Personalized Inclusion with GenAI: An Adaptive Strategy to Support Students with ASD in Higher Education

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Abstract. *Inclusion in abstract, cognitively demanding courses is difficult. This study presents an adaptive strategy that merges Universal Design for Learning (UDL) and Generative AI to tailor propositional-logic activities for a student with Autism Spectrum Disorder (ASD). Across four formative, reflective cycles, existing tasks were progressively reshaped; evidence came from observations, journals, and rubrics. The ASD learner showed sustained gains in engagement, conceptual grasp, and autonomy, indicating the value of the approach. The results suggest that educator-mediated GenAI, aligned with UDL, can foster more responsive and inclusive learning in higher education.*

1. Introduction

Despite advances in access policies, ensuring inclusive higher education remains a persistent challenge [Hehir et al. 2016, Svendby 2024]. Although the enrollment of students with disabilities has increased, their retention and academic success depend on adapted pedagogical practices, which often face structural and training limitations [Moriña 2017].

This challenge has intensified with the growing presence of neurodivergent students, particularly those with Autism Spectrum Disorder (ASD). In Brazil, the enrollments of students with ASD in basic education rose by 44.4% between 2023 and 2024, from 636,202 to 918,877 [Ministério da Educação 2025], signaling a trend toward higher education that demands responsive pedagogical strategies.

However, most university professors have limited training in inclusive pedagogy [Altes et al. 2024], constrained by workload pressures and lack of institutional support [Svendby 2024], which hinders the personalization needed by neurodivergent students. Universal Design for Learning (UDL) [CAST 2024] offers a framework to design flexible environments, addressing diverse learning styles and promoting equity.

Parallel to these efforts, Generative Artificial Intelligence (GenAI) tools, such as ChatGPT, have expanded the possibilities for personalized learning support in higher education. These tools have been used to automate feedback, generate examples,

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and design instructional materials [Imran and Almusharraf 2023, Sun et al. 2024, Guo et al. 2024, Elkins et al. 2024]. When aligned with pedagogical principles, GenAI can enhance personalization, reduce teacher workload, and offer on-demand mediation. However, most literature focuses on GenAI used by students [Chan and Hu 2023, Almassaad et al. 2024, Amaral et al. 2024, Silva et al. 2024b], with few studies exploring its intentional application by educators in inclusive practices. Additionally, research on educational strategies for individuals with ASD remains concentrated in basic education [Pereira and Barwaldt 2022, Sampaio and Pereira 2022, Pires et al. 2023, Silva et al. 2024a, Cunha and Carvalho 2024, Malpartida and Rodrigues 2024], with limited investigation in higher education contexts [Hehir et al. 2016, Moriña 2017].

This article presents an adaptive pedagogical strategy that integrates UDL principles with GenAI, focusing on teaching Mathematical Logic to a student with ASD and Attention Deficit Hyperactivity Disorder (ADHD). The strategy was developed through a hybrid research method that combines formative research intervention with reflective pedagogical cycles, involving iterative activity adaptation and personalized mediation. It aims to contribute to scalable inclusive practices in higher education.

2. Background

This section presents three main themes: (i) the challenges faced by neurodivergent students, (ii) the potential of GenAI as a support tool in higher education, and (iii) the principles of UDL as a foundation for inclusive pedagogical practices.

2.1. Challenges in Teaching Logic to Neurodivergent Students

The teaching of formal logic presents significant challenges for neurodivergent students due to its high cognitive demands related to sequential reasoning, symbolic abstraction, and analytical reading [Bajaña et al. 2024]. In the case of students with ASD, attentional selectivity, generalization difficulty, and resistance to change are common, which can make extensive or abstract tasks particularly difficult, leading to frustration, lack of motivation, or even dropout [Bajaña et al. 2024].

Although many of these students exhibit high cognitive potential, communicational, sensory, and social barriers may affect their academic engagement and performance [Stuurman et al. 2019, Shah et al. 2024]. As discussed by Shah et al. (2024), standardized pedagogical practices tend to overlook the divergent learning styles of autistic students, which compromises their retention and development, especially in areas such as Computing and Logic. However, there is a lack of research focused on adapting the teaching of logic for this audience in higher education.

2.2. GenAI as a Support for the Pedagogical Process

GenAI refers to computational models capable of producing content such as texts, code, and simulations from large volumes of data. Large language models (LLMs), such as ChatGPT, Claude, and Gemini, operate by predicting linguistic patterns, even though they lack genuine semantic understanding [Akhtar 2024].

In the educational field, GenAI has been explored as a support tool for tasks such as quiz creation, lesson planning, automatic feedback, and language reformulation [Guo et al. 2024, Elkins et al. 2024, Zhang 2024]. These applications have the potential to optimize teachers' time and personalize instruction, especially in subjects that require conceptual clarity and a high volume of corrections.

In addition to the scarcity of studies focused on teaching practices, authors such as [Luckin 2018, Holmes et al. 2022] emphasize the importance of developing pedagogical frameworks that integrate emerging technologies with critical intentionality and ethical commitment. In the context of educational inclusion, this integration must go beyond access to technological resources, requiring reflective practices that are situated and mediated by actively listening to students' needs [Rashid and Saqr 2024]. Recent literature also indicates that, to be effective, pedagogical adaptations must be sensitive to the cognitive, linguistic, and affective barriers that impact the learning process of neurodivergent students [Stuurman et al. 2019, Shah et al. 2024], especially in highly complex subjects such as logic, mathematics, and programming.

2.3. UDL Guidelines for Inclusive Practices

The UDL is a pedagogical approach aimed at expanding access and participation for all students, regardless of cognitive, sensory, or sociocultural characteristics. Developed by the Center for Applied Special Technology (CAST), UDL draws on neuroscientific evidence to guide intentional redesign of learning environments to reduce barriers and foster multiple forms of participation, representation and expression [CAST 2024].

Its framework is structured around three principles: (i) Engagement (why learn), strategies to spark and sustain interest; (ii) Representation (what to learn), diverse ways of presenting information; and (iii) Action and Expression (how to demonstrate learning), varied formats for student output. Figure 1 summarizes version 3.0 of the guidelines.

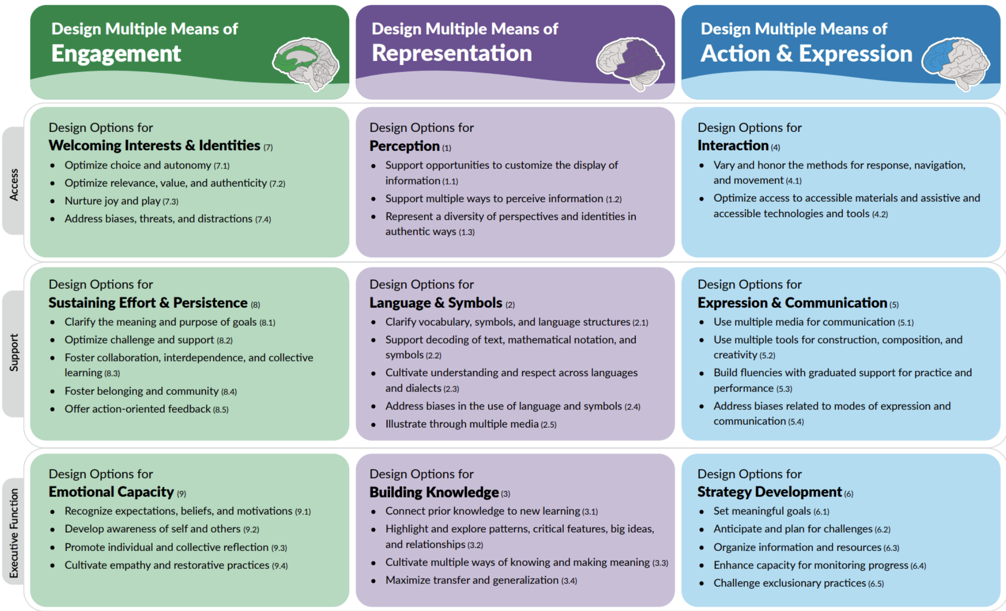


Figure 1. UDL Guidelines [CAST 2024]

In practice, UDL encourages diversified instructional methods, such as combining diagrams, videos, and texts, and flexible assessments that enhance participation and skill development. This flexibility is crucial in inclusive higher education, particularly for neurodivergent students, such as those with ASD [Tarconish et al. 2024].

Integrating UDL with GenAI expands opportunities for personalization. While UDL provides the pedagogical foundation, GenAI generates accessible variations of content, supporting tailored instruction and optimizing educators' time. Together, they promote more equitable and sustainable learning environments.

3. Related Work

The inclusion of students with ASD in higher education has been explored in Brazilian and international literature, highlighting barriers such as the absence of individualized plans, rigid assessments, and insufficient teacher training [Camalionte et al. 2021, Hehir et al. 2016, Moriña 2017]. Although institutional policies and accessibility services have advanced, effective pedagogical practices remain limited and often depend on individual instructor initiatives.

Qualitative studies [Araújo 2024] emphasize active listening and contextual adaptation but report a lack of systematic strategies for complex subjects such as logic. Technological initiatives, including the Becca app [Alves et al. 2024], the MEITEA model [Mourão et al. 2024], and gamified tools [Santos and Lima 2022], support socio-emotional skills but rarely address disciplinary content, revealing a gap in the technological adaptation of complex subjects in higher education.

Research indicates that predictable structures, symbolic supports, and visual organization foster engagement and reduce cognitive overload for neurodivergent students [Shah et al. 2024, Stuurman et al. 2019, Israel et al. 2020]. However, most work on GenAI focuses on student use [Chan and Hu 2023, Almassaad et al. 2024, Amaral et al. 2024, Silva et al. 2024b], and inclusive strategies remain concentrated in basic education [Pereira and Barwaldt 2022, Sampaio and Pereira 2022, Pires et al. 2023, Silva et al. 2024a, Cunha and Carvalho 2024, Malpartida and Rodrigues 2024].

Addressing these gaps, this study integrates UDL principles and GenAI tools to adapt mathematical logic activities for students with ASD, contributing to systematic and scalable inclusive practices in higher education. Compared with approaches such as the MEITEA model [Mourão et al. 2024] and gamified tools [Santos and Lima 2022], it uniquely combines GenAI with UDL guidelines for individualized adaptation without collecting sensitive data, extending application to complex disciplinary content.

4. Research Method

This study adopts a hybrid methodological approach, combining formative research-intervention [Melnyk and Morrison-Beedy 2012] with reflective pedagogical cycles [Schön 1983]. Its objective was to investigate and progressively refine a teaching strategy designed for a neurodivergent student diagnosed with ASD and ADHD, enrolled in a Mathematical Logic course in an undergraduate Computer Science program.

Given the student's profile, marked by difficulties in executive functioning such as sustained attention, working memory, planning, inhibitory control, and limitations in social communication skills, direct participation in the design phases was not feasible. Consequently, the intervention was based on systematic observation, instructional adaptation, and analytical monitoring of the student's responses across four iterative cycles. This design aligns with the epistemological foundations of formative research-intervention [Melnyk and Morrison-Beedy 2012], where the researcher acts as a practitioner-analyst, generating situated knowledge and promoting transformation within teaching practices.

The methodological process was structured into five interdependent and sequential stages. The intervention cycles within this process were grounded in the concept of reflective pedagogical cycles, emphasizing iterative processes of planning, action, observation, and reflection. In each cycle, systematic reflection on student engagement and learning outcomes informed adjustments to instructional strategies, aligning with the principles of reflection-in-action and reflection-on-action advocated by [Schön 1983].

i) Initial Contextual Diagnosis: The process began with a diagnostic activity (A1) designed to identify cognitive, linguistic, and behavioral barriers faced by the student in logical reasoning tasks. The activity involved simple propositions, truth tables, and contextualized problems. Observations were recorded in a field journal, focusing on time-on-task, verbalizations, signs of cognitive overload, and behavioral responses.

ii) Design of the Pedagogical Intervention: Based on the identified barriers, an adaptive pedagogical strategy was developed, integrating UDL principles and GenAI tools to personalize activities according to the student's needs. Activities A2 to A5, previously used with the general class and covering progressively more complex topics in classical logic, were selected as the basis for adaptation.

The initial redesign focused on three core UDL principles: linguistic clarity of instructions (Guideline 2), sequential organization of steps (Guideline 3), and diversity in modes of expression and response (Guideline 5). Considering the student's profile and observational records, the strategy was progressively refined to incorporate guidelines that promote engagement and self-regulation, such as addressing specific interests (Guideline 7), supporting persistence in challenging tasks (Guideline 8), and encouraging the use of metacognitive strategies (Guideline 9).

Prompts developed for GenAI explicitly reflected these guidelines and integrated qualitative evidence collected in the classroom, such as levels of engagement, conceptual understanding, and autonomy demonstrated by the student throughout the semester. Information recorded in each cycle guided the generation of more accessible and pedagogically adjusted versions of the activities. AI-generated outputs were critically reviewed by peers prior to each implementation to ensure conceptual fidelity and alignment with the student's evolving profile.

iii) Implementation of Intervention Cycles: The strategy was implemented across four iterative cycles, corresponding to Activities A2 to A5. Each cycle involved planning and adaptation of activities using GenAI tools, mediated implementation, and systematic recording of observed evidence.

The adapted activities were printed and provided in physical format, respecting the student's sensory preferences and learning pace. Each activity was preceded by an introductory explanation of objectives and expectations. The student had flexible time to complete the tasks under continuous guidance from the instructor-researcher, who mediated the process, closely observed emerging behaviors, and offered individualized support as needed.

Instructional mediation aimed to create a personalized support environment, considering the student's processing time and preferred modes of interaction. At the end of each session, the instructor updated a field journal and completed an analytical rubric based on classroom observations, evaluating engagement, conceptual understanding, and autonomy on a five-point scale.

This documentation enabled continuous monitoring of the student's development across the cycles and informed the progressive refinement of subsequent interventions, consistent with the iterative nature of formative research-intervention.

iv) Analysis of Effects and Developmental Patterns: The evaluation of the intervention's effects was qualitative, based on the triangulation of: (i) systematic entries in the instructor's field journal; (ii) structured classroom observations; and (iii) analysis of the student's spontaneous verbalizations during the activities.

At the end of each cycle, an analytical rubric was completed, assessing three dimensions: engagement [Fredricks et al. 2004], conceptual understanding [Anderson et al. 2001], and autonomy/self-regulation [Zimmerman 2002, Bandura 1997]. Scores were assigned on a five-point scale based on direct observations and field journal records. This systematic approach enabled the identification of learning patterns, affective responses, and progress in autonomy throughout the cycles.

v) Systematization and Critical Synthesis: At the end of the four cycles, all qualitative data and pedagogical records were compiled into a reflective portfolio documenting the instructional adaptation process and supporting replication in similar contexts. The portfolio included: (i) original and adapted versions of activities, (ii) GenAI prompts with commentary on modifications in each cycle, (iii) field journal records, (iv) analytical rubric scores, and (v) UDL guidelines incorporated in each adaptation.

The data were organized chronologically and by intervention cycle, providing a longitudinal view of the student's learning trajectory. This systematization consolidated the adopted strategies, adjustments made, and observed outcomes, contributing to the development of a replicable instructional model aligned with principles of formative intervention and applied research in inclusive contexts.

5. Results and Discussion

To ensure transparency and traceability of the intervention process, the results are presented in four iterative cycles, each corresponding to an adapted activity (A2–A5). This cyclical structure aligns with the methodological design adopted in this study and allows for a longitudinal analysis of the student's progression in engagement, conceptual understanding, and autonomy.

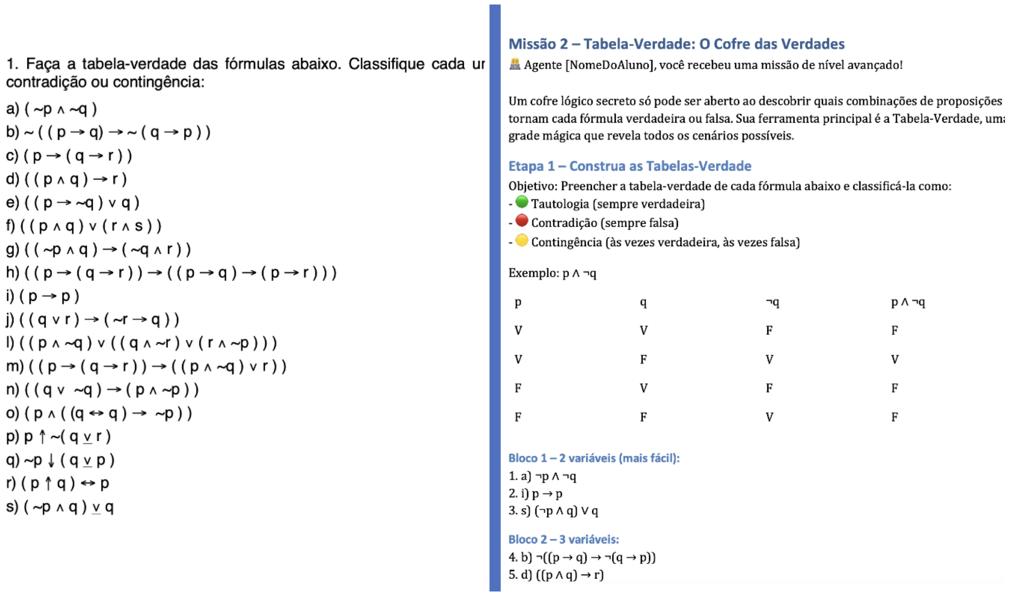
5.1. Assessment Instruments

At the end of each activity within each cycle, the lead instructor completed an analytical rubric encompassing three dimensions: engagement, conceptual understanding, and autonomy (rated from 1 to 5). Additional data included: (i) effective focus time (using a stopwatch); (ii) number of correct/incorrect answers; and (iii) behavioral observations in the instructor's field journal.

5.2. Cycle 1 – Activity A2 – The Student's Mission

Pedagogical Adjustment. The original version of Activity A2 contained dense statements and direct formal logic notation, which had previously led to task refusal in the diagnostic activity. Thus, it was necessary to adapt Activity A2 with the support of GenAI, using a prompt based on UDL Guidelines 2, 3, and 5. The adaptations included simplified language with step-by-step numbering, a predictable and organized visual structure, and a playful narrative framing the student as a "logic agent" on a mission.

Implementation and Evidence. During implementation, a reduction in initial resistance was observed. The student listened to the full explanation, remained focused on the activity for 20 minutes, and completed the task with minimal support. In solving Activity A2, he correctly identified the logical operators and even corrected an intentional error made by the instructor, demonstrating conceptual accuracy. The analytical rubric completed at the end of the class indicated the following scores: engagement = 3 (moderate involvement in the task), comprehension = 4 (correct responses with justification), and autonomy = 2 (need for direct mediation). The field journal included the following note: *"when I told him he had a personalized mission, he stopped looking at his phone and listened to everything."*


1. Faça a tabela-verdade das fórmulas abaixo. Classifique cada ur
contradição ou contingência:

a) (~p ∧ ~q)
b) ~ ((p → q) → ~ (q → p))
c) (p → (q → r))
d) ((p ∧ q) → r)
e) ((p → ~q) ∨ q)
f) ((p ∧ q) ∨ (r ∧ s))
g) ((~p ∧ q) → (~q ∧ r))
h) ((p → (q → r)) → ((p → q) → (p → r)))
i) (p → p)
j) ((q ∨ r) → (~r → q))
l) ((p ∧ ~q) ∨ ((q ∧ ~r) ∨ (r ∧ ~p)))
m) ((p → (q → r)) → ((p ∧ ~q) ∨ r))
n) ((q ∨ ~q) → (p ∧ ~p))
o) (p ∧ ((q ↔ q) → ~p))
p) p ↑ ~(q ⊻ r)
q) ~p ↓ (q ⊻ p)
r) (p ↑ q) ↔ p
s) (~p ∧ q) ⊻ q

Missão 2 – Tabela-Verdade: O Cofre das Verdades
Agente [NomeDoAluno], você recebeu uma missão de nível avançado!

Um cofre lógico secreto só pode ser aberto ao descobrir quais combinações de proposições tornam cada fórmula verdadeira ou falsa. Sua ferramenta principal é a Tabela-Verdade, uma grade mágica que revela todos os cenários possíveis.

Etapa 1 – Construa as Tabelas-Verdade
Objetivo: Preencher a tabela-verdade de cada fórmula abaixo e classificá-la como:
- Tautologia (sempre verdadeira)
- Contradição (sempre falsa)
- Contingência (às vezes verdadeira, às vezes falsa)

Exemplo: p ∧ ¬q

p	q	¬q	p ∧ ¬q
V	V	F	F
V	F	V	V
F	V	F	F
F	F	V	F

Bloco 1 – 2 variáveis (mais fácil):
1. a) ¬p ∧ ¬q
2. i) p → p
3. s) (¬p ∧ q) ∨ q

Bloco 2 – 3 variáveis:
4. b) ¬((p → q) → ¬(q → p))
5. d) ((p ∧ q) → r)

Figure 2. A2: Comparison between the original activity and the version adapted via GenAI.

Analysis and Interpretation. The results from Cycle 1 show a significant shift compared to the initial diagnostic phase, in which the student refused to complete any activity. The increase in engagement score from 1 to 3 indicates that the use of a narrative approach and the breakdown of tasks into smaller steps facilitated the student's connection with the content. The high level of conceptual understanding suggests that previous difficulties were more related to the activity's format than to logical competency itself.

Symbolic personalization and step-by-step structuring acted as elements of support and cognitive load reduction. The mission metaphor, by creating a sense of interest and purpose, functioned as both an emotional and attentional mediator, an aspect highlighted by [Shah et al. 2024] as essential for the initial engagement of students with ASD. This cycle, therefore, marks a turning point, demonstrating that formal barriers can be overcome through accessible strategies grounded in principles of inclusion.

5.3. Cycle 2 – Activity A3 – Guided Logical Equivalences

Pedagogical Adjustment. The second cycle was built on the results of the previous intervention, where the student demonstrated solid conceptual accuracy but low autonomy. Activity A3 was therefore adapted with support from GenAI, focusing on deepening the understanding of logical equivalences while reducing the need for direct mediation. The adaptations included worked examples with arrows indicating logical transformations, organization of the activity into numbered blocks with accessible language, and a visual checklist using symbolic markers, such as emojis, highlights, and arrows, to assist in self-verification.

Application and Evidence. During implementation, the student maintained continuous focus for 25 minutes, initiated attempts before teacher mediation, and asked for support only to validate the first example. According to the teacher's journal: *"he started trying without me prompting him, I only approached halfway through the task."* The rubric scores showed progress: engagement increased to 4, comprehension remained at 4 (consistent correct answers), and autonomy rose to 3, with signs of self-regulation.

Analysis and Interpretation. This pattern of development suggests that the use of solved examples, visual organization, and clear language contributed to reducing cognitive overload and enhancing the student's active role. The intervention aligns with the findings of [Shah et al. 2024], which highlight the positive impact of symbolic metaphors and predictable structures on the engagement of students with ASD, as well as with [Israel et al. 2020], who emphasize the role of visual organization in enabling active appropriation of abstract content.

Cycle 2 represents a qualitative step forward in the inclusive personalization process, showing that small structural adaptations, guided by UDL principles, can enhance autonomy without compromising the conceptual rigor of the activity.

5.4. Cycle 3 – Activity A4 – Logic Circuits with Visual Support

Pedagogical Adjustment. The third cycle aimed to deepen the understanding of mathematical logic concepts through graphical representations of circuits. Building on the progress observed in Cycle 2, Activity A4 was adapted with GenAI support, incorporating a playful narrative featuring the student as a "logic agent" decoding secret circuits, visual representations of logical connectors (AND, OR, NOT, NAND, and NOR) using wires, gates, and computer icons, as well as solved examples organized in a sequential structure with progress boxes and the use of emojis.

Application and Evidence. During the activity, the student remained focused for 30 minutes and showed greater initiative. He verbalized that he *"liked the mission"* and solved the challenges with minimal intervention. In the rubric, he maintained a score of 4 for both engagement and comprehension and achieved a 3 in autonomy, with entries in the teacher's journal noting that he *"started solving the challenges on his own, even before I asked if he needed help."*

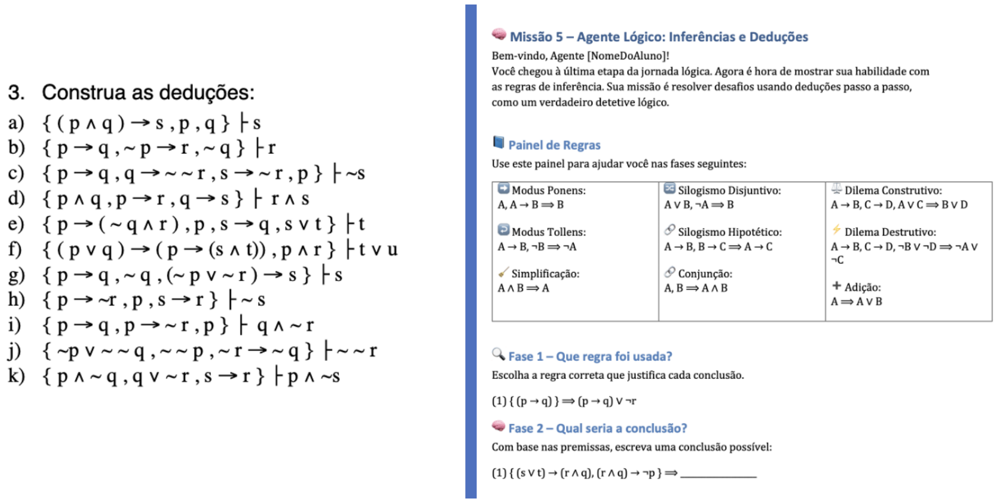
Analysis and Interpretation. The sustained high levels of engagement and comprehension, along with the growth in autonomy, indicate consolidation of the strategies initiated in the previous cycle. The integration of visual analogies and themes from the computing domain supported task persistence and reinforced the connection with the content.

Cycle 3 confirms that approaches incorporating visual, symbolic, and organizational elements promote continuous engagement and the onset of metacognitive processes. Although the student still requires occasional support, his behavior reflects increasing autonomy and a meaningful understanding of the subject matter.

5.5. Cycle 4 – Activity A5 – Formal Deduction with Symbolic Inference

Pedagogical Adjustment. The fourth cycle aimed to consolidate the student's conceptual mastery and autonomy through advanced formal deduction challenges. With the support of GenAI, Activity A5 was adapted to include challenges involving inference rules such as Modus Ponens, Modus Tollens, Syllogisms, and Dilemmas, organized into a structure divided into three phases: identifying the rule, determining the possible conclusion, and constructing the deduction with symbolic justification. Additionally, the activity provided space for reflective self-assessment and visualization of progress through icons and gradual stages.

Application and Evidence. The student maintained 38 minutes of continuous focus, answered all questions correctly, and completed the task without any mediation. At the end, he commented: *"It was hard, but I did it."* In the rubric, he received the highest score in all criteria: engagement (5), comprehension (5), and autonomy (5).



3. Construa as deduções:

a) $\{ (p \wedge q) \rightarrow s, p, q \} \vdash s$
b) $\{ p \rightarrow q, \sim p \rightarrow r, \sim q \} \vdash r$
c) $\{ p \rightarrow q, q \rightarrow \sim\sim r, s \rightarrow \sim r, p \} \vdash \sim s$
d) $\{ p \wedge q, p \rightarrow r, q \rightarrow s \} \vdash r \wedge s$
e) $\{ p \rightarrow (\sim q \wedge r), p, s \rightarrow q, s \vee t \} \vdash t$
f) $\{ (p \vee q) \rightarrow (p \rightarrow (s \wedge t)), p \wedge r \} \vdash t \vee u$
g) $\{ p \rightarrow q, \sim q, (\sim p \vee \sim r) \rightarrow s \} \vdash s$
h) $\{ p \rightarrow \sim r, p, s \rightarrow r \} \vdash \sim s$
i) $\{ p \rightarrow q, p \rightarrow \sim r, p \} \vdash q \wedge \sim r$
j) $\{ \sim p \vee \sim\sim q, \sim\sim p, \sim r \rightarrow \sim q \} \vdash \sim\sim r$
k) $\{ p \wedge \sim q, q \vee \sim r, s \rightarrow r \} \vdash p \wedge \sim s$

Missão 5 – Agente Lógico: Inferências e Deduções

Bem-vindo, Agente [NomeDoAluno]!
Você chegou à última etapa da jornada lógica. Agora é hora de mostrar sua habilidade com as regras de inferência. Sua missão é resolver desafios usando deduções passo a passo, como um verdadeiro detetive lógico.

Painel de Regras

Use este painel para ajudar você nas fases seguintes:

Modus Ponens: $A, A \rightarrow B \Rightarrow B$	Silogismo Disjuntivo: $A \vee B, \neg A \Rightarrow B$	Dilema Construtivo: $A \rightarrow B, C \rightarrow D, A \vee C \Rightarrow B \vee D$
Modus Tollens: $A \rightarrow B, \neg B \Rightarrow \neg A$	Silogismo Hipotético: $A \rightarrow B, B \rightarrow C \Rightarrow A \rightarrow C$	Dilema Destrutivo: $A \rightarrow B, C \rightarrow D, \neg B \vee \neg D \Rightarrow \neg A \vee \neg C$
Simplificação: $A \wedge B \Rightarrow A$	Conjunção: $A, B \Rightarrow A \wedge B$	+ Adição: $A \Rightarrow A \vee B$

Fase 1 – Que regra foi usada?

Escolha a regra correta que justifica cada conclusão.

(1) $\{ (p \rightarrow q) \} \Rightarrow (p \rightarrow q) \vee \neg r$

Fase 2 – Qual seria a conclusão?

Com base nas premissas, escreva uma conclusão possível:

(1) $\{ (s \vee t) \rightarrow (r \wedge q), (r \wedge q) \rightarrow \neg p \} \Rightarrow$ ____________

Figure 3. A5: Comparison between the original activity and the version adapted via GenAI.

Analysis and Interpretation. The adapted activity represented a breakthrough in the learning process. The phased progression, combined with symbolic metaphors and a clear visual structure, fostered student agency and self-regulation. The student demonstrated not only conceptual mastery but also the confidence to face challenges independently provided that the tasks are adapted. These findings reinforce prior evidence in the literature regarding the impact of predictable and symbolic structures on the engagement of students with ASD [Shah et al. 2024], as well as the role of guiding narratives in stimulating cognitive persistence [Israel et al. 2020].

5.6. Progress of Engagement, Comprehension, and Autonomy Indicators

Figure 4 summarizes the student's trajectory across the diagnostic and intervention cycles, based on engagement, comprehension, and autonomy scores on a 5-point scale.

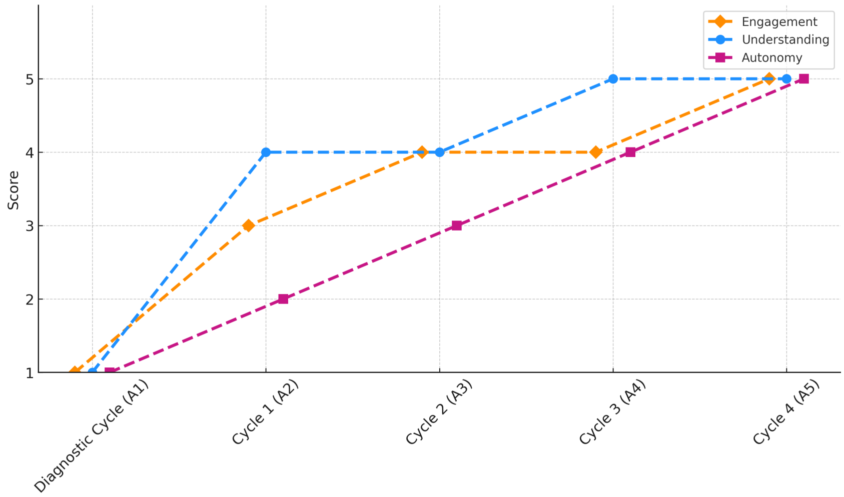


Figure 4. Progression of engagement, comprehension, and autonomy indicators across the cycles.

The data show consistent improvement across all dimensions. Initially, engagement, comprehension, and autonomy were rated at level 1. After the first intervention (A2), engagement rose to 3 and reached 5 by A5. Comprehension improved more rapidly, attaining 4 by A2 and consolidating at 5 in the final cycle. Autonomy evolved gradually, reflecting growing independence in task management.

These results align with the literature on neurodivergent learners. The increase in engagement supports findings by [Shah et al. 2024] on the role of narrative structures and motivational scaffolds for students with ASD. Rapid comprehension gains reflect UDL principles on multiple representations [CAST 2024, Tarconish et al. 2024] and corroborate studies highlighting diversified cognitive pathways for autistic learners in complex domains [Stuurman et al. 2019].

The progressive development of autonomy aligns with pedagogical models advocating gradual removal of support to promote self-regulation [Rashid and Saqr 2024, Zimmerman 2002]. Overall, the adaptation strategy, combining GenAI personalization and UDL guidelines, effectively addressed challenges typical of students with ASD, such as executive function deficits and difficulties with abstract reasoning. These findings contribute to filling the gap in structured pedagogical interventions for neurodivergent students in logic-intensive domains [Camalionte et al. 2021, Araújo 2024].

6. Evaluation of the Methodological Approach

The hybrid model, which combined formative research intervention with reflective pedagogical cycles, proved to be adequate to support a neurodivergent student. The iterative structure enabled responsive adjustments based on systematic observations, favoring individualized adaptations and promoting progressive autonomy, aligned with inclusive education principles. However, communication restrictions limited opportunities for dialogic co-construction and direct collection of student perceptions, requiring alternative observation strategies.

To mitigate potential biases, the instructor-researcher employed triangulation techniques, including structured rubrics, field journaling, and peer review of GenAI-generated materials. Field journal entries were reviewed by peers at the end of each cycle, enhancing data credibility. These mechanisms supported internal validity and reflexivity, both critical for intervention studies where the researcher is embedded in the process.

Despite these constraints, the methodology enabled the systematic refinement of instructional strategies and a detailed analysis of the student's learning trajectory. Although formative interventions proved effective, future research should explore complementary strategies, such as mediated self-assessments, to deepen data collection and strengthen student agency.

The study thus demonstrates the viability of hybrid methodologies in inclusive contexts and underscores the need for innovations that expand opportunities for expression and agency among neurodivergent students. The proposed protocol can be adapted to other disciplines, provided that clear pedagogical guidelines are available and the student's profile is known in advance.

7. Threats to Validity

As an exploratory study with a single participant, the generalizability of the results is limited. Data collection relied on qualitative sources (observations, classroom logs, and student verbalizations) rich in detail but restricting causal inferences. Potential bias may arise from the dual role of the instructor as both practitioner and researcher. To mitigate this risk, reflective journals and external peer reviews were employed.

Another limitation concerns the dependence on prompt quality and the curation of the instructor. Although GenAI adaptations reduced preparation time, they require expertise and may not easily scale. Future research should explore collaborative prompt libraries to facilitate broader application. Aspects such as social communication and anxiety were not measured in this study; their assessment is planned for future research using validated instruments.

8. Conclusion

This study presented a pedagogical adaptation strategy based on UDL principles and GenAI, aimed at teaching mathematical logic to a student with ASD and ADHD. In each cycle, personalization was guided by concrete evidence of learning and adjusted to address observed needs in terms of engagement, comprehension, and autonomy.

The results show consistent and significant progress. The student transitioned from an initial scenario of refusal and avoidance to an active and autonomous stance when faced with complex logical tasks. The combination of narrative metaphors, visual representations, progressive organization, and accessible language was fundamental in overcoming cognitive and affective barriers. By the end of the process, the student demonstrated conceptual mastery, initiative in problem-solving, and the ability to reflect on their learning. These findings reinforce the power of integrating technology with pedagogical intentionality to promote inclusion in traditionally challenging contexts. The instructor's role as curator and mediator of AI-generated adaptations was central to ensuring relevance, precision, and alignment with the student's profile.

Although this study focused on a single case, due to the low simultaneous enrollment of students with ASD in the Mathematical Logic course, the data reveal valuable contributions for designing future educational interventions. The proposed strategy demonstrates potential for replication and adaptation to different contexts and student profiles, especially in areas characterized by high symbolic abstraction, such as formal logic. Furthermore, the findings open new possibilities for broader investigations into the use of GenAI in responsive personalization in higher education.

Ethical Considerations

This study was conducted in accordance with Brazilian regulations for research involving human participants (National Health Council Resolutions No. 466/2012, No. 510/2016, and No. 674/2022, and Operational Norm No. 001/2013) and with the Brazilian General Data Protection Law (Law No. 13.709/2018). The intervention had an exclusively pedagogical nature, consisting of adaptations of activities already included in the course syllabus, without collecting personal or sensitive data. All analyses were based on observational records and anonymized artifacts produced during the regular course routine. No questionnaires, interviews, or clinical assessments were conducted.

The participant, an adult student, was informed about the objectives of the study, the nature of the adaptations and the use of the evidence for academic purposes and gave informed consent to participate and to anonymously distribute the results.

Specific precautions were taken regarding the ethical use of GenAI. No identifiable information was included in prompts, which were formulated generically and without references to the participant's identity. Following UNESCO's guidelines for AI in education [UNESCO 2021], the technology was used to support, not replace, human mediation. The instructor curated all AI-generated content to ensure alignment with learning objectives and the student's needs, avoiding generic or inappropriate outputs.

Given the minimal risk and absence of identifiable data processing, prior submission to a Research Ethics Committee was deemed unnecessary, as permitted by the aforementioned regulations. Future studies with larger samples and broader data collection should follow an ethics review protocol.

Availability of Artifacts

The materials produced in this study, including the adapted versions of the activities, the prompts used, the rubrics, and the anonymized observational records, are available in a public repository: `https://doi.org/10.5281/zenodo.15576822`.

References

Akhtar, Z. B. (2024). Unveiling the evolution of generative ai (gai): A comprehensive and investigative analysis toward llm models (2021–2024) and beyond. *Journal of Electrical Systems and Information Technology*, 11(1):22.

Almassaad, A., Alajlan, H., and Alebaikan, R. (2024). Student perceptions of generative artificial intelligence: Investigating utilization, benefits, and challenges in higher education. *Systems*, 12(10):385.

Altes, T. K., Willemse, M., Goei, S. L., and Ehren, M. (2024). Higher education teachers' understandings of and challenges for inclusion and inclusive learning environments: A systematic literature review. *Educational Research Review*, 43:100605.

Alves, A. G., Hostins, R. C. L., and Oliveira, N. A. D. (2024). Becca: Um aplicativo para inclusão de acadêmicos com autismo no ensino superior. *REPPE: Revista do Programa de Pós-Graduação em Ensino*, 8(2):2399–2412. Edição Especial: III Congresso Internacional de Ensino (CONIEN).

Amaral, L. W. G. D., Cordeiro, J. J. R., and Avelino, G. A. (2024). Ia generativa na educação: Personalizando histórias para facilitar o aprendizado de leitura em crianças. In *Anais do XXXV Simpósio Brasileiro de Informática na Educação (SBIE)*, pages 1877–1889.

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., and Wittrock, M. C. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. Longman, New York.

Araújo, D. K. (2024). Reflexões pedagógicas voltadas aos estudantes com transtorno do espectro autista na universidade do estado de mato grosso. *Eventos Pedagógicos*, 15(3):1040–1048.

Bajaña, C. C., Bajaña, G. R., and Cobas, R. G. (2024). El razonamiento lógico matemático en estudiantes con trastornos del espectro autista. *Revista Conrado*, 20(99):194–201.

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. W. H. Freeman, New York.

Camalionte, J., Kondo, J., and Rocha, R. (2021). Estudantes do ensino superior com transtorno do espectro autista: Uma revisão integrativa da literatura brasileira. *Revista Brasileira de Educação Especial*, 27(4):679–698.

CAST (2024). Universal design for learning guidelines version 3.0. `https://udlguidelines.cast.org`. Center for Applied Special Technology (CAST), Wakefield, MA.

Chan, C. K. Y. and Hu, W. (2023). Students' voices on generative ai: Perceptions, benefits, and challenges in higher education. *International Journal of Educational Technology in Higher Education*, 20(1):43.

Cunha, M. and Carvalho, L. (2024). Abc autismo frutas: Um aplicativo para crianças com autismo construído com base nas premissas do design centrado no usuário e do ensino estruturado. In *Anais do XXXV Simpósio Brasileiro de Informática na Educação*, pages 937–950, Porto Alegre, RS, Brasil. SBC.

Elkins, S., Kochmar, E., Cheung, J. C. K., and Serban, I. (2024). How teachers can use large language models and bloom's taxonomy to create educational quizzes. In *Proceedings of the AAAI Conference on Artificial Intelligence*, volume 38, pages 23100–23108.

Fredricks, J. A., Blumenfeld, P. C., and Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1):59–109.

Guo, S., Latif, E., Zhou, Y., Huang, X., and Zhai, X. (2024). Using generative ai and multi-agents to provide automatic feedback. *arXiv preprint arXiv:2411.07407*.

Hehir, T., Schifter, L. A., Grindal, T., Ng, M., and Eidelman, H. (2016). A summary of the evidence on inclusive education. Technical report, Abt Associates, Cambridge, MA. Technical Report.

Holmes, W., Bialik, M., and Fadel, C. (2022). Artificial intelligence in education: Promises and implications for teaching and learning. *OECD Education Working Papers*, 258.

Imran, M. and Almusharraf, N. (2023). Analyzing the role of chatgpt as a writing assistant at higher education level: A systematic review of the literature. *Contemporary Educational Technology*, 15(4):ep464.

Israel, M., Chung, M. Y., Wherfel, Q. M., and Shehab, S. (2020). A descriptive analysis of academic engagement and collaboration of students with autism during elementary computer science. *Computer Science Education*.

Luckin, R. (2018). *Towards Artificial Intelligence-Based Assessment Systems*. UCL Institute of Education, London.

Malpartida, K. F. and Rodrigues, K. (2024). Building games to exercise computational thinking in children on the autism spectrum through pre-defined templates and end-user development concepts. In *Anais do XXXV Simpósio Brasileiro de Informática na Educação*, pages 3106–3116, Porto Alegre, RS, Brasil. SBC.

Melnyk, B. M. and Morrison-Beedy, D. (2012). *Intervention Research: Designing, Conducting, Analyzing, and Funding*. Springer Publishing Company, New York. First Place AJN Book of the Year Award Winner in Nursing Research.

Ministério da Educação (2025). Crescem matrículas de alunos com transtorno do espectro autista. `https://www.gov.br/mec/pt-br/assuntos/noticias/2025/abril/crescem-matriculas-de-alunos-com-transtorno-do-espectro-autista`. Notícia publicada em 22 abr. 2025. Acesso em: 27 maio 2025.

Moriña, A. (2017). Inclusive education in higher education: challenges and opportunities. *European Journal of Special Needs Education*, 32(1):3–17.

Mourão, A., Ribeiro, D., Junior, G. S., Jardim, H., and Monteiro, P. (2024). Meitea: Modelo educacional inclusivo desenvolvido para orientar e recomendar estratégias educacionais e adaptações para estudantes com tea no ensino superior. In *Anais do III Workshop de Pensamento Computacional e Inclusão*, pages 106–117, Rio de Janeiro, RJ, Brasil. SBC.

Pereira, L. and Barwaldt, R. (2022). Elaboração de atividades gamificadas para estudantes com tea: um estudo utilizando pensamento geométrico. In *Anais do XXXIII Simpósio Brasileiro de Informática na Educação*, pages 390–402, Porto Alegre, RS, Brasil. SBC.

Pires, S., Silva, C., Fernandes, B., Souza, F., Leal, S., Cavalcance, T., Santos, W., and Araújo, R. (2023). Jogos sérios como subsídio tecnológico na educação de crianças com transtorno do espectro autista. In *Anais do XXXIV Simpósio Brasileiro de Informática na Educação*, pages 656–669, Porto Alegre, RS, Brasil. SBC.

Rashid, M. and Saqr, M. (2024). Reflective teaching practices and inclusive learning environments. *Education and Information Technologies*, 29(3):2435–2456.

Sampaio, L. and Pereira, C. (2022). Jogo digital educativo para auxílio a crianças com autismo. In *Anais do XXXIII Simpósio Brasileiro de Informática na Educação*, pages 597–608, Porto Alegre, RS, Brasil. SBC.

Santos, M. B. and Lima, S. R. P. (2022). Gamificação e tecnologias assistivas: Um estudo de caso com estudantes com transtorno do espectro autista. In *Anais do Simpósio Brasileiro de Informática na Educação (SBIE)*, page 19805, Campo Grande, MS, Brasil. Sociedade Brasileira de Computação.

Schön, D. A. (1983). *The Reflective Practitioner: How Professionals Think in Action*. Basic Books, New York, 1st edition.

Shah, S. M., Elliott, C., and Nedungadi, P. (2024). Square pegs and round holes: Pedagogy for autistic students in computing education. *IEEE Transactions on Education*, 67(6):919–931.

Silva, A., Santos, P., and Cunha, M. (2024a). Letramundo: Um jogo sério para alfabetização de crianças com transtorno do espectro autista (tea) em ambiente escolar. In *Anais do XXXV Simpósio Brasileiro de Informática na Educação*, pages 2747–2756, Porto Alegre, RS, Brasil. SBC.

Silva, T., Vidotto, K., Tarouco, L., and Silva, P. (2024b). Potencialidades do uso de inteligência artificial generativa como apoio ao ensino de programação. In *Anais do XXXV Simpósio Brasileiro de Informática na Educação*, pages 1942–1956, Porto Alegre, RS, Brasil. SBC.

Stuurman, S., Passier, H. J. M., Geven, F., and Barendsen, E. (2019). Autism: Implications for inclusive education with respect to software engineering. In *Proceedings of the 2019 Computer Science Education Research Conference (CSERC)*, pages 1–11.

Sun, D., Boudouaia, A., Zhu, C., and Li, Y. (2024). Would chatgpt-facilitated programming mode impact college students' programming behaviors, performances, and perceptions? an empirical study. *International Journal of Educational Technology in Higher Education*, 21(1):14.

Svendby, R. B. (2024). Inclusive teaching in higher education: Challenges of diversity in learning situations from the lecturer perspective. *Social Sciences*, 13(3):140.

Tarconish, D., Grabowski, D., May, C., McNulty, S., and Spence, B. (2024). Universal design for instruction & learning in higher education. *Journal of Postsecondary Education and Disability*, 37(1):35–54.

UNESCO (2021). Recommendation on the ethics of artificial intelligence. `https://unesdoc.unesco.org/ark:/48223/pf0000381137`. Accessed: 2025-05-25.

Zhang, Y. (2024). Incorporating chatgpt as an automated written corrective feedback tool into l2 writing class. *Journal of Language Teaching*, 4(2):24.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice*, 41(2):64–70.