Enhancing Digital Learning for Neurodivergent College Students: Exploring the Role of Multimodal Instruction and Scaffolding in Managing Cognitive Load

Cheryl Burris

College of Education and Human Development, George Mason University

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Dr. Angela Miller

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Contents

Abstract

A number of contemporary authors are examining the role of cognitive load, academic success in higher education, and online education. Their findings and the supporting evidence indicate that neurodivergent learners are encountering significant challenges in managing their cognitive load and self-regulated learning. This scenario raises concerns due to the critical role that these factors play in academic success. Additionally, it is troubling that higher education appears ill-equipped to create, foster, or support the learning needs of neurodivergent learners, despite the fact that foundational insights on the roles of cognitive load and executive function management are well-established and extensively researched. This study seeks to advance the field of research by exploring how college students with neurodivergent traits experience and perceive instructional design interventions aimed at reducing cognitive load. Employing a qualitative, design-based exploratory study that integrates formative evaluation principles, I intend to merge a phenomenological inquiry framework with Design-Based Research (DBR) methodology. My objective is to comprehend the experiences of college students diagnosed with neurodiverse traits, assess their levels of cognitive load in digital learning environments, and analyze their engagement with multimodal instructional materials and scaffolded interventions.

Keywords: Neurodivergent, instructional design, cognitive load, executive function, self-regulating learning, self-determination, multimodal learning, scaffolding

Enhancing Digital Learning for Neurodivergent College Students: Exploring the Role of Multimodal Instruction and Scaffolding in Managing Cognitive Load

In 2024, Le Cunff, Giampietro, and Dommett published an article titled “Neurodiversity and Cognitive Load in Online Learning: A Systematic Review with a Narrative Synthesis.” Their review aimed to address the challenging questions about the connections between cognitive load in online learning and neurodivergence. As they noted, this is not new information. However, despite this fact, they discovered an alarming lack of research investigating this connection. To their surprise, a systematic review of 90 studies conducted across 21 countries revealed that 92% of the studies neglected to consider neurodiversity as a potential factor affecting cognitive load in online learning, while only 8% included it (Le Cunff et al., 2024). Adding complexity to their findings was the emerging evidence that individuals diagnosed with neurodivergence may exhibit distinct patterns of cognitive load in digital learning environments (Le Cunff et al., 2024).

So, if it is known that there are concerns around cognitive load management and neurodiversity, why do the statistics tell a different story? Le Cunff (2024) provides further insight in his examination of the studies by noting that those studies which included neurodivergent learners primarily used subjective testing to measure their cognitive load. This choice of assessment suggested that there is no objective test available to measure cognitive load in neurodiverse individuals. Consequently, because neurodivergent traits have not been historically represented in cognitive load studies, there is a limited understanding of how cognitive load manifests for neurodiverse individuals, the eLearning experiences for learners

with neurodivergent traits, the impact of neurodivergent traits on cognitive load, and how to tailor instructional design offer scaffolding and support (Le Cunff et al., 2024).

Le Cunff et al. are not the only ones posing neurodiverse-centered questions. In 2023, Friedman and Nash-Lukenback highlighted the lack of learning theories and models for post-secondary neurodivergent learners, as well as the insufficient understanding of the adult neurodivergent experience. They further their examination by pointing out the critical issue that instructional design in higher education may not integrate neurodivergent intelligences or culturally relevant methods. While Hamilton and Petty (2023) examine pedagogy for neurodiverse learners in higher education, Kelly (2024) is sounding the alarm for improved accessibility and accommodations.

But why is this all important? As noted in 2020 by both Atiomo and Yu, Skek, and Zhu, emotional well-being and cognitive load are closely linked to academic achievement. Given that cognitive load and executive function management have a significant and measurable connection (Figueroa et al., 2017), and that both are tied to self-regulated learning (Meijs et al., 2021), motivation, and goal-setting (Ng et al., 2023), it should come as no surprise that college students with neurodiverse traits face greater challenges in college, exhibit lower motivation to study, and are at higher risk for impaired success (DuPaul et al., 2019). When considering these facts alongside the lack of objective cognitive load tests, the absence of neurodivergent pedagogy, and the deficiency of instructional design theories, why are we surprised that neurodiverse students struggle significantly when they are not included in the design of curricula or learning environments?

Statement of Purpose

It is widely recognized that a strong, measurable link exists between cognitive load and self-regulated learning, executive function management, and self-determination (Figueroa et al., 2017; Le Cunff et al., 2024; Meijs et al., 2021; Ng et al., 2023). However, due to the historical lack of representation of individuals with these traits in cognitive load studies (Le Cunff et al., 2024), the influence of neurodivergent traits on these connections has not been as thoroughly documented. Compounding this issue is emerging evidence suggesting that neurodivergent learners may exhibit unique cognitive load patterns, particularly in online learning contexts (Le Cunff et al., 2024). To design effective instructional strategies that facilitate cognitive load management, it is crucial to gain a deeper understanding of this subject.

The primary objective of this study will be to investigate the effects of multimodal instruction and scaffolding instructional design interventions on the learning experiences of college students with neurodivergent traits in digital learning settings. Specifically, the research will examine how these interventions impact cognitive load, a vital element of educational success, while also identifying methods to improve accessibility, engagement, and learning outcomes for neurodivergent students.

This research will prioritize the perspectives and experiences of these learners. The study's intent will be to offer evidence-based insights for instructional designers and educators. This, in turn, will support the creation of more inclusive and effective digital educational practices that may meet the distinct cognitive and emotional needs of neurodivergent

populations.

Research Questions

This study will explore how multimodal instruction and scaffolding instructional design interventions affect the cognitive load experiences of college students diagnosed with neurodivergent traits in digital learning environments. By examining these learners' interactions with tailored instructional strategies, I will seek to provide insights into optimizing digital learning for neurodivergent students, enhancing accessibility, and supporting academic success. Given the purpose of my study, this proposal's primary research question is: *How do college students with neurodivergent traits experience and perceive instructional design interventions that aim to reduce cognitive load?*

While this primary research question will guide my overall study, I also want to dig into several embedded aspects of this broader topic to gain a more nuanced understanding of the neurodivergent learners' experiences, perspectives, and situations. Therefore, in tandem with my primary question, I will use the following support questions to guide my study:

1. What specific features of multimodal instruction and scaffolding are most effective in reducing cognitive load for these learners?
2. How do neurodiverse traits uniquely interact with multi-instructional design elements?
3. What challenges do neurodivergent students encounter when engaging with multimodal instruction and scaffolding in digital learning environments?
4. How do these interventions influence constructs like attention regulation, motivation, and self-regulated learning?

By answering these questions, I will seek a deeper understanding of the experiences,

perspectives, and situations faced by neurodivergent learners. This insight will guide me in reducing the cognitive load encountered in digital learning spaces, improving the design of multimodal instruction, and enhancing the impact of scaffolding instructional design interventions. I'll then use what I learn to guide future iterations of improvements and developments of these interventions.

Context

This study will take place on the George Mason University campus to reduce barriers to participation and leverage the existing resources (such as facilities and wifi) and support systems (such as the Disabilities Services office and instructional designers). The campus will facilitate design collaboration and intervention testing. Participants will experience a structured digital learning environment featuring multimodal instruction and scaffolded support. This support may encompass a variety of resources, including interactive modules, video lectures with integrated quizzes, and guided problem-solving tasks. These interventions will simulate realistic academic tasks (e.g., reviewing course material, completing assignments, and engaging in collaborative spaces) tailored to the cognitive demands of neurodivergent learners. The focus will be on understanding the lived experiences of college students with diagnosed neurodiversity traits who engage in a digital learning environment.

Research Objective

With this study, I plan to be iterative, collaborative, and discovery-driven to understand cognitive load in neurodivergent learners, enhance instructional design methods that lower cognitive load, and advance the field of inclusive instructional design. The practical implications of my study will assist educators and neurodivergent learners by reducing cognitive load.

Researcher Positionality

As a researcher, I will approach this study from the dual perspectives of an instructional designer and a neurodivergent learner. My professional experience in instructional design will inform my understanding of the theoretical and practical complexities involved in creating accessible and inclusive digital learning environments. Concurrently, my lived experience as a student diagnosed with neurodivergent traits will provide an intimate awareness of the challenges faced by learners while navigating cognitive demands in educational settings. This positionality will enable me to bring a unique and empathetic lens to the research that will prioritize the voices and needs of neurodivergent students while ensuring the study's design reflects best practices in instructional design. However, I acknowledge that my dual role as a researcher and member of the participant community may introduce potential biases that could include assumptions about shared experiences or priorities.

To address this potential concern, I will practice reflexivity using a researcher's journal to critically analyze my assumptions and document how my positionality influences the research process. Next, I will highlight participants' voices and viewpoints through ongoing member checking and incorporating direct quotes to represent findings authentically. I will also seek objectivity by collaborating with peer researchers, advisors, and coders to validate the data analysis and interpretations. Additionally, I will be committed to upholding ethical transparency by clearly outlining my dual roles to participants to safeguard informed consent and build trust. This study will promote equitable practices for neurodivergent learners and be guided by evidence-based design principles that authenticate a sincere understanding of the

neurodivergent lived experience. My positionality will enhance this research by merging professional expertise with a genuine personal investment in the outcomes.

Researcher Epistemology

From an ontological perspective, I am deeply grounded in both relational and constructivist theories. Together, these perspectives emphasize that knowledge is formed through interactions and relationships, and meaning arises from engagement and experience. Epistemologically, I align with designerly ways of knowing and pragmatism because they foster practical outcomes derived from engaging with the design process and understanding learners' experiences. Consequently, I will adopt an inductive approach to comprehend the cognitive load experiences of neurodivergent learners and employ a Design-Based Research (DBR) method to investigate the digital environment and implement instructional design interventions for this population (Cobb et al., 2003).

Since I will examine the students' lived experiences, this study will be structured as a qualitative, design-based exploratory study with formative evaluation principles. The goal will be to gather insights from neurodivergent learners, enhance the design and impact of instructional interventions for them, and utilize these findings to inform future iterative cycles of design development and refinement. Specifically, I will apply a phenomenological inquiry framework to explore the participants' lived experiences and perceptions regarding cognitive load related to multimodal instruction and scaffolding instructional design interventions.

This method aligns with my goal of enriching the experiences of neurodivergent learners. By employing a phenomenological inquiry framework, I can thoroughly explore the participants' personal experiences. Additionally, a design-based research approach will

guarantee that the findings are practical and relevant to enhancing instructional design.

Literature Review

Summary

Several recent authors are exploring the role of cognitive load, success in higher education, and online education. Their findings and supporting evidence indicate that neurodivergent learners encounter challenges in managing cognitive load and self-regulated learning. This situation is concerning due to its impact on academic success. It is also troubling that higher education appears ill-equipped to create, foster, or support the learning needs of neurodivergent learners, even though the foundational insights are well-established and researched.

The review below synthesizes key findings from recent studies addressing neurodiversity, cognitive load, and instructional design in online learning environments. These articles were selected because they provided insights regarding neurodivergent learners, the role of cognitive load, and the design principles necessary to support inclusive and effective online education.

Cognitive Load and Neurodiversity in Online Learning

Le Cunff, Giampietro, and Dommett (2024) conducted a systematic review highlighting the unique cognitive challenges faced by neurodivergent learners and focused particularly those with ADHD and autism, in digital learning environments. These challenges include difficulties with information processing, working memory limitations, and increased susceptibility to distractions. Figueroa and Juárez-Ramírez (2017) similarly emphasize the role of graphical user interfaces (GUIs) in influencing cognitive load, noting that poorly designed

interfaces exacerbate executive function demands such as task-switching and attentional control. De Mooij et al. (2020) argue for tailoring online learning platforms to individual cognitive profiles and advocated for how personalized adaptations can mitigate cognitive overload and enhance learner engagement.

Self-Regulated Learning and Cognitive Load Management

Self-regulated learning (SRL) emerged as a critical strategy for managing cognitive load. Meijs et al. (2021) link executive functions, such as working memory and inhibitory control, to effective SRL strategies among adult learners in online education. Ng, Tan, and Leung (2024) explore the potential of AI tools like ChatGPT to scaffold SRL, helping learners set goals, monitor progress, and reflect on their learning processes. Le Cunff et al. (2024) echoe these findings when they underscore the importance of SRL training for neurodivergent learners. They suggest that explicit guidance can empower students to navigate the complexities of online learning environments with greater autonomy.

Instructional Design Interventions to Reduce Cognitive Load

Designing interventions that reduce cognitive load while enhancing accessibility and engagement is a central theme in the reviewed studies. Le Cunff et al. (2024) and Figueroa and Juárez-Ramírez (2017) underscore the significance of following multimedia design principles, such as segmenting information and minimizing extraneous load, to assist neurodivergent learners. De Mooij et al. (2020) promote adaptive learning systems that accommodate various cognitive profiles and provide personalized and targeted support. Ng, Tan, and Leung (2024) emphasize the potential of utilizing emerging technologies like AI to develop dynamic, responsive learning environments that adapt to individual needs.

Collectively, these studies emphasize the importance of minimizing cognitive load with inclusive instructional design methods. Neurodivergent students, especially those with ADHD and autism, encounter specific obstacles in online learning settings, requiring customized solutions. Self-regulated learning (SRL) strategies and adaptive technologies serve as crucial resources for boosting engagement and addressing cognitive challenges. Instructional design based on multimedia theory, together with personalization and innovative AI tools, provides practical strategies for lowering cognitive barriers and fostering fair learning results.

This literature review demonstrates the critical need to investigate instructional methods such as multimedia and scaffolding to effectively reduce cognitive load for neurodivergent learners. The findings will decisively inform the current study's design, which aims to enhance the learning experiences of college students with ADHD and autism. Furthermore, the review emphasizes integrating cognitive load, self-regulated learning (SRL) frameworks, and adaptive technologies into instructional designs. These considerations align perfectly with the study's objectives to establish inclusive and highly effective digital learning environments.

Constructs

There are seven constructs worth noting for this study, as they relate to the themes surrounding the unique needs of neurodiverse learners.

1. Cognitive Load - The mental effort required to process information or complete a task (Figueroa et al., 2017; Le Cunff et al., 2024).
2. Neurodivergent Learner - Individuals whose brains process, learn, and behave differently from typical standards, including those with conditions such as ADHD,

autism, dyslexia, and dyscalculia (Friedman & Nash-Luckenback, 2023; Hamilton & Petty, 2023; Le Cunff et al., 2024).

3. Executive Function - Mental skills that assist in planning, focusing, remembering instructions, and managing tasks (Figueroa et al., 2017; Meijs et al 2021).
4. Self-Regulated Learning - The ability to control and manage one's own learning processes. This includes setting goals, monitoring progress, managing time, and adjusting strategies (Meijs et al., 2021; Ng et al., 2023;).
5. Self-Determination - The ability to make choices and take control of one's own actions and decisions. This is particularly important for setting goals and pursuing them independently (Friedman & Nash-Luckenback, 2023).
6. Multimodal Instruction – An instructional method that provides multiple sensory experiences (such as visual, auditory, reading, writing, and kinesthetic) combined in various ways to offer choices for communication and representation, thereby enhancing learning. This includes materials such as text, images, videos, and graphics (McMenamin, C. & Cameron, K., 2024).
7. Scaffolding – Temporary support and guidance provided to students when they are learning a new skill or concept. As they progress toward independence, the support and guidance are gradually withdrawn (Kelly, 2024; Le Cunff et al.) 2024)

Implications for Instructional Design

The literature presents two significant implications. First, it offers practical outcomes for instructional design. The opportunity to enhance inclusivity through Universal Design for Learning and scaffolding supports both neurodivergent learners and promotes digital equity.

Second, by addressing the integration of cognitive load for neurodiverse learners, we can bridge the gap between psychology and instructional design. By considering neurodivergent traits as an influencing factor for cognitive load, we can make testing more inclusive, which will assist in addressing cognitive load issues more effectively earlier.

Key Debates and Controversies

While much of the literature review found common ground on many principles, several areas within these studies offer conflicting ideas and topics for discussion.

First, Le Cunff et al. (2024) and De Mooij et al. (2020) do not reach an agreement regarding the generalization of findings among neurodivergent learners. While Le Cunff (2024) presents research that highlights the variety of cognitive load challenges, De Mooij (2020) advocates for tailored learning interventions. Until we fully integrate AI into learning platforms to serve as an AI-assisted tutor, I cautiously support Le Cunff et al., as we cannot adequately provide tailored learning interventions at this time.

Next, Le Cunff et al. (2024) also call for more controlled studies to better understand cognitive load in neurodivergent learners while expressing hesitation about the difficulty of generalizing findings across diverse settings. Conversely, Ng, Tan, and Leung (2024) advocate for piloting interventions in real-world environments but raised concerns that this approach might lack experimental rigor control. AI needs to be studied more before it is widely disseminated because it is not understood. That said, there is the risk that we fall behind if we do.

Gaps/Limitations in Literature

As noted by Le Cunff et al. (2024), little is known of the impact of neurodivergent traits

on cognitive load because these traits have not been historically represented in cognitive load studies. This poses the most significant gap in the literature. Given how few studies were available that included cognitive load in learning environments, the lack of understanding about how cognitive profiles influence experiences may mitigate interventions. Additionally, there needs to be a better representation of the various types of neurodiverse learners in the studies.

Methods

Research Design

This research will be a qualitative, design-based exploratory study that incorporates formative evaluation principles by blending a phenomenological inquiry framework with Design-Based Research (DBR) methodology. I will aim to understand the experiences of college students diagnosed with neurodiverse traits, investigate their level of cognitive load in digital learning environments, and analyze their engagement with multimodal instructional materials and scaffolded interventions. Rooted in relational and constructivist ontologies, my study will highlight the importance of engagement and interaction in meaning-making. Epistemologically speaking, it will draw from approaches used with pragmatism and designerly ways of knowing to focus on producing actionable results through iterative cycles of design and analysis.

Description

The study will be organized into three iterative phases: Exploration, Intervention Design, and Evaluation/Refinement. During the Exploration Phase, participants will join semi-structured interviews to discuss their experiences with cognitive load in digital learning environments. This phase seeks to uncover fundamental themes and challenges related to multimodal instruction and scaffolding. The Intervention Design Phase will use insights gained from the exploration

phase to guide the creation of instructional design interventions with an emphasis on multimedia and scaffolded support tailored to the identified needs. Finally, the Evaluation/Refinement Phase will involve implementing these interventions. The researcher will collect observational data on participants' interactions using screen recording and system analytics. The participants will provide feedback through reflective recording think-aloud protocols during interviews and focus groups. Data analysis will be conducted iteratively to enhance the interventions and ensure they meet participants' requirements.

Step-by-Step Plan

To accomplish this study, I will follow the following steps to execute my research plan:

- **step 1 – recruitment and participation of participants**: I will partner with GMU's Disabilities Services office to recruit 20-30 college students with a medical diagnosis for neurodivergent traits. I will ensure participant diversity in gender, cultural backgrounds, and neurodiverse traits. I will obtain informed consent and maintain the confidentiality of all participants.
- **step 2 – iterative design process**
    - **phase 1 – exploration:** I will conduct semi-structured interviews with participants to examine their experiences with cognitive load in digital learning environments. I will use prompts to investigate their views on multimodal instruction and scaffolding interventions. I will transcribe and analyze the interviews. I will code the interviews using themes and the constant comparative method to challenge what I am learning from my data as I move into the next phase.

  - **iterative phase 2 – intervention design:** I will use the insights I gain from phase 1 to co-design and scaffold instructional interventions with participant feedback. Working with an instructional designer, I will ensure practical and inclusive elements are included in the more neuro-friendly design interventions. I will create prototypes of the design interventions to be tested in the digital learning environment.
  - **iterative phase 3 – evaluation and refinement:** I will implement the co-developed instructional design interventions in a controlled digital learning environment. I will employ the think-aloud technique as participants engage with the interventions to gather real-time feedback. I will conduct follow-up focus groups to extract additional insights about the effectiveness and usability of the interventions. I will refine the interventions based on participant feedback and continued analysis

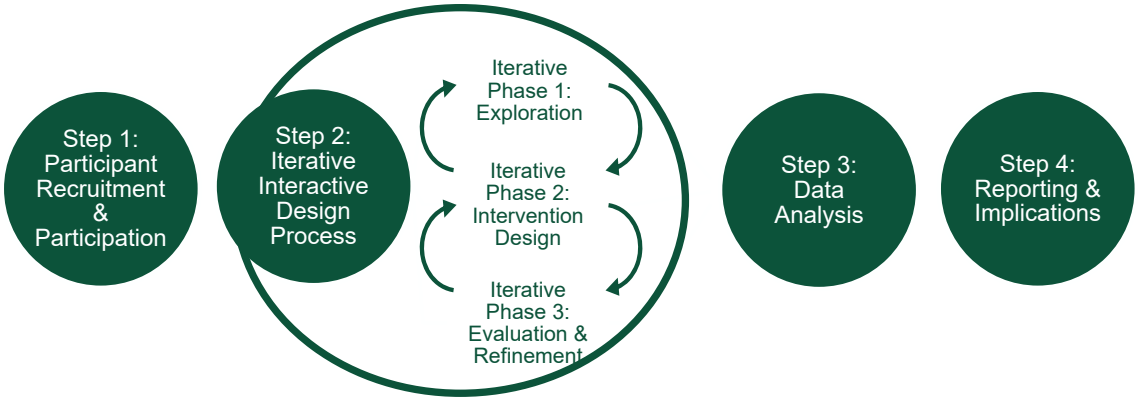
- **step 3 – data analysis:** I will carry out iterative analysis of data themes from the interviews, the think-aloud sessions, and focus groups. I will utilize member checking to verify the accuracy and credibility of my interpretative findings. I will document emerging patterns and refine the interventions in each iteration.
- **step 4 – reporting and implications:** I will create a comprehensive report and summarize the findings with an emphasis on the lived experiences of participants and the effectiveness of the interventions. I will suggest actionable recommendations for creating neuro-inclusive digital learning environments that cater to the cognitive load of neurodivergent learners. I will discuss the implications

for future instructional design research and practices.

This plan for an iterative, participant-centered process will ensure the study records valuable insights into the experiences of neurodivergent learners. From the data, I will create practical interventions focused on reducing cognitive load in digital learning environments.

Figure 1

Research Plan: Step-by-Step Process



Setting

I will conduct this study during the 2025-2026 academic year at George Mason University (GMU). Three main reasons led to the selection of this institution: its location, the diversity of its student population, and my access. In Fairfax, Virginia—a suburb near Washington, DC—GMU consistently receives high marks in accessibility, diversity, program offerings, research, and national rankings. In 2018, it was ranked #1 in Virginia for campus diversity and was recognized nationally as one of the top 10 most diverse public universities (George Mason University, n.d.). This diversity is essential for recruiting a wide array of

participants.

George Mason University's dedication to a diverse student body was showcased when it received the Higher Education Excellence in Diversity (HEED) Award in October 2024 and hosted the Access to Research and Inclusive Excellence (ARIE) National Conference in Spring 2024 (Hollis, 2024). As someone diagnosed with neurodiverse traits, their commitment to supporting and engaging neurodivergent learners is a significant reason I chose GMU for my doctorate in education. Due to my diagnosis, I benefit from their support and am well-acquainted with the Disability Services, Accessibility Support Services, and Assistive Technology Initiative. This experience grants me a unique level of access compared to other student researchers. Together, these three factors explain why my study will focus on students enrolled at GMU and registered for disability support services.

To maximize the potential for success and minimize interruptions and interference, the study will take place on the GMU campus for several reasons. First, a campus setting will provide access to the target population, along with technology and network support, and recruitment assistance through collaboration with the Disability Services office. This study aims to raise awareness on campus about the unique needs of neurodivergent students and demonstrate the university’s commitment to supporting its diverse learners. Secondly, the campus will offer a contextually relevant environment that reflects the learners’ specific challenges and opportunities. This will also yield insights for the university regarding the demand for requirements and resources. Third, the study will create opportunities for communication, collaboration, and cooperation with additional university departments, including faculty, learning and technical support offices, and instructional design teams. These

partnerships will enhance stakeholder interests, boost the study's credibility, and increase the fidelity of the selected interventions. Fourth, conducting the study on campus will lower barriers to engagement—such as time, accessibility, academic support, and environmental familiarity—by providing convenience for the researcher, campus partners, and participants. Finally, once the initial study is completed, the campus setting will offer a real-world context for a pilot with iterative design and testing opportunities. This will ensure that solutions are practical, applicable, and integrated into university life, systems, and structures. By leveraging GMU's campus as the research setting, this study will align its goals with the needs, resources, and interests of the university while ensuring the desires for practical relevance and impact are also met.

Participants

For the purposes of this study, I will collaborate with the Disabilities Services office to recruit participants. The rationale is that students who receive assistance from their office have a documented medical diagnosis and are already receiving services. As a result, the Disabilities Services office has the contact information for the predetermined population: higher-education learners diagnosed with neurodivergent traits.

Since the population will be at a local university, George Mason University, the sample will consist of volunteers invited via email through the Disability Services office. My targeted sample size will be 10-15 students. While this sample size is small and manageable but large enough to have some diversity among the participants.

Selection Criteria

My inclusion criteria for participants will be the following: they must be enrolled at

GMU, have diagnosed neurodivergent traits (genetic or acquired), be registered with the college's disability services office, be at least 18 years old, and be able to provide informed consent.

My exclusion criteria will be those students without a formal diagnosis or who do not engage in digital learning environments.

There will be no inducements for participation at this time

Data Collection

I will collect data throughout the study and facilitate a thorough triangulation process to provide deeper insights and enhance the reliability of the findings. The data collection will involve qualitative measures and use interviews and observational studies to capture participants' perspectives on instructional design interventions and cognitive load. This comprehensive approach will allow for a more nuanced understanding of their issues while engaged in a digital learning environment.

Data Sources

I will have three sources of data for this study: participants, artifacts, and documents. The participants are GMU students who have been formal diagnosed with neurodiverse traits and registered with the college's disability service office.

The study's artifacts will include the online learning platform, analytics on student engagement with the interventions, and any course materials created for them.

The documents will be the participants' reflective learning diaries and transcripts from the interviews and focus groups.

Data Collection Procedures

I will employ the following methods to collect data for my qualitative study:

- Semi-structured interviews will be conducted before and after the intervention to capture participants' initial load experiences and explore their reactions to the multimodal instruction and scaffolding interventions.
- Participants will maintain learning diaries to document their daily experiences with the interventions and record instances of cognitive strain or success.
- Focus groups will be organized in small group discussion sessions to examine participants' experiences.
- Observational data will be gathered on participants' interactions with the digital learning environment using screen recordings (with consent) and system analytics (e.g., time spent and interaction patterns).

Ethical Considerations

Protection is a guiding principle for research. To ensure I am correctly protecting my participants, informed consent, protection of confidentiality, and protection of privacy will be important for my study.

Protection

Informed consent is a cornerstone of ethical research practice. I will employ active consent measures and ensure that I receive an informed consent form from every volunteer. Before they sign the form, I will ensure they understand the purpose of the study, along with the nature and value of their participation. I will implement strategies to present the consent clearly and in simple language, providing a detailed explanation of the risks and benefits. I will allow ample time for them to review the directions and the consent form, offering it in text,

video, and audio formats to ensure accessibility. Once they have completed it, I will provide ample opportunities for them to ask questions before signing.

Protection of Confidentiality and Privacy

I will protect the participants' privacy by allowing them to decide how their information is shared. This will include an option for complete withholding. I will also give the participants the ability to opt in or decline to receive information about the study.

I will protect the participants' confidentiality by using pseudonyms to conceal their identities. I will also protect the data collected during the study by using a secured, encrypted database with restricted access.

Freedom to Withdraw

Participants have the right to withdraw from the study at any time for any reason. Their participation will not be constrained or constrained, and choosing to withdraw will not adversely affect their involvement.

Protection from Mental and Physical Harm

This study is designed to be low-risk because the focus is on understanding the participant's experiences and enhancing learning experiences in a respectful and supportive manner. However, this study will involve participants interacting with technology and potentially experiencing negative feelings such as frustration, confusion, or annoyance. As a result, protective measures will be taken to minimize the risk of experiencing the effects of mental or physical harm. I have provided a list of potential risks and mitigating measures in Table 1 below that will be freely offered to participants.

Table 1

Potential Risks and Precautions

Potential Risks	Precautions
Cognitive load management	Offer breaks
Psychological stress such as confusion, frustration, annoyance	-Monitor participants -Offer and opportunity to freely withdraw
Understanding consent	-Use simplified language and visual aids -Provide time to answer questions -Provide multimodal options
Undue influence	-Clearly explain the nature of the study -Explain there is no inducement
Population Vulnerability	-Work with the disability office to validate -my recruitment strategy

Benefits

I will explain to them the benefits of their study participation. As part of that explanation, I will discuss with the participants how their involvement will shape the future of instructional design practices, offer an increased understanding of cognitive load in neurodivergent learners, and aid in broadening inclusivity for neurodivergent learners. The following is a list of potential benefits that may result from this study:

1. **enhanced learning experiences.** Interventions will improve digital learning spaces by reducing cognitive load. This will make it easier to process information and lead to academic success.
2. **personalized insights**. Participants will be allowed to offer insights into their unique learning experiences, processes, and strategies.

3. **advocacy and representation.** This study will provide a platform for participants to voice their experiences and express their challenges as neurodivergent learners. In doing so, they may learn more about their own learning process and strategies.
4. **inclusion.** This study will give participants the opportunity to contribute to the creation of a more inclusive educational learning environment.
5. **empowerment.** This study will allow participants to be agents of change by enabling participants to contribute to the design process.

Statement of IRB application

This study aims to explore cognitive load among neurodivergent learners and identify instructional design strategies to reduce their load. Participation is voluntary, and individuals will not be excluded based on their neurodivergent characteristics. A debrief will occur to ensure participants understand the study's purpose and are allowed to ask questions.

Proposed Data Analysis

I will examine the data and identify themes to comprehend the factors influencing cognitive load for neurodivergent learners in a digital learning environment.

Thematic Analysis

I will use thematic analysis to code the interview transcripts, learning diaries, and focus group discussions to identify patterns and themes related to cognitive load and instructional design experiences. I will use an iterative coding process to refine themes through collaboration with a second coder for reliability. To ensure I understand the lived experiences of the participants, the effectiveness of the instructional interventions, and the actionable design improvements, I will use the following combined coding methods:

1. I will use in vivo coding to establish initial codes based on the participants' discussions and understanding of terms. I will also pre-code the transcriptions and diaries to determine initial themes.
2. I will use focused coding to refine my initial codes into categories or themes. This will help determine the significant or recurring data patterns.
3. I will use emotion coding to capture the participants' emotional responses. This will allow me to match their emotional reactions to the intervention or their experience, which will be particularly helpful in identifying cognitive load.
4. I will use causation coding to identify the causal relationship, which will assist me in connecting related moments. This will be particularly helpful when analyzing participants' perceptions of specific interventions and determining their relationship to their cognitive load.
5. I will use pattern coding to establish overarching themes and patterns. This will help me examine themes across participants.

Analytical Framework

I will organize my findings around the interaction of the neurocognitive participants' reactions, cognitive load categories (intrinsic, extraneous, germane), and instructional design interventions.

Software

I will use the qualitative data analysis tools by ATLAS.ti to systematically manage and organize codes, themes, and excerpts.

Trustworthiness

To ensure the reliability of this study, I will include strategies that promote and demonstrate credibility, transferability, dependability, and confirmability.

Credibility

To ensure the study is truthful, accurate, and credible, I will employ triangulation by gathering data from various sources th, including interviews, diaries, focus groups, and observations. I will conduct member checking by sharing initial findings with participants to confirm accuracy and validate that their experiences correctly interpreted. I will dedicate adequate time to interact with the participants to build trust and gain a deeper understanding of their experiences. I will collaborate with critical friends to discuss findings, explore interpretations, and gain additional perspectives.

Transferability

To ensure that my findings will be applicable to other contexts, I will provide thick, rich descriptions of the contexts, participants, and settings so that others can evaluate their own relevance. I will also use purposeful sampling to select participants with diverse experiences to ensure that the findings can be generalized to a broader neurodivergent population.

Dependability

To maintain consistency in my findings over time, I will establish an audit trail that records my research decisions, processes, and iterations throughout data collection and analysis. This approach will enhance transparency and enable others to understand my methodology. I'll also keep a reflexive journal to capture my thoughts, biases, and decisions throughout the study to illustrate my reflexivity. Additionally, I'll participate in the code-recoding process to verify the consistency of my initial data coding in thematic analysis ***over***

time.

Confirmability

To maintain objectivity and neutrality, I will perform reflexive journaling regularly to recognize and address my biases and preconceptions as a researcher. Additionally, I will involve an external reviewer to assess the research process and validate my conclusions. I will incorporate direct quotes from participants to ensure my interpretations are firmly rooted in the data.

To maintain trustworthiness, I will uphold strict standards and offer actionable insights into the experiences of neurodivergent participants. To boost overall credibility, I will follow the ethical considerations mentioned earlier. This means I will ensure I obtain informed consent, protect their confidentiality, and make it abundantly clear that participation is voluntary and can be withdrawn at any time without penalty.

Conclusion

In conclusion, this qualitative study aims to gain a deep understanding of the lived experiences of college students diagnosed with neurodivergence and gain insights into how multimodal instruction and scaffolding instructional design interventions affect their cognitive load experiences in digital learning environments. For neurodivergent students, this study will provide insights into optimizing digital learning, enhancing accessibility, and supporting academic success by examining the participants' interactions with tailored instructional strategies.

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