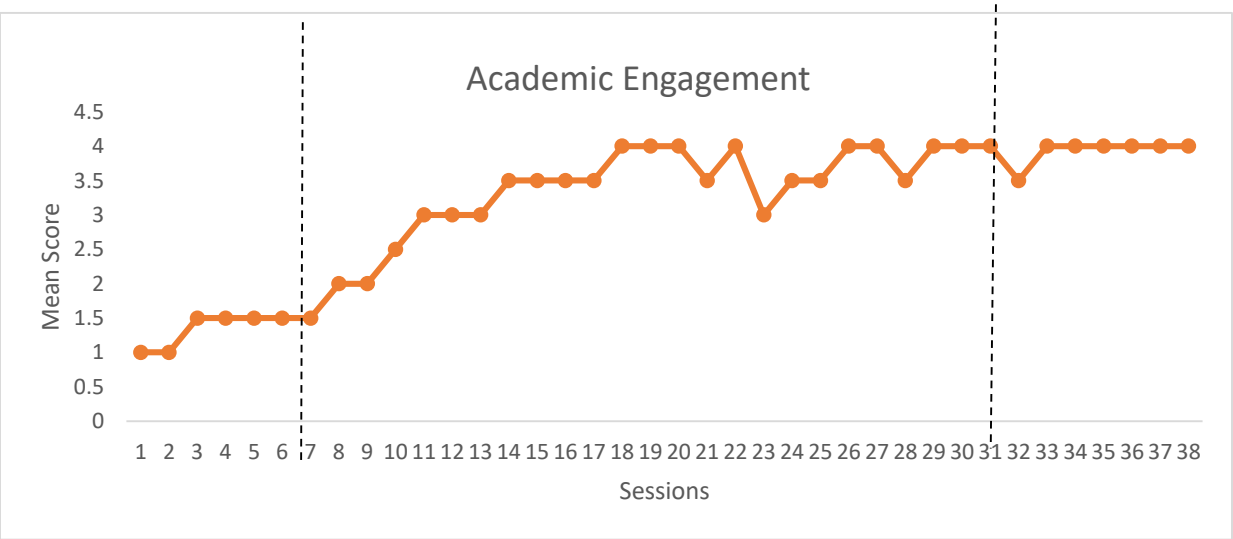
The experiment was conducted in baseline (Day 1-7), intervention (Day 8-31), and maintenance (Day 32-38). Fidelity monitoring was also applied only to the intervention and maintenance. The teachers completed the checklist at the conclusion of each session. The calculation of fidelity percentages was implemented as items/ total items x 100, with≥90% adherence as the limit.

Inter-Rater Reliability

In order to create observational reliability, a second trained observer independently coded a section of intervention sessions, and Cohen Kappa (k): was computed to determine inter-rater reliability (Landis and Koch, 1977).

Data Analysis

Academic Engagement



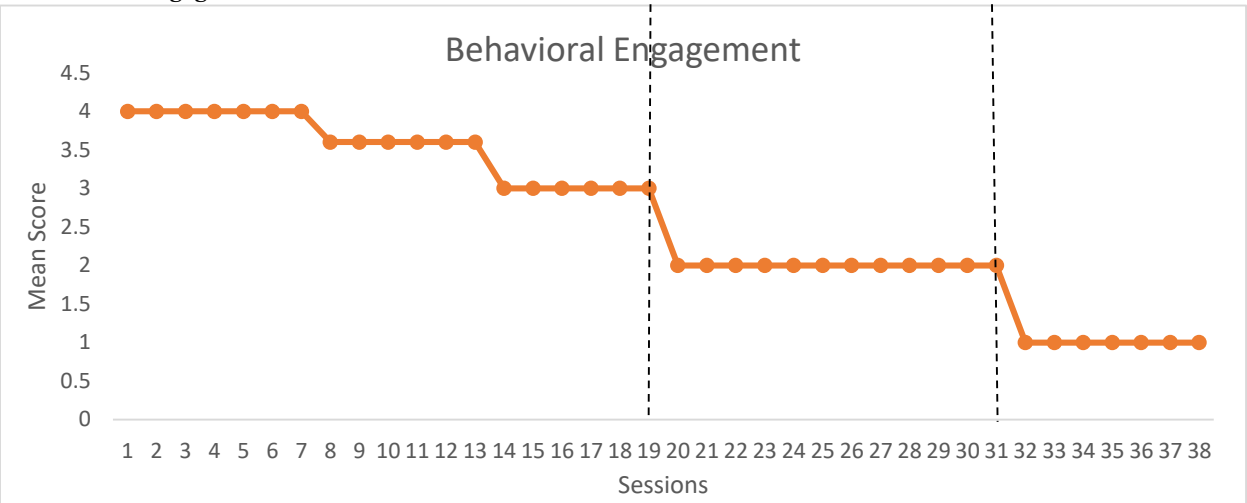
The graphical evaluation of the academic interest of Student 1 shows that there is a positive, steady increase in academic involvement throughout the stages of the interventions, which alters the aspect of the long-term learning engagement, and academic responsiveness. The academic engagement during the baseline period (Sessions 1-7) was consistently low and at the same time the engagement was between 1.0 and 1.5. The trend indicates a low level of academic engagement, lack of concentration on tasks, and low participation in organized learning activities, which reflects the inability to remain attentive and stable in classroom performance before the introduction of the intervention. The effects of the intervention were evident during the intervention phase (Sessions 8-31) when there was a strong and steady upward trend in academic engagement which indicated a significant improvement compared with the conditions at baseline.. The scores of the AE increased at a steady pace as 2.0 changed to 4.0, indicating a substantial improvement in task involvement, on-task behavior, and proactive reaction to instructions. The sustained high level of engagement during this phase suggests that the AI-based intervention contributed to the improvement in academic activity, motivation, and attention throughout the learning activities. The academic engagement level remained high between 3.5 and 4.0 during the maintenance stage (Sessions 32-38). Such stability implies a high maintenance effect, that the behavioral and attentional gains achieved during the intervention were maintained even after withdrawal. The student continued to exhibit an independent involvement and active performance in the school, which underscores the sustainability of the intervention effects and generalization. Overall, the student has a significant and persistent improvement in academic engagement. The student had low engagement at baseline, and he actively engaged and independently both during and after the intervention. This trend highlights that the intervention process has been effective in increasing academic motivation and learning readiness.

Tau-U Effect Sizes for Academic Engagement

Phase Comparison	Tau	Z	P-Value	CI 95%	Effect Size Interpretation
Baseline → Intervention	1.00	5.61	0.00	[0.65,1.00]	Very Large Effect
Intervention → Maintenance	0.52	2.93	0.00	[0.17, .87]	Moderate Effect

The Tau-U effect size analysis of the graphical patterns of Academic Engagement shows a statistically significant and meaningful improvement after the AI-powered intervention. The Baseline-Intervention phase comparison presented a Tau-U value of 1.00 ($Z = 5.61$, $p < .001$, 95% CI [0.65, 1.00]), which is high. This ideal positive value indicates the existence of steady and high academic engagement after the intervention. The scale of this effect means that most data points throughout the intervention period were higher than those in the baseline phase, indicating that the intervention induced a strong and immediate increase in task attention, responsiveness to academic work, and sustained engagement. A moderate effect size, Tau-U value of 0.52 ($Z = 2.93$, $p < .001$, 95% CI [0.17, 0.87]) associated with the Intervention-maintenance comparison. This observation suggests that the subject continued a fairly high level of engagement following the removal of the intervention. The overall rate of improvement was slightly decreased. However, this outcome was statistically significant and in the positive direction, showing the positive effects of the intervention on the follow-up stage. It proves the preservation of behaviors and attention. In general, the Tau-U findings indicate that Student has a very high and statistically significant increase in academic engagement as a result of the intervention, and a moderate but stable effect on academic engagement following intervention. The results support the appropriateness and efficacy of AI-mediated learning-teaching interventions in improving learning interests in students with ASD.

Behavioral Engagement



(Lingokids), which implies the interactive and structured learning experience enabled the participant to have more control over their behavior, better concentration, and engagement. During the follow-up (Sessions32-38), the scores remained at 1.0, which is an additional positive change in behavioral engagement and a few disruptive incidents despite the active intervention stage being over. This unchangeable post-intervention performance with successful generalization and maintenance of positive behavioral change over the time period is presumably supported by internalized routines and teacher-mediated reinforcement. Overall, the graphical trend shows that the problem behaviors decreased gradually and significantly in all levels, and it is possible to say that the intervention based on AI is effective and sustainable to improve the behavioral outcomes of the participant.

Tau-U Effect Sizes for Behavioral Engagement

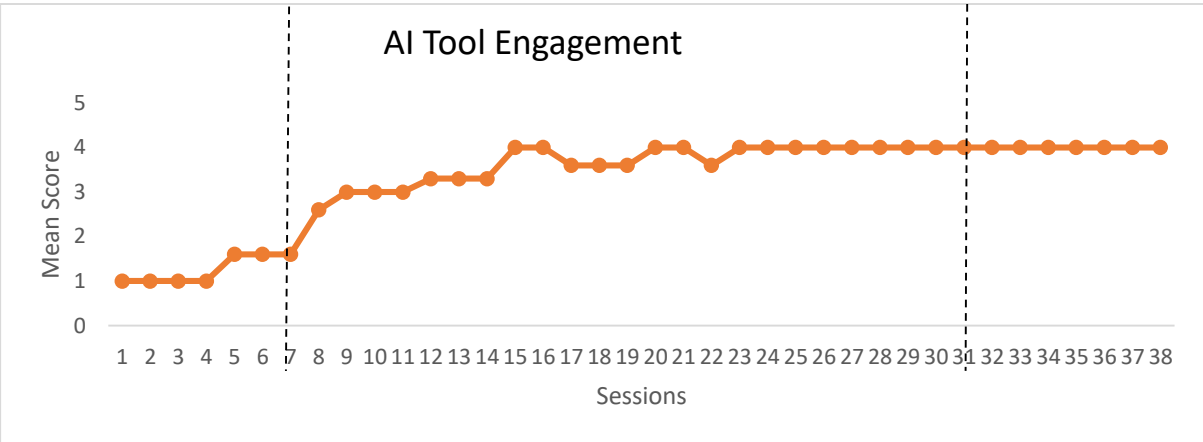
(Reverse coded: lower scores indicate improved behavior)

Phase Comparison	Tau-U	Z	p-Value	95% CI	Effect Size Interpretation
Baseline → Intervention	−1.0000	−6.54	< .001	[−1.00, −0.70]	Very Large Reduction in Disruptive Behavior
Intervention → Follow-Up	−1.0000	−5.02	< .001	[−1.00, −0.61]	Sustained Very Large Reduction

The analysis of Student 1 using the Tau-U showed very high and statistically significant increases in behavioral engagement in both stages of the study. The Baseline and Intervention comparison of Tau-U −1.0000 (Z = −6.54, p < .001, 95% CI [−1.00, −0.70]) that corresponds to a very high decrease in disruptive behaviors after the implementation of the Lingokids AI-based intervention. This ideal negative effect size indicates that the data points during the intervention stage had fewer behavioral challenges than in the baseline. Likewise, in the Intervention-Maintenance comparison, a Tau-U value of −1.0000 (Z = −5.02, p < .001, 95% CI [−1.00, −0.61]) also indicated a very high long-term reduction in undesirable behaviors. The meaning of this finding is that the behavioral gains are not only maintained, but entirely stabilized over time, the maintenance and generalization

effects are high in spite of the fact that the AI tool is still used. Generally, these findings support the usefulness and sustainability of the AI-driven intervention in facilitating self-regulation, attentional control, and positive classroom behavior in Student 1, as it is consistent with the existing evidence on the long-term behavioral effects of AI-supported learning in students with ASD

AI Tool Engagement



In the Baseline Phase (Sessions 1-7), the student had a very low and constant level of engagement (ranging between 1.0 and 1.6), which indicated that the student had poor interaction with the AI-based activities and low interest or familiarity with the tool. The- low baseline- is a consistent one, and it shows that the first exposure did not cause a strong motivation or habitual pattern of use. A significant positive trend appeared with the Intervention Phase (Sessions 8-31). The level of engagement rose significantly during the early intervention sessions, from 2.6 to 3.3 and eventually 4.0, which indicates that the student gained confidence and independence in the AI tool in the process. The small variations (e.g., between 3.3 and 3.6) in the middle of the intervention can be attributed to the instances of adaptation or variation in novelty; however, the general trend was considerably positive. The engagement stabilized at 4.0, with high and regular participation in AI-assisted learning activities, at the end of the intervention. Maintenance Phase (Sessions 32-38) had the same highest score of 4.0, which suggests that the student managed to remain highly engaged despite the direct intervention support being removed. In general, the graphic data show that engagement in AI tools during the baseline and maintenance phases was significantly and consistently increased, and that the intervention resulted not only in developing more positive initial interactions but also in creating the following interaction-based patterns with the AI learning tool.

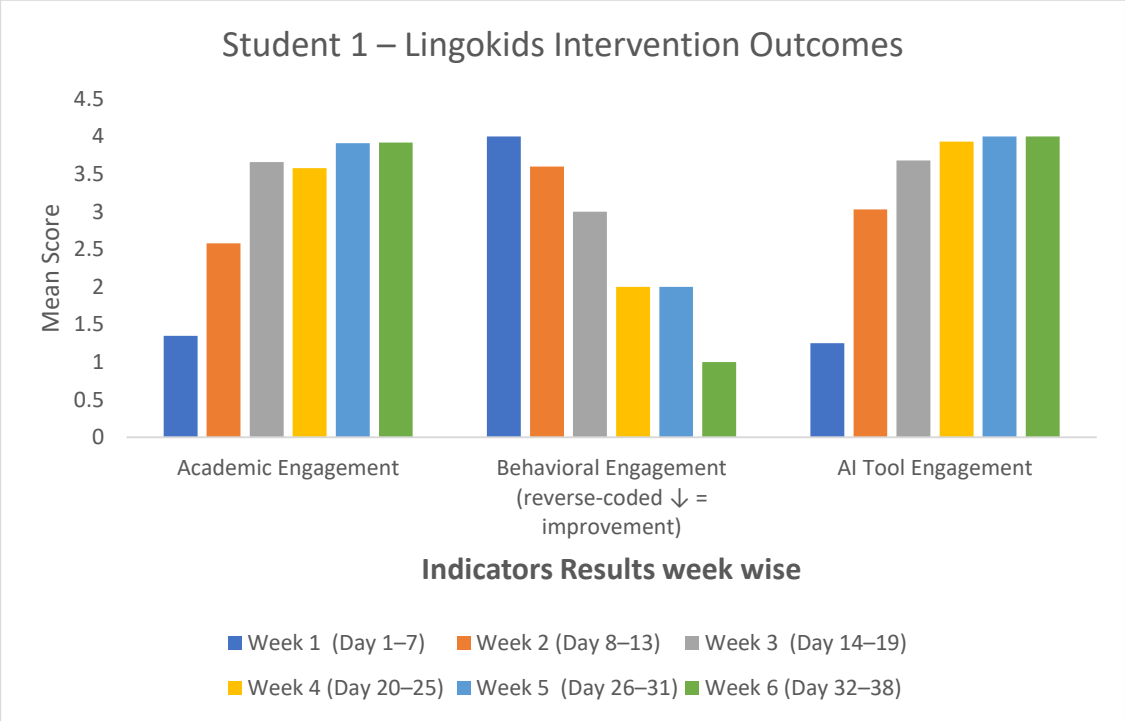
Tau-U Effect Sizes for AI Engagement

Phase Comparison	Tau-U	Z	p-Value	95% CI	Effect Size Interpretation
Baseline → Intervention	1.00	5.61	< .001	[0.65, 1.00]	Very Large Effect
Intervention → Follow-Up	0.46	2.57	.010	[0.11, 0.81]	Moderate Effect

Interpretation of Tau-U Results

The Baseline to Intervention phase of AI Engagement had a Tau-U value of 1.00 (Z = 5.61, p < .001; 95% CI [0.65, 1.00]. This result suggests that there is a statistically significant and full positive shift in AI engagements after Lingokids was introduced. The enormous effect size indicates that the student demonstrates a high level of active interaction with the AI platform in progressive responsiveness, task completion, and interest in the digital learning sessions. In the case of the Intervention to Maintenance, the Tau-U value declined to 0.46 (Z = 2.57, p = .010; 95% CI [0.11, 0.81]), which is a moderate effect. This indicates that AI engagement was noted as high throughout the intervention. The student continued meaningful and statistically significant engagement behaviors in maintenance. The average of the effect indicates a partial saving of the motivation to learn digitally and familiarity with the AI-based learning tools. It highlights the long-term influence of Lingokids on the autonomous learning behavior.

Lingokids Intervention Outcomes



The 6-week Lingokids intervention produced definite and systematic progress in all the measured parameters of the student, and shows immediate responsiveness as well as engagement in the process over time. The academic engagement showed a significant increasing pattern, with the mean of the Week 1 baseline at 1.35 rising to 3.92 in Week 6. Weeks 1 to 3 showed the strongest gains, which suggests a high intervention effect at the beginning of the intervention, followed by a short-lived and low fluctuation in Week 4. This was further accompanied by Weeks 5 and 6 stabilizing at a high level, which implies that they were able to consolidate academic engagement skills but not momentary novelty effects. All in all, this trend indicates a significant improvement in students' attendance, engagement in, and persistence in academic activities by the Lingokids platform.

The reverse-coded behavioral engagement, in which high scores indicate improvement, portrayed a gradual, monotonic decrease during the intervention period, with the highest mark of 4.00 in Week 1 and the lowest mark of 1.00 in Week 6, and this represents a steady positive tendency in behavior management, reduction in

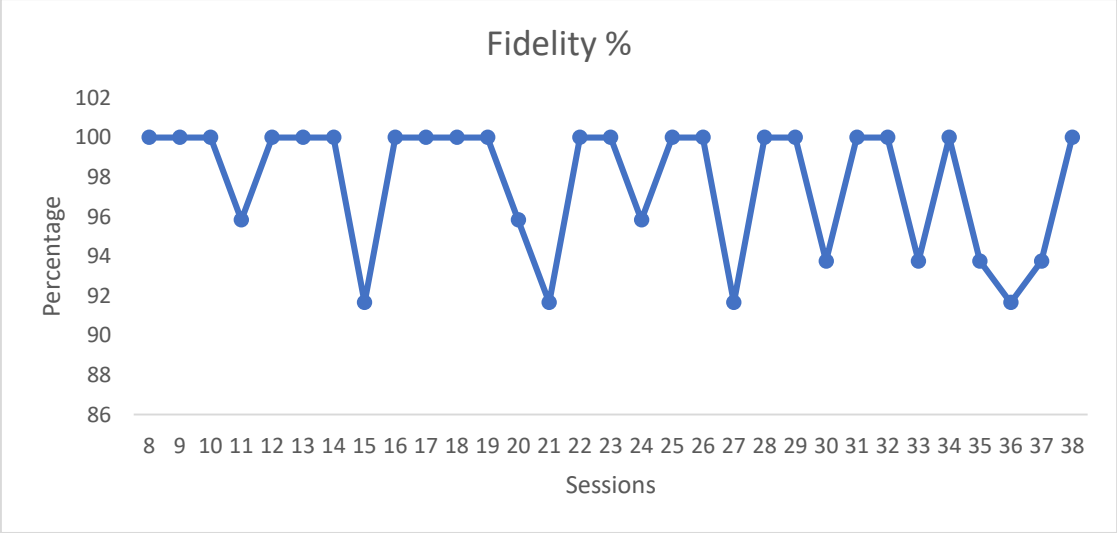
off-task behavior, and enhancement of attention to instructional demands. The lack of variability in the last few weeks is also indicative of the fact that behavioral gains were retained by the end of the week. This pattern is rather indicative that the Lingokids intervention not only helps in academic engagement, but also enhances behavioral engagement in the learning environment.

The use of AI tools showed an upward and sustained trajectory; tool usage significantly increased in Week 1 (1.25) and, almost, stabilized at the highest point of 4.00 (Week 5 and 6). This trend means that the AI-based learning setting can be familiarized with and accepted promptly, and the level of interaction will be high consistently. The initial high engagement indicates that Lingokids was mature and intrinsically engaging to students, and the subsequent plateau was indicative of long-term usability and no lack of interest over time.

Student 1 — Treatment Fidelity (Lingokids)

Session #	Fidelity Score (/12)	Fidelity %	Criterion Met?	Notes (Deviations only)
8	12	100	Yes	—
9	12	100	Yes	—
10	12	100	Yes	—
11	11.5	95.83	Yes	Warm-up shortened
12	12	100	Yes	—
13	12	100	Yes	—
14	12	100	Yes	—
15	11	91.66	No	Prompting step missed
16	12	100	Yes	—
17	12	100	Yes	—
18	12	100	Yes	—
19	12	100	Yes	—
20	11.5	95.83	Yes	Partial comprehension check
21	11	91.66	No	Delayed login
22	12	100	Yes	—
23	12	100	Yes	—
24	11.5	95.83	Yes	Engagement monitoring partial
25	12	100	Yes	—
26	12	100	Yes	—
27	11	91.66	No	Session closure omitted
28	12	100	Yes	—
29	12	100	Yes	—
30	11.5	93.75	Yes	Prompting partial
31	12	100	Yes	—
32	12	100	Yes	—
33	11.5	93.75	Yes	Warm-up shortened
34	12	100	Yes	—

35	11.5	93.75	Yes	Comprehension check partial
36	11	91.66	No	Internet delay in preparation
37	11.5	93.75	Yes	Session closure shortened
38	12	100	Yes	–



The student received treatment fidelity monitoring in Session 8-31 in a 12-item procedural checklist, where the percentage of fidelity was calculated as (implemented items/total items) x 100. An adherence threshold of ≥85% was set as the level of acceptable procedure reliability, as advised in single-subject and school-based studies (Horner et al., 2005; Lane et al., 2007). The obtained fidelity scores were 91.66% to 100%, with a mean fidelity of 97%, indicating that the fidelity implementation was high. Minor procedural deviations, e.g., abridged warm-up activities, incomplete comprehension checks, or even session delays, were reported but did not compromise the overall treatment integrity. The fidelity of the Lingokids intervention is consistently high as the intervention was administered as planned, establishing the internal validity of intervention outcomes.

Inter Rater Reliability

Academic Engagement

Academic Engagement	k	SE	Z	p	95% CI		% Agreement
					Lower	Upper	
Measure of Agreement	Kappa .773	.125	4.778	.000	0.52	1.01	92.10

Inter-rater reliability of the Academic Engagement construct was measured using the Cohen statistic (k) of inter-rater reliability. In all the recorded Student sessions, the coefficient of the result was k= 0.773 (SE= 0.125, Z= 4.778, p= 0.001). The confidence interval was [0.52, 1.01], and the percent agreement of the observed value was 92.10%. According to the interpretative

thresholds suggested by Landis and Koch (1977), a kappa value between 0.61 and 0.80 represents substantial agreement, and values greater than 0.80 are classifiable as almost perfect. As a result, a reliability estimate was substantial to near-perfect concordance between raters in coding academic engagement behaviors. This strong percentage agreement (more than 90%) supports the quality of the material under observation, so the observed changes in behavior between the stages of the interventions are valid and not attributable to the intervention, observer bias, or coding errors.

Behavioral Engagement

Behavioral Engagement	k	SE	Z	p	95% CI		% Agreement
					Lower	Upper	
Measure of Kappa Agreement	.681	.120	4.196	.000	0.44	0.91	84.21

Cohen's kappa was also used to assess the reliability of the Behavioral Engagement coding. In the case of Student 1, the calculated coefficient was $\kappa = .681$ (SE = .120, Z = 4.196, $p < .001$), with a 95% interval of [0.44-0.91] and an overall agreement rate of 84.21%. Using the Landis and Koch (1977) interpretive framework, the range of values of kappa (0.61 to 0.80) corresponds to significant agreement. Although the agreement rate is slightly below the commonly used 85% threshold in the literature, agreement is high, and all the raters' ratings are consistent. These results confirm that observer ratings of behavioral indicators of the student were highly consistent, and it is valid to consider behavioral engagement measurement in the next phase-based analysis and in effect-size calculations.

AI Engagement

AI Engagement	k	SE	Z	p	95% CI		% Agreement
					Lower	Upper	
Measure of Kappa Agreement	.745	.119	4.630	.000	0.50	0.98	89.73

Cohen's kappa was used to evaluate the inter-rater reliability of AI Engagement. In the case of the student, the coefficient was estimated to be $\kappa = .745$ (SE = .119, Z = 4.630, $p < .001$), with a 95% confidence interval ranging from 0.50 to 0.98 and an overall percentage agreement of 89.73%. Landis and Koch (1977) have defined a kappa of 0.61 to 0.80 as substantial and a kappa of 0.80 and above as almost perfect reliability. Therefore, the coefficient of correlation confirms a high rate of inter-rater consistency, which is supported by a percentage of agreement of nearly 85% is often considered reasonable in the case of a single-subject experiment (Horner et al., 2005; Lane et al., 2007). The results validate that ratings of AI-engagement behaviors were consistent and reliable as well as the procedural reliability and high measurement fidelity were maintained at the intervention and maintenance stages.

Discussion

The observed positive changes in both academic and behavioral engagement following the Lingokids AI-based intervention can be supported by literature that proves the effectiveness of technology-mediated and adaptive learning interventions in autistic students. According to the current literature, digital and AI-based solutions make the educational process more engaging due to the presence of structured,

predictable, and visually rich learning conditions which, in turn, align with the cognitive and the learning profiles of the autistic students (Ouriel Grynszpan P. L., Perez-Diaz F., and Gal E., 2013; Knight et al., 2013). Although computer-aided teaching, mobile, and adaptive online systems have been shown to support academic engagement, persistence, and on-task behavior (Odom et al., 2015; Khowaja and Salim, 2013), systematic reviews show that such methods can be effective only in certain situations These results supplement the visual and quantitative evidence of greater academic engagement during the Alphabet Tracing task with AI support in the present study. Thus, academic-related activities supported by AI help to maintain attention and engage in meaningful activities.

Similarly, the Calm Down Yoga behavioral engagement activity is consistent with the research results that show that technology-mediated self-regulation and mindfulness-based intervention can reduce off-task behavior and enhance behavioral control in students with ASD (Simione ' L. et al., 2024; Mitsea E. et al., 2023).The ability to control emotions and adherence is facilitated by the digital environments that incorporate directed habit and constant feedback when interventions are embedded within the regular patterns of instruction. This is further supported by meta-analytic findings indicating that technology-enhanced interventions have been effective in learners with ASD. According to Knight et al. (2013), there were moderate to high effects of technology-based instruction, specifically the emphasis on pacing individualized and immediate feedback that can be regarded as a distinctive characteristic of AI-based platforms, including Lingokids, to add academic and behavioral interest to school attendance. These results support the slow and consistent positive changes in behavioral involvement during the introduction of the intervention that was delayed in the current multiple-baseline design.

The steady rise in AI use aligns with the literature that identifies the motivational opportunities of adaptive educational technologies. More dynamically responsive to learner input digital learning environments offer greater levels of autonomy, less cognitiveload, and ongoing engagement (PergantisP.etal., 2025; Sungetal., 2016). In the case of students with ASD, this responsiveness can be beneficial, as it reduces the level of social pressure but preserves the structure of instructions. Altogether, the results suggest that AI-based learning interventions can be effective tools and methods for enhancing academic and behavioral engagement in students with ASD, as the instructional material, rate, and feedback are tailored according to students' needs. With the help of a well-organized single-subject design, such interventions can provide strong evidence of functional relationships between AI-based teaching and engagement results and play an important role in both research and inclusive classroom learning.

Conclusion

This study determines the effectiveness of the Lingokids learning program, an AI-based learning program, on the academic and behavioral interaction of a learner with Autism Spectrum Disorder (ASD). These results showed clear improvement in academic engagement, as evident in the Alphabet Tracing activity, and behavioral engagement, as evident in the Calm Down Yoga activity, following the introduction of the intervention. The visual analysis and the effect-size indices all showed a functional relationship between the Lingokids intervention and the engagement-related outcomes. The ever-growing levels of AI use also indicate the possibility of adaptive, AI-driven features that maintain interactions between learners over time. In general, the research provides empirical evidence that AI-based educational applications are effective tools for improving the engagement of students with ASD in inclusive classroom environments.

Recommendations

Based on the findings of the study, the following recommendations are proposed:

1. Teachers must look into using AI-powered applications like Lingokids to promote academic learning and behavioral control in ASD

children, specifically in tasks requiring focus of attention and self-control.

2. The training on the efficient and ethical utilization of AI-based learning resources, with the emphasis on the choice of the tasks and on the consideration of the engagement and the extraction of data to make appropriate instructional decisions, should be included in the professional development programs.

3. Scholars are encouraged to repeat this study using larger sample sizes, more participants and a longer-term maintenance to increase the external validity as well as to determine long-term outcomes of interventions.

4. The use of AI-driven instructional technologies in the context of inclusive education is an evidence-based practice that should be encouraged by educational policymakers in a manner that complies with standards of accessibility and data privacy.

Limitations

Although it has provided its contribution, the study has some limitations that must be pointed out:

1. This restricts the generalizability of the findings because the number of participants used is only one, which agrees with the objective and strengths of single-subject experimental research.

2. The engagement was assessed using particular Lingokids activities (Alphabet Tracing and Calm Down Yoga) that do not necessarily reflect all the academic or behavioral scenarios.

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