

# Understanding GenAI for Teaching and Learning in Secondary Classrooms

**Heidi Reichert**

North Carolina State University  
Raleigh, NC, USA  
hreiche@ncsu.edu

## Abstract

Large Language Models (LLMs) and Generative AI (GenAI) have markedly changed the landscape of many fields, including education. While these tools have significant capabilities, they also require understanding to effectively and responsibly use them. Additionally, little work has been done to evaluate how these tools can best benefit education at the secondary level, with design insights from instructors. My work focuses on informing secondary instructors of these tools, receiving their input on how to make these tools work best for them, and finally using this input to create and evaluate an in-class Retrieval-Augmented Generation (RAG)-based chatbot for their students to use to improve learning outcomes. This work aims to bridge the gap between the latest in computing technology and secondary education classrooms.

## Introduction

LLMs and GenAI are controversial, and many published works have discussed their uses and relevance in the classroom (Giannakos et al. 2024). Much of this work has concerned higher education, particularly in university settings. However, these works have thus far focused in limited capacity on the secondary classroom. Students' success at the secondary level impacts their future success in higher education (Pustjens et al. 2004). These classrooms face similar challenges as undergraduate ones, with increasing students and fewer teachers to guide them (Murnane and Steele 2007).

LLMs and GenAI may be of benefit to secondary students and teachers alike. ChatGPT-3.5 may be used to personalize learning material for students, and students have been found to enjoy using the GenAI-modified material; however, these GenAI tools still need to be developed and optimized for secondary students (Jauhainen and Guerra 2023). In an exploration of using GenAI in secondary educational contexts, Tang et al. argued that students should critically engage with GenAI content and strengthen their critical thinking and creative skills in the process; they ultimately suggest a further exploration of GenAI's pedagogic potential (Tang et al. 2024). In an interview study, Laak and Aru found that most of their participants of K-12 teachers were using GenAI to

make their work more efficient and modifying their teaching processes to incorporate or consider GenAI (Laak and Aru 2024). Additionally, Nyaaba et al. found that pre-service teachers were interested in using GenAI as a teaching resource, particularly for students to use as a learning assistant (Nyaaba et al. 2024). However, thus far, no studies that I have found have incorporated teacher feedback into the design of a classroom assistant chatbot suitable and tailored for teachers and students; nor have they studied the potential impacts of such a system on student learning outcomes.

In this work, I attempt to contribute to bridging the gap between GenAI and secondary classrooms. To do so, we look from the ground-up to understand the benefits and place of LLMs in the secondary classroom, as understood by instructors and then tested with students.

## Current Progress

In Reichert et al., we developed and evaluated a comprehensive series of workshops for secondary education instructors on GenAI (particularly ChatGPT) in the classroom during the summer of 2023 (Reichert et al. 2024). We detailed the development and deployment of these workshops with a cohort of secondary teachers involved in a summer research experience. These participants were interviewed via focus group before and after the workshops, as well as several months after the workshops. These interviews were then thematically analyzed for positive and negative attitudes (i.e., how teachers' attitudes toward LLMs changed due to the workshop series), as well as for understanding the longer-term impacts of the workshops on the participants. I worked with my research colleagues on creating the curriculum and creating the slide decks for two of the four workshops. I presented the second workshop of the series and worked with a research colleague to conduct the pre-, post-, and long-term post-workshop interviews. After data collection, I created a plan for thematic analysis, working with my colleague to code and group participants' data. Finally, I structured and was the primary writer and presenter of the resulting paper. This work, to our understanding, is the first free, publicly available, and research-vetted course for secondary teachers to learn about LLMs and GenAI.

## Anticipated Progress

In proposed study 1 (P1), we have completed the data collection process and are in the process of data analysis. I individually designed and planned this study, which consisted of engaging a new cohort of secondary teachers with the LLM workshops described in Reichert et al. with updated materials reflecting the use of GPT-4 during the Summer of 2024. For their final projects, participants were guided using a worksheet I designed to reflect on how they would like a chatbot-based LLM for their classroom to look, behave, etc. A research colleague and I administered all four workshops, while I led participants in the final project. The final project consisted of a planning session followed by a design session, during which participants in small groups physically crafted versions of their ideal chatbots using paper, pencil, note cards, etc. A colleague and I then interviewed the participants via focus group, focusing on their design processes and opinions on chatbots for their classrooms. Since then, a separate colleague and I have been in the process of thematically analyzing the transcripts, using inductive coding to tag the focus group session, planning sessions, and design sessions. We will use affinity diagramming to understand the common features of the teachers' designed chatbots. The results of these analyses will then be used to answer the following questions:

1. What uses/roles do secondary teachers believe that LLM-based chatbots have in their classrooms?
2. What features and functionalities will secondary school teachers incorporate when designing an ideal classroom chatbot for both students and teachers?
3. What attributes are similar and different in teacher-designed LLM chatbots across varying disciplines?

I anticipate that this work will be completed by February 2025.

In proposed study 2 (P2), we intend to use the results of P1 to inform the creation of an RAG-based chatbot for students. Along with support from an undergraduate colleague, I intend to be the primary developer of this tool. Preliminary results suggest that secondary teachers would prefer a tailored GenAI agent in their classroom, rather than simply using ChatGPT or an equivalent system. Using a RAG-based system will allow us to tailor the chatbot based on instructor feedback, as well as to ensure age and discipline-appropriate content is provided to students. This process will likely involve pre-generation query optimization and post-generation data control.

I will then evaluate this system with secondary students in a quasi-experimental setup in which students in at least one section of a class will use a chatbot for their lesson, while the other section will not. Students will be given pre- and post-tests to measure their respective learning outcomes, and students who used the tool will be given surveys with Likert-scale questions and open-ended responses on their experiences with the tool. Additionally, the classroom teacher (or teachers, in the event of there being multiple classes) will be surveyed on their perceptions on tool deployment and use, particularly focusing on the ease of use for the teachers themselves. The survey questions will be analyzed through

a series of descriptive statistics and thematic analysis, conducted with at least one other researcher. We aim to answer the following questions:

1. To what extent do the design considerations of secondary teachers map to a RAG-based chatbot?
2. How well does the chatbot work? Can it support or improve student learning outcomes?

I anticipate that this work will be in-progress by February 2025.

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