

Empowering Special Needs STEM Students Through Unique Generative AI Tools: A Path to Inclusive Learning

Professor James R. Mallory
Rochester Institute of Technology
National Technical Institute for the Deaf
United States of America
jrmnet@rit.edu

Abstract: Generative AI is reshaping the learning experience for students with diverse needs. This paper explores using AI to enhance efficiency and empower students with individualized learning needs, such as deaf or hard of hearing (DHH) students. Generative AI allows educators to create dynamic, engaging, personalized learning experiences that resonate with every student, regardless of their unique situation or special needs. Traditional teaching methods in STEM fields often struggle to engage DHH students, who gravitate toward visual and interactive resources. AI, with its adaptability and personalization capabilities, emerges as a promising solution. The author, an expert in teaching and tutoring students for CompTIA technical certifications, highlights the challenges faced by DHH students. By harnessing AI, the author created individualized, student-centered content. Importantly, these insights extend beyond DHH students, offering valuable lessons applicable to all learners. This paper introduces the potential impact of AI-driven tools on student engagement and comprehension.

Introduction

Welcome to the future of teaching and learning! The field of Generative AI is growing rapidly. This paper aims to investigate the utilization of Generative Artificial Intelligence (AI) tools in empowering students with diverse needs, particularly those in STEM education. By focusing on the integration of AI technologies, this study delves into the potential of AI to remove barriers and enhance the learning experiences of students with unique requirements, such as deaf or hard of hearing (DHH) or other individuals with special needs. Many of the students in this study are college-level students with strong technical knowledge but possess only an eighth grade reading level. These students have American Sign Language (ASL) as their first language and English as their second or third language. They often prefer to find a YouTube video or animation or read a very simple text explanation to learn a concept rather than enduring lengthy, verbose technical explanations. This study provides an overview of the context within which the research is conducted, emphasizing the significance of leveraging Generative AI for an inclusive learning environment. Specific applications of AI will be mentioned along with their results. In this paper, the terms Generative Artificial Intelligence (AI), AI, AI tools, AI chat, AI engine, AI models, AI system, and Large Language Models (LLMs) are often used interchangeably.

The Study

This study involves investigating the use of several Generative AI models when tutoring and developing individualized, student-centered instruction for DHH students. The scope of the actual implementation was limited to DHH students attempting to pass their CompTIA A+ and Security+ technical certifications.

Of the ten students who participated in this study, most needed tutoring or specific answers to technical questions or clarification of certification objectives. These questions resulted from technical concepts about topics, or the objectives covered in the CompTIA A+ or Security+ tests. The questions and answers were text-based but needed to be broken down to a minimum of an eighth grade reading level for understanding. The actual certification tests are written in English, so this is usually a challenge with these unique individuals. AI was used to locate appropriate YouTube videos and animations to help them further understand the concepts.

The theoretical framework for this study draws upon concepts of inclusive education and the transformative potential of AI in educational settings. It integrates theories related to personalized learning experiences, adaptability in teaching methodologies, and the role of technology in addressing the diverse needs of learners starting specifically with DHH students. By grounding the study within this framework, it seeks to explore how Generative AI can serve as a catalyst for fostering inclusive learning environments, particularly in STEM fields.

Findings

Choosing the AI Model

After researching several of the AI models for teacher and student use shown in Table 1 below, the author chose to use ChatGPT 3.5 and Bing CoPilot for this study because they were free and readily available for student use. Although many AI tools can create images, art, and videos, the focus of this study was on text-based answers and references to YouTube videos and animations, so the first two listed below were adequate for this study.

Table 1: Commonly Used Generative AI Models

| Model/URL | Developed by | Brief Explanation | Cost |
|---|---------------|--|--|
| Bing Copilot https://copilot.microsoft.com/ | Microsoft | Everyday AI companion for boosting productivity. Helps users understand information better with a simple chat experience. | Available within Microsoft Edge or Chrome browsers on Windows and Mac OS. |
| ChatGPT https://chat.openai.com/ | OpenAI | Versatile language model for various tasks, including coding, Engaging conversations, insights, automation, and more using AI-generated human-like text Available as an API. | Free Unlimited messages. - Plus: \$20/user/month. - Team: \$25/user/month (billed annually). - Enterprise: Custom pricing. |
| Sora https://openai.com/sora | OpenAI | Text-to-video model creating realistic scenes from text instructions. | Not Specified |
| Gemini https://gemini.google.com/ | Google | Language model for accurate and fast responses. | Free: Gemini Pro, Advanced: \$19.99/month. |
| Claude https://claude.ai/ | Anthropic | AI assistant excelling in coding, math, and reasoning. | Pricing varies based on model. |
| Perplexity AI https://www.perplexity.ai/ | Not specified | Provides access to multiple large language models (LLMs), including GPT-3.5 with Copilot. | Free: version includes GPT-3.5 and Copilot. |
| Eduaide.ai https://www.eduaide.ai/ | Eduaide | Generative AI system to simplify workflow for teachers. Combines AI algorithms, machine learning, and natural language processing for instructional planning. | Free: Limited content generation. - Pro: \$5.99/month or \$49.99/year for unlimited access. |

Training the AI Model – Prompt Engineering

The second most important step after choosing which AI model to use was to train it. There is an entire field called Prompt Engineering, which refers to “...the art and science of querying foundation models like LLMs (Large Language Models) with the right inputs to achieve a desired output.” Scribble Data (2020). Since LLMs are somewhat like a “black box” from the teacher’s or student’s perspective, correctly prompting them is essential for success. The following reference concisely defines prompt engineering. “Prompt engineering is a technique used in artificial intelligence (AI) to optimize and fine-tune language models for particular tasks and desired outputs. Also known as prompt design, it refers to the process of carefully constructing prompts or inputs for AI models to enhance their performance on specific tasks. Prompts are used to guide and tweak the desired behavior from the AI system and obtain accurate and desired responses from AI models.” Mascellino (2023)

To set up the AI used for the DHH students in this study, the author and his students would begin to prompt and train the AI engine with the following input shown in the Text Dialogue 1 box below.

Text Dialogue 1: Prompting AI for Tutoring

I am currently studying to obtain my CompTIA Security+ SYS-701 certification. I want you to act as if you are a content expert and my tutor who is preparing me for the test. I am going to ask you about a variety of different concepts. I want your answers to include a few things including:

1. Very briefly, concisely, and simply a general overview of the concept.
2. What I might need to know about it for the SYS-701 Security+ exam.
3. Make your answers in very simple English because English is not my first language.
4. Please show any relevant YouTube movie or animated examples and references if they are highly rated and relevant because I do not like to read, I learn visually and prefer pictures, diagrams, animations, or movie explanations. Please list the exact full YouTube title, date, author, and how many views in case the URL link does not work in addition to the embedded URL links or images of URL links you provide.

Answer all my questions in this format, until I say otherwise. Can you do that for me, please?

Topics are:

List questions or topics here....

The author found that Copilot did an excellent job of providing external links, whereas ChatGPT 3.5 would mention a reference as words or embedded links but was not able to provide active, clickable URLs or links. This required extra time and effort to find these references, which became tedious. This is why the prompt in Text Dialogue 1 box above includes the sentence “Please list the exact full YouTube title, date, author, and how many views in case the URL link does not work in addition to the embedded URL links or images of URL links you provide.” This made it easier to locate these videos using the detailed information. It was also found that Copilot was always available, whereas ChatGPT 3.5 was frequently down or unavailable when needed.

AI was also great for quickly clarifying an acronym or a concept. For example, suppose a student was studying for his/her CompTIA SYO-701 Security+ test and forgot what NIPS meant and what it was for. Since the input prompt for the AI Engine was already prepared properly as previously described in Text Dialogue 1, merely typing in “NIPS” would generate the following output shown in Text Dialogue 2.

Text Dialogue 2: ChatGPT Output Sample– Clarification of NIPS Acronym

NIPS (Network-based Intrusion Prevention System):

1. **Overview:** NIPS is a security tool that actively monitors and analyzes network traffic to detect and prevent security threats at the network level.
2. **For SYS-701:** Know that NIPS devices examine network packets, identify potential attack patterns or anomalies, and take actions like blocking or alerting when threats are identified.

Here's a video titled "**What is a Network Intrusion Prevention System (NIPS)?**" by SecureNinjaTV from September 11, 2014, explaining NIPS: Watch Video - Views: 43,000.

These videos should help in visualizing and understanding DLP, HIDS, EDR, and NIPS concepts better. If you have more questions or need further explanation, feel free to ask!

ChatGPT3.5 was great for laborious summaries and related them to the certification objectives. For example, there is an overwhelming amount of information that needs to be learned for these certification tests. On the CompTIA A+ 2201-1101 Core 1 and 220-1102 Core 2 certification tests, for example, there are a total of almost 400 acronyms that students need to know (approximately 226 for Core 1 and 170 for Core 2). As one example, the author would copy all of the acronyms from a given objective sheet and ask AI to list these as a nice summary for students. The prompt for this had to be concise. Unfortunately, with the free versions ChatGPT3.5 and Copilot there is a 2000-character limit, so the acronyms had to be copied and pasted in separate sections ten acronyms at a time. If more than ten at a time were entered, the AI output would just end without defining the remaining acronyms with no feedback about an input error. This seemed laborious and tedious and required constant error checking to make sure none were missing. If GPT version 4.0 or above was used, then the whole document could have been uploaded and this would have been much more time efficient. Sticking with the rationale mentioned previously, the limited free version was used for this study. Shown in Text Dialogue 2 below are just two of the items representative of the numerous acronyms a student would have to know for his/her 220-1101 CompTIA A+ Core 1 certification test. Since the input prompt for the AI Engine was already prepared properly as previously described in Text Dialogue 1, merely typing in “list the following acronym definitions with their purpose in the certification exam” would generate the following output shown in Text Dialogue 3.

Text Dialogue 3 ChatGPT 3.5 AI Output Sample – Summarizing Acronyms

AAA: Authentication, Authorization, and Accounting

A+ 220-1101 Exam: You might need to understand that AAA refers to three important security processes in computer networks. Authentication is confirming the identity of users or devices. Authorization is granting access rights based on the authenticated identity. Accounting involves tracking the actions of users for security and auditing purposes.

AP: Access Point

A+ 220-1101 Exam: You might encounter questions about wireless networking where you need to understand that an Access Point (AP) is a device that allows wireless devices to connect to a wired network using Wi-Fi. It acts as a bridge between wireless devices and the wired network.

Future AI Usage

There are too many AI models to cover within the scope of this short paper, but to get an idea of possible future AI releases, the following are some AI engines that can be researched: Grok-1.5 (xAI), Llama 3 (Meta AI),

Meta GPT, Ajax GPT (Internal use by Apple), Claude-Next (Anthropic), G3PO (OpenAI), Arrakis (Possibly GPT-4.5?), Gobi (Possibly GPT-5?), Olympus (Amazon), AuroraGPT (ScienceGPT), Mistral Small (Mistral AI), Mistral Large (Mistral AI), Hanooman (Reliance), Ask (Apple), Reka Edge (Reka AI), Reka Flash (Reka AI). Keep in mind that these models are continually evolving, and their specific use cases may expand as researchers and developers explore their capabilities further.

Conclusions

This study is a work in progress, but the preliminary results are promising. Using two free and readily available Generative AI tools, ChatGPT 3.5 and Bing CoPilot, the author was successfully able to engage students and help them succeed in their quest for technical certification. The tools used in this study gave immediate feedback to students, regardless of the time of day or time zone where they were studying. Both the students and the teachers learned different ways to discuss topics with the large language models and technical databases that optimized the results. The technical queries needed to be structured so that they could be interpreted and understood so that the proper technical details were obtained. The AI models would nudge the instructor or the student for certain results, so the instructor would sometimes need to help guide the student on how to use these tools. The instructor is still an important part of this process, AI will not replace the instructor. Technical concepts need to be checked for accuracy because errors with technical details are not uncommon. AI is not perfect yet, but it is rapidly getting smarter and faster and is becoming integrated into all of technology. The author's findings underscore the potential of AI in fostering inclusive education, particularly in the STEM field. By customizing learning experiences for DHH students and students with unique needs, gaps are bridged, and students are empowered to learn and thrive in STEM fields. Beyond DHH, this approach holds promise for all learners, emphasizing the need for adaptable, interactive tools. AI will not replace the technical teacher, but it is certainly a valuable tool in the teacher's educational toolbox. As educators, administrators, and curriculum developers, Generative AI should be embraced as a catalyst for positive change in the classroom or tutoring session.

References

- Arthi, K., & Tamilarasi, A. (2008). *Prediction of autistic disorder using neuro fuzzy system by applying ANN technique. International Journal of Developmental Neuroscience*, 26, 699–704.
- CompTIA. (2023). *CompTIA A+ Certification Exam Objectives*. Retrieved from <https://www.comptia.org/>.
- CompTIA. (2023). *CompTIA Security+ Certification Exam Objectives*. Retrieved from <https://www.comptia.org/>.
- CompTIA. (2021). *The Role of AI Systems in Cybersecurity*. Retrieved from <https://www.comptia.org/>.
- CompTIA. (2023). *AI/Automations You Should Be Using on Your Network*. Retrieved from <https://www.comptia.org/>.
- Drigas, A. S., & Ioannidou, R.-E. (2023). *A Review on Artificial Intelligence in Special Education. Communications in Computer and Information Science*, 4573.
- Georgopoulos, V. C., Malandraki, G. A., & Stylios, C. D. (2003). *A fuzzy cognitive map approach to differential diagnosis of specific language impairment. Artificial Intelligence in Medicine*, 29, 261–278.
- Lanzilotti, R., & Roselli, T. (2007). *An Experimental Evaluation of Logiocando, an Intelligent Tutoring Hypermedia System. International Journal of Artificial Intelligence in Education*, 17, 41–56.
- Levesque, E., Duncan, J., & Snoddon, K. (2023). *Deaf students and the transformative potential of Artificial Intelligence (AI). Deafness & Education International*.

- Mascellino, A. (2023) *Prompt Engineering*. Techopedia. <https://www.techopedia.com/definition/prompt-engineering>.
- Nanni, L., & Lumini, A. (2008). *Ensemble generation and feature selection for the identification of students with learning disabilities*. *Expert Systems with Applications*, 36, 3896–3900.
- OpenAI. (2023). *ChatGPT (Mar 14 version)* [Large language model].
- Public Law, *Individuals with Disabilities Education Act (IDEA)*, USA, pp. 101–476 (1990).
- Rebolledo-Mendez, G., & De Freitas, S. (2008). *Attention modeling using inputs from a Brain Computer Interface and user-generated data in Second Life*. In: *The Tenth International Conference on Multimodal Interfaces (ICMI 2008)*, Crete, Greece.
- Rebolledo-Mendez, G., Dunwell, I., Martínez-Mirón, E. A., Vargas-Cerdán, M. D., de Freitas, S., Liarokapis, F., & García-Gaona, A. R. (2009). *Assessing NeuroSky's Usability to Detect Attention Levels in an Assessment Exercise*. In: *Jacko, J. A. (ed.), HCI International 2009, Part I*, LNCS, vol. 5610, 149–158. Springer, Heidelberg.
- Russell, S. J., & Norvig, P. (2003). *Artificial Intelligence: A Modern Approach* (2nd ed.). New Jersey.
- Scribble Data, (2020), *Prompt Engineering: Introduction, Techniques, Limits, and Future Perspective*, Scribble Data Blog. <https://www.scribbledata.io/blog/prompt-engineering-introduction-techniques-limits-and-future-perspective>.
- Smith, E. F., & Johnson, G. H. (2024). *Artificial Intelligence in Education: A Comprehensive Review*. *Educational Innovations*, 18(2), 67-82. DOI: 10.5678/edinov.2024.7890.
- Stanger, J. (2019). *Putting AI and Machine Learning to Work in IT*. *CompTIA*. <https://www.comptia.org/blog/ai-and-machine-learning-for-it>.
- Wu, T. K., Meng, Y. R., & Huang, S. C. (2006). *Application of Artificial Neural Network to the Identification of Students with Learning Disabilities*. In: *International Conference on Artificial Intelligence*, 162–168.
- Xu, W., & Ouyang, F. (2022). *The application of AI technologies in STEM education: A systematic review from 2011 to 2021*. *International Journal of STEM Education*, 9, Article number: 591.