

DiverseClaire: Simulating Students to Improve Introductory Programming Course Materials for All CS1 Learners

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Abstract

Although CS programs are booming, introductory courses like CS1 still adopt a one-size-fits-all formats that can exacerbate cognitive load and discourage learners with autism, ADHD, dyslexia and other neurological conditions. These call for compassionate pedagogies and Universal Design For Learning (UDL) to create learning environments and materials where cognitive diversity is welcomed. To address this, we introduce DiverseClaire a pilot study, which simulates students including neurodiverse profiles using LLMs and diverse personas. By leveraging Bloom’s Taxonomy and UDL, DiverseClaire compared UDL-transformed lecture slides with traditional formats. To evaluate DiverseClaire controlled experiments, we used the evaluation metric the average score. The findings revealed that the simulated neurodiverse students struggled with learning due to lecture slides that were in inaccessible formats. These results highlight the need to provide course materials in multiple formats for diverse learner preferences. Data from our pilot study will be made available to assist future CS1 instructors.

CCS Concepts

• Social and professional topics → Computing education programs.

Keywords

CS1, Inclusive Education, Universal Design for Learning, Large Language Models

ACM Reference Format:

Wendy Wong, Yuchao Jiang, and Yuekang Li. 2026. DiverseClaire: Simulating Students to Improve Introductory Programming Course Materials for All CS1 Learners. In *Proceedings of the 57th ACM Technical Symposium on Computer Science Education V.2 (SIGCSE TS 2026)*, February 18–21, 2026, St. Louis, MO, USA. ACM, New York, NY, USA, 2 pages. <https://doi.org/10.1145/3770761.3777340>

1 Introduction

Neurodivergent learners, such as students with attention-deficit hyperactivity disorder (ADHD) or autism spectrum disorder (ASD), enrol in undergraduate computer science programs in substantial numbers [2] Self-reported disabilities, including ASD and ADHD, in Australian higher education increased by 163% from 4,054 students

in 2021 to 10,665 students in 2024¹. The course format and content impact the learning experience of neurodiverse university students, contributing to their lower completion rates[7].

Additionally, course materials often lack digital accessibility features needed by neurodiverse students.

Universal Design For Learning (UDL) offers a framework to make teaching more inclusive. Its principle of Multiple Means of Representation [4] encourages educators to present ideas and information through varied and flexible formats so that learners can access, engage with and comprehend content regardless of their sensory, linguistic or cultural needs [1].

Simulating students via large language models (LLMs) offers an inexpensive way to pilot pedagogical interventions [3]. By creating synthetic personas with demographic and behavioural attributes, researchers can explore how learners with diverse prior knowledge, engagement levels and learning attitudes might respond to new materials before conducting resource-intensive human-subject studies. To our knowledge, this approach has not yet been used to evaluate whether UDL-inspired improvements to lecture slides make introductory computer science courses more accessible.

The main contributions of this work are:

- LLM-based simulations: We use RCTs with large-language models (via few-shot prompting and retrieval-augmented generation) to predict student performance on UDL-enhanced and original lecture slides.
- Diverse personas: Our synthetic learners integrate demographic, behavioural and learning traits, enabling evaluation across a broad spectrum of neurodiverse experiences.
- ASD insights: The simulations reveal that UDL improvements on lecture slides provided no benefit to ASD learners, indicating a need for more tailored accessibility strategies.

2 DiverseClaire

The DiverseClaire pilot includes a UDL-guided approach to explore whether making introductory programming resources more accessible could benefit learners with different neurodiversity profiles. In Figure 1, the approach consists of four stages: a) design assessment questions using GPT-4o² b) select personas representative of a diverse university student population, c) create personas with diverse characteristics and d) experiments using Claude 4 Sonnet³, an LLM capable of generating text and code with reasoning capabilities.

We designed randomised controlled experiments (RCTs) using students’ personas — representing dyslexia, ADHD, ASD and neurotypical learners to simulate how individuals might interact with course materials. Stanford University’s lecture slides from the course



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ACM ISBN 979-8-4007-2255-4/2026/02

<https://doi.org/10.1145/3770761.3777340>

¹<https://shorturl.at/zeiYp>

²<https://openai.com/index/hello-gpt-4o/>

³<https://www.anthropic.com/news/claude-4>

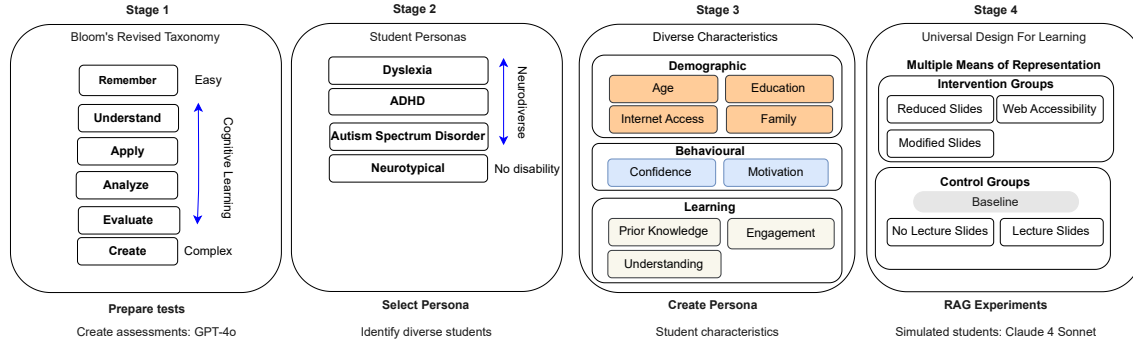


Figure 1: DiverseClaire: An UDL Guided Approach to Improve CS1 Programming Lecture Slides For Accessibility

CS106A: Programming Methodologies in Spring 2025 (Week 3) ⁴ served as our content base. We used GPT-4o an LLM supporting curriculum design [6] we produced assessment questions and solutions covering the six levels of Bloom's revised taxonomy.

To transform the slides into a more inclusive format, we applied UDL's Multiple Means of Representation and Web Content Accessibility Guidelines (WCAG) 2.2 in the DiverseClaire framework (Figure 1) to enhance lecture slides' inclusiveness. Following these principles, we removed duplicate slides; modified slide content by adding image alt-text, using sans-serif fonts for headings, and increasing font size to 28pt or higher; changed slides into an accessible Adobe PDF file format.

We generated synthetic students using few-shot prompts with Claude 4 Sonnet based on our experiments comparing multiple versions of GPT, Gemini ⁵ and Claude. Each persona combined demographic, behavioural and learning attributes such as age, prior knowledge and engagement [8]. Three pedagogical factors were emphasised: prior knowledge, which provides context and improves the accuracy of LLM responses; knowledge background combined with engagement, which helps instructors tailor material; and behavioural or learning beyond demographics, since simulations based solely on demographic traits tend to fail.

Using an RCT design, we assigned experiments to a *control group* or *intervention group* in Table 1. We applied RAG to generate responses and measured the intervention's effect. Each persona completed five simulations. We evaluated LLM-based student responses against correct answers. The evaluation metric was the average score M . M represents the proportion of correctly answered questions across six levels of Bloom's revised taxonomy.

3 Findings

First, Stanford University's slides were presented in formats lacking digital accessibility for neurodiverse learners [5]. To address this, we compared UDL-transformed slides against the original slides (Table 1). The prediction accuracy of the simulated student suggests that with improvements to slides (Section 2), learners with dyslexia, ADHD, and neurotypical learners would be able to access slides in a UDL-format with *fewer slides and web accessibility* and on average scored higher against control groups. Dyslexia and neurotypical learners preferred *fewer slides, modified content with web accessibility* and *fewer slides, modified content without web accessibility*. Both interventions on average scored higher against the control

Table 1: RCT Results: Claude 4 Sonnet Student Simulations

Average Score (M)				
Scoring Method	Dyslexia	ADHD	ASD	Neurotypical
Control Groups:				
Baseline I: no lecture slides	0.00	0.00	0.33	1.33
Baseline II: lecture slides + w/o accessibility	0.67	2.00	2.50	4.17
Intervention Groups:				
modified content + w/o accessibility	0.00	2.33	1.83	4.50
lecture slides + accessibility	0.50	2.67	1.83	4.83
modified content + accessibility	0.33	2.50	2.33	3.83
reduced slides + w/o accessibility	0.50	0.67	1.67	5.00
reduced slides + modified content + w/o accessibility	2.67	2.00	1.83	4.50
reduced slides + accessibility	1.83	2.50	2.17	4.83
reduced slides + modified content + accessibility	2.17	1.00	2.00	4.83

groups. ADHD learners on average scored the highest for *lecture slides with web accessibility* ($M = 2.67$), followed by identical scores ($M = 2.50$) for *fewer slides and modified content*. We discovered that UDL interventions to slides offered no benefit to ASD learners, with each intervention rated lower on average than the original slides ($M = 2.50$). Neurotypical learners favoured *fewer slides* ($M = 5.00$).

4 Conclusion

The current research suggests that accessibility needs vary by learner. Neurotypical learners and those with dyslexia or ADHD preferred UDL-transformed slides, while learners with ASD did not. These results highlight the potential to offer CS1 course materials in multiple formats to accommodate different learner preferences.

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⁴<https://tinyurl.com/Stanford-University-CS106A>

⁵<https://tinyurl.com/LLM-Gemini-Pro-2>