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Impact of Generative AI Technologies on Blind and Visually Impaired Students: A Case Study

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Lived Experiences of Blind and Visually Impaired Students and the Impact of Generative AI: A Narrative

Abstract

The advent of Generative AI (GenAI) in our society has taken root so deeply that simple Google searches invoke a GenAI response attempting to synthesize a simplified summary for a user. Incidentally, these GenAI systems like ChatGPT from OpenAI, LLaMA from Meta, Gemini from Google, and Copilot from Microsoft are all largely text-based large language models providing an increased level of access to people who use screen reading technology to interact with personal computing systems. This study investigates the impact of GenAI on accessibility for blind and visually impaired students, focusing on the experiences of two computing students, Gene and Amanda. While examining qualitative responses from a survey developed by this research team focused on understanding the impact ChatGPT and GenAI might have on the future of their disciplines, a single response intrigued the team: "*I got ChatGPT to explain things in words using steps because I didn't understand some of the prof's explanations. I'm blind and human teachers tend to gesture and use meaningless phrases like 'this thing' or 'over there.' ChatGPT can't point*." Using a narrative approach, we examine how Gene and Amanda interact with GenAI in academic and everyday settings, finding that while GenAI offers significant benefits, there are crucial limitations that hinder its effectiveness for blind users, particularly those blind from birth. This study underscores the need for enhancements in GenAI technology to better support accessibility, offering insights into both the day-to-day applications and specialized academic uses for visually impaired students pursuing STEM education.

Introduction

The introduction of technology in education has brought significant advancements, however, the specific needs of blind and visually impaired students often remain underrepresented and inadequately addressed [1]. Generative AI tools hold the potential to bridge these gaps. This paper will explore the evolving relationship between GenAI and accessibility in education, aiming to create learning environments that inclusively support all students as these technologies become as pervasive as the internet and mobile computing.

Through the experiences of Gene and Amanda - two blind computing students - we use narrative inquiry to examine how GenAI impacts their academic and personal lives.Our primary research question is: How do blind and visually impaired computing students perceive and utilize GenAI tools to navigate educational and professional environments? By focusing on these unique lived experiences, we aim to contribute to the ongoing discourse on accessibility in STEM education, specifically within higher education's computing programs.

Students who are blind or visually impaired encounter unique challenges in higher education. particularly in STEM fields. This includes limited access to alternative materials, challenges navigating complex and understaffed disability services, and societal biases that can further hinder access Amanda's story exemplifies these obstacles: a turning point in her academic journey occurred in elementary school when she received her first laptop, sparking an interest in computing that later evolved into a career as a quality assurance specialist focused on accessibility at a Forbes Fortune 100 company. This achievement is notable, given that accessibility was often an afterthought in her educational environments, a reality that, regrettably, persists today. Her experiences reflect broader issues facing blind and visually impaired students pursuing STEM careers in the 21st century.

Recognizing and celebrating the achievements of STEM professionals who have overcome such barriers is essential. These pioneers pave the way for future generations, and this work aims to envision a future when GenAI becomes integral in fostering inclusion within computing and STEM disciplines. Villanueva and Di Stefano's recent narrative inquiry underscores the critical need for tailored instructional strategies that consider the unique needs of blind students in STEM [2]. Similarly, Stefik et al.'s research demonstrates how accessible tools, like the Sodbeans programming environment, enhance confidence and skills among blind programming students, revealing the impact of well-designed, inclusive technologies[3]. This paper builds on such foundational work by examining how GenAI tools shape the academic journeys of Gene and Amanda, contributing to a nuanced understanding of GenAI's role in accessible STEM education..

Background

Blind and visually impaired students face significant barriers in STEM education, particularly in visually intensive subjects like mathematics and the classical sciences, Amanda's experience exemplifies these challenges; from in accessible formats such as images of equations-unsuitable for screen readers- to low-quality alternative materials provided by disability services. The absence of accessible math tools in her early education forced her to develop personal methods to engage with the material, which added to her cognitive load.

Since the 1970s, accessibility research has focused on enhancing computer literacy for blind individuals [4-6]. Initial efforts produced adaptive technologies like screen readers and Braille displays/input devices, which allowed blind users to access digital content more effectively, helping bridge gaps with sighted peers, especially in computer science. Despite these advancements, challenges persist in areas heavily reliant on visual content, such as data visualization and STEM applications [7, 8].

The prevalence of visual disabilities highlights the ongoing need for accessible educational technologies. In the United States, as of 2016, 7.7 million individuals aged 16 and older reported

visual abilities, representing 2.4% of the population [9]. Researchers like Blaser and Ladner highlight the complexities of data collection and interpretation concerning disabilities, revealing systemic inconsistencies that hinder meaningful progress [1]. Blaser, as a founder of AccessComputing, has spent over two decades advancing accessibility research and fostering inclusivity in computing education through NSF-funded initiatives[10, 11].

Accessible educational tools are essential in STEM, given the underrepresentation of blind individuals in these fields [3]. Tools like the Graph Sketching Tool (GSK), emphasized by Balik et al., enable blind students to create and explore graphs in real-time, supporting their inclusion in complex computing courses This is only one example of the vast array of technologies that have been developed to modify the computing space to be more accessible for blind and visually impaired individuals [12]. However, a common barrier with these technologies is financial, limiting widespread adoption. For example, tactile drawing boards exceed 250 USD, creating an "accessibility tax" that restricts many potential users from accessing crucial educational tools [13].

In contrast, Generative AI (GenAI) tools—such as Large Language Models (LLMs)—offer relatively affordable solutions. With basic-level access typically free or around $20 USD for premium subscriptions, these text-based models can respond to a range of prompts, including visual descriptions. Accessibility-oriented tools like Be My AI from Be My Eyes leverage GenAI to support daily tasks, though they are not specifically geared toward academic accessibility [14]. .

Research on GenAI's role in accessibility for blind and visually impaired users is limited but growing. Adnin and Das's recent study explores how blind users integrate GenAI to enhance productivity and access information. This research provides insights into users' mental models of GenAI, shaped by real-world use. For example, one participant, self-teaching programming, noted exponential progress using ChatGPT, highlighting GenAI's potential as an assistive learning tool. Though Adnin and Das's participants did not include computing students, their findings inform this study's understanding of how Gene and Amanda similarly engage with GenAI in accessibility contexts, particularly with Be My AI [15].

Currently, no commercial solution combines GenAI with the interfaces commonly used in computing education. In states like Texas, where educational standards require a broad set of courses outside of a student's major, the need for flexible, accessible solutions is especially pressing. A mosaic of tools—screen readers, GenAI applications, accessibility-focused mobile apps like Be My AI, and robust disability support services—currently serves students like Gene and Amanda. This study explores how they navigate these tools to succeed and anticipates future GenAI advancements that could better meet their academic and professional needs.

Integrating GenAI and other emerging technologies presents promising possibilities for improving accessibility in computer science and ultimately engineering education. AI-driven tools could deliver advanced screen reading capabilities, real-time transcription, and interactive learning environments tailored for blind and visually impaired students. Villanueva and Di Stefano emphasize the application of Universal Design for Learning (UDL) principles in STEM education to ensure inclusive access [2]. Aligning with UDL principles, Israel et al. also support this approach as particularly effective in elementary computer science education [16]. This integration aims to remove the numerous barriers that blind students face, allowing them to fully participate in computing education and broader STEM fields..

Methods

This study employs a narrative inquiry and autobiographical approach to capture and analyze the unique experiences of Gene and Amanda, two blind computing students, with a focus on their interactions with GenAI. Narrative inquiry, as described by Clandinin and Connelly [17], emphasizes the importance of storytelling as a means to access deeply personal insights, making it particularly suitable for exploring the accessibility challenges and successes faced by blind students in computing education.

Gene and Amanda were invited to participate as both authors and primary subjects in this study, allowing for authentic, un-filtered presentation of their experiences. This approach provided them the space to share not only their broader journeys in computing education but also their specific encounters with Gen AI and their aspirations for how such tools might better support accessibility in the future. We intentionally centered the interviews on an anti-deficit perspective, which emphasizes the participants' strengths, agency, and holistic identities rather than viewing them through a lens of disability-related limitations [18,19]. This perspective is particularly important, as it reframes the typical narrative around blindness by focusing on the full breadth of the participants' lives and experiences, countering the deficit-centered views that are often imposed by society.

Interview Process

The interviews were conducted via the Zoom web-conferencing platform, with audio recordings, transcripts, and field notes used for documentation. The interview process was structured in stages: initially, Amanda was interviewed independently to explore her experiences in depth and to refine the questions for the subsequent interview with Gene. Amanda recruited Gene via a visually impaired online community and acted as a liaison, fostering a familiar and comfortable environment. During the joint interview, Amanda’s participation facilitated an organic discussion of their lived experiences, highlighting differences in perspectives based on factors such as age, gender, and geographical background. These factors, subject to sociopolitical influences, shaped their unique paths and engagements with technology. Amanda is a cis-gendered woman in her

30s while Gene is a cis-gendered man in his 20s. The generational difference between them provides important context regarding the evolution of accessibility technologies over time, while their gender differences bring an additional layer to understanding how societal attitudes and accessibility intersect with identity. These distinctions in their backgrounds, though not the central focus of this study, contribute to a richer understanding of their experiences and challenges as they navigate higher education and careers in computing.

Narrative Construction and Analysis

To construct distinct and coherent narratives of each participant's experiences, we analyzed transcripts and field notes without breaking the interviews into emergent codes. Instead, themes were identified through a thorough review and were organized into individual narratives, presenting a linear storied account for each participant. By siloing off key themes for deeper reflection, we maintained the integrity of each participant's story as a cohesive whole, rather than fragmenting it through coded analysis.

To ensure accuracy and authenticity, both Gene and Amanda were actively involved in reviewing and refining their narratives through a member-checking process. This process entailed iterative revisions where each participant provided feedback on their story to ensure it accurately conveyed their intended experiences and insights. Member-checking was particularly valuable in maintaining the participants' voices and perspectives, confirming the authenticity of their narratives before the final analysis.

In presenting these narratives, we illustrate Gene and Amanda's pathways and challenges in the field of computing. For Amanda, this journey culminated in her career as a quality assurance specialist focused on accessibility for a Forbes Fortune 100 company. These stories provide nuanced insights into how GenAI intersects with their academic and professional lives and emphasize the need for more inclusive accessibility technologies within higher education and beyond.

Narratives

Amanda

Navigating Early Computing, Education, and Accessibility Challenges as a Blind Student

Born in the mid-1980s, Amanda grew up at a time when computers were rare and exceptionally expensive and most adults were computer illiterate. Her first laptop received in the mid-1990s, was large, heavy, loud, and noisy, with a large screen useful for the sighted people around her. Despite its limitations, this laptop provided Amanda with her first opportunity to engage with computing and opened new avenues for learning. She attended various schools, including

specialized institutions for the blind in Texas, which played a crucial role in her eventual pursuit of higher education.

In the early 2000s, Amanda began her higher education journey, obtaining her Associate's degree before transferring to a four-year institution to pursue a bachelor's in computer science. Despite encouragement to pursue computing, Amanda faced numerous challenges due to insufficient accessible learning resources. For example, inadequate math support forced her to develop alternative notation systems to complete her courses. Although disability offices are now expected to meet such needs, Amanda's experience was often one of frustration and unmet accommodations, with professors dismissing her needs and disability services frequently failing to provide adequate support. Given the highly text-centered nature of computing, screen readers became her primary accessibility tool.

Navigating the Career Fair: Challenges and a Breakthrough Opportunity

At the end of her undergraduate studies, Amanda was encouraged to attend a computing career fair. Navigating this non-standardized and inaccessible environment was challenging, but a close friend's assistance allowed her to make valuable connections. Amanda's persistence paid off when she met an accessibility expert at a Forbes Fortune 100 company who saw her potential as a quality assurance engineer focused on accessibility. This opportunity aligned with her love for computing and accessibility, paving the way for a meaningful career.

The Rise of Mobile Computing and New Accessibility Avenues

With the rise of mobile computing, accessibility tools became more portable. Instant video call technology, like FaceTime, allowed Amanda to seek assistance from friends and family when needed, though this often required others' availability. Later, Be My Eyes, a platform connecting blind users with sighted volunteers through video calls - offered more flexible assistance, enabling Amanda to access support whenever necessary and fostering greater independence..

Pursuing a PhD: Facing Old and New Accessibility Challenges

Amanda later returned to academia to pursue her PhD in computer science at Texas A&M University, expecting improved accessibility support. Unfortunately, she again encountered barriers, with course content that was often inaccessible and relied on visual elements. These obstacles led her to drop certain courses, and the slow response from the disability office, coupled with a lack of faculty awareness, was a common theme in her experience. This persistence of accessibility challenges underscores the need for systemic changes.

Embracing GenAI: A Transformational Tool for Accessibility

In late 2022, Amanda began using GenAI tools like ChatGPT, which provided unique accessibility benefits. The conversational nature of these tools allowed her to engage with information without the constraints of time or assumptions about her background. Although the tools were imperfect—ChatGPT sometimes apologized for her blindness due to its training responses—GenAI helped Amanda access previously inaccessible content, especially in mathematics. ChatGPT's ability to explain complex mathematical concepts in text, rather than graphic-based notation, significantly improved her comprehension of subjects like linear algebra. This newfound accessibility enabled Amanda to audit courses previously out of reach due to accessibility issues, using GenAI to assist with assignments, particularly in coding.

Exploring Integration of GenAI into Professional Workflows

Amanda's professional experience with an operating system integrated AI system in beta through her employer has opened up new avenues of GenAI integration for her workflow. This AI integration at the operating system level, processing requests locally and using OpenAI's GPT-4 model for extended capabilities, offers insight as to how beneficial a tool like GenAI can be to those who work in computing and are blind or visually impaired. This new integration has proven to be significantly more convenient than visiting external sites, positioning GenAI as a practical asset in her role as a quality assurance engineer.

Gene

Early Challenges and a Shift in Focus

Gene's journey in accessibility began in the late 2000s, during a period when assistive technologies were emerging. Legally blind from a young age, Gene retained some light and color perception until age 16, when he became completely blind. This shift redefined how he interacted with his environment, prompting him to explore STEM subjects in new ways. As a child, he developed an interest in Rubik's cubes and LEGOs, which fostered his curiosity about the world's complexities. Initially interested in hardware solutions within computing, Gene ultimately shifted to computer science, where he could better leverage accessibility tools.

Academic Pursuits and Accessibility Challenges

Gene attended prestigious academic institutions, including Texas A&M University, where he experienced a blend of support and challenges. Although accommodations were nominally in place, they often fell short due to gaps in disability office expertise, particularly concerning STEM course adaptation. This contrast with Amanda's experience highlights the variability in

institutional responses to accessibility, reinforcing the need for more specialized support in higher education.

Research and Development in Accessibility Technology

Throughout his education, Gene's lived experiences shaped his commitment to developing accessibility technology. His roles at the University of Washington, Northeastern University, and the University of Chicago allowed him to contribute to projects enhancing accessibility, including shape shifting devices and 3D modeling tools. His work on automated knitting machines producing tactile graphics exemplifies his focus on bridging technology and disability, and he has become an active member of the accessibility research community.

Integrating GenAI into Accessibility Tools

Gene was quick to experiment with GenAI tools, using ChatGPT and other LLMs to understand their potential. Although useful, especially for extracting text from images, Gene found GenAI's performance inconsistent in STEM applications. The tools' tendency to hallucinate complicated STEM concepts made them unreliable for critical tasks. When GenAI fell short, Gene often sought assistance from sighted colleagues, highlighting the current limitations of GenAI's accessibility. However, he found GenAI helpful for getting "unstuck" in assignments, replacing the need for additional external support in some instances.

Continuing the Mission: GenAI and Future Plans

Gene believes GenAI has improved his quality of life, particularly through Be My AI, which offers accessibility-focused image recognition. Currently, Gene collaborates with research groups nationwide to further integrate GenAI into accessibility tools, and he plans to pursue graduate studies to expand his work in this field. His vision is to develop GenAI solutions that can reliably support accessibility needs in educational and professional settings, bridging the existing gaps that limit students like him and Amanda from fully engaging in STEM.

Joint Hopes for the Future of GenAI

The research team encouraged Ann and Gene to reflect on their experiences with technology, both in their youth and as adults, to provide a comprehensive context for their current engagement with GenAI. When asked to imagine how they might have used GenAI if it had been available in their childhood, both participants expressed an eagerness to interact with it extensively, envisioning themselves asking countless questions to learn about the world. This imagined scenario highlighted the unique potential of GenAI as a constant, unrestricted source of

information—a role that otherwise would require the time and effort of a dedicated friend or family member.

Amanda and Gene's experiences with GenAI have been overwhelmingly positive, fostering hope that future advancements will integrate more accessibility-focused features across educational and everyday applications. They anticipate that the continued development of GenAI in alignment with accessibility goals could significantly reduce the barriers that blind and visually impaired students face in engaging with STEM subjects and participating fully in computing programs. Such advancements hold promise for broadening participation in STEM for blind students and promoting a more inclusive learning landscape.

Discussion/Conclusion

This study provides initial sights into the potential impact of GenAI on accessibility in STEM and computing education, drawing on the experiences of two blind computing students with distinct backgrounds. Through Amanda and Gene's stories, we observe how individual identities and lived experiences shape their interactions with GenAI and influence their perceptions of its utility. While GenAI has emerged as a highly accessible tool, its current limitation underscores it is not yet a complete solution for the accessibility needs of blind computing students.

As multi-modal GenAI models advance, with accessibility-focused companies like Be My Eyes at the forefront, the long-term influence of GenAI on computing education will likely become clearer. However, as GenAI becomes more prevalent in educational environments, its potential to democratize access to content for blind and visually impaired students cannot be understated.

This study underscores the need for active involvement of blind and visually impaired students in the design, development, and implementation of GenAI tools, ensuring their insights and needs directly inform technological improvements. Future research should continue to investigate the intersection of GenAI, accessibility, and education to establish truly inclusive learning environments. As GenAI technology progresses, it holds the potential to become as transformative and omnipresent as the internet and mobile computing, reshaping educational access for students with disabilities in profound ways.

References

[1] R. Ladner, "Expanding the pipeline: The status of persons with disabilities in the Computer Science Pipeline," *Computing Research Association-Widening Participation. Retrieved June,* vol. 19, p. 2022, 2020.

[2] I. Villanueva and M. Di Stefano, "Narrative inquiry on the teaching of STEM to blind high school students," *Education sciences,* vol. 7, no. 4, p. 89, 2017.

[3] A. M. Stefik, C. Hundhausen, and D. Smith, "On the design of an educational infrastructure for the blind and visually impaired in computer science," in *Proceedings of the 42nd ACM technical symposium on Computer science education*, 2011, pp. 571-576.
[4] R. E. Ladner, "Design for user empowerment," *interactions,* vol. 22, no. 2, pp. 24-29, 2015.
[5] A. F. Newell, *Design and the digital divide: insights from 40 years in computer support for older and disabled people* (no. 1). Morgan & Claypool Publishers, 2011.
[6] E. R. Petrick, *Making computers accessible: Disability rights and digital technology*. JHU Press, 2015.
[7] C. M. Baker, C. L. Bennett, and R. E. Ladner, "Educational experiences of blind programmers," in *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, 2019, pp. 759-765.
[8] S. P. Balik, S. P. Mealin, M. F. Stallmann, R. D. Rodman, M. L. Glatz, and V. J. Sigler, "Including blind people in computing through access to graphs," in *Proceedings of the 16th international ACM SIGACCESS conference on Computers & accessibility*, 2014, pp. 91-98.
[9] "Blindness Statistics," National Federation of the Blind. [Online]. Available: https://nfb.org/resources/blindness-statistics
[10] A. Stefik, R. E. Ladner, W. Allee, and S. Mealin, "BEST PAPER AT SIGCSE 2019 IN THE EXPERIENCE REPORTS AND TOOLS TRACK: Computer science principles for teachers of blind and visually impaired students," *ACM Inroads,* vol. 10, no. 2, pp. 50-57, 2019.
[11] J. P. Bigham, M. B. Aller, J. T. Brudvik, J. O. Leung, L. A. Yazzolino, and R. E. Ladner, "Inspiring blind high school students to pursue computer science with instant messaging chatbots," in *Proceedings of the 39th SIGCSE technical symposium on Computer science education*, 2008, pp. 449-453.
[12] S. M. Kelly, "Access technology for blind and low vision accessibility," ed: SAGE Publications Sage CA: Los Angeles, CA, 2020.
[13] "DRAFTSMAN Tactile Drawing Board." APH. https://www.aph.org/product/draftsman-tactile-drawing-board/ (accessed.
[14] M. Paris. "Introducing: Be My AI." Be My Eyes. https://www.bemyeyes.com/blog/introducing-be-my-ai (accessed.
[15] R. Adnin and M. Das, "“I look at it as the king of knowledge”: How Blind People Use and Understand Generative AI Tools," *people,* vol. 16, no. 54, p. 92, 2024.
[16] M. Israel, G. Jeong, M. Ray, and T. Lash, "Teaching elementary computer science through universal design for learning," in *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*, 2020, pp. 1220-1226.
[17] D. J. Clandinin, *Handbook of narrative inquiry: Mapping a methodology*. Sage publications, 2006.
[18] R. R. Valencia, *Dismantling contemporary deficit thinking: Educational thought and practice*. Routledge, 2010.
[19] L. P. Davis and S. D. Museus, "Identifying and disrupting deficit thinking," *National Center for Institutional Diversity,* 2019.