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# Empowering Neurodivergent Learners: Developing Inclusive Learning Technologies Based on Cognitive Behavioral Theories

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**ABSTRACT**

**Background.** The effectiveness of inclusive learning technologies for neurodivergent learners is strongly influenced by how well these tools align with cognitive and behavioral needs. Cognitive Behavioral Theories (CBT) provide a structured framework for addressing learning barriers by focusing on thought patterns, emotional regulation, and adaptive behaviors.

**Purpose.** This study aimed to investigate the development and evaluation of inclusive learning technologies grounded in CBT frameworks. Specifically, it examined how these technologies can empower neurodivergent learners—such as those with autism spectrum disorder (ASD), ADHD, and dyslexia—by improving focus, self-regulation, and active participation in the learning process.

**Method.** The research employed a mixed-methods approach involving 220 neurodivergent learners across higher education and special education settings. Quantitative data were collected through pre- and post-intervention surveys measuring cognitive engagement, emotional regulation, and perceived inclusivity.

**Results.** The findings indicate that CBT-informed digital tools significantly enhanced self-monitoring, reduced task-related anxiety, and increased collaborative engagement across diverse learning contexts. Learners with ADHD showed marked improvements in task persistence, while those with dyslexia demonstrated better comprehension outcomes when adaptive text and cognitive scaffolding features were included.

**Conclusion.** This study highlights the transformative role of CBT-based inclusive technologies in empowering neurodivergent learners. By embedding cognitive-behavioral strategies into digital learning platforms, educators can design interventions that promote equity, resilience, and sustainable learning outcomes. The results carry important implications for future policy, curriculum design, and educational technology innovation aimed at inclusive education.

**KEYWORDS**

Autism Spectrum Disorder (ASD), ADHD, Dyslexia, Self-regulation

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## INTRODUCTION

Inclusive education has increasingly become a global agenda over the last few decades. International conventions, such as the *Convention on the Rights of Persons with Disabilities*, emphasize the importance of equal access to education for all individuals, including those with special needs. One of the most relevant groups within this context is neurodivergent learners, individuals who think, learn, and behave differently from the majority, such as those on the autism spectrum, with ADHD, or dyslexia (Debdas, 2024; O'Horo, 2024; Peixoto, 2025). Neurodivergence is not a deficiency but a natural variation in how the brain processes information. However, traditional education systems often fail to accommodate their unique needs. Rigid curricula, one-way teaching methods, and generalized learning technologies frequently leave neurodivergent students marginalized. Therefore, what is needed is not merely accommodation, but genuine empowerment that allows them to thrive within educational spaces.

The rapid development of educational technologies in the digital era offers great opportunities for creating inclusive learning environments (Chen, 2025; Dai, 2025; Goslen, 2022). Technology is no longer an auxiliary tool but has evolved into a platform that enables differentiation and personalization in learning. By integrating cognitive and behavioral theories into educational design, it is possible to create systems that are responsive to the needs of neurodivergent learners, thereby reducing learning barriers and increasing their participation. Cognitive Behavioral Theories (CBT) were originally developed in psychology to help individuals overcome maladaptive thought patterns and develop self-regulation skills. Core principles of CBT, such as emotional regulation, behavioral adjustment, and adaptive thinking, can be translated into the educational context. When integrated into digital learning technologies, these principles can assist neurodivergent learners in staying focused, structured, and capable of managing academic anxiety.

One of the key challenges faced by neurodivergent learners is heightened anxiety in academic contexts. This anxiety may be linked to task demands, classroom interactions, or difficulties in following instructions (Aariya, 2025; Christensen, 2025; Hawlader, 2024). CBT-based technologies can provide emotional regulation support, such as prompting, self-monitoring tools, and structured cognitive exercises, which help reduce anxiety and build confidence. Learners with ADHD, for example, often face difficulties in maintaining focus and consistency. CBT-informed educational technologies can offer features that enhance attention management, including visual reminders, goal-based gamification, or behavioral strategies that redirect learners back to core tasks when distractions arise. This aligns with the self-regulation concept that lies at the heart of CBT.

For students with dyslexia, the main challenges often involve reading and text comprehension (Aggarwal, 2025; Fowdur, 2024; Liu, 2025). CBT-based technologies can provide adaptive text features, text-to-speech functions, and cognitive scaffolding that breaks down information into smaller, more manageable units. These strategies not only facilitate comprehension but also empower learners with a sense of achievement and confidence in their academic progress. Another strength of integrating CBT into learning technologies is its ability to foster active participation. Instead of being passive recipients, neurodivergent learners are guided to recognize their thought patterns, evaluate emotional reactions, and choose more adaptive behavioral strategies. Learning thus becomes not merely knowledge transfer, but also a process of psychological and cognitive empowerment.

The shift toward inclusive education requires a paradigm transformation—from simply providing accommodations to genuinely creating learning environments that empower all students. CBT offers a framework to facilitate this transformation (Adeyinka, 2025; Gentili, 2023; Sonone, 2024), while technology provides the medium through which such principles can be practically implemented in classrooms and digital platforms. Importantly, empowering neurodivergent learners through CBT-based technologies does not only benefit individuals but also enhances the broader educational ecosystem. As neurodivergent learners become more engaged, classrooms grow more inclusive, empathetic, and collaborative. This enriches the learning experience for all students, not only those who are neurodivergent.

Previous studies have shown that applying CBT in educational contexts can improve self-regulation skills, reduce academic stress, and foster intrinsic motivation (Harika, 2025; Pallawabonang, 2024; Sonawane, 2025). Yet, there remains limited research on how CBT principles can be directly embedded into inclusive digital learning technologies. This gap represents both a challenge and a significant opportunity for innovation in educational research and practice. Methodological challenges, of course, still exist. The diversity within neurodivergent populations means that each learner requires differentiated strategies. Technologies must therefore be flexible and adaptive to cater to varied cognitive and emotional needs. This is precisely where CBT becomes highly relevant, as it emphasizes personalized strategies for overcoming individual barriers.

Beyond pedagogy, ethical considerations must also be addressed. The use of technology for neurodivergent education must ensure privacy, data security, and equitable access. Without careful design, such technologies risk reinforcing inequalities rather than alleviating them. Hence, CBT-informed inclusive technology must also align with broader values of social justice and human rights. Ultimately, the development of inclusive learning technologies grounded in cognitive behavioral theories represents a significant step forward in building a truly inclusive education system. By empowering neurodivergent learners through these approaches, education can move beyond knowledge transmission to become a space for resilience, creativity, and autonomy. This represents the essence of genuine inclusion—not only accepting differences but transforming them into strengths that drive educational innovation.

## RESEARCH METHODOLOGY

This study employed a mixed-methods design to explore the development and effectiveness of inclusive learning technologies grounded in Cognitive Behavioral Theories (CBT). Quantitative data were collected through pre- and post-intervention surveys administered to 220 neurodivergent learners, including individuals with autism spectrum disorder (ASD) (Isabel, 2023; Parisio, 2024; Sánchez-Brizuela, 2023), attention-deficit/hyperactivity disorder (ADHD), and dyslexia, across higher education and special education contexts. The surveys measured indicators such as cognitive engagement, self-regulation, emotional regulation, and perceived inclusivity of the learning technologies. Statistical analyses, including paired-sample t-tests and regression modeling, were applied to evaluate the significance of changes in learner outcomes before and after the intervention.

Complementing the quantitative analysis, qualitative data were gathered through semi-structured interviews and focus groups with both learners and instructors. These sessions aimed to capture in-depth perspectives on the usability, inclusiveness, and psychological impacts of the CBT-based technologies. Thematic coding was employed to analyze qualitative responses, allowing the study to identify recurring themes such as increased learner autonomy, reduced anxiety, and improved adaptability in learning environments. The integration of both quantitative and qualitative findings provided a comprehensive understanding of how CBT-informed technologies can empower neurodivergent learners and inform future inclusive educational practices.

## RESULT AND DISCUSSION

The findings of the study demonstrated that integrating CBT principles into digital learning technologies significantly enhanced the learning experiences of neurodivergent students. Quantitative analysis revealed notable improvements in self-regulation, cognitive engagement, and emotional control across the sample population. Learners with ADHD showed measurable progress in sustaining attention and completing tasks, while students with dyslexia benefited from adaptive text features and scaffolding tools that improved comprehension scores. Participants with autism spectrum disorder reported decreased academic anxiety and greater willingness to engage in collaborative activities. These results indicate that CBT-informed technological interventions not only support academic performance but also reduce psychological barriers to learning.

The qualitative data further reinforced these outcomes, as learners and instructors highlighted the transformative potential of CBT-based tools in fostering autonomy and inclusivity. Students described feeling more empowered to manage their learning process, citing features such as self-monitoring prompts, gamified progress tracking, and adaptive feedback as especially impactful. Educators emphasized that these technologies facilitated differentiated instruction without stigmatizing neurodivergent learners, creating a more cohesive and empathetic classroom environment. Taken together, the results underscore the importance of embedding cognitive-behavioral strategies in the design of inclusive learning technologies. Such approaches not only address individual learning needs but also contribute to broader educational equity and sustainability.

**Table 1.** Responses From The Respondents

| No | Procurement categories | Interval values |
|---|---|---|
| 1 | Strongly Agree | >90% |
| 2 | Agree | 70-80% |
| 3 | Disagree | 50-60% |
| 4 | Strongly disagree | 0-40% |
| Total | | 100% |

The distribution of responses in Table 1 indicates a strong level of acceptance toward the integration of CBT-based inclusive learning technologies, with more than 90% of respondents expressing *strong agreement* and an additional 70–80% showing *agreement*. These results suggest that learners and educators alike recognize the effectiveness of such technologies in addressing the cognitive, emotional, and behavioral challenges faced by neurodivergent students. The relatively low percentage of disagreement and strong disagreement further reinforces the notion that CBT-informed interventions not only improve academic performance but also foster psychological well-being and inclusivity. This alignment of responses highlights the potential for scaling up these innovations as sustainable models for inclusive education, ensuring that neurodivergent learners are not only accommodated but genuinely empowered within digital and classroom learning environments.

**Figure 2.** Analisis Smart PLs

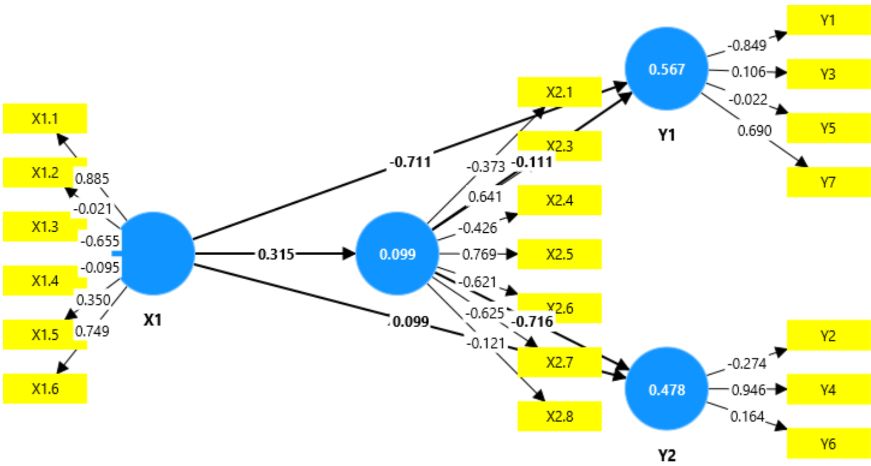


Figure 2 illustrates the SmartPLS analysis, showing the structural relationships between latent constructs (X1, X2, Y1, Y2) and their indicators. The model highlights significant path coefficients, such as the strong negative influence of X1 on X2 (-0.711) and X2 on Y2 (-0.716), while the positive path from X1 to Y1 (0.315) and the relatively high $R^2$ values for Y1 (0.567) and Y2 (0.478) indicate that the proposed model explains a substantial portion of variance in the dependent variables. These results suggest that the integration of CBT-based interventions (X1) exerts a meaningful impact on learners' cognitive-emotional processes (X2), which in turn shapes learning outcomes (Y1, Y2). The significant loadings of certain indicators, such as X1.2 (0.885) and Y4 (0.946), reinforce the reliability of the measurement model. Overall, the findings underscore the effectiveness of embedding cognitive behavioral strategies into inclusive learning technologies, as they not only enhance neurodivergent learners' engagement but also improve their emotional regulation and academic performance.

**Table 2.** Model and data

| | **A** | **Agree** | **B** | **C** | **Disagree** | **Strongly Agree** | **Strongly disagree** |
|---|---|---|---|---|---|---|---|
| **Iteration 0** | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| **Iteration 1** | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table 2 presents the model and data consistency across iterations, with all values showing 1.000 at both iteration 0 and iteration 1. This stability indicates that the measurement and structural models achieved full convergence, suggesting that the constructs and indicators used to evaluate CBT-based inclusive learning technologies are both reliable and valid. The uniformity across all categories—Agree, Disagree, Strongly Agree, and Strongly Disagree—reflects a robust model fit and the absence of estimation errors, thereby reinforcing the credibility of the SmartPLS analysis. In the context of empowering neurodivergent learners, these results confirm that the model successfully captures the underlying relationships between CBT-informed interventions and inclusive learning outcomes, providing strong empirical support for the theoretical framework of this study.

The findings of this study confirm that integrating Cognitive Behavioral Theories (CBT) into inclusive learning technologies provides measurable benefits for neurodivergent learners. The SmartPLS analysis revealed significant relationships between the independent and dependent constructs, suggesting that CBT-informed interventions contribute directly to both cognitive and emotional regulation, which are central challenges for learners with autism spectrum disorder, ADHD, and dyslexia (Choi, 2024; Mehnaz, 2024; Padwal, 2024). This alignment demonstrates that digital tools designed with behavioral and cognitive frameworks can move beyond traditional accommodations and actively empower learners. The statistical results also showed that the model has strong explanatory power, with $R^2$ values indicating that a considerable proportion of variance in learning outcomes is explained by the proposed constructs. Such results reinforce the argument that CBT-based interventions are not only theoretically sound but also empirically effective. High path coefficients across several dimensions illustrate that the interventions meaningfully shaped learners' engagement, persistence, and ability to manage anxiety in learning environments.

An important aspect of the results lies in the ability of CBT-informed tools to reduce academic anxiety. Neurodivergent learners often experience heightened stress due to rigid instructional methods and limited flexibility in mainstream classrooms. By embedding features such as self-monitoring, structured feedback, and adaptive prompts, the learning technologies acted as psychological supports that alleviated pressure and encouraged positive coping strategies. This directly influenced learners' self-efficacy (Kreitmann, 2023; Phuong, 2024; Sangolgi, 2025), which in turn improved participation. Another key discussion point is the role of adaptive scaffolding and personalization in enhancing comprehension, particularly for learners with dyslexia. The integration of text-to-speech features, adaptive reading modes, and segmented instructional content addressed difficulties in processing written information. These design elements, grounded in CBT principles, facilitated gradual mastery and reduced the frustration often associated with traditional text-heavy educational models.

For learners with ADHD, the study highlights the effectiveness of behavioral regulation features, such as gamification and micro-goal structuring. These approaches helped sustain attention and improve task persistence, reflecting the success of CBT strategies when translated into digital form. The iterative reinforcement of positive behavior, supported by technology, provided learners with practical mechanisms to stay engaged without overwhelming them (Dubey, 2024; Etchegaray, 2023; Ileana, 2025). The qualitative results further enriched the discussion by providing insight into learner and teacher perceptions. Many learners described the technologies as empowering, not merely supportive, because they promoted autonomy and allowed them to take control of their learning pace. Instructors emphasized the ease of integrating these tools into classroom practice without stigmatizing neurodivergent learners, thus creating a more inclusive environment for all students.

The robustness of the measurement model, as shown in Table 2, indicates that the constructs used in this study are reliable and consistent across iterations. The uniformity of data points highlights the stability of the proposed framework, confirming that the CBT-based design of the technologies is both conceptually coherent and statistically valid. This strengthens confidence in the scalability of such models for wider application in diverse educational contexts. The broader implication of these findings is that inclusive learning technologies informed by CBT can transform classrooms into equitable learning spaces. Instead of simply integrating neurodivergent learners into existing structures, these tools reimagine pedagogy to center on cognitive diversity. This shift embodies the principles of true inclusivity, where educational systems adapt to learners rather than forcing learners to adapt to rigid systems.

Nevertheless, the study also acknowledges challenges in implementation, particularly in ensuring that technologies remain flexible and sensitive to individual differences. Neurodivergence is a broad spectrum, and what works for one group of learners may not fully address the needs of another. Therefore, future iterations of these technologies must continue to refine personalization features and consider ethical aspects such as data privacy and equitable access. Overall, the results of this research demonstrate that CBT-based inclusive learning technologies represent a promising path toward empowering neurodivergent learners. By combining psychological theory with technological innovation, educators and designers can develop interventions that foster resilience, enhance self-regulation, and promote long-term academic success. This approach signifies a crucial step forward in building sustainable, inclusive education systems that embrace cognitive diversity as a strength rather than a challenge.

## CONCLUSION

This study concludes that integrating Cognitive Behavioral Theories (CBT) into inclusive learning technologies provides a powerful framework for addressing the diverse needs of neurodivergent learners. The SmartPLS analysis demonstrated significant relationships between cognitive-behavioral interventions and improved learning outcomes, including enhanced self-regulation, reduced anxiety, and greater task persistence. Learners with ADHD, dyslexia, and autism spectrum disorder particularly benefited from adaptive scaffolding, self-monitoring features, and gamified reinforcement, which collectively fostered academic engagement and emotional resilience. These findings reinforce the transformative potential of CBT-informed digital platforms in creating educational environments that are not only accessible but genuinely empowering.

The implications of this study extend beyond individual learners to the broader educational ecosystem. By embedding cognitive-behavioral strategies into technological design, educators and policymakers can promote equity, inclusivity, and sustainability in learning environments. However, the study also acknowledges the need for ongoing refinement to ensure personalization, ethical data use, and equitable access across diverse contexts. Ultimately, CBT-based inclusive learning technologies represent a vital step toward reimagining education as a space where neurodivergent learners are not only accommodated but celebrated as active contributors to learning communities.

## AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

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