Neuro-Embracing Educational Design Framework:

A Conceptual Approach to Bridge Cognitive Accessibility Gaps Through GenAI Support

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Abstract

This paper introduces the Neuro-Embracing Education Design (NEED) Framework, which merges Romiszowski's skill taxonomy (2009) with generative AI (GenAI) to address the needs of neurodivergent students. By aligning skill challenges with neurodivergent profiles, the framework helps identify tailored interventions while emphasizing students' strengths. Grounded in cognitive load, executive function management, self-regulated learning, and self-determination theories, it operationalizes Reigeluth et al. (2017) Learner-Centered Paradigm and incorporates Mollick and Mollick's (2023) seven AI approaches. Focusing on cognitive diversity instead of deficits, the NEED Framework personalizes learning with GenAI to bridge skill gaps and amplify strengths and aims to redefine neurodiversity as a primary educational design consideration.

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Keywords: neurodivergent, Skills Schema, Learner-Centered Paradigm, instructional design, artificial intelligence (AI), personalized learning, cognitive load

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Over the past few years, there has been a surge in technological advances that enable convenient and self-paced instruction (e.g., citation), provide immediate knowledge for specific tasks or problem-solving (e.g., citation), and suggest a promising path for personalized learning for everyone (e.g., citation). When the flexibility of on-demand learning, the specificity of just-in-time learning, and the personalization afforded by Generative Artificial Intelligence (Gen-AI) converge, it is an exciting time to be in higher education for many. However, despite these advancements, some learners struggle in higher education because their challenges are not fully understood, considered, or accommodated in digital learning environments (citation). Rarely acknowledged by the institutions, instructors, and instructional designers responsible for creating their learning environments, many neurodiverse learners feel overwhelmed and unsupported despite the latest technological advances (citation).

Literature Review

In recent conversations around the use of AI, Siemens et al. (2022) noted that "learning, sensemaking, and decision-making" (p. 2) were the overlapping areas between artificial and human cognition. In this overlapping area, emerging research reveals that AI's transformative potential supports neurodivergent learners through personalized and strengths-based approaches to reduce cognitive load and enhance executive function (Author, 2025; Laudato & Zaugg, 2025). For neurodivergent learners in higher education, AI can benefit them in several ways (Researcher, 2025): the creation of accessible and equitable learning environments, the elimination of barriers through supports provided by adaptive technologies, and the provision of responses and clarifications. Additionally, AI-assisted audio-learning modules have proven effective in increasing reading engagement and academic success by adapting content through multiple modalities (Jafarian & Kramer, 2025).

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Researchers also emphasize that AI can effectively address skill gaps across various neurodevelopmental profiles. Iannone and Giasanti (2023) highlighted that integrating machine learning with assistive technologies enhances social reciprocity for individuals with autism by examining real-time interactions. At the same time, natural language processing (NLP)-driven tools assist dyslexic students in interpreting complex texts through visual-spatial translations (“Using generative AI”, n.d.). These approaches align with the framework presented by Mollick and Mollick (2023), which considers AI across seven different approaches (including Mentor, Coach, and Simulator) and focuses on the learner’s metacognitive growth while avoiding excessive dependence on automated solutions.

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However, critical discussions arise regarding the ethical implementation of AI tools. While AI can empower learners with customizable support (Laudato & Zaugg, 2025), researchers caution against potential biases in diagnostic algorithms and stress the importance of including neurodiverse training datasets (Mishra, 2024). The U.S. Department of Education (2023) further underscored the need for “human-in-the-loop” systems that maintain learner autonomy while harnessing AI’s adaptive features (Gibson, 2024). Overall, this body of literature highlights AI's potential to effectively apply Universal Design for Learning (UDL) principles on a broad scale, provided that strict safeguards for privacy and security self-determination accompany implementations (Mollick & Mollick, 2023).

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Conceptual Discussion

Conceptualizing a Framework

To address the areas discussed in the literature review, expressed by neurodivergent learners (Pierrès et al., 2024), and required by technological advances, it is essential to reconsider what instructional design should look like in the future. To answer this call, it is time to reconsider how neurodivergent learners engage with learning, how instructional designers craft the educational opportunity, and ensure that the engagement methods are learner-centered, skills-focused, and GenAI-

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enabled. It is time to consider a new framework to address emerging needs: The Neuro-Embracing Education Design (NEED) Framework.

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Establishing Learner-Centered Profiles

Using a rationalist technological epistemological approach to instructional design in 1981, Romiszowski laid the foundation for differentiating instructional outcomes by analyzing knowledge and skills as core elements. Differentiating between knowledge, information that you are aware of, and skills, what you can do, Romiszowski created *The Skills Schema* as a systems thinking framework for evaluating instructional points of struggle before seeking practical solutions to overcome them. His Skills Schema is divided into four categories (2016):

1. Cognitive Skills: logical reasoning, information processing
2. Psychomotor Skills: physical coordination, sensory motor tasks
3. Reactive Skills: dealing with oneself and one's attitudes, beliefs, habits, and self-control
4. Interactive: dealing with others and one's social emotional regulation, habits, and interpersonal communication and engagements

Romiszowski's framework (2016) also addresses both the reproductive (or procedural) dimension and the productive (or creative/problem-solving) dimension of knowledge within these skills. Reproductive skills may resemble learned habits, applying standard operating procedures, and understanding conventional rules, whereas productive skills may involve innovation, synthesis, adaptive thinking, and creative design. In keeping with the systems thinking approach, each neurodivergent profile interacts uniquely with Romiszowski's categories. When considered collectively using a systematic design process of development (Thanaraj, 2022), a neurodivergent learner-centered profile can be established by identifying barriers, leveraging strengths, and mapping interactions (Azuka et al., 2024; Burgstabler, 2018; CAST, 2024; DuPau, et. al, 2018; Friedman & Nash-Luckenbach, 2024; Green & Rabiner, 2012; Hamilton & Petty, 2023; Pierrès et al., 2024; Roa, 2021; Wallace, et al., 2016). Appendix

A, Table 1, presents profiles of neurodivergent learners based on challenges, strengths, and skills schema alignment.

Establishing Learner-Centered Scaffolding

Building on Reigeluth, Myers, and Lee's discussion of their Learner-Centered Paradigm of Education (2017), GenAI can be used to personalize learning pathways ("AI in personalized education", 2025; Halkiopoulos & Gkintoni, 2024; Kelly, 2025) for each learner profile to ensure that the educational experience is tailored to meet the unique needs of every learner. In doing so, other educational benefits are offered such as reduced cognitive load (Asma & Dallel, 2020; Atiomo, 2020; Banu et al., 2021; Le Cunff et al., 2024; Taylor, 2013; Wheeler, 2024), well-being (Hamilton & Petty, 2023; Yu et al., 2018), self-regulation (Meijs et al., 2021; Ng et al., 2024), self-determination (Alamri et al., 2020; Oga-Baldwin, 2015), executive function management (Figueroa et. al, 2017; Grosvenor, 2022; Jones et. al, 2016; Meijs, 2021; Southon, 2022) and autonomy during self-directed learning opportunities (Adinda & Mohib, 2020; Al Mamun et. al, 2020). Employing real-time adaptive scaffolding assists learners in navigating complex information more easily (Doo et. al, 2020; Kelly, 2024), seeks to amplify learners' strengths through multimodal expressions, and creates opportunities for learners to enhance their understanding and skills across various formats. By integrating a learner-centered focus with GenAI, learner-centered scaffolding can offer support tailored to specific solutions for neurodivergent learners' skill-based challenges by aligning them with the strengths and needs of neurodivergent individuals across Romiszowski's four skill categories. Appendix B, Table B1, illustrates GenAI support scaffolded tailored to the four skill-based categories, while Appendix B, Table B2, demonstrates GenAI's versatility in addressing the overlapping needs of neurodivergent learner profiles.

Establishing Learner-Centered Workflow

Framework Implementation – A Four-Phase Approach

Phase 1: Skill Assessment. GenAI diagnostic tools may identify each neurodivergent learner's strengths and challenges (Halkiopoulos & Gkintoni, 2024; Weng & Chiu, 2023) and facilitate adaptive assessment across Romiszowski categories. For instance, an ADHD learner might demonstrate exceptional abilities in productive skills due to hyperfocus but simultaneously face difficulties with reactive tasks due to impulsivity control issues.

Phase 2: GenAI Customization. GenAI customization emphasizes cognitive load management (Banu, et al., 2021) by breaking down complex tasks into manageable micro-steps and amplifying strengths found in the learner profiles. For example, ChatGPT-4 can create a detailed writing checklist specifically designed for ADHD learners, while DALL-E generates visual templates that help dyslexic learners articulate their ideas in non-verbal ways.

Phase 3: Universal Design for Learning (UDL) Integration. Integrated UDL guidelines can foster learner engagement and representation to enhance the educational experience (CAST, 2024). Engagement becomes a priority when AI gamifies repetitive tasks for ADHD learners, aids representation by converting text into 3D audio maps for those with visual impairments, and encourages action or expression due to a choice of preferred output formats such as video, audio, or text.

Phase 4: Metacognitive Feedback. GenAI may also provide real-time input and feedback (Adolphe, 2024; Bailey & Warner, 2025; Diaz & Nussbaum, 2024; Martin et al., 2020) regarding the learners' executive function management. For example, it may prompt a learner by asking, "You spent 20 minutes on Step 3—would you like a shorter approach?"

Workflow Overview. To view an illustration of the workflow cycle to establish and assess the Learner Profile, see Appendix C, Figure 1.

Theoretical Alignment

The NEED Framework is underpinned by theoretical alignments such as Romiszowski's Skills Schema (2016) and Reigeluth, Myers, and Lee's Learner-Centered Paradigm (2017). Using these, the learner profile prioritizes self-determination by allowing co-design instructional paths through personalized AI tools. It also incorporates Cognitive Load Theory (Le Cunff et al., 2024), as GenAI aims to reduce extraneous cognitive load by automatically offering tailored support and acting as "executive function coaches" to support self-regulated learning.

Ethical Considerations

Ethical considerations are paramount (Huriye, 2023). To mitigate bias, GenAI should be trained on neurodiverse datasets to avoid producing stereotypical outputs (Adolphe, 2024). Privacy concerns are addressed through localized AI processing to ensure that sensitive learner data remains protected and is not exploited (Khanal & Pokhrel, 2024). Importantly, learners should retain agency over AI customization by being allowed to opt out of features such as emotion tracking.

Integrating Support

The NEED Framework also provides integrated support based on the ongoing assessment of the learner profile. It can structure personalized support, relying on the feedback loop results. Appendix D, Table D1, offers examples of how to transform neurodivergent challenges into innovative learning opportunities by mapping neurodivergent learner profiles to GenAI.

The NEED Framework can be significantly improved by systematically integrating the seven pedagogical approaches to AI use proposed by Mollick & Mollick in 2023. This thoughtful combination results in a comprehensive framework that empowers educators to make intentional decisions regarding the deployment of generative AI within neuro-inclusive educational environments. By strategically utilizing the seven roles of AI, educators can effectively address specific challenges neurodivergent individuals face while simultaneously harnessing their unique strengths. This tailored approach aims to create a supportive learning environment that accommodates various profiles and skill domains, ultimately enhancing the educational experience for all students. Appendix D, Table D2, presents how the seven GenAI roles can promote learner independence by providing personalized strategies tailored to each learner profile

Integrating the NEED Framework

Integrating the NEED Framework into educational practices requires careful consideration. As Mollick and Mollick (2023) highlight, educators should prioritize establishing certain safeguards to address the pedagogical risks when implementing pedagogical approaches involving AI. First, teaching all learners how to critically evaluate AI outputs through structured verification tasks is essential to foster a mindset of inquiry and skepticism. Second, to enhance understanding of AI, developing an AI literacy curriculum tailored to the unique capabilities and limitations relevant to each neurodivergent profile is crucial. Additionally, educators should adopt a Progressive Independence Model that starts with high levels of support and views AI as a tool or teammate before gradually transitioning to more metacognitive approaches where AI takes on the role of coach or mentor. Finally, to ensure that AI usage fosters independence rather than dependence, regular self-determination checkpoints should be integrated into the learning process to assess whether AI enhances student agency.

Conclusion

Looking ahead, the integrated NEED Framework paves the way for future research directions. Future areas for research include measuring the differential impact of various AI approaches across different neurodivergent profiles, identifying the optimal points of transition between AI roles as learners gain skills, and developing prompting strategies explicitly tailored for neurodivergent learners with each AI role. Moreover, it will be beneficial to explore how various AI platforms, such as multimodal versus text-only systems, perform within this framework in order to contribute to a deeper understanding of AI's role in education. However, by understanding impacts and mitigation strategies (Gerlich, 2025) and thoughtfully integrating these approaches, educators can create supportive learning environments tailored to the diverse needs of neurodivergent learners.

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Appendix A

Neurodivergent Learner Profiles: Challenges, Strengths, and Skills Alignment

Table 1

Neurodivergent Learner Challenges and Strengths by Skill Schema Categories

Neurodivergent Learner Profile	Challenges			Strengths
	Intellectual/ Cognitive	Psychomotor	Reactive/ Interactive	Productive
ADHD	distraction during procedures	restlessness	impulsivity in social tasks	hyperfocus on interests
Autism	literal Interpretation	sensory sensitivities	social reciprocity challenges	deep focus on specialized topics
Dyslexia	text decoding and working memory	N/A	verbal delays in communication	visual-spatial creativity
Visual Impairments	visual information processing	spatial navigation	non-verbal cue recognition	auditory/verbal innovation

Note: This table presents the challenges and strengths of each neurodivergent learner profile, organized according to the four categories outlined in Romiszowski's Skill Schema.

Appendix B

GenAI Supports for Neurodivergent Learner Profiles

Table B1

Learner-Centered Scaffolding for Neuro-Inclusive Support

Schema Skill Category	ADHD Supports	Autism Supports	Dyslexia Supports	Visual Impairment Supports
Intellectual	chunked task breakdowns	literal-to-contextual bridging	text-to-speech simplification	audio-tactile data conversion
Psychomotor	movement-based AI reminders	sensory modulation prompts	N/A	haptic navigation guides
Reactive/ Interactive	emotion recognition feedback	social script generation	conversational summarization	non-verbal cue narration
Productive	interest-driven idea organizers	specialized topic expansion	visual mind-mapping tools	voice-to-design prototyping

Note: This table illustrates how learner-centered scaffolding can be tailored to the learner profile and provide opportunities to support strengths rather than address challenges.

Table B2

GenAI Neuro-Inclusive Learner Profile Matrix

GenAI Function	ADHD	Autism	Dyslexia	Visual Impairment
Task Chunking	breaks down multi-step tasks	simplifies abstract concepts	segments reading assignments	divides spatial tasks
Multimodal Translation	converts text to audio	converts metaphors to visuals	converts text to mind maps	converts visuals to audio
Real-Time Feedback	alerts off-task behavior	guides social reciprocity	corrects phonetic errors	narrates environmental cues
Strength Amplification	channels hyperfocus	deepens specialized interests	enhances visual creativity	optimizes auditory innovation

Note: This table highlights how GenAI's versatility meets the overlapping needs of neurodivergent learner profiles.

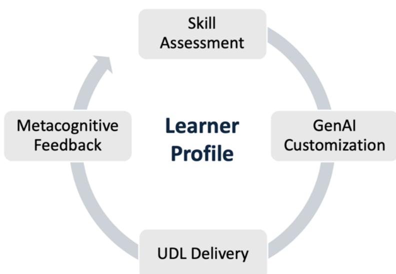
Appendix C

Commented [DH15]: I think this can go into the body of the proposal.

Overview of Workflow for the NEED Framework

Figure 1

The NEED Framework Workflow



Note: The workflow is a continuous cycle to assess the learner profile.

Appendix D

Support Integration

Table D1

NEED Framework Integrated Support Matrix

Neurodivergent Challenge / Skill	GenAI Capability/ Support	Use Case Examples
Organization and Time Management	Automated reminders, schedule planning, etc.	ADHD: Daily task checklists
Reading Comprehension	Summarization, text simplification	Dyslexia: Summarize articles
Written Communication	Grammar, spell check, structure suggestions	Dysgraphia: Essay drafting
Social Communication	Conversation simulation, feedback on tone	Autism: Practice social scenarios
Focus and Attention	Distraction minimization, chunking tasks	ADHD: Break down assignments
Visual Processing	Text-to-speech, image description	Visual Impairment: Describe images
Emotional Regulation	Motivational prompts, stress management tips	Anxiety: Coping Strategies

Note: This matrix offers educators examples for how the framework can offer support during times of teacher instruction and student learning.

Table D2

NEED Framework – AI Role Integration Matrix

GenAI Role	ADHD Applications	Autism Applications	Dyslexia Applications	Visual-Impairment Applications
Mentor	Provides just-in-time feedback during task switching	Offers concrete, literal feedback on social interactions	Validates alternative expression methods beyond text	Provides descriptive feedback on spatial concepts
Tutor	Delivers content in engaging, high-stimulation formats	Structures information with explicit patterns and categories	Presents content through audio/ visual alternatives	Creates non-visual conceptual models
Coach	Monitors attention patterns and suggests refocusing strategies	Helps navigate transitions between activities	Encourages metacognitive strategies for decoding	Builds confidence in spatial navigation skills
Teammate	Compensates for working memory gaps during collaborative tasks	Translates social cues and emotional contexts	Handles text-heavy portions of group work	Describes visual elements in collaborative documents
Student	Creates teaching opportunities for hyperfocus domains	Allows structured explanation of specialized interests	Enables teaching through visual-spatial strengths	Facilitates teaching through auditory strengths
Simulator	Creates low-stakes environments for impulse control practice	Provides social scenario rehearsal without overstimulation	Offers reading practice with adaptive difficulty	Simulates spatial environments for practice
Tool	Automates tasks for organization and executive function	Converts implicit to explicit instructions	Provides text-to-speech and speech-to-text conversion	Generates rich audio descriptions of visual content

Note: GenAI roles can promote learner independence by providing personalized strategies tailored to each learner profile.