

AI-Driven Programming Education for Black, Latinx, and Afro-Caribbean Communities

By

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A thesis submitted to the University of Michigan School of Information in partial fulfillment of
the requirements for the degree of Master of Science in Information

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August 7, 2024

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Acknowledgment: The author gratefully acknowledges the support and resources provided by the University of Michigan.

Personal Acknowledgments

This thesis is the culmination of my graduate school experience in the Master's of Science in Information Science (MSI) program, a significant achievement shaped by learning new programming languages (Python, R, HTML, CSS, JavaScript) during my degree and exploring the growing field of artificial intelligence. The interplay between programming and AI opened new avenues for understanding and innovation. While meeting the demanding requirements of a graduate degree was challenging, the journey fostered growth, humility, and collaboration.

Growing up in Saint Thomas, US Virgin Islands, in the early 2000s, I was captivated by emerging technologies like smartphones and the internet, often dismantling and rebuilding computers at home. In sixth grade, I ventured into entrepreneurship by selling CDs to classmates, innovating at the time by sharing music on portable disks. This allowed people to access music who otherwise couldn't, as streaming services like those we have today didn't exist. While I initially pursued a hospitality/tourism degree, my dream of earning a STEM degree led me to the MSI program at the University of Michigan School of Information, where I was fortunate to couple it with an MBA from the Stephen M. Ross School of Business. Taking this leap after five years in my career felt like a rebirth of my destiny.

Now, moving from my story to expressing gratitude, I want to acknowledge the important people who made this journey possible. First, my faculty advisor, Professor Steve Oney, who has been a great mentor, coach, and advisor. I appreciate the months we worked on this research together and the ways you challenged me. Thank you for taking on the role of mentor and advisor at short notice.

Special thanks to my committee: Dean Cliff Lampe, Professor Barbara Ericson, and Judy Schabel, for dedicating your time to evaluate my thesis and providing resources and encouragement over these months. A special shoutout to Devon Keen for your immense support throughout my graduate studies, and to Dr. Elle O'Brien for your R Studio class, which was integral in analyzing data for this research. I hope this work contributes to developing resources for students of color not only in the Master of Science in Information program but also in broader computer science, engineering, information, and other tech programs at both undergraduate and graduate levels. Special thanks to my writing coaches at the Sweetland Writing Center and my dedicated coach, Chris Deason.

To my family: my mother (Mrs. Danita Penn-Green), my big brother (Kieshawne J. Green), my father (Gerald Green), my little brother (Kolaiah J. Green), my aunt (Aunty Mavelyn), and my late aunt (Danette Penn) – thank you for pushing me to new heights and encouraging me to return to school. To my sisters in Christ, Brittany and Ilysha, thank you for your incredible support; Ilysha, for suggesting I pursue my MBA and MSI degrees, and Brittany, for your unwavering encouragement and prayers. I love you all!

To my best friends and church families: Ali Sultan, Max Hill, and Dion Mauck, your support has been a beacon of light. Ali, thank you for your kindness and willingness to share resources. I

appreciate your encouragement throughout grad school and this research process. Now, I get to root for you during the DPM program. Max, your prayers and encouragement have meant the world to me. I am grateful to have met you and excited for you and TG as you welcome your new bundle of joy. Dion, thank you for being a great friend and brother. I am so encouraged by you and Ana and very thankful to have you both in my life.

Finally, my church families in Ann Arbor at Redeemer Church and New Life Church, especially Sara-Marie Kuntz and Nik Spasovoski, thank you for being the hands and feet of Christ from the beginning of my graduate school experience. To my church family at Redeemer Church, including The Kozler Family, Sofia Ortiz, and Hayoung Oh, your support has been invaluable.

Honorary mentions from the Michigan Ross Community: I must acknowledge the significance of the MBA curriculum and the blend of experiences between the MSI and MBA that contributed to my thesis. I am thankful for classes taught by Professors Cheng Gao, Mike Barger, Marcus Collins, Andrew Wu, and MSK. In particular, the Generative AI masterclass taught by Professor Andrew Wu and Strategic Brand Management with Professor Marcus Collins helped shape this research. To my closest friends—Andrea Gutierrez Marty, Robin F. Baker, Sasha Rodriguez Kolodkin, Seth Olson, Chelsea Hamm, Maria Guerrero, Trace Grain, Lasya Gulibhi, Carina Bustos, Darin Carter, Miriam Odabe, Ricardo Iglesias III, SY Kim, Joi James, Meredith Maimoni, Jennifer Ugheoke, Jason Barbier, Bryan Wyche, Aaron Valdes, Tirth Patel, Ogo Okoye, Joi James, Jordan Dodson, and Taylor Joiner—thank you for being part of my life.

In closing, the support and guidance I've received from my committee, and everyone mentioned have been bedrock for my thesis. This work represents more than an academic achievement; it is a testament to collaboration, mentorship, and shared vision. Thank you from the bottom of my heart for being a part of my journey. I'm thankful for the opportunity to have this thesis published and available to a global audience. To future readers, I hope this work inspires you to pursue your passions and embrace the power of collaboration in all your endeavors. Go Blue!

Abstract

My thesis explores the potential impact of artificial intelligence (AI)-assisted tools on programming education for African American, Latinx, and Afro-Caribbean students. I use an explanatory sequential design, collecting quantitative data through surveys and, subsequently, gathering qualitative insights from in-depth interviews. The findings indicate that AI tools enhance learning engagement, motivation, and retention by providing immediate feedback and personalized learning experiences. However, the study also highlights concerns about a possible over-reliance on AI, suggesting a need for careful and balanced integration. Additionally, the research considers how AI might improve access to programming education, addressing unique challenges each demographic group faces and fostering more inclusive learning environments. Insights from this study may contribute to developing innovative educational interventions to improve outcomes for marginalized communities in higher education and the tech industry.

Keywords: AI-assisted learning, computer science education, educational equity, African American students, Latinx students, Afro-Caribbean students, learner engagement, programming education, retention rates, personalized learning, digital divide, inclusive education, adaptive learning technologies, educational disparities, student motivation, intelligent tutoring systems, cultural diversity in education, STEM education, educational interventions, digital literacy, technology in education.

Preface

Maria is a bright, curious sophomore at a local high school known for its resilience and strong community spirit. She dreams of becoming a software engineer one day. Despite her passion for technology and innovation, Maria faces significant obstacles. Her high school lacks

resources and remains in deplorable condition after terrible hurricanes a few years prior. Additionally, the school only offers introductory technology courses, with no hands-on programming opportunities. Many other students in the region, including Maria, face educational disparities that stifle their potential and dim their dreams. Her story is not unique. A few hundred miles away, Jamal, an African American teenager, shares a similar struggle. Despite his keen interest in programming and computer science, Jamal has limited access to quality programming education due to his school's outdated technology and lack of extracurricular or mentorship programs. He lives in a city known for its rich history and cultural diversity but also faces economic disparities and under-resourced public schools, which serve as significant barriers to his aspirations. He spends evenings scouring the internet for resources and trying to teach himself programming languages, but the lack of structured support and community makes his journey challenging. Maria and Jamal's stories embody the struggles countless students from historically marginalized communities face, revealing the stark reality that talent and ambition are universal, but opportunities are not. Their stories underscore the critical need for targeted interventions to close the educational and technological divide for African American, Latinx, and Afro-Caribbean communities.

This story incorporates real-life accounts from individuals I grew up with in my community. I changed their names to maintain confidentiality and used their stories after

obtaining permission. This addition acknowledges the authenticity of the shared experiences while respecting the individuals' privacy.

AI Programming Education for Communities of Color

Computer programming, a vital skill in the 21st century, is crucial not only for future careers in computer science but also for career advancement in today's digital economy (Surtini, 2021). Balankskat et al. (2014) define computer programming as “the process of developing and implementing various sets of instructions to enable a computer to perform a certain task, solve problems, and provide human interactivity.” Programming is planning, designing, and testing code, while coding is the act of translating a set of instructions into a language that computers can understand (Voong-Fadel, 2020). Computer programmers spend their entire careers learning various popular programming languages such as Python, JavaScript, C++, Ruby, and PHP (Wilkins, 2021). Employers are increasingly seeking basic programming skills for future employment, as labor market reports identify analytical thinking and technology literacy, including programming, as top skills in demand (Wilkins, 2021; World Economic Forum, 2023).

Programming is a foundational skill in computer science because it transforms theoretical concepts into practical implementations, enabling real-world execution and rapid testing, as well as democratizing advanced technological innovations (Jessup University, n.d.). However, African American, Latinx, and Afro-Caribbean students face significant challenges in learning how to program despite the growing significance of these skills. African American and Latinx groups face numerous challenges, including low academic performance, limited prior programming experience, and social barriers that restrict access to quality programming education (Albarakit, 2023). These groups also struggle with the lack of role models in technology-related fields and limited access to academic resources, further hindering their ability to succeed in computer science programs (Albarakit, 2023). More specifically, African American and Black students face underrepresentation, isolation, and lack of support (Newsome, 2022).

Challenges and Representation of African American, Latinx, And Afro-Caribbean Students in Computer Science

African American refers to individuals in the United States who have origins in any Black racial group in Africa (National Park Service, 2024). African Americans have been widely known for their African origins for the past two hundred years (National Park Service, 2024). “Black” is a broader and more inclusive term than African American, including Afro-Caribbean individuals reflecting a shared identity and culture beyond skin color (NIH, 2024). Black students earn a low percentage of computer science degrees, and there is a lower percentage of Black faculty members in computer science and engineering departments at major universities (Newsome, 2022). Only 9% of Black students earned bachelor’s degrees in computer science, with 13% earning master's degrees and 7% research doctorates (Fry et al., 2021). Historically Black colleges and universities (HBCUs) have been an integral source of support for Black students. However, they alone cannot address the systematic issues that contribute to Black representation in STEM, especially since most Black students do not attend HBCUs (Newsome, 2022).

Latino/a, Latinx, and Latine are persons whose origins are in Latin America, including Cuba, Mexico, Puerto Rico, South America, and Central America (NIH, 2024). Latinx students face significant barriers in accessing and succeeding in programming within computer science education. We use “Latino” to refer to men and “Latina” to refer to women (NIH, 2024). However, a mixed-gender group of Latin American descent would use the masculine “Latinos” (NIH, 2024). Additionally, “Latinx” is a gender-neutral term primarily used by English-speaking people in the United States, serving as a research-based designation rather than a communitybased language (NIH, 2024). “Latinx” should only be used if someone has stated they identify that way, as it is not widely accepted or used by many Latinos (NIH, 2024). For the purposes of this research, the term “Latinx” will be used to describe individuals of Latin

American descent, recognizing its function as a gender-neutral identifier in academic research. Latinx students are underrepresented in computer science, holding only 8% of jobs in computing despite accounting for nearly 18% of the US workforce (Newsome, 2022). Latinx students face significant hurdles, including economic barriers, as many hail from lower-income backgrounds, making it difficult to afford college tuition and associated costs (Newsome, 2022). The financial stress of Latinx students impacts their ability to enroll and complete computer science degrees at major universities (Newsome, 2022). Latin America and Caribbean regions have disparities between public and private education, affecting access to higher education in computer science (Pias et al., 2024). Public universities have limited spaces for students and favor students from highquality private high schools, while many lower-income students must resort to private universities with higher tuition fees or give up on higher education altogether (Pias et al., 2024). Economic barriers and limited access to quality education contribute to the underrepresentation of Latinx individuals in the tech industry.

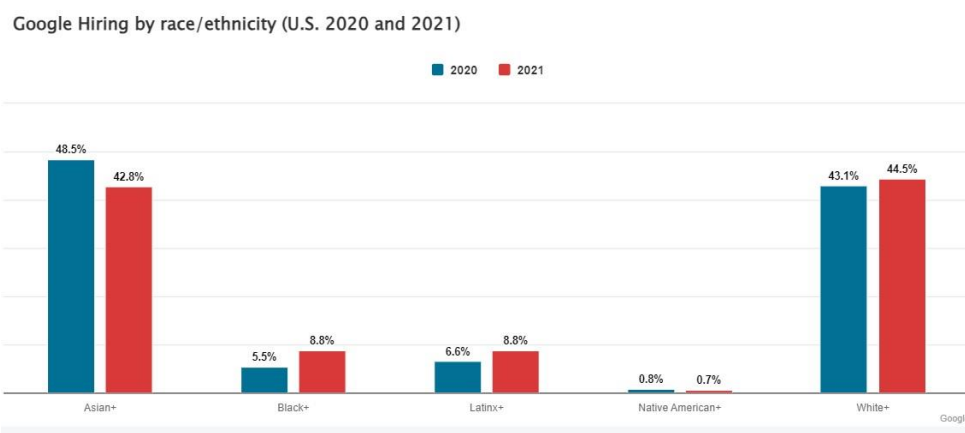
The term Afro-Caribbean refers to people of African descent born or living in the Caribbean with full or partial ancestry traced back to Africa (Merriam-Webster, 2024). AfroCaribbeans were primarily brought to the Caribbean as enslaved people during the trans-Atlantic slave trade and maintained cultural ties to both Africa and the Caribbean (Merriam-Webster, 2024). The students from the community face unique challenges in developing proficiency in programming and technology due to suboptimal educational settings and infrastructure (Mohan, 2003). Afro-Caribbean students have restricted access and a lack of early exposure to technology, which hinders the development of crucial digital skills and diminishes their competitiveness in the global market (Pias et al., 2024). The Caribbean region faces immense geographical and economic constraints, a shortage of qualified educators, and insufficient federal support that

contributes to a low adult literacy rate, with 54% of adults performing below the sixth-grade level (Mohan, 2003). Barriers such as personal obligations, lack of sense of belonging, in-class confusion, and lack of confidence not only affect individual student outcomes but also pose significant challenges to diversifying the tech field, highlighting the need for targeted interventions and systematic changes (Salguero et al., 2021).

Disparities in programming education among African American, Latinx, and AfroCaribbean students extend into the professional realm, revealing a stark underrepresentation in the tech industry. Data from the American Survey Data, as cited by the New York Times, indicates that among computer science and engineering graduates, 54% are white, 26% are Asian, 8% are Latinx/Hispanic, and 6% are Black (Bui, 2016). Education demographics influence employment disparities in the “Computer and Tech” sectors. Forty percent of Asian and 19% of white graduates work in tech compared to only 16% of Black and 12% of Latinx/Hispanic graduates, with even lower representation at major tech companies like Google (Carlton, 2023). Figures 1 and 2 visualize these employment trends. Technology companies employ strikingly few Black and Hispanic/Latinx employees, often attributing this to a lack of candidates with relevant degrees (Bui, 2016). However, data indicates that while many Black and Hispanic students major in computer science and engineering, a significant number do not graduate or transition into tech roles, thereby underscoring issues within the education trajectory, recruitment pipeline, and, possibly, company cultures.

Figure 1

Google Hiring by race/ethnicity (US 2020 and 2021)

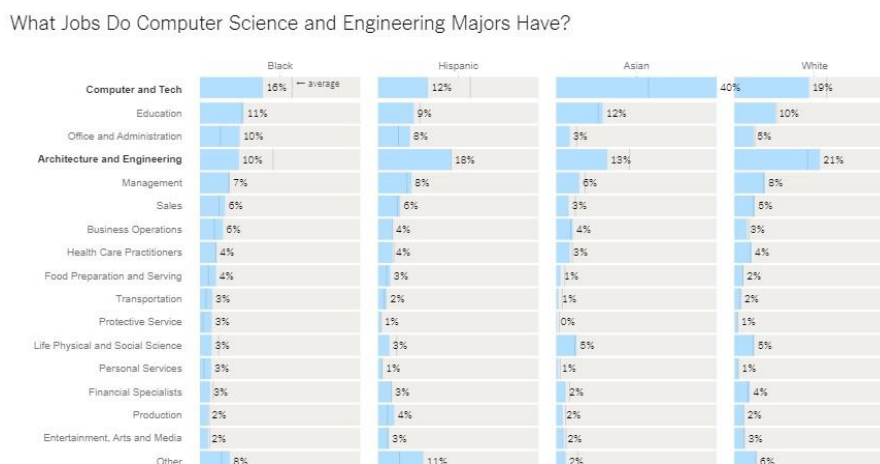


Note. The figure shows Google’s U.S. hiring percentages by race/ethnicity for 2020 and 2021.

Key trends include a decrease in Asian hires from 48.5% to 42.8%, an increase in Black hires from 5.5% to 8.8%, and an increase in Latinx hires from 6.6% to 8.8%. White hires increased slightly from 43.1% to 44.5%, while Native American hires saw a minor decrease from 0.8% to 0.7%.

Figure 2

What Jobs Do Computer Science and Engineering Majors Have?



Note: This figure displays the distribution of job sectors among Computer Science and Engineering majors, broken down by race/ethnicity, including Black, Hispanic, Asian, and White. The chart reveals that the highest percentage of majors work in the “Computer and Tech” sector, particularly among Asians (40%) and Whites (30%), followed by significant representation in

“Architecture and Engineering” and “Office and Administration” across all groups. Notably, other sectors such as “Management,” “Education,” and “Business Operations” present varying but lower percentages of employment, indicating diverse career paths for graduates in these fields. This diversity of career paths should inspire us to be open-minded and inclusive in our approach to employment in the tech industry.

Research Focus and Questions

The purpose of my thesis is to examine and explore, using quantitative and qualitative methods, the effectiveness of artificial intelligence (AI)-assisted tools in programming education for African American, Latinx, and Afro-Caribbean students. My research aims to understand how AI platforms may enhance engagement and retention in these underrepresented groups. High failure rates in introductory computer science (CS1) courses, ranging from 30% to 50% in many U.S. institutions, significantly impact the engagement and retention of underrepresented groups such as Black and Latinx/Hispanic students (Holanda et al., 2021; Robins, 2019; Stephenson, 2018; Margulieux et al., 2020). These high failure rates can be attributed to various difficulties, including ineffective instructional methods and broader educational issues (HijónNeira et al., 2023). Students often struggle to grasp foundational programming concepts during their first year in college or university (Hijón-Neira et al., 2023). Robins (2019) noted that the consistently high dropout and failure rates in early programming courses are due to the inherent difficulty of the content and intense demands, reinforcing the need for more effective pedagogical strategies. Holanda et al. (2021) emphasized the necessity of educational initiatives to increase diversity and support within CS1 courses to address these challenges. Stephenson (2018) discussed systematic issues and proposed solutions such as implementing peer mentoring programs, providing supplemental instruction, and incorporating active learning techniques to improve retention rates. Margulieux et al. (2020) found that using subgoal-labeled worked

examples can reduce cognitive load and improve problem-solving performance, leading to lower withdrawal and failure rates. Holanda et al. (2021) also observed that CS1 courses often exhibit a bimodal grade distribution, where early success or failure impacts future performance. CS1 courses are the first step for students in computer science programs and include fundamental programming concepts such as variables, conditionals, loops, functions, arrays, and recursion, which are crucial for building foundational skills for more advanced computer science coursework (Hijón-Neira et al., 2023). As Mohan (2003) highlights, “learning object technology can alleviate many of the problems associated with providing quality education,” and this foundation can be further enhanced by integrating AI technologies into STEM education.

The incorporation of AI into STEM education, particularly in programming education, has the potential to not only enhance learning experiences but also to address and mitigate the educational disparities faced by students from historically marginalized communities (Chine et al., 2022). AI technologies in STEM education offer a promising avenue for mitigating some of the challenges faced by students from historically marginalized communities by providing personalized support, adaptive learning paths, and immediate feedback (Chine et al., 2022). Examples include the integration of intelligent tutoring systems, adaptive learning platforms, large language models, and data analytics platforms that serve to provide extensive personalized learning experiences (Chine et al., 2022). The implementation of AI in STEM education should not be seen as a panacea but as part of a larger and multifaceted strategy meant to foster educational access and quality, improve educational outcomes, provide professional development opportunities, and foster community engagement to support students’ educational journeys (Chine et al., 2022). Xu et al. (2022) provided a systematic review that categorized AI applications in STEM education into six major areas: learning prediction, intelligent tutoring systems, student behavior detection, automation, educational robots, and other innovative resources. Salas-Pilco et

al. (2022) emphasized AI's role in promoting inclusive education by addressing pedagogical, technological, and sociocultural barriers. Incorporating AI into STEM education transforms learning experiences for historically marginalized communities, creating more equitable educational outcomes and opportunities.

Currently, there is a significant gap in the peer-reviewed literature regarding the effectiveness of AI-assisted tools in programming education, particularly for underrepresented groups such as African American, Latinx, and Afro-Caribbean students, to enhance engagement and retention rates (Albaraki, 2023; Antoine, 2023; Mohan, 2003). My research aims to bridge this lacuna and understand how AI technologies can transform educational access and outcomes for African American, Latinx, and Afro-Caribbean groups. The dual potential of AI could either exacerbate or reduce economic and racial disparities (Antoine, 2023). Economic and racial disparities underscore the importance of deploying AI solutions in education, as they can act as powerful equalizers, addressing these disparities effectively (McKinsey, 2023). Antoine's (2023) insights resonate with the broader conversation about leveraging AI to dismantle educational and societal barriers, emphasizing career opportunities, societal impact, representation, and empowerment for Black and other students of color to engage with AI.

The research questions include the following:

1. How do African American, Latinx, and Afro-Caribbean students rate AI-assisted tools in terms of their effectiveness, learning engagement, and retention effort in programming education?
2. How will African American, Latinx, and Afro-Caribbean students describe AI-assisted tools' effectiveness on learning, learner engagement, and retention effort in programming?

3. How do African American, Latinx, and Afro-Caribbean students perceive the role of AI-assisted tools in reducing barriers to entry and success in computer science education?

For detailed definitions and explanations of key terms used in these research questions, please refer to [Appendix BB](#). My thesis explores students' evaluation and perception of AI-assisted tools in enhancing learner engagement, retention, and educational outcomes by offering personalized and accessible educational opportunities for underrepresented groups in computer science education, specifically African American, Latinx, and Afro-Caribbean students. The findings suggest that AI can significantly impact programming education and support ongoing integration to address educational challenges faced by underrepresented communities.

Chapter 2: Conceptual Frameworks

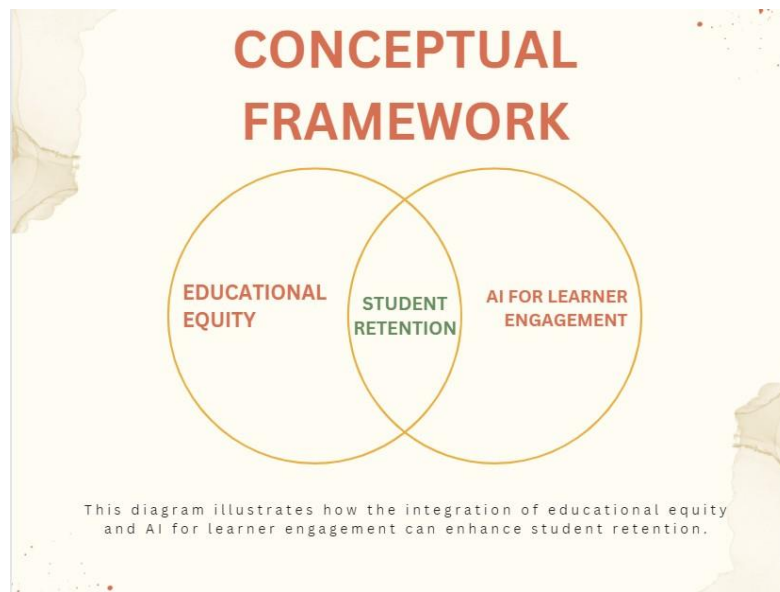
Educational equity is the foundation of this study's conceptual framework, including AI for learner engagement and student retention rates. Figure 3 illustrates the correlation between these areas, highlighting their interconnection. Educational equity advocates for equal learning opportunities for all students, transcending barriers such as socioeconomic status, gender, immigrant status, and family background (Levison, 2022). Regardless of their unique background or challenges, students can access the support and resources needed to achieve their educational aspirations (Levinson, 2022). AI for Learner Engagement enriches this framework by showcasing how AI-driven personalized learning can be a powerful tool for realizing the goals of educational equity (van der Vorst & Jellicic, 2019). AI has the potential to mimic the benefits of one-on-one tutoring, offering a scalable solution to personalize education for every student (van der Vorst & Jellicic, 2019).

Student retention strengthens this framework by ensuring that students, particularly those from underrepresented backgrounds, can persist in their educational journeys. Computer science programs have the highest dropout rate among college majors at 9.8% in 2020, underscoring the urgent need for improved retention strategies (HESA, 2020). The lack of diversity in computer science education in the U.S. has been a focus of numerous conversations in tech companies, popular culture, government, and academia (Association for Computing Machinery, 2018). The possible reasons for diversity challenges are up for debate among significant stakeholders. Despite this, one thing is clear: computer science programs are not retaining students from diverse populations during their academic careers, hindering the development of a diverse workforce in the tech industry (Association for Computing Machinery, 2018). Diversity challenges begin in schools, carry into higher education, and persist in the tech workforce (Association for Computing Machinery, 2018). Effective retention strategies, including AI-driven

personalized learning, can help create an inclusive environment that supports all students. Educational equity, AI for Learner Engagement, and student retention collectively address systematic barriers where all students can thrive and succeed (Giannakos et al., 2016; Wawiwa Tech, 2020).

Figure 3

Conceptual Framework Diagram



Note: The conceptual framework in this figure showcases the interconnectedness of educational equity, AI for learner engagement, and student retention. As defined by Levinson (2022), educational equity emphasizes providing equal learning opportunities for all students, regardless of their socioeconomic status, gender, or background. AI for learner engagement, explored by van der Vorst and Jellic (2019), leverages AI to personalize learning experiences, mimicking the benefits of one-on-one tutoring and enhancing student involvement. The intersection of these two elements leads to improved student retention rates, particularly in fields like computer science, by addressing systemic barriers and creating supportive, engaging, and inclusive educational environments.

Educational Equity in Computer Science

Computer science education has not been equitably available to all students, marked by significant disparities along gender, racial, and socioeconomic lines. (Weisenbeck, n.d.). Inclusive teaching models that provide intentional learning opportunities create equity in computer science (Weisenbeck, n.d.). Some examples of innovative approaches to bridging these gaps include coding workshops (Rea). Developers have created these initiatives outside of traditional academic pathways to increase access to programming proficiency, which this thesis highlights (Rea). The social justice exploration of programming literacy education focuses on using coding boot camps as literacy sponsors, which impart technical skills and nurture confidence, agency, and a sense of belonging among participants (Rea). These initiatives prioritize an inclusive curriculum that acknowledges and addresses the barriers underrepresented groups face, aiming to foster an environment where all students feel welcome, supported, and empowered (Rea). The research suggests that effective interventions must be designed with an acute awareness of these complexities, ensuring that efforts promoting equity do not inadvertently exclude or marginalize. Rea (2022) emphasizes the role of coding workshops and boot camps as literacy sponsors, which provide technical skills and nurture confidence, agency, and a sense of belonging among participants.

Coding boot camps and workshops, which offer an accelerated pathway for those traditionally underrepresented in the tech industry, play a pivotal role beyond their practical utility. They promote equity within computer science education by providing accessible opportunities for skill development. However, it is important to acknowledge certain drawbacks associated with these programs, such as the considerable personal and financial investment required and the potential barriers students face when transitioning into the software industry. While boot camps offer significant opportunities for marginalized groups and women to enter the

tech field at an accelerated pace, there is a need for comprehensive support mechanisms beyond technical training to fully leverage these programs toward achieving the ideal state of education equity. Coding boot camps face challenges, particularly for underrepresented graduates facing industry skepticism of their credentials. Older participants are impacted by age-related biases, which may affect their overall job prospects. This highlights the need for broad support to ensure all graduates, regardless of background or age, can fully leverage their boot camp experience toward a successful career in tech. This aligns with my research on AI-assisted tools in computer science education, as both aim to democratize access to technology education and improve engagement and retention among underrepresented groups.

While discussing coding boot camps and their potential to broaden access to tech careers for underrepresented groups, it is essential to consider the educational content and pedagogies employed within computer science. Implementing justice-centered approaches offers a tangible means of enriching the educational experiences of marginalized communities. My research pertains to justice-centered approaches as it focuses on enhancing engagement and retention among underrepresented students in computer science through equitable and inclusive educational practices. Expanding on this, justice-centered approaches in computer science, as advocated by Lin (2022), emphasize the need to reframe computer science learning as a means of advancing peace, anti-racism, and social justice by challenging the normative focus on profitdriven outcomes. This pedagogical shift aims to democratize access to technology education and reimagine the role of computer scientists in society. Lin (2022) highlighted the need for integrating a justice-centered framework into computer science curricula, empowering students to view their technical skills through social responsibility and ethical engagement. By emphasizing ethics, identity, and political vision, justice-centered approaches align with equity goals by ensuring that all students, regardless of background, have access to a curriculum that

acknowledges and values their unique perspectives (Vakil, 2018). This approach enhances learner engagement by connecting technical skills with real-world social issues, making learning more relevant and motivating for students from diverse backgrounds (Vakil, 2018).

It is clear from the research that this transition draws upon a critical examination of the societal impacts of technology. This encourages students to design and implement solutions that contribute to a more equitable society. Educators can nurture technologists skilled in coding and dedicated to social good by integrating social justice principles into tech education. This guidance empowers students to use their skills to benefit society. Coding boot camps provide an essential platform for broadening participation in the tech industry. Additionally, adopting justice-centered pedagogies within computer science education represents a significant step toward achieving prolonged educational equity and transformation.

AI for Learner Engagement

The advent of AI in education heralds a transformative shift towards personalized learning that tailors educational experiences to each learner's unique needs and pace (van der Vorst & Jellicic, 2019). Bloom (1984) demonstrated a two-standard deviation improvement in individually tutored students. However, the practical constraints of availability and the high costs of personal tutoring have limited its feasibility on a larger scale. Recent advancements in machine learning algorithms offer a promising avenue to overcome these educational barriers. These technological breakthroughs allow AI applications to deliver personalized learning and provide opportunities to catalyze a one-to-one experience for students (van der Vorst & Jellicic, 2019). AI innovations in education have the potential to not only improve learning outcomes but also address the increasing workload challenges faced by educators, offering a dual benefit that enhances student learning while optimizing teacher productivity (van der Vorst & Jellicic, 2019). A thorough examination of AI's impact on education drives consideration for several critical areas:

technological advancements, legal implications, societal effects, and ethical considerations.

Technological advancements include developing intelligent tutoring systems, adaptive learning platforms, and data analytics tools that personalize learning experiences and improve student engagement and outcomes (Xu et al., 2022). Legal implications are significant because they concern data privacy and intellectual property. AI systems in education must comply with data protection laws like GDPR and FERPA to ensure the privacy and security of student data (The Franklin Law, 2023). Intellectual property concerns also arise regarding the ownership and use of AI-generated content, necessitating clear guidelines and firm regulation (Panagopoulou et al., 2023; The Franklin Law, 2023). Societal effects include AI's potential to democratize education, making high-quality learning accessible to historically marginalized communities (Salas-Pico et al., 2022). Challenges also arise with ensuring AI systems do not perpetuate existing biases or create new forms of inequality (Salas-Pico et al., 2022). Finally, ethical considerations are paramount and should be taken to the highest degree regarding accountability, transparency, and bias prevention in AI applications. These ethical frameworks guide the development and implementation of AI in education to ensure it benefits all students equitably and responsibly (International Journal of Educational Technology in Higher Education, 2023).

Integrating human mentorship with AI-driven tutoring systems may enhance educational equity for marginalized populations in STEM education based on the Personalized Learning² approach (PL²) (Chine et al., 2022). The PL² approach combines human mentoring with AI tutoring in a hybrid model, demonstrating promising results in STEM subjects through improved scoring and testing measures (Chine). It has proved more effective than traditional mentoring/tutoring models (Chine). This approach has been primarily tested and utilized within K-12 educational settings with the potential for application in higher education within programming and computer science learning. Using human-computer teaming/mentorship

provides mentors with access to personalized resources via AI software based on students' existing math learning software, mentor input, and feedback (Chine). Personalized AI learning combines technology and human interaction, seeking to narrow the achievement gap by providing low-cost personalized learning opportunities toward more equitable educational outcomes (Chine et al., 2022).

Rathore et al. (2024) explained the importance of personalization in education, particularly in programming, using AI models to segment students by proficiency and provide tailored tools and materials to enhance critical thinking and problem-solving skills. These AI models highlight the necessity of interactive and user-friendly systems that actively engage students in the learning process. Jin et al. (2024) explored the use of large language models (LLMs) as teachable agents in programming education. Their study demonstrates how LLMs can help learners identify knowledge gaps and discover new knowledge through interactive activities. AI agents can simulate misconceptions and initiate knowledge-building questions that enhance learning experiences and reduce development costs (Jin et al., 2024). The insights from Rathore et al. (2024) and Jin et al. (2024) underscore the potential of AI-driven personalized learning systems in democratizing access to high-quality education. These systems provide tailored resources and foster interactive learning environments essential for addressing educational disparities, especially for students from underrepresented communities.

The integration of AI for novice programmers marks a pivotal shift towards personalized and interactive learning environments. Tools like OpenAI Codex have demonstrated their capacity to enhance the learning experience by providing real-time feedback, adaptive learning paths, and interactive problem-solving sessions tailored to an individual's learning pace and style (Ericson et al., 2023). These AI-assisted platforms can democratize access to programming education while fostering a more engaging and efficient learning process, allowing students to

progress at their own pace and according to their unique learning preferences. This approach aligns with the findings of Vorst et al. (2019), who emphasize the transformative potential of AI in creating personalized learning experiences that cater to the diverse needs of learners, maximizing educational outcomes and engagement.

On the other hand, ChatGPT has emerged as one of the most dominant educational tools with transformative opportunities for novice programmers (Koza et al., 2024). ChatGPT extends beyond mere coding assistance to encompass broader educational utility, offering an innovative approach to learning computer science. It has demonstrated capabilities to facilitate code management, provide programming tutoring, and enhance natural language processing capabilities, making it an invaluable resource for beginners (Anagnostopoulos, 2023). The application of ChatGPT in generating and refining code in real-time allows learners to experiment and learn from interactive feedback, reducing the learning curve associated with programming languages (Anagnostopoulos, 2023). Furthermore, empirical research suggests that integrating ChatGPT into programming courses does not negatively impact student performance, indicating that ChatGPT is a safe and effective tool when appropriate measures are in place to support its use (Kosar et al., 2024).

Student Retention in Computer Science

The conceptual framework for understanding student retention in computer science education emphasizes the critical role of educational equity and learner engagement in improving retention rates. Educational equity ensures that all students, regardless of background, have equal access to high-quality computer science education (US Department of Education, 2024; All4Ed). Quality computer science education is essential for fostering a diverse and inclusive learning environment (Pear Deck, 2023; American et al., 2023). Initiatives like justice-centered pedagogies address systemic barriers and promote social justice to achieve equity (Vakil, 2018).

Educators enhance learner engagement by creating supportive and challenging learning environments that connect technical skills with real-world applications, making the learning process vibrant for students from diverse backgrounds (Giannakos et al., 2016).

Integrating educational equity and learner engagement initiatives could improve student retention by addressing barriers such as negative stereotypes and poor teaching quality while enhancing students' sense of belonging and satisfaction with their educational experience. This prepares students for successful careers in the tech industry (Stephenson et al., 2018; Association for Computing Machinery, 2018; Giannakos et al., 2016). Retention and persistence in computer science are distinct but related concepts. Retention refers to the institution's ability to keep students enrolled in their programs until graduation, regardless of their field of study (Association for Computing Machinery, 2018). On the other hand, persistence in computer science refers to a student's continued enrollment and progress within the field, influenced by academic performance, learning assistance, peer interaction, and a sense of belonging shaped by ongoing interactions with their institution's academic and social systems (Albarakati, 2021; Tinto, 1975). Tinto (1975) highlights persistence through ongoing interactions between students and higher education's academic and social systems. Albarakati (2021) emphasizes improving non-cognitive factors like academic performance satisfaction, learning assistance, peer interaction, and a sense of belonging. Retention efforts in education encompass a range of strategies designed to keep students enrolled and engaged in their studies to improve retention and persistence (Kuh, 2007; Tinto, 1993). Retention effort is used as a variable to assess AI-assisted tools' impact on student engagement and persistence in programming education. This variable measures the impact of initiatives and actions taken to ensure students remain enrolled and engaged in programming education. It evaluates student engagement and identifies barriers to retention, referencing the strategies implemented to support students' persistence and success.

Review of Literature

AI-Driven Retention Strategies and Ethical Considerations in Technology Adoption

This theme covers AI-driven retention strategies and the ethical considerations in technology adoption to provide a comprehensive understanding of the impact of AI tools on programming education, especially for underrepresented groups. There is a nuanced understanding of AI tools, specifically code generators like Codex, that provide a blueprint for novice programming environments. These tools not only assist in the completion of programming tasks but also contribute to deeper engagement with learning material. AI tools increase retention by providing more profound engagement with learning material (Anagnostopoulos, 2023; van der Vorst & Jelcic, 2019). By offering personalized feedback and allowing for iterative learning through trial and error, AI code generators foster an environment where novice programmers can experiment, learn from their mistakes, and gain confidence in their coding abilities (Chen et al., 2021; Sun et al., 2022). AI code generators have shown progress in assisting with immediate task completion and supporting long-term retention in programming concepts (Ericson et al., 2023; Anagnostopoulos, 2023).

Adopting ChatGPT in programming education raises critical ethical considerations, one being plagiarism, where the proper citation and acknowledgment of automatically generated code is paramount (Li et al., 2023). The ongoing discussion emphasizes the growing concern, highlighting the need for accurate attribution, which is crucial in software development, forensics, and quality analysis (Li, 2023). To that end, Brey and Dainow (2023) have emphasized the growing concern within the research community regarding the ethical development of AI systems, suggesting a push towards establishing a standard code of ethics by international organizations to address these comprehensively. Bias and fairness in AI-generated content present potential ethical challenges. These issues are observed in various AI-generated content but are not

explicitly associated with ChatGPT. Early research by Caliskan et al. (2017) has shown that biases in training data can lead to biased or discriminatory code suggestions. This indicates a pressing need to mitigate such biases to ensure equitable and fair use of AI in programming education.

Cultural Implications of AI and ChatGPT

Understanding the cultural implications and effectiveness of AI-assisted programming tools is critical for developing inclusive educational strategies that bridge the digital divide. This theme highlights the importance of netnography—ethnographic research conducted online—in capturing the authentic voices and experiences of diverse user groups as a methodology for studying the cultural implications of AI tools (Collins, 2023). The introduction of AI and platforms like ChatGPT into the programming world has ushered in a complex web of cultural implications that challenge the notions of learning, coding, and the nature of creativity in software development. 92% of US-based developers are using AI coding tools both inside and outside of work (Shani, 2023). Users express a range of sentiments, from exhilaration at AI’s capacity to simplify coding tasks to concerns over diminished motivation for learning due to AI’s efficiency in problem-solving (Buchanan, 2023). The breakdown of this netnography feedback from Twitter, Reddit, and Quora is presented in [Appendix C](#). The social dialogue from these platforms echoes broader discussions in the tech community about balancing leveraging AI for productivity gains and preserving the foundational learning experiences critical for deep understanding and innovation in coding (Buchanan, 2023). These mixed reactions suggest that AI tools like ChatGPT can democratize access to coding by acting as on-demand mentors, but they also introduce ethical considerations and potential dependencies that can stifle the creative challenges fostering true innovation (Li, 2022; Shani, 2023). Furthermore, the use of AI in broader societal contexts—from everyday tasks to groundbreaking scientific research—

highlights its pervasive influence on our work and leisure, pointing to a future where AI's integration into our lives is both a source of convenience and a catalyst for reevaluating the human role in creativity and problem-solving processes (Buchanan, 2023; Twitter Reviews; Reddit Reviews; Quora Reviews).

Collins (2023) emphasized the impact of cultural dynamics on technology adoption and utilization, highlighting that cultural contexts are essential for interpreting how different communities engage with technological innovations. Developers experience a technological and cultural shift that reshapes their roles and creative processes with AI entering the programming field (GitHub, 2024). This perspective encourages a nuanced understanding of AI's impact, highlighting the importance of integrating it as a tool to enhance human ingenuity and talent rather than replace it (Fortino, 2023). Such an approach supports the evolution of programming education and fosters an environment where AI complements and augments the natural abilities of developers (Teveine, 2023).

A nuanced understanding of AI's impact ensures its integration into programming education and practice enriches rather than diminishes the development experience, fostering an environment where AI is seen as a tool for augmentation rather than a replacement for human ingenuity. Highlighting a pivotal research gap, the interaction of AI and tools like ChatGPT in programming education calls for a culturally responsive approach that would empower African American, Afro-Caribbean, and Latinx students (Hutchinson et al., 2020). A culturally responsive approach is vital to overcoming the digital divide and making AI's benefits universally accessible. Future research should aim at inclusivity to devise strategies to enhance participation and innovation among underserved populations in the tech landscape, thereby ensuring AI's educational potential is fully realized across the diverse societal spectrum (McKinsey, 2023; Antoine, 2023).

Research Gaps in Computer Science Education Intervention Methods

Innovation Interventions. A variety of intervention methods have been implemented to enhance diversity and inclusion within STEM fields. For example, the University of Maryland’s Ambassador Program focuses on supporting historically marginalized students in STEM, significantly improving retention rates and empowering students to tackle diversity issues through mentorship and community engagement (Kramarczuk et al., 2021). Another approach involves Integrated Development Environments (IDE) interventions in computing courses, where software enhancements in IDE aim to foster social interaction and programming skills, emphasizing the value of collaboration and self-reflection among undergraduate computing students (Olivares et al., 2021). Additionally, gamification techniques using Scratch programming have been employed to address coding phobia among early learners, promoting critical thinking and coding skills while shifting perceptions from “code-phobia” to “code-philial” (Berry & Walcott, 2019). Furthermore, the Ecological Belonging Intervention, targeting firstyear engineering students, specifically aims to bolster belonging and academic success for Black, Latinx, and Indigenous students, thus improving their academic outcomes and sense of community (Godwin et al., 2023).

CS Education for Communities of Color. Despite these interventions, significant challenges remain in computer science education, especially for communities of color. Current support strategies require critical reassessment to address the persistent issue of high dropout rates in introductory programming courses, which stand at a staggering 50% across the general population (Margulieux et al., 2020). This situation underlines the urgent need for innovative methods that can significantly influence the retention and success rates of ethnic minority students in the field (Albarakit, 2023). Additionally, there is a notable lack of research focusing on the unique experiences and needs of Black, Latinx, and particularly Caribbean communities within the AI programmer demographic. This gap highlights the critical need for targeted studies

to better understand how AI-assisted interventions can effectively support these underrepresented groups in computer science education (Albarakit, 2023; McKinsey & Co., 2023; Antoine, 2023).

Declining Interest in Computer Science Studies. Recent findings from the University of Rhode Island have unveiled an unexpected challenge: women and ethnic minority students, including Black and Latinx groups, despite engaging with academic support services like tutoring, mentoring, and study groups, show a paradoxical trend of declining interest in continuing their computer science studies (Albarakit). For instance, research from the University of Florida has provided evidence on how isolation and lack of support are significant contributing factors to the high dropout rates among Black students in computer science doctoral programs (Gilbert, 2020). Despite the availability of academic support services, these students often feel a lack of belonging and mentorship, which are critical for retention and success in STEM fields (Gilbert; Albarakit). Albarakit (2021) highlights a study conducted in the 2018–2019 academic year that surveyed 208 students in introductory computer science course and found that 56% of underrepresented students, along with women, left the computer science major after taking introductory courses, compared to 49% of students who switched majors overall during this period. Results from this study indicate that underrepresented students face additional challenges compared to their white classmates. Underrepresented students in this study reported lower satisfaction with their academic performance and were more likely to seek academic help, but help-seeking behavior was negatively associated with their intention to persist in the computer science major (Albarakit, 2021). Academic support is available, but it may not meet the specific needs of underrepresented students effectively, thus contributing to higher attrition rates (Godwin et al., 2023).

A systematic review of diversity-focused STEM programming in the U.S. revealed that Black and Latinx students often attend open-access community colleges with fewer resources,

which hinders their academic progress and completion rates in contrast with white peers at selective institutions who benefit more from resources and support (Espinosa, 2011; McGee, 2020). Similarly, a study conducted at the University of San Diego further identified additional non-academic barriers to student success in computer science courses, such as personal obligations and socio-emotional challenges like lack of belonging and confidence, which are not typically addressed by traditional academic support systems (Salguero et al., 2021). The convergence of these findings indicates a pressing need for educational interventions that extend beyond traditional academic support, targeting a broader array of challenges that disproportionately affect underrepresented groups in the field of computer science (Salguero et al., 2021; Albarakit, 2023). Mentoring, tutoring groups, and study groups are traditional forms of academic support that may not meet the specific needs of these underrepresented groups, suggesting a pivotal area for future research and intervention design in computer science education (Albarakit, 2023). Figure 4 below illustrates these research gaps in computer science education, highlighting the challenges and areas for future focus.

Synthesis of Research Gap. Recent findings from the University of Rhode Island reveal an unexpected challenge: women and ethnic minority students, including Black and Latinx groups, despite engaging with academic support services like tutoring, mentoring, and study groups, show a paradoxical trend of declining interest in continuing their computer science studies (Albarakat). Research from the University of Florida further highlights how isolation and lack of support significantly contribute to the high dropout rates among Black students in computer science doctoral programs. Despite the availability of academic support services, these students often feel a lack of belonging and mentorship, which are critical for retention and success in STEM fields (Gilbert, 2020).

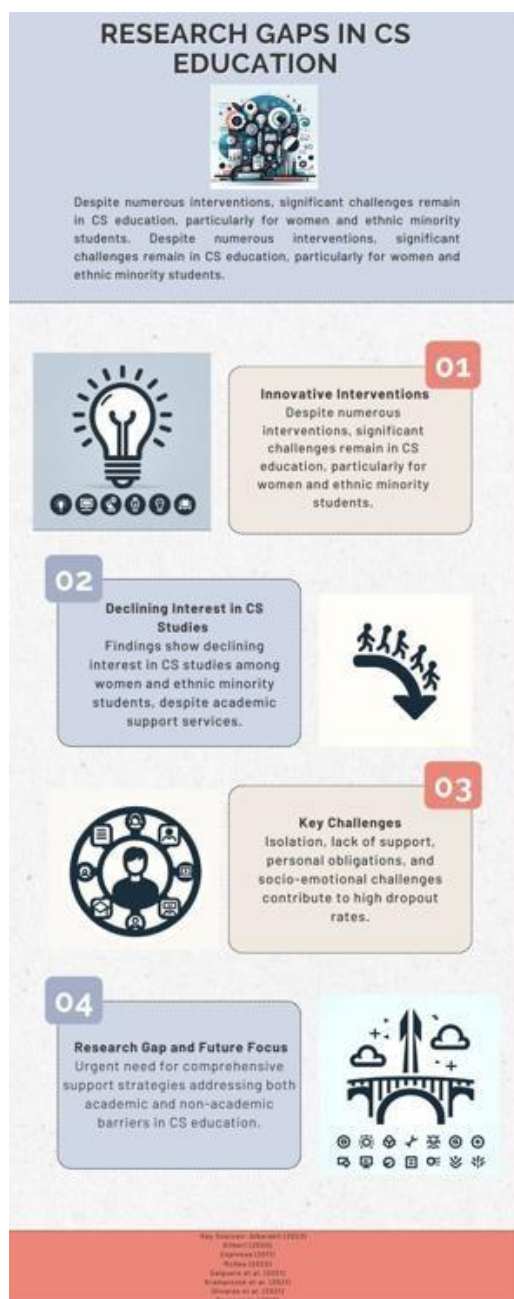
A systematic review of diversity-focused STEM programming in the U.S. reveals that Black and Latinx students are more likely to attend open-access community colleges with fewer resources, impeding their academic progress and completion rates compared to their White peers at more selective institutions (Espinosa, 2011; McGee, 2020). Similarly, a study at the University of San Diego identifies additional non-academic barriers to success in computer science courses, such as personal obligations and socio-emotional challenges like lack of belonging and confidence, which are not typically addressed by traditional academic support systems (Salguero et al., 2021).

The convergence of these findings underscores a pressing need for educational interventions that extend beyond traditional academic support, targeting a broader array of challenges disproportionately affecting underrepresented groups in computer science (Albarakati). Traditional forms of academic support, such as mentoring, tutoring, and study groups, may not meet the specific needs of these underrepresented groups, highlighting a pivotal area for future research and intervention design in computer science education (Albarakati & DiPippo, 2021). Figure 4 below illustrates these research gaps in computer science education, emphasizing the challenges and areas for future focus.

Transition to Research Study. The research aims to bridge the gap by examining and exploring the effectiveness of AI-assisted tools in computer science for Black, Latinx, and AfroCaribbean students. By understanding how AI platforms may enhance engagement and retention rates in these groups, this study seeks to contribute to the development of innovative educational interventions for underrepresented students.

Figure 4

Bridging the Research Gaps in Computer Science Education for Ethnic Minority Students.



Note: This infographic provides a concise overview of the ongoing challenges in computer science education for ethnic minority students. It highlights the need for innovative interventions and comprehensive support strategies to address both academic and non-academic barriers to improve retention and success rates in the field. This area covers the research gap, emphasizing the critical need for targeted studies and interventions.

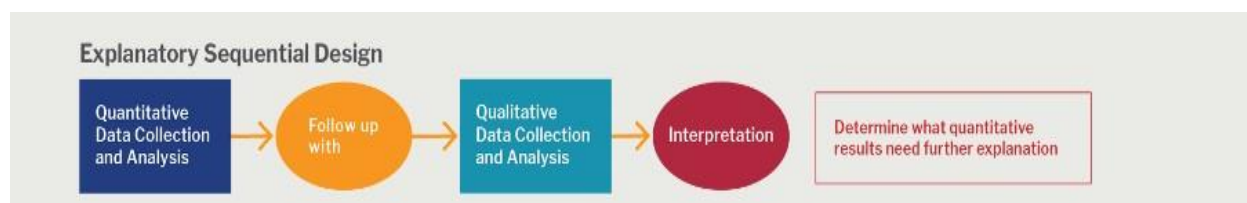
Study Setup

My thesis employed an explanatory sequential design method involving two distinct phases: a quantitative phase followed by a qualitative phase (Ivankova et al., 2006; Wipulanusat et al., 2020). This mixed-methods approach was particularly effective in addressing the complex nature of the study as it balanced the power of numbers and generalizable outcomes from the survey with contextual insights from the interviews (Wipulanusat et al., 2020). By integrating the findings from both phases, this approach provides a well-rounded and comprehensive understanding of the research problem, enhancing the overall rigor of this study (Ivankova et al., 2006).

First, the quantitative data was collected and analyzed for numerical trends, considering programming and AI experiences. Next, I collected qualitative data to explain and elaborate on the quantitative findings (Ivankova et al., 2006). My study included in-depth interviews with selected participants and a thematic analysis to explore their perspectives and experiences in greater detail. The qualitative phase was designed to provide additional insights, contextualizing the quantitative results and ensuring a comprehensive understanding of the research problem (Wipulanusat et al., 2020). Figure 5 below illustrates the explanatory sequential design method used in this study, showing how quantitative and qualitative phases are integrated (Ivankova et al., 2006). The explanatory sequential design starts with collecting and analyzing quantitative data, which informs the subsequent qualitative phase (Ivankova et al., 2006). The qualitative data collection follows up on the quantitative results, providing a deeper understanding of specific areas, and the interpretation stage integrates both phases to offer broader insight into the research problem (Ivankova et al., 2006).

Figure 5

Explanatory Sequential Design



Note: This figure depicts the steps involved in an explanatory sequential design, which starts with quantitative data collection and analysis, followed by a qualitative follow-up to explore the quantitative results further. The process includes an interpretation phase to determine the insights gained from the qualitative data, providing a comprehensive understanding of the research findings.

Setting of the Study

The study took place at the University of Michigan, a leading institution known for its trailblazing AI environment. The University of Michigan is currently at the forefront of the generative AI wave, with platforms like UM-GPT significantly influencing the academic and research landscape. My study leveraged extensive resources, including research papers, SPSS software, and networking with thought leaders and faculty from the Michigan AI Research Lab. The rich environment provided an opportunity to explore cutting-edge AI developments like UM GPT, U-M Maizkey, and the U-M GPT Toolkit. Additionally, the initial research design of this study was presented at the generative AI (Gen AI) Showcase panel by Technique, an emerging campus club that is breaking barriers in technology. The Gen AI showcase panel provided a platform to discuss the study's implications. It fostered a collaborative dialogue among students and faculty on the innovative uses of AI in research, thereby enhancing the study's depth.

Study Participants

Demographics of Participants

The study participants included African American, Latinx, and Afro-Caribbean students. The demographic data, combined with pie charts and bar graphs in Appendix T, shows that 25%

of participants identified as African American/Black, 11.1% hailed from a Latinx background, and approximately 8 to 9% came from the Afro-Caribbean. Participants came from a broad range of academic backgrounds, with 19% having less than a high school diploma or equivalent, 14% having a high school diploma or equivalent, 12% having some college experience but no degree, 10% holding an associate degree, 24% having a bachelor's degree, 39% having completed a master's degree, and 2% holding a professional degree. There were no participants with trade/technical/vocational training or doctorate degrees. [Appendix U](#) outlines the breakdown of educational backgrounds in the pie and bar charts. The diverse ethnic backgrounds, educational experiences, and programming experiences contribute to a valuable data set for understanding the various impacts and experiences with AI-assisted tools in programming education.

The University of Michigan and Other Education Partners' Samples

My study employed two different sampling methods to recruit participants: purposive sampling and quota sampling. I used purposive sampling to select the University of Michigan sample and other educational partnerships. Purposive sampling allows the intentional selection of participants who meet specific criteria relevant to the study's objective (Campbell et al., 2020). I purposely sampled participants from the Ross School of Business, the School of Information, and the Computer Science and Electrical Engineering departments. The survey asked participants the following specific questions to determine their eligibility: "How would you describe your current level of programming proficiency?" "How have you used AI-assisted tools for educational purposes, if at all? Please explain the context," and "Which of the following AI programming assistants have you used?" If participants answered "no" to proficiency in programming or using AI for programming, their responses were excluded from the study. I focused the research questions on participants' experiences with learning programming and using AI and built the survey questions based on these research questions. Participants highlighted Python as the most

familiar programming language and ChatGPT as the number one AI tool used for programming purposes. Please refer to [Appendix W](#) and [Appendix X](#) for detailed programming language use and AI tool results from this sample. Purposeful criterion sampling ensured that the participants had the necessary background to contribute meaningfully to the research on AI and programming (Campbell et al., 2020). Figure 6 below illustrates the self-reported programming proficiency levels of the University of Michigan sample, highlighting that most respondents identify as beginners, followed by intermediate and expert levels.

The survey was made available in the middle of March 2024 and closed on April 15, 2024. Once the survey closed, participants could enter a drawing for five \$25 prizes, awarded through a random drawing. I recruited participants from the University of Michigan's Ross School of Business, School of Information, and the Engineering and Computer Science departments. I sent mass emails to the School of Information using the school listserv, highlighting the survey criteria and who could participate. I also directly targeted the Black@SI organization, sending emails to the club's inbox and messages through GroupMe, and had club leaders forward the survey to their members. Understanding that not all Black students or students of color are part of Black@SI, I also distributed the survey over Slack, a central connection hub for University of Michigan students. For the Ross School of Business, I implemented a different approach. I sent Slack messages to students in the Consortium for Graduate Studies in Management, an alliance of top business schools and corporate partners dedicated to enhancing diversity in business education and leadership by providing full-tuition fellowships to underrepresented minorities. The business school limits survey distribution, so I followed their guidelines and specifically sent the survey to groups of minority students. I targeted Black Business Association, Latin American Association, and Hispanic Business Association students.

Additionally, club members promoted the survey at Technique Gen AI Panel and forwarded the survey to undergraduate BBA students with approved and consistent language. I sent mass emails through their listserv for the Engineering and Computer Science student population. I also targeted other groups like the Black Student Union, Color Code, NSBE, Caribbean Student Union, and the African Student Association with mass emails. The rationale for selecting participants from these specific schools and organizations stems from the need to gather various insights pertinent to the research objectives.

The Ross School of Business, School of Information, and the Engineering and Computer Science departments each offer unique perspectives that are critical for understanding the academic and professional backgrounds of the student body. Black@SI, Consortium, and the other minority student groups were essential for capturing the inclusion of a wide audience of minority student voices. I ensured the survey reached a broad yet relevant audience using well-established university communication channels like Slack, GroupMe, and email.

Appendix AA contains the specific emails and messaging used for survey distribution, providing transparency and allowing readers to understand the communication strategy. I partnered with the Virgin Islands Department of Education to recruit participants to take the survey from the University of the Virgin Islands to reach students in the Caribbean. Moreover, I targeted Caribbean student groups on Facebook and Instagram platforms to ensure the survey reached a broad yet relevant audience in the Caribbean. The survey distribution commenced on April 15, 2024.

Figure 6

Current Level of Programming Proficiency: University of Michigan and Educational Partners Sample

2. How would you describe your current level of programming proficiency?

36 responses



Note. This pie chart illustrates the self-reported programming proficiency levels of 36 respondents. Most respondents (69.4%) identify as beginners with zero to one year of experience. Intermediate programmers with two to four years of experience comprise 22.2% of the respondents. Experts with more than four years of extensive knowledge and expertise constitute 8.3% of the respondents.

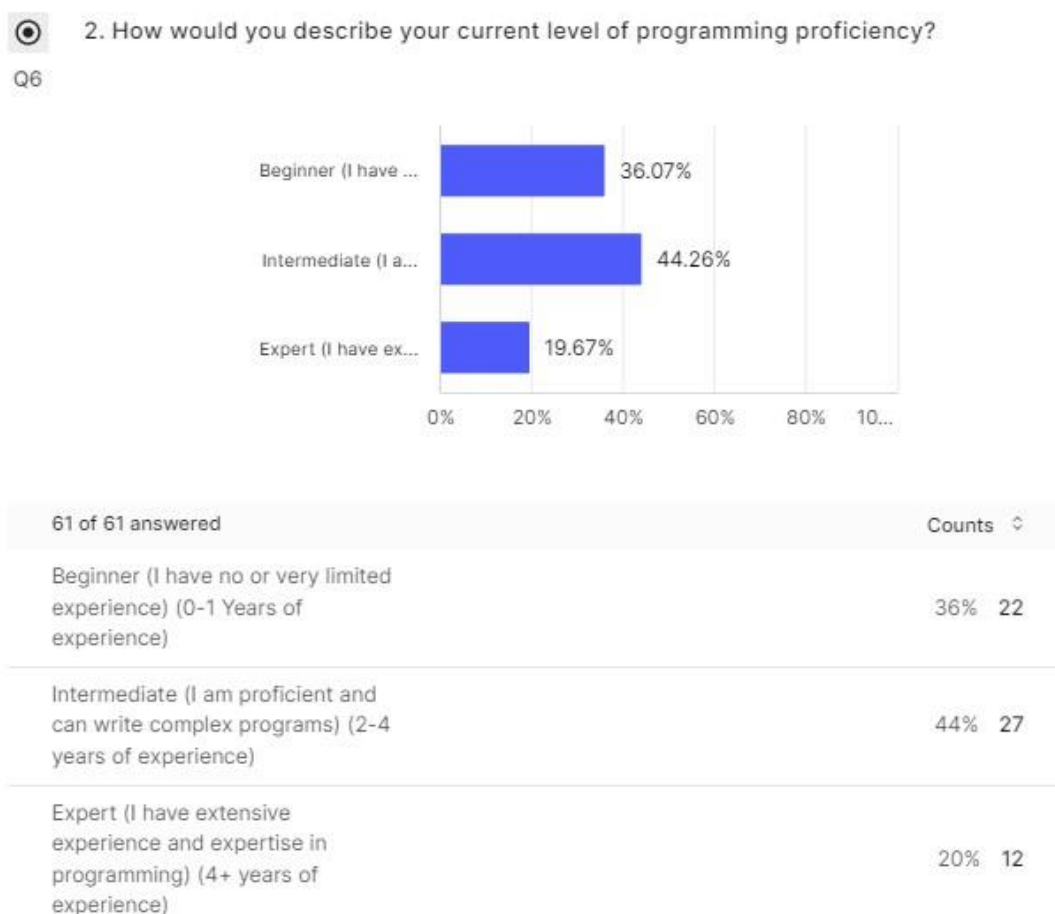
External Sample - Centiment Service

I utilized quota sampling for the external sample through the Centiment survey tool service. This method aimed to ensure that the sample adequately represented specific subgroups. Participants were drawn from a US audience and included Black, Latinx/Hispanic college students or tech industry employees who were recent graduates in the last two to three years. We asked participants the following specific questions to determine their eligibility: “How would you describe your current level of programming proficiency?” “How have you used AI-assisted tools for educational purposes, if at all? Please explain the context,” and “Which of the following AI-programming assistants have you used?”

Responses from participants who answered “no” to proficiency in programming or using AI for programming were excluded from the study. I focused the research questions on

participants' experiences with learning programming and using AI and built the survey questions based on these research questions. Notably, JavaScript was the most familiar programming language among participants, and ChatGPT was the number one AI tool used for programming purposes. Refer to [Appendix Y](#) for detailed results on programming language use and [Appendix Z](#) for AI tools results from this sample. Figure 7 below showcases the self-reported programming proficiency level of 61 respondents. The data shows that 36.07% consider themselves beginners with 0-1 years of experience. Roughly 40% identify as intermediate programmers, with two to four years representing the larger portion. Finally, 19.67% identify as experts and have more than four years in programming.

Centiment employs a rigorous methodology to ensure that specific subgroups are adequately represented in their sample and maintain a low margin of error for their surveys, which is a company standard. It uses an intentional approach that allows participants to selfidentify their racial or ethnic background, helps maintain the integrity of the subgroup representation, and aligns with the survey objectives. The primary target group was college-aged students aged 18 to 23 majoring in computer science at U.S. universities. I identified tech industry workers as young professionals who are recent graduates working in the tech industry. The quota sampling ensured natural fallout across these subgroups, maintaining a balance in representation and allowing for a comprehensive analysis of diverse perspectives on AI and programming within these demographics (Simkus, 2023). The Centiment team recruits participants through social media platforms like LinkedIn, university connections, and Facebook groups, including participant incentives in the survey price package quote. I also partnered with the Centiment team and leveraged my LinkedIn network of over 4,000+ connections and 5,000 followers to post a message recruiting participant who met the survey criteria. Please refer to [Appendix I](#) for the specific LinkedIn message we sent.

Figure 7*Current Level of Programming Proficiency: Quota Sampling*

Note. This bar chart illustrates the self-reported programming proficiency levels of 61 respondents. The data shows that 36.07% (22 respondents) are beginners with zero to one year of experience. A more significant portion, 44.26% (27 respondents), identify as intermediate programmers with two to four years of experience. Lastly, 19.67% (12 respondents) classify themselves as experts, having more than four years of extensive knowledge and expertise in programming.

Interview Sample

I conducted seven interviews to corroborate or refute the survey data. I primarily pulled interview participants from the University of Michigan and additional participants from other

universities, such as MIT, the University of the Virgin Islands, and the University of Miami, who became aware of the survey through natural network effects. I excluded the external sample of participants from the interviews due to policy rules set by the Centiment service. The interview sample was a convenience sample, selected based on participants' availability and willingness to participate. I prioritized expert and intermediate programmers because they likely have more extensive experience with AI tools and troubleshooting programming languages. Convenience sampling, a non-probability sampling method used for expeditious recruitment by selecting readily accessible subjects, ensured representation from all demographics included in the study, enhancing generalizability (Etikan et al., 2016). Table 1 shows the diverse demographic groups, academic affiliations, programming proficiency levels, and recruitment methods of participants. We recruited participants from institutions such as the University of Michigan, the University of the Virgin Islands, the University of Miami, and MIT through an initial email mass outreach, followed by confirmations through Slack and WhatsApp. [Appendix H](#) includes the interview questions and consent forms used in the interviews.

Table 1

	Participant Demographic Programming	School/Department Recruitment	Level of Proficiency	Method of ID Group
P1	African American	University of Michigan: School of Information/ Ross School of Business	Expert	Email/Slack
P2	Latinx	University of Michigan: School of Information/ Ross School of Business	Beginner	Email/Slack
P3	Afro- Caribbean	University of the Virgin Islands	Beginner	Email/WhatsApp

P4	Latinx	University of Miami: College of Electrical Engineering and Computer Science	Expert	Email/WhatsApp
P5	African American	University of Michigan: School of Information	Beginner	Email/WhatsApp
P6	Latinx and Caribbean descent	MIT	Intermediate	Email/Slack
P7	African American	University of Michigan: Ross School of Business	Beginner	Email/Slack

The table presents a detailed breakdown of the interview participants, including their demographic group, school/department affiliation, level of programming proficiency, and recruitment method. I recruited participants from various institutions, including the University of Michigan, the University of the Virgin Islands, the University of Miami, and MIT. The demographic groups represented include African Americans, Latinx, and Afro-Caribbeans. Levels of programming proficiency ranged from beginner to expert. Recruitment methods included Slack and WhatsApp, reflecting the diverse approaches used to engage participants.

Data Collection Method Overview

Quantitative Data Collection and Procedure

My study utilized mixed methods sequential explanatory design to gather comprehensive insights into the research questions. This design involves collecting and analyzing quantitative data first, followed by qualitative data to further explain and elaborate on the quantitative findings (Ivankova et al., 2006; Wipulanusat et al., 2020). I started by analyzing and reporting the quantitative data sequentially. The quantitative data collection phase used a survey to measure participants' programming proficiency, experience with AI tools, and demographic information and education. Refer to Appendix G for the detailed list of the survey questions. I gathered the

survey responses from the University of Michigan and external samples through the Centiment service. I received a total of 90 responses from both samples combined. We collected the University of Michigan sample using a Google Form and the external sample using the Centiment tool service. I disqualified participants from the results if they did not meet the demographic criteria or lacked experience with programming or using AI-assisted tools. About 30 responses were disqualified from participants who did not fit the demographic criteria, were not proficient in programming, or had no knowledge of using AI tools in programming. I retained approximately 61 responses for further analysis following extensive data cleaning in Excel, which involved removing incomplete responses and ensuring the data met the inclusion criteria. I safely discarded survey responses that did not meet the study's criteria, ensuring the integrity and relevance of the research findings.

Qualitative Data Collection and Procedure

The qualitative phase involved conducting seven interviews to support, corroborate, and refute the survey data. We primarily selected interview participants from the University of Michigan due to policy restrictions by the Centiment service that prevented external sample participants from participating in interviews. However, I also included respondents from the University of the Virgin Islands, MIT, and the University of Miami due to the natural network effects of the survey and their willingness to participate in the interview. I compensated interview participants with a \$25 Amazon gift card for their time and efforts. We conducted the interviews virtually via Zoom, each lasting approximately one hour. I recorded the sessions with the participants' consent. Zoom provided a transcript, which I used to analyze the data. [Appendix](#)

[H](#) includes the interview questions and consent forms used in the interviews.

Survey Design and Setup Process

First, I incorporated methodologies from Wipulanusat et al. (2020) and Ivankova et al. (2006) for the data collection in the quantitative phases. This phase involved designing and administering a survey to capture participants' programming proficiency, experience with AI tools, and demographic information. I carefully planned the data collection procedure for the qualitative phase of the study by incorporating methodologies from Carroll, Warren, and Ivankova to ensure thoroughness and relevance. Some steps included preliminary consideration steps and the interview design and process, which is detailed in the following section.

Preliminary Considerations

Research Alignment Table: A research alignment table was utilized to logically set up the research topic area, problem statement, purpose statement, and research questions, providing a coherent approach to the study for both phases to emphasize systematic planning (Ivankova et al., 2006). [Appendix M](#) displays the outline of the research alignment table.

Literature Review: I conducted an extensive literature review using a literature review grid. This grid outlined the methodologies and findings from relevant literature, helping to identify gaps and frame the research questions effectively. [Appendix D](#) outlines the literature review grid.

Integrating Quantitative and Qualitative Insight by Applying Ivankova's Sequential Explanatory Design and Thematic Analysis

The survey was designed based on the literature review to ensure the questions were relevant and comprehensive. Data cleaning and initial analysis align with the best practices in data processing (Wipulanusat et al., 2020). This process ensures that only complete and relevant responses are retained for analysis to improve the quality and reliability of the data.

The survey revealed predominantly positive feedback on the use of AI tools in learning programming. Participants indicated that AI tools could help them understand programming concepts, making learning more engaging and motivating them to continue learning programming within the first five statements. The need for further exploration of the real-world application of AI tools emerged, identifying the most prominent AI tools for discovery and continued learner engagement. However, statements 16 and 17 highlighted that racial and identity factors influenced how participants learned and used AI tools, with responses ranging from agree to disagree to strongly disagree. Ivankova et al. (2006) provided guidance on connecting the quantitative and qualitative phases. I first identified key quantitative findings, including the positive overall perception of AI tools and the specific outlier responses related to racial and identity influences. For example, I asked participants how their racial or cultural identity affected their learning experience with AI tools and to describe any specific challenges they faced related to their identity when using these tools. I added an additional research question to understand how African American, Latinx, and Afro-Caribbean students perceive the role of AI-assisted tools in reducing barriers to entry and success in computer science education. Specific questions included: “How do African American students perceive the barriers to entering the field of computer science?” “What barriers do Latinx students face when entering the field of computer science?” and “What challenges do Afro-Caribbean students encounter in this field?” Questions posed directly to individuals based on their racial experiences, with each racial group following the same line of questioning. This approach aimed to uncover detailed insights into specific issues each group faces, suggesting understanding for inclusive educational environments.

Ivankova et al.’s (2006) process of identifying internal and external factors and literature composite variables began to ensure validity and reliability before being administered to a large

sample of African American, Latinx, and Afro-Caribbean students in computer science and adjacent programs. I derived these factors through a thorough literature review and theoretical models related to student persistence, retention, educational equity, and learner engagement. I included the quality of curriculum, support services, student motivation and engagement, and the accessibility of resources as internal factors. Additionally, I considered external factors like socioeconomic background, community and family support, industry perceptions, cultural attitudes, and representation in the tech industry.

I used various works as grounding literature to identify critical composite variables for understanding student retention efforts. These composite variables included the perceived potential for learning, interest and engagement potential, motivation for further learning, perceived accessibility of learning, and encouragement of separated concepts of retention and persistence. I drew on grounding literature, including “Exploring Factors that Influence Underrepresented Students to Persist in Computer Science” by Albarakati and DiPippo (2021), “Failure Rates in Introductory Programming Revisited” by Watson and Li (2021), and “Studying the Effect of AI Code Generators on Supporting Novice Learners in Introductory Programming” by Kazemitabaar et al. (2023), to ensure that the survey items were comprehensive and relevant. Albarakati and DiPippo’s work examined non-cognitive factors such as academic performance satisfaction, learning assistance, peer interaction, and sense of belonging, identifying how these factors impact the persistence of underrepresented students in computer science. This study informed variables like motivation for further learning, supportive learning environment, and inclusivity in the learning community by highlighting the importance of peer interaction and a sense of belonging. I carefully defined each variable to capture specific internal and external factors influencing persistence. By thoroughly analyzing existing research, I formed a wellrounded set of survey questions to measure the identified factors accurately. Grounding the

survey in established theoretical models and empirical studies ensured that the composite variables reflected a holistic view of the elements affecting student persistence in computer science programs. I formulated survey questions directly linked to these constructs and structured the survey to ensure clarity and logical flow, using a Likert scale for consistency. I consulted with a quantitative survey design expert whose feedback helped to refine the questions and overall survey design to ensure validity and reliability.

Interview Design and Setup

Warren (2011) emphasized that developing a flexible and structured interview guide is essential to ensure all the key themes are covered from the research questions while allowing for the rise of new insights during the interview process. Warren's (2011) methodology guided us in designing the interview protocol to identify the main themes and areas of inquiry related to the research questions. Themes from the literature, survey creation, and initial insights gathered during the survey data collection informed the development of the interview protocol. Questions adopted the participants' backgrounds and experiences ensured a respectful and culturally sensitive interview process.

Participant Selection

Interview participants were primarily selected from the University of Michigan and other educational partners in the purposive sample due to policy restrictions by the Centiment service that prevented external sample participants from participating in interviews. Participants were chosen based on their availability and willingness to participate, ensuring a representative sample from all demographics included in the study. Scheduling: Interviews were conducted via Zoom, each lasting approximately one hour. I chose the time and virtual setting to accommodate participants' schedules.

Conducting Interviews

The methodological processes from Warren (2011) and Ivankova et al. (2006) blend well, allowing a systematic process where the qualitative phase builds upon the quantitative findings. Warren (2011) emphasizes the interviewing process, ensuring that social context and interaction are paramount and aligned with natural and intentional interaction between the interviewer and respondent, providing a deep exploration of the meaning-making process.

Conducting interviews involves several critical measures to ensure the collection of comprehensive and relevant data (Warren, 2011). First, the thematic process begins by clearly understanding the themes to explore based on the research questions. This step is crucial to guide the focus of the interviews. The design process for the questions consists of developing main questions, probes, and effective follow-up questions that adhere to the interview protocol effectively (Warren, 2011). Interviews will provide comprehensive data once the questions elicit relevant information. Zoom provided a transcript of each interview, ensuring the accuracy and completeness of the data. The primary emphasis was placed on the interaction between the researcher and the interview respondent to ensure the social context was considered and respected (Warren, 2011). The University of Michigan is a rapidly growing AI environment where everyone is aware of the university's rapid developments and the institution's desire to be at the forefront of AI development. Warren's emphasis on social and substantive contours, where meaning is co-constructed during the interview process, draws a natural alignment between the researcher and the respondent to develop an intentional meaning-making process.

Chapter 4 - Data Analysis and Results

Chapter 4 presents the study's results, highlighting the quantitative and qualitative findings on the effectiveness of AI-assisted tools in programming within computer science education broadly. I analyzed response percentages to understand participant views, patterns, and trends clearly. This chapter presents a summary of how African American, Latinx, and AfroCaribbean students perceive AI tools, exploring their engagement levels, perceived benefits, and potential challenges.

Quantitative Analysis Procedure

I broke down the data analysis procedure into two parts: first, we analyzed the quantitative survey data, which we used to inform the creation of the qualitative interviews (Ivankova et al., 2006). In the quantitative phase, data was collected via a web-based Google form survey and analyzed using SPSS software. I coded the survey scales using a scale from -2 to 2 and facilitated the coding of words to numbers using the Excel function COUNTIF. The coding scheme was as follows: "Strongly Agree" was assigned a value of 2, "Agree" was assigned a value of 1, "Neutral" was assigned a value of 0, "Disagree" was assigned a value of -1, and "Strongly Disagree" was assigned a value of -2. Measures of central tendency, including mean, median, mode, and percentage of responses, were calculated. I used Excel to calculate the percentage of responses and built a graph to summarize the data in aggregate. Referring to Ivankova et al. (2006), we followed these steps in the quantitative data analysis process: (1) Data was collected using a web-based survey, (2) the survey items were measured using Likert-type scales and coded the data numerically, and (3) SPSS was employed for statistical analysis, calculating descriptive statistics that include measures of central tendency such as mean, median, and mode. Furthermore, my study aligns well with the methodological procedure outlined by Ivankova et al (2006) when using SPSS for statistical analysis and the focus on measures of central tendency.

Using Excel for initial coding and graphical representation enhances the accessibility and comprehension of the data, maintaining the integrity of a mixed-methods explanatory design.

Qualitative Analysis Procedure

Qualitative analysis followed the process outlined by Warren (2011), involving several detailed steps to ensure comprehensive analysis, as explained in Appendix L. The first step involved transcribing the recorded interviews into text using the transcription feature in Zoom. Transcribing the recorded interviews was crucial to ensure accurate documentation of all data. Following transcription, the initial analysis was conducted by thoroughly reviewing the transcriptions to familiarize myself with the data, noting key themes and patterns. A rigorous review was employed, which included reviewing each participant's transcript to highlight essential quotes, grouping these quotes into themes, and listening to playback recordings. The process spanned over a five to six-day period to ensure detailed and accurate analysis. Coding techniques were then employed to categorize and interpret data, identifying patterns and themes through a color-coding system for each theme (Warren, 2011). Qualitative themes were organized on a Miro board to visualize and categorize the findings effectively.

My process for analyzing interview notes followed an inductive approach that blended Warren's (2011) process with the affinity construction taught in SI 501 and 622 courses. The inductive approach allows for the emergence of new and unexpected patterns to provide a comprehensive understanding of the data (Kyngas et al., 2020; Shang, 2019; Warren, 2011). The inductive process includes familiarization with the data, identifying key quotes, initial coding, developing basic themes, reviewing and refining themes, defining themes, and a final write-up (Warren, 2011). The themes in my analysis were built directly from the quotes provided by participants. Quotes served as the foundation for building sub-themes, which were defined through detailed analysis. These quotes provided deep insights into connecting various aspects of

the data and highlighted the nuances of participants' experiences. For instance, under Theme 4: Support for Continuous Learning and Retention, the sub-themes such as "Facilitates continuous practice," "Improves retention of programming concepts," and "Encourages ongoing learning" were derived from specific quotes. Participants' statements, such as "I feel more confident tackling new programming challenges with AI assistance" and "I use ChatGPT to understand new technologies and programming concepts," offered a clear understanding of how continuous learning and retention are supported. These sub-themes were not only descriptive but also interpretative, capturing the essence of participants' experiences and providing a richer, more nuanced understanding of the data. The inductive approach ensured that the analysis remained grounded in the data, allowing for authentic themes to emerge, which accurately reflected the participants' perspectives.

Quantitative Results

The researcher used the results section to present the quantitative analysis to answer the research questions regarding the effectiveness of AI-assisted tools in programming education. Central tendencies, including mean, median, mode, and percentage of responses, are used. The analysis of percentages provides a clear understanding of the distribution of participant views, allowing researchers to identify patterns and trends (Ivankova et al., 2006). Central tendencies help summarize the data comprehensively to identify typical responses and draw patterns within the data, which are integral for making meaningful conclusions (Ivankova et al., 2006; Wipulanusat et al., 2020).

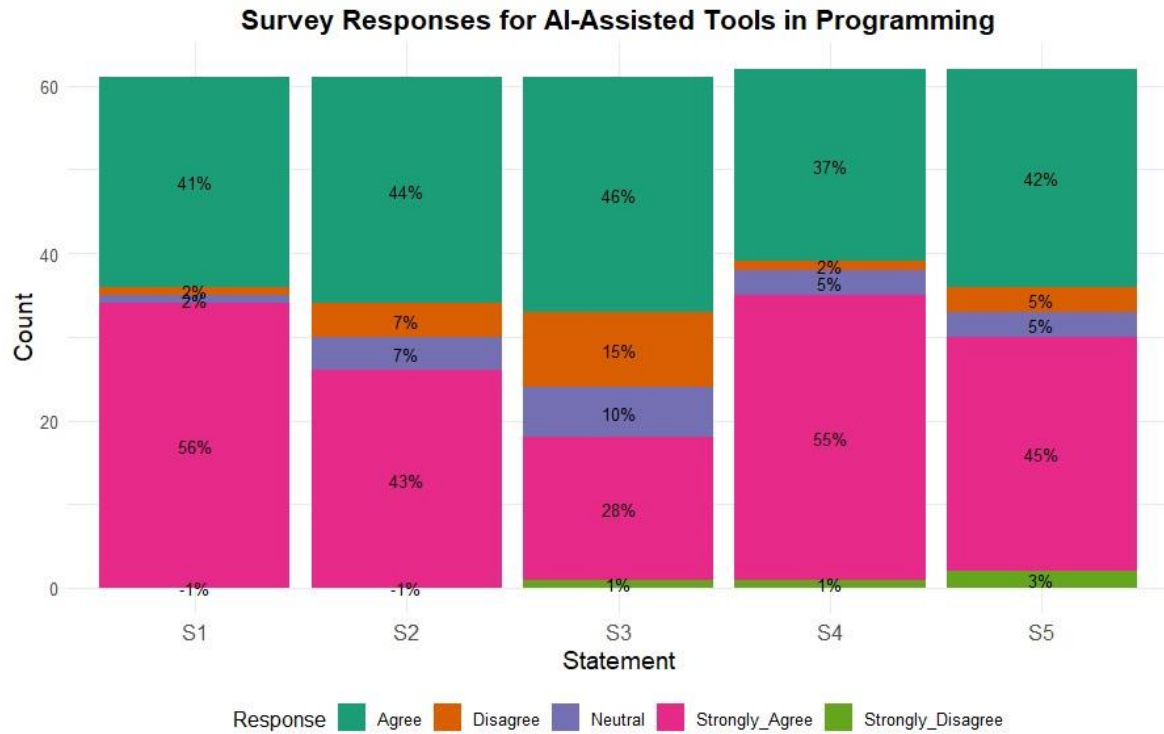
Effectiveness of AI-Assisted Tools in Programming Education Among African American, Latinx, and Afro-Caribbean Students

The study gathered responses on the effectiveness of AI-assisted tools in various aspects of learning programming. For the perceived potential for learning, 56% of respondents strongly agreed with Statement 1, "I believe AI-assisted tools could help me understand programming

concepts, even if I have little to no programming experience,” while 41% agreed, 2% were neutral, and 2% disagreed. Regarding interest and engagement potential, 43% of respondents strongly agreed with Statement 2, “I think using AI-assisted tools would make learning programming engaging,” whereas 44% agreed, 7% were neutral, and 7% disagreed. For motivation for further learning, 28% of respondents strongly agreed with Statement 3, “The availability of AI tools makes me motivated to start or continue learning programming,” and 46% agreed, 15% were neutral, 10% disagreed, and 2% strongly disagreed. Respondents responded to the perceived accessibility of learning programming for beginners or those with limited programming experience, with 55% strongly agreeing with Statement 4, “I feel that AI-assisted tools could make learning programming accessible for beginners or those with limited programming experience,” with 37% agreeing, 5% being neutral, and 5% disagreeing. Regarding the statement on overcoming challenges when learning programming with AI tools, 45% of respondents strongly agreed with Statement 5, “I believe that with AI tools, I would be equipped to overcome challenges when starting to learn programming.” In comparison, 42% agreed, 5% were neutral, and 5% disagreed. The bar chart in Figure 9 below illustrates the survey responses on the effectiveness of AI-assisted tools in learning programming. Table 2 below highlights all the central tendencies of each survey question.

Figure 9

Survey Responses on the Effectiveness of AI-Assisted Tools in Programming (Statements 1–5)



Note: This figure, created in R Studio using a colorblind-friendly palette, presents survey responses on the use of AI-assisted tools in programming. The statements (S1 to S5) are presented below:

- **S1:** AI tools can help understand programming concepts.
- **S2:** AI tools make learning programming engaging.
- **S3:** AI tools motivate starting or continuing programming.
- **S4:** AI tools make programming accessible for beginners.
- **S5:** AI tools help overcome programming challenges.

Each bar illustrates the levels of agreement (Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree) with rounded percentages. The percentages have been rounded to ensure they sum to 100% for each statement. Key observations include a majority agreeing or strongly agreeing with most statements, especially S1, S2, and S4, while neutral and disagree responses were less common.

Table 2*Central Tendencies on the Effectiveness of AI Tools on Programming Education*

Central Tendencies Results on the Effectiveness of AI Tools on Programming Education			
Statement	Mean	Median	Mode
I believe AI-assisted tools could help me understand programming concepts, even if I have little to no programming experience.	2	2	2
I think using AI-assisted tools would make learning programming engaging.	1	1	1
The availability of AI tools makes me motivated to start or continue learning programming.	1	1	1
I feel that AI-assisted tools could make learning programming accessible for beginners or those with limited programming experience.	1	2	2
I believe that with AI tools, I would be equipped to overcome challenges when starting to learn programming.	1	1	2

Note: The table summarizes survey responses on the effectiveness of AI-assisted tools in learning programming, providing the mean, median, and mode for five different statements regarding understanding concepts, engagement, motivation, accessibility for beginners, and overcoming challenges.

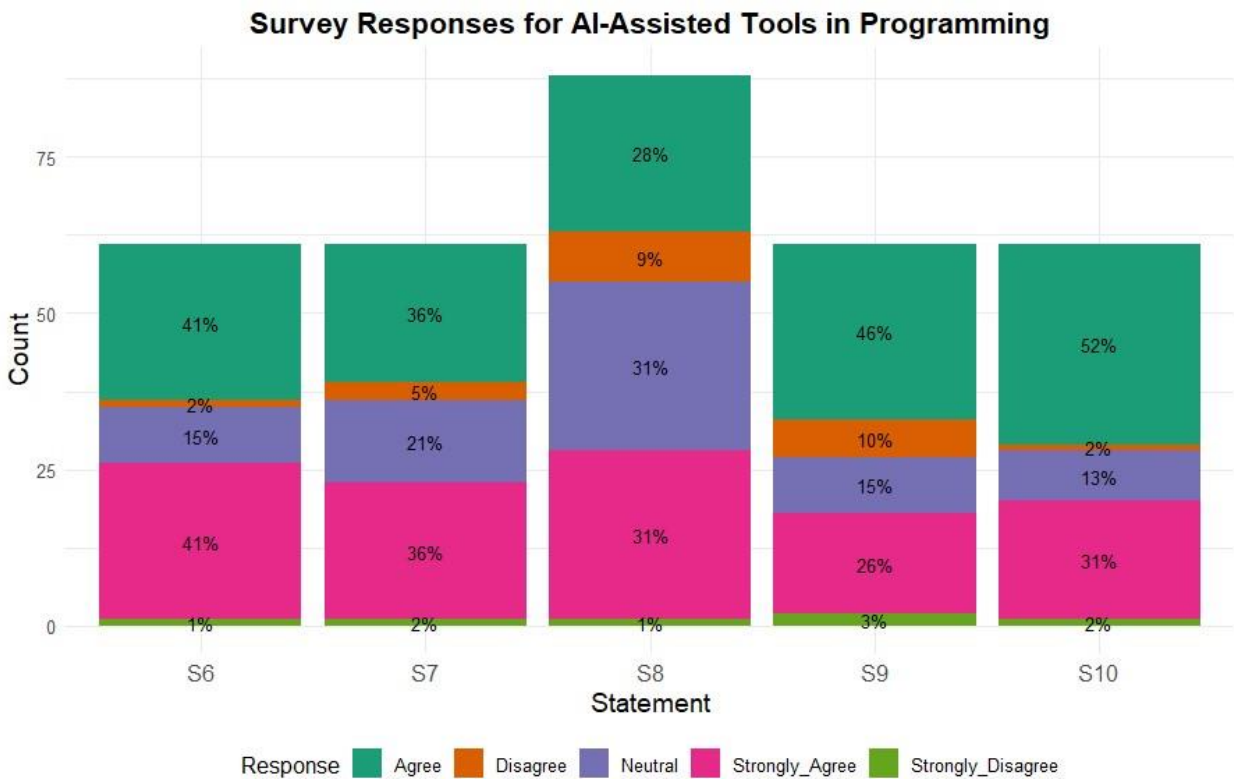
Learning Engagement with AI-Assisted Tools in Programming Education: Perspectives from African American, Latinx, and Afro-Caribbean Students

The study revealed several key findings regarding learner engagement provided by AI-assisted tools in learning programming. First, we asked respondents whether AI-assisted tools could significantly enhance their engagement in learning programming, even as a beginner or non-programmers. The results revealed that 41% strongly agreed, 41% agreed, 15% were neutral, and 2% disagreed (statement 6). We also asked respondents whether AI-assisted tools would motivate them to engage with programming. The results showed that 36% strongly agreed, 36% agreed, 21% were neutral, 5% disagreed, and 2% strongly disagreed (statement 7). For the statement that AI tools have the potential to make computer science exciting and enjoyable for someone with limited or no experience in programming, 31% of respondents strongly agreed,

28% agreed, 31% were neutral, 9% disagreed, and 1% strongly disagreed (statement 8). For the statement “The use of AI-assisted tools makes me inclined to explore programming further,” 26% strongly agreed, 46% agreed, 15% were neutral, 10% disagreed, and 3% strongly disagreed (statement 9). Finally, we asked respondents whether they believed that with AI tools, they would be engaged to overcome challenges when starting to learn programming. The results showed 31% strongly agreed, 52% agreed, 13% were neutral, 2% disagreed, and 2% strongly disagreed (statement 10). The bar chart in Figure 10 below illustrates the survey responses on the effectiveness of AI-assisted tools in learning programming. Table 4 below highlights all the central tendencies of each survey question.

Figure 10

Survey Response for AI-Assisted Tools in Programming (Statements 6–10)



This figure, created in R Studio using a colorblind-friendly palette, presents survey responses on the use of AI-assisted tools in programming for statements 6 to 10. The statements (S6 to S10) are given here:

- S6: AI tools can enhance engagement in learning programming, even for beginners.
- S7: AI tools make learning programming engaging.
- S8: AI tools make computer science interesting and enjoyable for beginners.
- S9: AI tools encourage further exploration of programming.
- S10: AI tools help overcome challenges in learning programming.

Each bar shows levels of agreement (Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree) with rounded percentages. The percentages have been rounded to ensure they sum to 100% for each statement. Key observations include a majority agreeing or strongly

agreeing with most statements, particularly S8 and S10, while neutral and disagree responses were less common.

Table 4

Central Tendencies on the Effectiveness of AI Tools on Learner Engagement

Central Tendencies on the Effectiveness of AI Tools on Learner Engagement			
Statement	Mean	Median	Mode
I believe AI-assisted tools could significantly enhance my engagement in learning programming, even as a beginner or non-programmer. .	1	1	1
I think that using AI-assisted tools would motivate me to engage with programming engaging .	1	1	1
AI tools have the potential to make computer science interesting and enjoyable for someone with limited or no experience in programming.	1	1	1
The use of AI- assisted tools makes me inclined to explore programming further.	1	1	1
I believe that with AI tools, I would be engaged to overcome challenges when starting to learn programming.	1	1	1

Note: The table summarizes survey responses on the effectiveness of AI-assisted tools in learning programming, providing the mean, median, and mode for five different statements regarding understanding concepts, engagement, motivation, accessibility for beginners, and overcoming challenges.

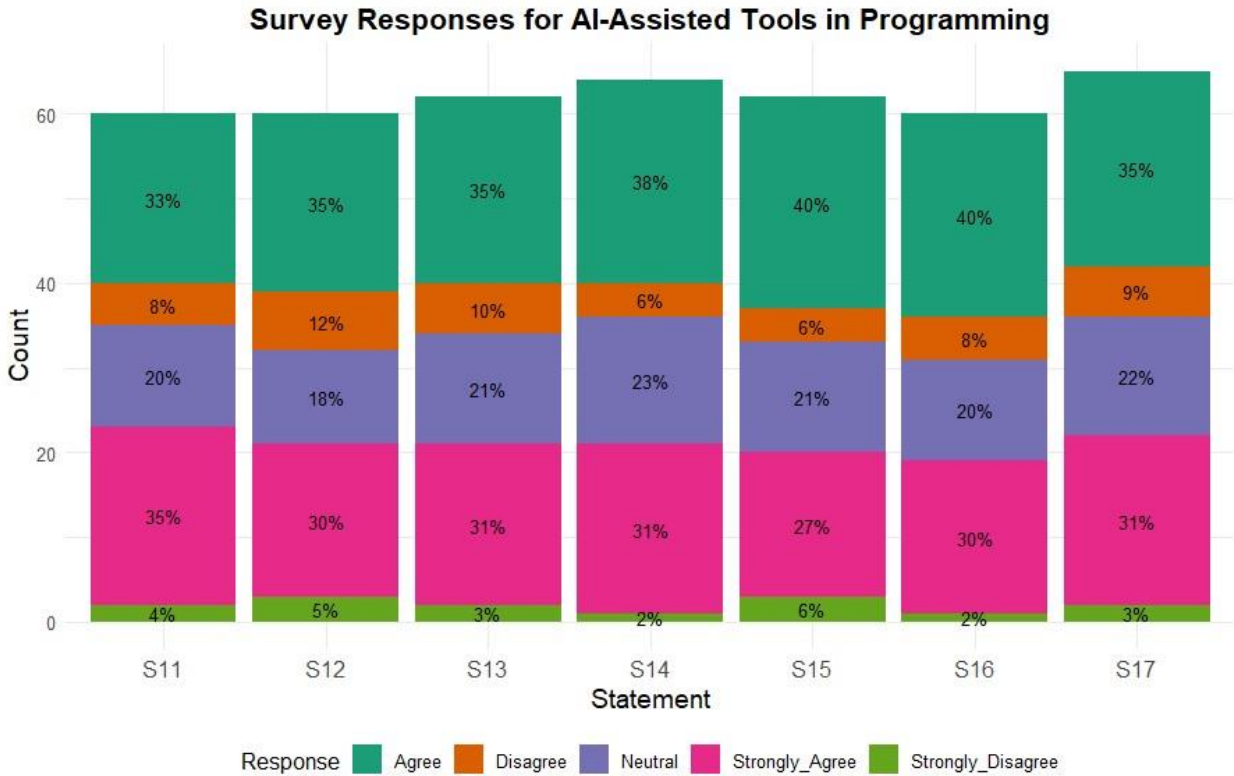
Retention Rates of African American, Latinx, and Afro-Caribbean Students Using AI-Assisted Tools in Programming Education

We gathered responses on the effectiveness of AI-assisted tools in promoting retention rates in programming education. The results showed that AI-assisted tools may facilitate learning and retention in programming education; 33% strongly agreed, 35% agreed, 20% were neutral, 8% disagreed, and 4% strongly disagreed (statement 11). Additionally, 31% of respondents strongly agreed that AI-assisted tools have the potential to create supportive learning environments for students in their computer science education journey, regardless of their initial

skill level. This finding should instill optimism, as 35% agreed, 18% were neutral, 12% disagreed, and 5% strongly disagreed (statement 12). The results showed that 31% strongly agreed that AI-assisted tools have significantly boosted students' confidence in tackling programming courses, even as beginners or those with limited programming backgrounds. This finding should be reassuring, as 28% agreed, 31% were neutral, 10% disagreed, and 2% strongly disagreed (statement 13). Respondents also responded to the use of AI technologies' contribution to creating an inclusive learning community that welcomes students from diverse backgrounds, including those new to programming, with 38% strongly agreeing, 31% agreeing, 21% neutral, 6% disagreeing, and 2% strongly disagreeing (statement 14). Similarly, respondents were asked about the effectiveness of AI-assisted learning interventions in encouraging persistence and retention in computer science education among beginners or students from underrepresented racial/ethnic backgrounds. The results showed that 40% strongly agreed, 40% agreed, 15% were neutral, 6% disagreed, and 1% strongly disagreed (statement 15). Finally, 30% of respondents strongly agreed that racial identity influences the ways in which students use AI tools, with 40% in agreement, 20% neutral, 8% disagreeing, and 2% strongly disagreeing (statement 16). Similarly, 31% of respondents strongly agreed on the influence of racial/ethnic identity on how students learn, with 35% in agreement, 22% neutral, 9% disagreeing, and 3% strongly disagreeing (statement 17). The bar chart in Figure 11 below illustrates the survey responses on the effectiveness of AI-assisted tools in learning programming. Table 5 below highlights all the central tendencies of each survey question.

Figure 11

Survey Response for AI-Assisted Tools in Programming (Statements 11-17)



This figure, created in R Studio using a colorblind-friendly palette, presents survey responses on the use of AI-assisted tools in programming for statements 11 to 17. The statements (S11 to S17) are given below:

- S11: AI tools can enhance my engagement in learning programming, even for beginners.
- S12: AI tools make learning programming engaging.
- S13: AI tools make computer science enjoyable for beginners.
- S14: AI tools make me want to explore programming further.
- S15: AI tools help overcome challenges in learning programming.
- S16: AI tools provide personalized feedback and guidance.
- S17: AI tools help me understand complex programming concepts.

Each bar presents the levels of agreement (Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree) with rounded percentages. The percentages have been rounded to ensure they sum to 100% for each statement. Key observations include a majority agreeing or strongly

agreeing with most statements, particularly S14 and S15, while neutral and disagree responses were less common.

Table 5

Central Tendencies on the Effectiveness of AI Tools on Retention Efforts in Programming Education

Central Tendencies on the Effectiveness of AI Tools on Retention Rates in Programming Education				
Statement	Mean	Median	Mode	
I believe AI-assisted tools may promote learning and retention in programming education.	1	1	1	
AI-assisted learning environments make me feel supported in my programming education journey.	1	1	1	
Using AI-assisted tools has increased my confidence in tackling programming courses, even as a beginner or someone with limited programming background.	1	1	1	
AI technologies contribute to creating an inclusive learning community that welcomes students from diverse backgrounds, including those new to programming.	1	2	2	
AI-assisted learning interventions are effective in encouraging persistence and retention in programming education among students who are beginners or from underrepresented backgrounds.	1	1	1	
My racial/ethnic identity has influenced the ways in which I use AI tools.	0	0	0	
My racial/ethnic identity has influenced the ways in which I learn.	1	1	1	

Note: The table summarizes survey responses on the effectiveness of AI-assisted tools in learning programming, providing the mean, median, and mode for five different statements regarding understanding concepts, engagement, motivation, accessibility for beginners, and overcoming challenges.

Qualitative Results

We based our detailed findings on the coding analysis of the qualitative data, which highlighted several key themes: enhanced accessibility, reduction in bias, improved confidence and engagement, support for continuous engagement and retention, the complementary nature of

AI tools to traditional learning methods, and challenges for each demographic.

Reduction of Learning Barriers and Bias

As highlighted by qualitative data, participants' views on the effectiveness of AI tools are significant. When asked about the ways in which AI-assisted tools are effective or ineffective, many pointed out that these tools provide immediate feedback and support, reducing the time needed to solve problems and increasing access to learning resources. One participant emphasized, "AI tools like ChatGPT simplify difficult concepts and offer instant help, a crucial aspect of the learning process." Another participant noted, "The immediate feedback from AI tools saves me hours of debugging and keeps me engaged."

Participants were asked, "How effective do you feel AI-assisted tools enhance your understanding and retention of what you learned in programming?" They indicated that AI reduces barriers in leveling the playing field, reducing intimidation, and addressing educational gaps. Participants note the digital divide remains a critical means to address despite the benefits of AI tools. One participant highlighted that AI tools help reduce educational disparities, support language learning, and provide equitable access to resources while addressing biases in AI tools would be essential to leverage its benefits fully. All participants highlighted ChatGPT as a convenient method for accessing instant, round-the-clock assistance. Finally, one participant expressed a moral justification for using AI tools to "catch up" with peers who have had more advantageous educational experiences, which reflects a nuanced view of the ethical use of AI in education. Another participant echoed this sentiment, expressing moral justification for using AI tools to bridge the educational gap with their peers.

Improved Confidence and Engagement

Participant feedback highlighted the impact of AI tools on increasing confidence and engagement levels. Many AI tools are available for free or at low cost, providing accessible

alternatives to expensive tutoring and resources. Many participants noted that financial barriers could be a significant financial barrier. When asked, “In what way or ways would you describe specific instances, if any, where an AI-assisted tool noticeably enhanced your learner engagement with programming learning materials or activities?” participants noted that interacting with AI tools in a private, judgment-free manner helps build confidence, making engaging with and succeeding in computer science easier. One participant stated, “AI pointed out the exact line where the error was, saving me hours debugging,” illustrating how AI tools can provide quick and accurate assistance with tasks like debugging complex SQL and Python code. Another participant mentioned that AI tools assist in understanding and practicing complex concepts through interactive engagement, which is beneficial for grueling assignments and project work because they provide detailed explanations and practical examples not often offered in the classroom.

In summary, all participants agreed that AI played a significant role in reducing learning intimidation and improving retention through consistent reinforcement and practical assistance. A prime example of this was when a participant noted that AI tools were instrumental in explaining broad concepts like Markov Modeling and in completing data analysis tasks to improve understanding and accuracy in coursework.

Another participant contrasted by stating, “AI tools often do not meet specific accessibility standards, requiring additional steps to ensure compliance.” They also noted that the lack of consistent integration of AI tools in university curricula with some courses is a significant factor in creating learning discrepancies that often affect students’ confidence levels.

Support for Continuous Learning and Retention

The theme of reducing learning barriers and supporting continuous learning emerged prominently from the qualitative analysis of the Miro board in [Appendix J](#). A significant insight from this analysis is the student group’s perception of AI tools as instruments. Multiple

participants expressed that AI tools simplify understanding complex coding problems, thus making learning more accessible and enhancing learning outcomes. For instance, Participant 7 noted, “It simplifies understanding complex coding problems.” Participant 6 shared, “Using ChatGPT regularly helps me keep up with and retain the new programming skills I learn.” Another participant remarked, “I now feel confident in continuing with more complex programming projects,” indicating the confidence boost provided by the consistent use of AI tools.

However, qualitative insights also showed a significant concern about over-reliance on AI tools. Some participants indicated that this dependence might hinder the deeper understanding of programming concepts and limit the development of independent problem-solving skills. As one participant mentioned, “I sometimes worry that I rely too much on AI tools and do not push myself to solve problems on my own.” This concern, voiced by the students, contributes to the variability in students’ perceptions of AI tools and should be taken into consideration.

Complementary to Traditional Learning Methods

Students highlight that AI tools contribute to higher retention rates by complementing traditional learning methods, including traditional lectures, office hours, peer mentorship groups, and group learning/discussion. Most participants highlighted, “AI tools are beneficial for students who don’t have access to traditional learning resources.” All participants agreed that AI is a vital learning tool that enhances teaching methods and can be a great supplement alongside other methods when asked “How would you compare AI-assisted learning to traditional learning methods like tutoring, office hours, direct instruction from traditional lecturing, peer mentorship group learning/and the like?”

Participants emphasized that “AI tools provide essential supplementary support in the absence of traditional academic support systems.” AI tools serve as a “thought partner,” helping

students articulate their coding goals and solutions, even if they do not directly use the output from AI. Qualitative positive insights highlighted that AI tools offer a safe, judgment-free space for students to ask questions and clarify doubts multiple times, which is crucial for those who may feel intimidated in traditional classroom settings. Additionally, AI tools provide a neutral, supportive space that can counteract negative experiences in traditional academic settings, such as microaggressions or biases from peers and faculty.

Unique Challenges of Each Demographic Group (African American, Latinx, Afro-Caribbean)

This final section covers the unique challenges faced by each demographic group, including African American, Afro-Caribbean, and Latinx, to account for their distinct experiences. Overall qualitative insights reveal that all populations perceive AI tools as instrumental in reducing barriers to entry and success in computer science education. By providing immediate feedback, personalized guidance, and unbiased support, AI tools foster more inclusive and supportive learning environments. These individual insights from each demographic seek to highlight the unique challenges faced and provide contrast on specific barriers relevant to each group. The insights drawn from the Miro board analysis of the interviews, as detailed in [Appendix N](#), highlight several challenges students face in their educational journeys.

African American Perspectives

Interview responses showed that overall, African American students often face the most significant educational disparities, including stigma and bias, limited access to quality educational resources, and economic barriers. African American students were specifically asked, “What are the barriers that African American students face when entering the field of computer science?” One participant highlighted, “Economic disparities mean less access to technology and AI.” All participants agreed that economic disparities are the primary driving force hindering progress in

learning to program/code for African American communities. Examples of economic barriers drawn from interviews include racial bias, lack of representation, and inadequate funding for coding education.

To that end, participants focused on the positive fact that AI tools can be a true equalizer by providing free education and skills that can offer early exposure for African American students. Qualitative insights highlight that African American students encounter stigma and bias, which impacts their confidence and engagement in learning environments. One participant shared how they lost confidence early in their computer science undergraduate studies and quickly switched majors due to a lack of confidence and earlier exposure to challenging programming concepts. Limited early access to quality education is a significant catalyst for inadequate preparation. Another participant noted, “The digital divide is a significant issue, affecting access to high-speed internet and resources.”

One participant also noted, “But if you’re Black and going into big tech, there will be a ceiling very early in one’s career,” underscoring the broader industry challenges beyond education. Despite these challenges, African American students see AI as providing unbiased support to reduce the impact of stigma and bias. Another participant bravely noted that “AI tools help compensate for the lack of support and resources in some educational environments.” AI tools boost a student’s confidence by providing a safe, judgment-free space to ask questions and participate in the classroom, with participants emphasizing that “AI tools provide a form of assistance that is often missing in underfunded schools.”

Afro-Caribbean Perspectives

Afro-Caribbean students often reported in interviews that they face compounded challenges due to higher poverty rates and lower-funded education systems that do not prioritize technology education. Economic constraints further limit their access to advanced educational

opportunities. As a participant highlighted, “Limited access to high-quality tech resources is a challenge for many Afro-Caribbean students. There is often a lack of exposure to advanced technologies in early education.” When we asked participants about the barriers Afro-Caribbean students face when entering the field of computer science, all participants responded similarly. They emphasized that most students in the Caribbean, such as those in the U.S. Virgin Islands (a U.S. Territory), Puerto Rico, and other surrounding Caribbean islands, are not introduced to coding at a young age. One participant estimated that around 90% to 95% of children in the Caribbean might not know what coding is due to the absence of coding programs at elementary, junior high, and high school levels. Another participant noted that “schools in the Caribbean do not offer the same types of programs and certifications available in the U.S., which puts students at a disadvantage when pursuing technological careers.” Additionally, one participant bluntly explained that transitioning from the islands to renowned U.S. institutions was particularly difficult and impacted their confidence and abilities to thrive in such a fast-paced environment. They shared, “Being the only one in this kind of dynamic made it hard for me to ask for help to avoid judgment from majority white audiences of faculty members, classmates, and tutors.”

Finally, participants were allowed to share their perceptions on how AI tools could help them overcome challenges when entering computer science. One participant noted, “AI provides a supportive learning environment often missing in traditional education settings. They help me fill the gap where traditional education systems may be lacking.” Participants also shared that the major problem is that many students in the Caribbean may not see high-tech careers, such as positions at major tech companies like Google or Amazon, as attainable due to the lack of outreach and representation in these fields. They mentioned that traditional DEI programs are not in the Caribbean because the environment is already diverse enough and doesn’t need forceful DEI programs to create diversity. Participants believe AI tools can create more access when

learning to code and more broadly within computer science education. Still, the slow pace of innovation in the Caribbean significantly hinders students' development in tech education, making the integration of AI tools more necessary and highly crucial.

Latinx Perspectives

Participants from the Latinx community consistently highlighted language barriers as the most significant challenge when entering the computer science field. One participant remarked, "ChatGPT assists with technical writing and communication, which is particularly helpful for non-native English speakers." Another participant added, "It helps overcome language barriers by providing clear explanations." To illustrate the nature of these language barriers, a participant explained, "For someone who has English as a second language, sometimes one has to translate a piece of code not just once but twice, by translating their thoughts from Spanish to English and then to that particular coding language." Moreover, cultural representations in computer science were another critical factor discussed among participants. One participant noted, "Odds are if you are describing a programmer, no one will describe someone Latinx. If AI is asked to generate an image of a programmer, it would present someone of white or Asian descent."

The sense of isolation and immense hostility within the computer science field was directly expressed by another participant: "The space of computer science/tech industry can feel hostile, feeling like being the 'other' and 'only' of one's race is hard." This sentiment rang true through all participants, who emphasized the need for cultural change within the tech industry to foster better parity and genuine inclusion efforts. Finally, all participants across all demographics agreed that the tech industry's culture needs to shift but emphasized more Latinx participants, given the unique nature of the language and cultural barriers. They stressed that true inclusion and parity for Latinx individuals in computer science would only be attainable with a significant change in the industry's culture.

Chapter 5 Discussion Section

The purpose of this study is to explore the effectiveness of AI-assisted tools in programming within computer science education with a direct focus on African American, Latinx, and Afro-Caribbean students. The research aimed to understand how these students perceive the impact of AI on learning, engagement, and retention in computer science on a grand scale. Chapter 5 brings together key findings from both qualitative and quantitative data by integrating them with existing literature and providing a comprehensive discussion. [Appendix R](#) presents a detailed breakdown of how the identified quantitative and qualitative themes interrelate. My study contributes to the understanding of AI-assisted tools' impact on African American, Latinx, and Afro-Caribbean students' learning, engagement, and retention in programming education within computer science by highlighting their unique needs and experiences. Quantitative and qualitative data are integrated into my study by identifying challenges such as over-reliance on AI and the influence of racial and ethnic identities, offering recommendations for more inclusive and effective AI integration in educational curricula.

Enhancing Programming Education Through AI Assistance

Enhanced learning and engagement emerged strongly from both the quantitative and qualitative data. Quantitative survey findings show that about 43% of participants strongly agreed and 38% agreed that AI-assisted tools help them understand programming concepts even with little to no programming experience. 54% of respondents strongly agreed and 40% agreed that the availability of AI tools motivates them to start or continue learning programming. The study gathered responses on the effectiveness of AI-assisted tools in various aspects of learning programming. For the perceived potential for learning, 56% of respondents strongly agreed with Statement 1, "I believe AI-assisted tools could help me understand programming concepts, even

if I have little to no programming experience,” while 41% agreed, 2% were neutral, and 2% disagreed. Qualitative data insights strongly corroborate that AI tools provide immediate feedback and support that reduce the time required to solve complex coding problems along with providing access to accessible learning resources. As one participant mentioned, “AI tools like ChatGPT do simplify difficult concepts and offer instant help, which is crucial for my learning process.” Qualitative themes reveal that AI tools are invaluable for leveling the educational playing field, providing accessible assistance that bridges gaps in knowledge and resources. These tools help align students’ current understanding with the requirements of their programming courses, making learning more attainable. The non-judgmental nature of AI tools reduces the intimidation often associated with seeking help, making students more comfortable and proactive in their learning. One student noted, “I definitely feel like I can understand code, certain code, and to be honest, maybe even in general have a better understanding of coding languages in general now from AI.” While beneficial, it is crucial to address the digital divide to ensure equal access to these technologies. Overall, AI tools enhance engagement and retention by offering clear explanations and practical support.

Zawacki-Richer et al. (2019) bluntly indicate that AI tools enhance learning outcomes and student engagement by providing personalized feedback and adaptive learning pathways. Also, Kulik & Fletcher (2016) highlight intelligent tutor systems that can be used to support learners by offering instant feedback and constant iteration to better understand and increase retention of complex concepts. Computer science curricula should better integrate AI technologies effectively to maximize the benefits of AI tools. Computational thinking and AI provide students with critical thinking and problem-solving skills (Grover & Pea, 2013).

Wing (2006) provides deeper insight by emphasizing that the inclusion of AI tools is meant to assist students in developing skills for the 21st century. However, this is hindered by the

stringent computer science and higher education curriculum that can unfortunately hinder students' learning through inflexible and bureaucratic policies that do not always serve diverse learning needs (Beyer, 2014). Prestigious institutions like the University of Michigan should be advised of these research recommendations and seek to integrate AI tools into computer science, engineering, information, and other technical educational programs. Some participants bluntly highlighted that the School of Information at the University of Michigan needs to improve the curriculum structure to better integrate AI tools and accommodate diverse learning needs. Furthermore, participants highlighted that academic service professionals need to be more supportive and properly address the needs of students, especially those of color from first-generation backgrounds who may struggle to navigate bureaucratic university systems. All participants agreed that this lack of support compounds the challenges, especially for those of color from first generation backgrounds who struggle to navigate bureaucratic university systems. All universities should ensure that they are addressing diverse learning needs and promoting equity in education (Means et al., 2010). Quantitative and qualitative insights supported by strong literature reflect the importance of AI assistance tools in enhancing learning and engagement for African American, Latinx, and Afro-Caribbean students in learning to program and in computer science more broadly. The breakdown of how these insights relate is outlined in a table located under [Appendix R](#).

Improved Confidence and Motivation

Confidence and motivation are another prominent theme found within the quantitative and Qualitative insights. 54% of respondents strongly agreed and 40% agreed that the availability of AI tools motivates them to start or continue learning programming. Additionally, 37% strongly agreed and 38% agreed that using AI-assisted tools increased their confidence in tackling computer science (CS) courses. Qualitative themes support these quantitative findings where

participants mentioned that AI tools provide a judgment-free environment often not found in tutoring, office hours, and other academic support at universities. One participant noted, “AI pointed out the exact line where the error was, saving me hours of debugging.” Another stated, “AI tools help me feel more confident because I get instant feedback and support whenever I need it.” Personalized feedback and adaptive learning paths provided by AI tools assist with students feeling more competent and engaging with the material (Woolf et al., 2013). AI tools can provide immediate assistance and direct clarification, reducing the anxiety and frustration that often accompany challenging subjects like programming (Lajoie & Azevedo, 2006).

Qualitative insights support this literature with participants agreeing that AI tools have encouraged them to take a more active role in coding assignments and projects, thereby enhancing their engagement. One participant stated, “Having the AI tool gave me the confidence to try coding tasks I was previously afraid to tackle.” All participants believe that AI tools have increased accessibility to learning resources and reduced the barrier of confidence, making it easier for students to engage with and persist in computer science beyond just the programming aspects. These resources allow students to embrace a growth mindset in their studies. Dweck’s (2006) growth mindset theory emphasizes the belief that abilities and intelligence can be developed through dedication and hard work, where AI tools can be a direct catalyst for providing a supportive environment where students receive constructive feedback and are encouraged to view challenges as opportunities to learn and grow.

Margulieux et al. (2024) explored how undergraduate introductory programming students use generative AI tools to solve programming problems. Students with higher self-efficacy and lower fear of failure used AI tools less frequently, relying on them more as supplementary aids rather than primary ones. The study suggests that AI tools can support self-regulation and metacognition by providing scaffolding that helps students manage their learning processes more

effectively (Margulieux et al., 2024). Further research indicates that AI tools are effective in creating equitable learning opportunities. As stated in the literature review, Chine et al. (2022) highlights personalized learning combined with human mentoring and found that students who used AI tools demonstrated significant improvement in their learning outcomes. AI tools can help level the playing field by providing both cognitive and emotional support, fostering a more inclusive and motivating learning environment (Chine et al., 2022).

Promoting the Balanced Use of AI for Continuous Learning and Retention

The findings from Chapter 4 reveal that AI tools reduce learning barriers and support for continuous learning, as highlighted in the qualitative analysis of the Miro board in [Appendix J](#). AI tools make learning more accessible by simplifying coding problems and providing immediate feedback. Participants noted enhanced learning and retention of programming skills using AI tools as support partners. However, concerns about over-reliance, which could hinder the development of independent problem-solving skills, were also prominent.

Survey responses provide deeper insights into the perceptions of respondents regarding the role of AI technologies in creating an inclusive learning environment for statement 14. Specifically, 36% of respondents strongly agree that AI technologies contribute positively to such an environment, welcoming students from diverse backgrounds, including those new to programming. Twenty-nine percent agree with this sentiment, 28% remain neutral, and 6% disagree. The distribution indicates a variety of opinions about the use of AI in programming education. The standard deviation was calculated to be approximately 0.95. This measure of variability showcases the range of differing opinions and emphasizes the diversity of perceptions among students. Variability is crucial in this context as it indicates that despite the overall positive trend, a significant portion of respondents have differing views. Educators and developers must consider diverse student responses when implementing AI technologies in educational settings.

This conversation is particularly relevant for students, professors, and policymakers navigating the integration of AI tools in educational environments. While many students view AI positively, others have reservations. Addressing these concerns ensures AI tools are effective and inclusive, especially for beginners in programming. A systematic review highlights that AI can improve performance and engagement but faces challenges like technological issues and cultural differences (Salas-Pilco et al., 2022). The study from the University of Michigan emphasizes that students' use of LLMs is influenced by their perceptions of peer use and future aspirations (Padiyath et al., 2024). Additionally, the normalization of LLM use by peers can influence students' decisions to adopt LLMs in programming despite initial skepticism or concerns about over-reliance on AI tools, which may negatively impact learning outcomes (Padiyath et al., 2024). Case studies from UNESCO and California show AI's potential to personalize learning and adapt to various cultural contexts, improving student engagement (McNulty, n.d.). Understanding these dynamics is vital for informed decision-making. [Appendix S](#) provides a breakdown of the standard deviation calculation and visual representation.

Qualitative insights highlight concerns about over-reliance on AI. Some participants note that dependence on AI tools can hinder the development and deeper understanding of programming and problem-solving skills. As a participant mentioned, "I sometimes worry that I rely too much on AI tools and do not push myself to solve problems on my own." Variability in students' perceptions of AI tools contributes to concerns of over-reliance. Weiner's (1985) attribution theory asserts that students should develop a deep sense of attribution by directly attributing their success in programming tasks to their own efforts, alongside support from AI. Problem-solving abilities and self-efficacy, combined with AI tools as thought partners, provide a balanced approach to cultivating students' learning abilities. Bandura (1997) highlights self-efficacy as "an individual's belief in their capacity to execute behaviors necessary to produce

specific performance attainments. It reflects confidence in the ability to exert control over one's own motivation, behavior, and social environment.”

Educators can combat over-reliance by encouraging balanced use, fostering reflective practices, and integrating theories into teaching. Encouraging balanced use involves promoting AI tools as supplementary resources rather than primary ones to ensure students engage in independent problem-solving (Sweller et al., 2011; Mayer, 2004). Fostering reflective practices involves having students analyze how they use AI and identify areas where they can challenge themselves to solve problems independently (Boud et al., 1985). Cognitive load, self-efficacy, and growth mindset theories should be incorporated into instructional design to create a balanced learning environment that leverages AI tools without diminishing critical thinking skills (Bandura, 1997; Dweck, 2006). “Cognitive load refers to the amount of mental effort being used in working memory and is important in learning because excessive cognitive load can hinder the processing of information, while an optimal cognitive load can enhance learning and problemsolving abilities” (Sweller et al., 2011). The study from the University of Michigan found that students who perceived over-reliance on LLMs correlated with decreased self-efficacy later in the course, underscoring the need for balanced use of AI tools (Padiyath et al., 2024). The results from the U-M study further suggest that experienced students expressed concerns that the widespread use of LLMs might be undermining their peers' understanding of programming fundamentals, highlighting the importance of foundational skills in conjunction with AI tool use (Padiyath et al., 2024). Kazemitabaar et al. (2023) revealed that novice learners using AI code generators like OpenAI Codex showed significantly higher code-authoring performance without a decrease in manual code-modification performance. However, concerns about over-reliance were noted, as some learners relied heavily on AI-generated code, which might hinder their ability to write code independently in the future (Kazemitabaar). AI tools performed slightly

better on retention tests conducted one week later, although the difference was not statistically significant, highlighting the importance of balancing AI use with manual coding practice to prevent dependency and promote deeper learning (Kazemitabaar). Additionally, the debate between open-source and closed-source AI models is relevant in this context. Meta's Llama 3 is a notable open-source model that aims to balance the need for innovation and accessibility with responsible AI development (Razzaq, 2024; Basheer, 2024). Llama is available on major platforms like AWS, Google, and Meta, seeking to foster widespread adoption and collaboration within the AI community to enhance the model's utility in various educational settings (Basheer, 2024). The choice between open-source and closed-source AI models in education depends on specific needs, resources, and the goals of the institution. Both approaches offer unique benefits and challenges, requiring careful evaluation to determine the best fit for enhancing educational outcomes.

Unique Challenges Faced by Each Demographic

This final section combines findings by providing an analysis of the racial and ethnic identities that influence the experiences of students in computer science, particularly regarding unique racial challenges and ways leveraging AI tools can foster a more inclusive learning environment. Quantitative insights from surveys show that a significant number of students feel their racial or ethnic identity affects how they use AI tools and learn programming. Responses from surveys show that a great number of students do believe their racial and ethnic identity affects how they use AI tools and learn in programming education. When respondents were asked, "My racial/ethnic identity has influenced the ways in which I use AI tools," 17% strongly agreed, and 22% agreed. Similarly, when asked, "My racial/ethnic identity has influenced the ways in which I learn," 27% strongly agreed, and 30% agreed. These findings suggest that many students perceive their racial or ethnic identity as a factor influencing their engagement with AI

tools and the learning process in programming education. However, some students do not share this same sentiment and perception of AI tools' correlation to their race. 19% disagreed and 18% strongly disagreed that their identity influences how they use AI tools, while 19% disagreed and 13% strongly disagreed that their identity affects their learning process. The variation in responses highlights the diversity of experiences amongst students while students feel their identities play a role in their education where others do not perceive the same. Educators and collegiate institutions should understand the complexities of these different perspectives among students of color. Gay (2000) explores how identity influences learning processes and outcomes, reinforcing the need to consider diverse student experiences when implementing technological solutions in education.

A regression analysis was conducted to examine the influence of racial/ethnic identity on the use of AI tools and learning experiences among computer science students. The analysis revealed a weak linear relationship between these variables, with an R-squared value of 0.035. This value explains only 3.5% of the variability in the use of AI tools and learning experiences. Many other factors, such as socioeconomic status and prior exposure to technology, also influence how students engage with AI tools. The graph for the regression analysis is in Appendix V, showing the distribution of data points and the regression line that highlights the overall trend. Additionally, the statistical significance of the relationship is indicated by the pvalue, which determines whether the observed relationship is due to random chance. Confidence intervals for the regression coefficients provide a range within which the true relationship lies with a certain level of confidence (e.g., 95%). The weak relationship suggests that racial/ethnic identity is not a primary factor influencing the use of AI and learning experiences but remains an important element within a broader context. The concept of intersectionality can explain how multiple

aspects of identity, including race, gender, and socioeconomic status, interact to shape experiences (Crenshaw, 1989).

Papageorge et al. (2020) highlight how socioeconomic status can influence academic outcomes and engagement with new technologies, suggesting that students from higher socioeconomic backgrounds might have more opportunities and resources to interact with AI tools. DiMaggio and Hargittai (2001) discuss how socioeconomic factors contribute to differential access and use of technology, underscoring the digital inequality that affects learning experiences. Institutional support significantly impacts engagement in STEM fields among different racial groups (Riegle-Crumb et al., 2019). Supportive institutional environments can mitigate some of the challenges faced by underrepresented minority students, enhancing their engagement with AI tools (Riegle-Crumb). Litzler and Young (2012) further examine the role of institutional climate and support in influencing student engagement and retention in engineering and computer science programs, indicating that positive institutional support can play a crucial role in student success.

Qualitative data from interviews provide deeper insights into the specific challenges faced by African American, Afro-Caribbean, and Latinx students, supporting quantitative findings. African American students face economic disparities, stigma, and bias that hinder progress. They use AI as a potential equalizer to provide accessible programming education and resources for career growth. An African American student remarked, “AI tools bridged the gap created by the limited support from classmates and professors.” Afro-Caribbean students encounter high poverty rates and underfunded education systems, making transitions to U.S. institutions challenging. They view AI tools as a means to fill educational and opportunity gaps on a granular scale. Latinx students highlight language barriers and cultural isolation in the tech industry. They value AI tools for helping with technical communication and overcoming

language barriers but stress the need for cultural change within the tech industry and more intentional inclusion efforts.

Quantitative and qualitative data together provide a comprehensive overview: racial and ethnic identities do influence students' use of AI tools and learning experiences, but the impact is multifaceted and influenced by a range of economic, educational, and cultural factors.

Addressing these challenges requires a holistic approach that considers the diversity of needs and experiences of students at large. Future research should include more inclusive practices to ensure all voices are heard equally. Recommendations based on findings and recent literature provide guidance on future enhancements for inclusivity in AI education. These include new curricula that incorporate cultural perspectives with tangible case studies and examples relevant to different cultural backgrounds (Pias et al., 2024). Social responsibility should be incorporated into AI to address ethical issues and cultural practices, ensuring technologies are fair and equitable to all communities (UNESCO IESALC principles, 2024). For language barriers, Latinx students should be supported with AI tools for English as a Second Language programs and translation tools (Pias et al., 2024). Universities should invest in AI-driven adaptive learning platforms that personalize education, identifying optimal learning strategies and barriers for each student (Grassini, 2023). Universities like Emory University have created new interdisciplinary AI minor studies focused on integrating AI with other disciplines to address broader global challenges and innovative solutions (Emory University, 2023; Gong et al., 2023).

Chapter 6: Limitations and Future Work

Sampling Procedures

One of the primary limitations of my thesis is the convenience sampling methods used. Convenience sampling may introduce bias and limit the generalizability of the findings. I drew participants from university students who might not represent the broader population of learners using AI tools in programming education. Future research should gather perspectives from a broader range of participants, including those in coding boot camps, those who failed out of computer science programs, and those from diverse educational backgrounds (Bersin, 2012).

Representation of Afro-Caribbean Participants

Afro-Caribbean participants were absent in this study, symbolizing the broader issue of a small tech pipeline within the Caribbean region. We actively sought out Afro-Caribbean participants, but systemic problems in the tech education pipeline posed challenges. Pias et al. (2024) discuss the educational disparities and challenges faced by students in the Caribbean, contributing to the low number of Afro-Caribbean participants. Literature and scholarly resources on the Caribbean have also been limited and challenging. Future research should investigate how to incorporate computer science and tech education into the Caribbean education system. It should also work with policymakers and educators to enhance the education landscape through investments and policy changes (Pias et al., 2024).

Class Observation and Office Hours Observation

Observing classroom settings and office hours can provide a more comprehensive understanding of how AI tools are used in academic settings and how they impact learning in the long term. Classroom observations would allow researchers to see firsthand how students interact with AI tools and how these tools influence the learning process (Patton, 2002).

Observations during office hours can reveal additional insights into how AI tools support or hinder students' independent problem-solving skills outside the formal classroom environment (Angrosino, 2007).

Future research should include longer-term ethnographic studies in classrooms and office hours to capture a more nuanced picture of the use of AI tools in educational settings.

Ethnographic studies allow researchers to immerse themselves in the educational environment over an extended period and observe the social dynamics at play (Spradley, 1980). Collins (2023) highlights innovations in research like ethnography that have enabled novice researchers to effectively conduct ethnographic studies. My study included some elements of ethnography from social media platforms and from text, memes, videos, and other multimedia, which serve as a means of observing people naturally behaving in their social environments (Collins, 2023). Ethnographic insights combined with self-reported data can provide a more robust understanding of the benefits and challenges of AI tools in programming education.

Limitations of Qualitative Methods

Qualitative research offers rich, detailed insights but has limitations. It is often more subjective and can be influenced by researchers' personal biases. Smaller sample sizes can limit the generalizability of the findings (Rahman, 2017). Interviews can introduce bias and make it challenging to replicate studies or extend findings to larger populations. These limitations lend themselves to longer-term ethnographic studies that involve immersive observations in participants' natural environments (Collins, 2023).

Limitations of Quantitative Methods

Quantitative studies provide statistical insights but come with significant limitations. Lack of engagement can result in data that does not reflect participants' views and experiences (Krosnick, 1991). Surveys often fail to fully engage participants or elicit thoughtful and accurate

responses that capture a wide array of detailed perspectives (Rahman, 2017). The central tendencies and percentages of responses can also be limiting, as they may obscure the nuances of individual experiences.

The research from my thesis suggests a balanced and inclusive view of experiences. We took representative samples from each demographic group, ensuring that we included ten people from each group. African American voices were most prominent, reflecting the significant levels of racism and discrimination this group experiences in the United States (Jones, 2016). Due to the quantitative results' surface-level nature, I added a research question to capture the essence of educational equity. I needed this to fully explain how individuals experience equity in their day-to-day learning in higher education. Within Chapter V, I also included a fundamental regression analysis to illustrate the point further, providing a deeper understanding of educational equity beyond what the quantitative data alone could offer. This combination of methods offered a more comprehensive view of the participants' experiences and the systemic issues they face.

Scarcity of Peer Review Literature and Contributions

One significant limitation of my study is the lack of peer-reviewed literature, mainly focusing on the Afro-Caribbean population. Consultations with alumni from the University of the Virgin Islands and professionals at the Virgin Islands Department of Education highlighted several challenges, including lack of funding and access to resources to conduct AI-related studies. This feedback reinforced the understanding that existing infrastructure and financial support in some Caribbean Islands often fall short, making it challenging to undertake comprehensive research in AI and contributing to the scarcity of relevant peer-reviewed studies (UVI Alumni and DOE, personal communication, 2023). A comprehensive search of academic databases such as JSTOR, PubMed, Google Scholar, and computer science-related databases available through the University of Michigan, including IEEE Xplore, ACM Digital Library, and

SpringerLink, along with a collaboration with Sara Barbrow, a librarian specializing in this area, yielded very few studies that directly address this demographic. The paucity of primary research required reliance on secondary sources such as government reports, organizational studies, and historical analyses, which may not always provide the most accurate or current data. Consequently, the findings and conclusions drawn in this thesis are subject to the limitations inherent in the available literature, including potential biases and generalizations present in secondary sources.

A notable limitation is the lack of studies exploring how AI and related technologies could improve outcomes for African American, Latinx, and Afro-Caribbean students in programming. Most existing literature focuses on the negative aspects, such as failure rates and disparities, without offering solutions. The few studies that discuss the potential benefits of large language models and other AI tools focus on programmers who generally do not represent underrepresented populations. For example, Padiyath et al. (2024) examine general usage patterns and self-efficacy among diverse study bodies but do not specifically address underrepresented groups. This gap makes it difficult to draw specific conclusions about how AI technologies might support underrepresented groups in programming. Secondary studies provided notable insights and were used in my study to fill the gap where peer-reviewed articles could not provide a comprehensive understanding of the potential impacts of AI on African American, Latinx, and Afro-Caribbean students. Adopting a justice-centered approach to computer science education becomes important considering these limitations. Lin (2022) explains that the justice-centered approach helps address the gaps identified in this study and fosters an inclusive and socially responsive educational environment, ensuring that the voices of marginalized communities are heard and valued. Dominant approaches in higher computer science education overlook the critical importance of identity and political vision (Lin). This oversight fosters the development of

students with anti-political values, perpetuating injustice and marginalization of certain groups, particularly Black women in computing (Lin, 2022).

Chapter 7: Conclusion

My thesis explores the potential role of AI tools in supporting African American, Latinx, and Afro-Caribbean students in computer science programming education. My study suggests that future research should delve into the individual experiences of each demographic group to better understand their unique challenges better. Academic support services could begin to be more tailored to meet the needs of underrepresented students by understanding the specific challenges faced by African American, Latinx, and Afro-Caribbean communities. AI tools have the potential to help bridge educational gaps and foster inclusion by providing unbiased support and complementing traditional learning methods. Existing research indicates that AI applications show promise, even though we have yet to realize their full potential in these areas. Institutions like the University of Michigan, with the School of Information's motto "Information Changes Everything," can be pivotal in promoting educational equity. Continued research and careful implementation of AI could address educational challenges specific to underrepresented communities.

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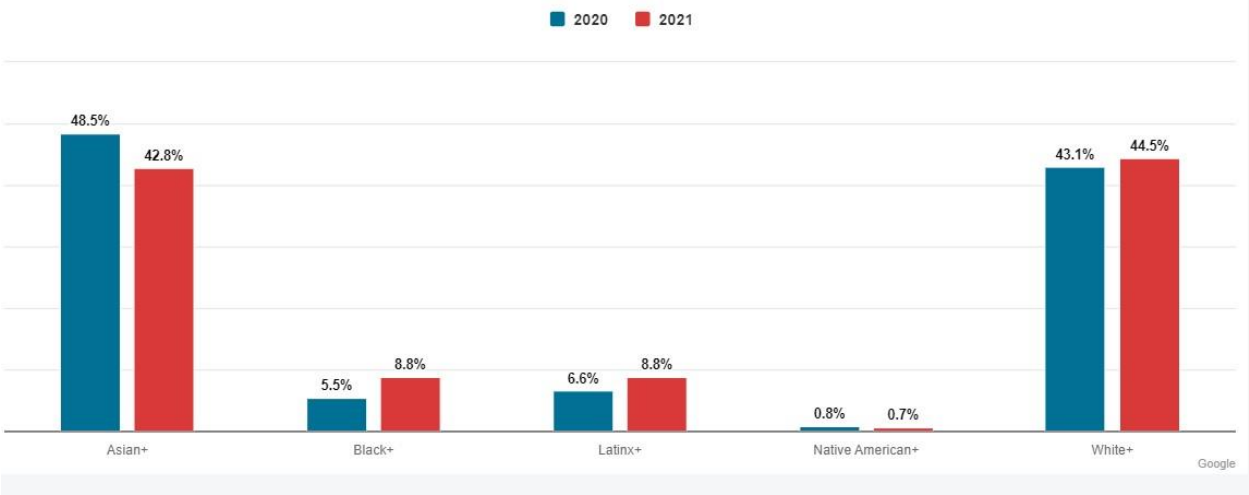
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Appendices

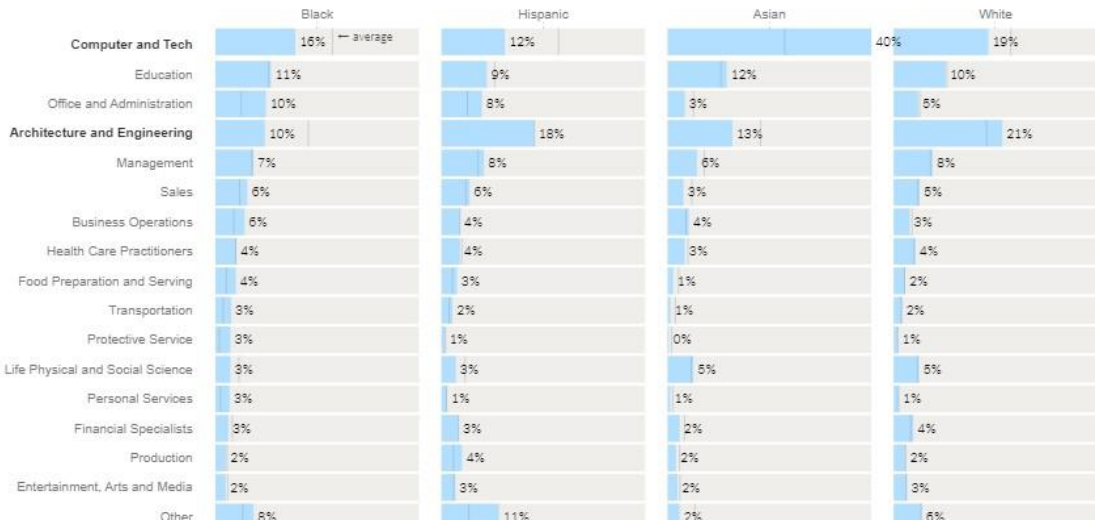
Appendix A Exploring the Tech Diversity Gap (Hiring Trends at Google)

Google Hiring by race/ethnicity (U.S. 2020 and 2021)



Appendix B Employment Distribution of Computer Science and Engineering Majors by Race

What Jobs Do Computer Science and Engineering Majors Have?



Appendix C Cultural Impact of AI Usage on Programming (Netnography Collection from Reddit, Twitter, and Other Social Media Platforms)

Source	Date	User (Anonymized)	Sentiment	Quotes/Summary
Reddit	October 2023	User 1	Negative	Since I've been using ChatGPT my motivation to get better at python has dropped. I am an amateur and still have ways to go. I know that becoming a good coder (in any language) takes time and is a learning curve, but I feel like almost every coding problem is done better by ChatGPT. How, even why, should I continue to try to get better then? It feels like a waste of time tbh.
Reddit	October 2023	User 2	Positive	You will not make the next groundbreaking application or tool using ChatGPT. However, if you use it as a knowledge base for rudimentary operations and questions, it can be an exceptional way to learn. Nothing will ever substitute the learning aspect of programming and you will not get stellar results without practice. At the same time, track GPT is a good way to really open the door for a new situation or a possibility of a situation that you may not be aware of within your programming. The basic rule of there are always 10 ways to 10 really applies here. Consider chat GTP as a knowledge base of aggregated ideas they get randomized and spewed out over time in the most rudimentary of ways. You can actually ask the same question in two different chats and get two different answers that both will most likely work for rudimentary and simplistic programs. That being said though, there is a significant amount of time that it just produces wrong

				information that won't even run properly. That's not a bad thing if you're attempt is to learn, but if you come into the game knowing absolutely nothing then it can be extremely frustrating if you are trying to use it as a learning tool.
Quora	March 2023	User 3	Positive	No, ChatGPT has not made learning code pointless. ChatGPT is an AI-based platform that uses natural language processing (NLP) to understand code-related queries and help users write their own code. It may be able to provide some assistance with certain types of coding projects, but it can only do so in certain contexts and with limited accuracy. In general, it is not a replacement for learning how to code. A better understanding of coding concepts and techniques, along with practice, is still necessary for any programmer. Additionally, ChatGPT's importance should be seen as an augmentation of the learning process, not a replacement. It can help you understand certain concepts better or create a basic structure for a program, but it cannot teach you the full range of coding skills necessary to become a successful programmer.

Appendix D Literature Review Grid - Used to Summarize Key Findings and Methodologies From Relevant Literature

Author(s), Year, Title	Methodology	Sample	Variables Measured	Data Collection	Top Findings
Belonging in Engineering for Black, Latinx, Indigenous Students: Promising Results From an educational intervention in an introductory programming course	The study utilized a quasi-experimental design. It was conducted in the context of a first-year engineering programming course, where an ecological belonging intervention was implemented. This design allowed for the examination of the intervention's impact on students' sense of belonging and academic performance.	The study involved 693 students enrolled in a first-year engineering programming course. The participant pool likely included a mix of BLI students and students from other demographics for comparative analysis.	The study focused on measuring students' sense of belonging in engineering and academic performance. Specifically, it looked at changes in students' perceptions of their belonging in the engineering community and their academic performance in the course.	Data were collected through pre- and post-semester surveys. These surveys likely included questions designed to measure students' feelings of belonging and their perceptions of the learning environment. Academic records were also used to gather data on students' performance in the course.	Normalizing Struggle and Challenges in Engineering: Engineering, and particularly programming courses, can be challenging, and students often face significant academic hurdles. For Black, Latinx, and Indigenous (BLI) students, these challenges can sometimes be amplified by feelings of isolation or not fitting in, especially if they see fewer peers or role models from their own backgrounds in these fields. The intervention aimed to convey to students that encountering difficulties and struggles is a common and expected part of the learning process in engineering. By normalizing these experiences, the intervention sought to reduce feelings of impostor syndrome, where students might falsely believe that they are the only ones struggling or that their struggles indicate a lack of ability or belonging. This normalization helps students understand that their experiences are shared by many others, thereby reducing feelings of isolation and increasing their perseverance and resilience.
					Addressing Belonging Uncertainty: Belonging uncertainty refers to doubts that students might have about whether they fit into a particular field or academic environment. For BLI students, this can be a significant concern due to underrepresentation and potential experiences of bias or microaggressions. The intervention focused on explicitly acknowledging and addressing these feelings of uncertainty. It likely involved discussions, activities, or messaging that reinforced the idea that BLI students are valued and integral members of the engineering community. By directly confronting belonging uncertainty, the intervention aimed to foster a more inclusive and welcoming environment for these students. This could include sharing stories of successful engineers from similar backgrounds, providing mentorship opportunities, or creating spaces where students can express and discuss their concerns and experiences.
The Power of Mentoring Programs in Retaining Women and Black, Indigenous, and Students of Color in Undergraduate Computing Majors		Participant Demographics: Information about the participants' demographics, including their age, gender, ethnicity, academic year, and major. Recruitment Methods: How participants were recruited for the study, such as through university programs, clubs, or classes.	Retention Rates: The primary focus might be on the rates at which students remain in their computing majors. Perceptions of Mentorship: Students' perceptions and experiences with the mentoring program, including satisfaction, usefulness, and impact on their academic choices. Academic Performance: Measures of students' academic success, such as GPA or course completion rates.		Effectiveness of Mentorship: Results indicating how mentoring influences the retention and academic experiences of women and BIPOC students in computing majors. Key Factors for Success: Identification of specific aspects of the mentoring program that were most beneficial. Recommendations for Improvement: Suggestions for enhancing mentoring programs based on the study's findings.

Appendix E Gen AI Showcase Promotion Flyer by Technique

AI SHOWCASE

FREE LUNCH PROVIDED!

**REGISTER
NOW!**





📍 Ross, R1240 or Zoom

📅 Friday, 12 april

🕒 2-4 pm



ASHLEY AUSTIN
Content Strategist, Apple
Career journey, and use
cases for AI



LANCE FUCHIA
CS '24
Co-Founder
AccoAI



DR. SANJEEV KUMAR
Ross Professor
Future of AI + Use
cases in Business

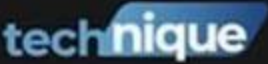


K.J. GREEN
UMSI + MBA
AI in Programming
education



JULIAN HEMMINGS
Law student
AI in law &
Sci-Fi Writing







Appendix F Interview Participants

Participant ID	Demographic Group	School/Department	Level of Programming Proficiency	Method of Recruitment
P1	African American	University of Michigan: School of Information/Ross School of Business	Expert	Slack
P2	Latinx	University of Michigan: School of Information/Ross School of Business	Beginner	Slack
P3	Afro-Caribbean	University of the Virgin Islands	Beginner	WhatsApp
P4	Latinx	University of Miami: College of Electrical Engineering and Computer Science	Expert	WhatsApp
P5	African American	University of Michigan: School of Information	Beginner	WhatsApp
P6	Latinx and Caribbean descent	MIT	Intermediate	Slack
P7	African American	University of Michigan: Ross School of Business	Beginner	Slack

Appendix G Survey Questions/Statements/Consent Forms

Title of Study: Impact of AI-Assisted Tools on Programming Education for Communities of

Color

Primary Researcher/Main Point of Contact: Karon J. Green, Masters in Information

Science Graduate Student, University of Michigan School of Information

Faculty Advisor/Committee Member: Steve Oney - Associate Professor of
Information/Engineering/Computer Science

2nd Faculty Committee Member: Cliff Lampe - Associate Dean of Academic Affairs

UMSI DEI Staff Advisor : Judy Schabel - Assistant Dean of DEI

Purpose of the Study:

This study aims to understand the potential role of AI-assisted programming education in enhancing career development and programming proficiency in Black, Latinx, and AfroCaribbean communities. Your participation in this survey will contribute valuable insights towards this goal.

Procedures:

If you agree to participate, you will be asked to complete a survey that includes closed-ended (Likert scale) questions. The survey is expected to take approximately 10-15 minutes to complete in full.

Voluntary Participation:

Your participation in this survey is entirely voluntary. You are free to skip any questions you prefer not to answer or to withdraw from the survey at any point without any penalty.

Confidentiality:

Your responses will be kept confidential and anonymous. Data collected through this survey will be summarized and reported in aggregate form. No individual responses or personal identifiers will be disclosed in any publications or presentations resulting from this research.

Risks and Benefits:

There are no significant risks associated with your participation in this survey. While there are no direct benefits to you, your responses will contribute to our understanding of AI-assisted programming education and its potential impact on the communities mentioned.

As a token of our appreciation for your time and insights, we are offering a \$10 incentive to 5 randomly selected survey participants. If you complete the survey, you will be eligible for this random draw. Winners will be contacted directly via the contact information provided at the end of the survey.

Contact Information: If you have any questions or concerns about the study, you can contact the primary researcher at karongre@umich.edu

Consent:

By completing and submitting this survey, you are indicating your consent to participate in this research study.

1. Please select the category that best describes your racial or ethnic background.

*Note: While this survey primarily focuses on the experiences of African American, AfroCaribbean, and Latinx students and other populations in computer science/programming education, we welcome and value insights from individuals of all racial and ethnic backgrounds to ensure a comprehensive understanding of AI-assisted tools in programming education.**

African American: Refers to individuals of African descent who are primarily from the United States. This group encompasses a wide range of cultural backgrounds due to the diaspora's history and geographical spread.

Latinx: A gender-neutral term for individuals of Latin American origin or descent, encompassing those traditionally referred to as Latino or Latina. This term captures the wide variety of cultures, languages, and countries within Latin America, ensuring inclusivity.

Afro-Caribbean: Describes people from Caribbean nations who have predominantly African ancestry. The term acknowledges the unique cultural and historical experiences of the African diaspora in the Caribbean islands.

2. How would you describe your current level of programming proficiency?*

Beginner (I have no or very limited experience) (0-1 Years of experience)

Intermediate (I am proficient and can write complex programs) (2-4 years of experience)

Expert (I have extensive experience and expertise in programming) (4+ years of experience)

3. Which of the following programming languages are you familiar with? (Select all that apply)* Python

JavaScript

Java C++

Ruby

PHP

1. How do you use AI-assisted tools for educational purposes, if at all? Please explain the context.

5. Which of the following AI-programming assistants have you used?

GitHub CoPilot

Alpha Code

Tabnine

Code T5

Chat GPT (GPT 3/4)

Open AI Codex

Other:

2. What is the highest level of education you have completed or are currently pursuing?

(Please select the highest level that applies.)*

*

Less than high school diploma

High school diploma or equivalent (e.g., GED)

Some college, no degree

Trade/technical/vocational training

Associate Degree (e.g., AA, AS) - completed or in progress

Bachelor's Degree (e.g., BA, BS) - completed or in progress

Master's Degree (e.g., MBA, MS, MEd) - completed or in progress

Professional Degree (e.g., MD, DDS, DVM, JD) - completed or in progress

Doctorate Degree (e.g., PhD, EdD) - completed or in progress

Quest

1. I believe AI-assisted tools could help me understand programming concepts, even if I have little to no programming experience.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

2. I think using AI-assisted tools would make learning programming engaging.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

3. The availability of AI tools makes me motivated to start or continue learning programming.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

4. I feel that AI-assisted tools could make learning programming accessible for beginners or those with limited programming experience.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

5. I believe that with AI tools, I would be equipped to overcome challenges when starting to learn programming.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

6. I believe AI-assisted tools could enhance my engagement in learning programming, even as beginners or non-programmer.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

7. I think using AI-assisted tools would make learning programming engaging.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

8. AI tools have the potential to make computer science interesting and enjoyable for someone with limited or no experience in programming.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

9. The use of AI-assisted tools makes me inclined to explore programming further.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

10. I believe that with AI tools, I would be engaged to overcome challenges when starting to learn programming.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

11. I believe AI-assisted tools may promote learning and retention in programming education.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

12. AI-assisted learning environments make me feel supported in my programming education journey.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

13. Using AI-assisted tools has increased my confidence in tackling programming courses, even as a beginner or someone with limited programming background.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

14. AI technologies contribute to creating an inclusive learning community that welcomes students from diverse backgrounds, including those new to programming.

Strongly Agree

Agree

Neutral

Disagree

Strongly Disagree

15. AI-assisted learning interventions are effective in encouraging persistence and retention in programming education among students who are beginners or from underrepresented backgrounds.

Strongly Agree

Agree

Neutral

Disagree

Strongly disagree

16. My racial/ethnic identity has influenced the ways in which I use AI tools.

Strongly Agree

Agree

Neutral

Disagree

Strongly disagree

17. My racial/ethnic identity has influenced the ways in which I learn.

Strongly Agree

Agree

Neutral

Disagree

Strongly disagree

18. Based on your insights shared in this survey, we are interested in inviting some participants for a follow-up interview to delve deeper into their experiences and perspectives. Would you be open to participating in a brief interview to further discuss your views on AI-assisted tools in programming education? Your participation would be invaluable to our research.

Yes, I am interested and open to participating in a follow-up interview.

No, I am not interested in participating in a follow-up interview.

19. Please provide your email address if you are interested in participating in the follow-up interview. By sharing your email, you'll allow us to contact you with more details regarding the interview process.

Additionally, your email address will automatically enter you into a raffle, serving as an incentive for your valuable participation. We're excited to offer this opportunity as a token of our appreciation for your insights and time.

Your answer

Appendix H Interview Questions/Statements

Opening Statement: Thank you for agreeing to participate in this interview. Today, we'll be discussing your experiences and perspectives on the use of AI-assisted tools in computer science education. Your participation is voluntary, and you may choose to withdraw at any time without penalty. All responses will be kept confidential and used solely for research purposes. Do you consent to participate under these conditions and do you agree to have this interview recorded for accurate data analysis?

The study focuses on African American, Latinx, and Afro-Caribbean students across different levels of programming expertise. It aims to explore the impact of AI-assisted tools in computer science education on two distinct groups:

- **Non-Programmers:** The study seeks to understand how AI tools can introduce and clarify computer science concepts for individuals with minimal or no programming background, potentially making the field more accessible and increasing diversity.
- **Programmers:** For those with programming experience, the research will assess how AI tools contribute to enhancing their programming skills, addressing complex problems, and supporting their continued engagement and persistence in computer science. This dual focus allows the study to capture a broad spectrum of experiences and perceptions

regarding the effectiveness of AI tools in supporting and advancing computer science education among underrepresented groups.

Interview Protocol Consent Form

Title of Study: Exploring the Effectiveness of AI-Assisted Tools in Computer Science Education Among African American, Latinx, and Afro-Caribbean Students

Researcher Information: KJ Green; MSI Graduate Student; karongre@umich.edu

Study Description: This study aims to understand how AI-assisted tools, such as ChatGPT and Codex, impact the learning experiences, engagement, and retention rates of African American, Latinx, and Afro-Caribbean students in computer science. Your participation involves a one-on-one interview that will explore your personal experiences and perceptions related to the use of AI tools in your education.

Voluntary Participation: Participation in this study is entirely voluntary. You have the right to withdraw at any time without any consequences.

Confidentiality: Your responses will be kept confidential. Data will be anonymized, and any identifiable information will be removed or altered before analysis and reporting.

Recording: The interview will be recorded for transcription purposes to ensure accuracy in capturing your responses. Recordings will only be accessible to the research team and will be securely stored.

Consent to Participate: By signing this form, you consent to participate in the study under the conditions outlined above. You acknowledge that you have been informed about the study's purpose, procedures, and your rights as a participant.

Questions: If you have any questions about the study or your participation, please feel free to ask now or contact [Researcher's Name] at [Contact Information].

Signature: _____

Date: _____

Researcher's

Signature: _____

Date: _____

Please ensure you provide a space for participants to sign and date the form, as well as a section for your signature as the researcher. Adjust any details to accurately reflect your study and institution's requirements.

1. Research Question Theme: How will African American, Latinx, and AfroCaribbean students describe the effectiveness of AI-assisted tools for learning how to program?

How would you describe your experiences with AI-assisted tools in learning programming?

- a. How would you describe in what ways these AI-assisted tools are effective or ineffective for you?

How would you describe specific situations and instances where an AI-assisted tool directly impacted your learning in programming in an effective way?

- b. How would you describe the outcome of the situation or situations?

In your experience, how do you feel AI-assisted tools effectively cater or do not cater to your learning needs within the field of computer science education?

How effective do you feel AI-assisted tools are in enhancing your understanding and retention of what you learned in programming?

- c. How would you compare AI-assisted learning to traditional learning methods like tutoring, office hours, direct instruction from an expert, lecture, peer mentorship groups/group learning, and the like?

Depends on the instructor and the professor of that class. Wouldn't take AI over an instructor and depends on the application.

i. Which approaches between the two were most effective?

2. Research Question Theme: How will African American, Latinx, and Afro-Caribbean students describe the *effectiveness of AI* tools on learner engagement?

How do you feel AI-assisted tools have influenced learner engagement in programming classes or projects, if at all?

a. In what way or ways would you describe specific instances, if any, where an AI-assisted tool noticeably enhanced your learner engagement with programming learning materials or activities?

3. Research Question Theme: How will African American, Latinx, and Afro-Caribbean students describe the effectiveness of AI-assisted tools on retention rates in postsecondary training within the field of Computer Science?

How would you describe the effectiveness of AI-assisted tools in promoting retention rates in post-secondary training within the field of Computer Science? Is the faculty pushing it or not?

- What do you feel is effective, if anything?
- How do you feel AI-assisted tools can promote retention rates in post-secondary training in the field of computer science?

Appendix I Linked Post for Survey Respondents



Karon J. Green (He/Him) • You

Incoming Product Manager, Executive Associate
Program at M&T Bank | Michigan MBA + MIS | AI Bu...
3mo • Edited • 🌐

...

🌟 Join A Tech Research Initiative! 🌟

Exciting news! I am excited to share that I'm partnering with the **University of Michigan - School of Information** and the **Computer Science and Engineering at the University of Michigan**. 🙌 We're embarking on a research journey into AI's role in programming education, with a keen focus on uplifting communities of color.

We Need:

Software Engineers 🧑💻

Product Managers 📊

Designers 🎨

Tech Students & Enthusiasts 🎯

Share your experiences with tools like GitHub Copilot and ChatGPT to help us explore their impact on the tech industry and education.

🚀 Participate by:

Completing a quick survey

Sharing your AI tool experiences

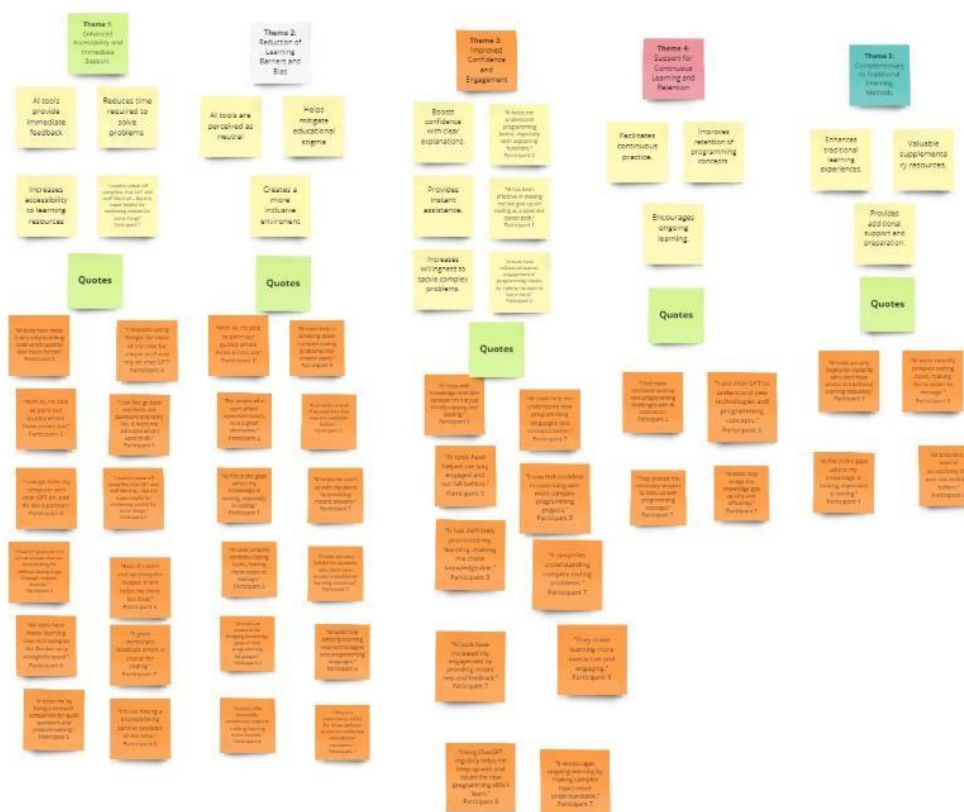
Rating their educational impact

This research aims to make tech education more inclusive and effective. Your input is vital. Participants will be entered into a raffle for a chance to win a special prize! 🏆

🔗 <https://lnkd.in/gNkdVEtV>

#TechResearch #AlinEducation #AIExpert #techKJ

Appendix J Interview Thematic Analysis - Main Quotes from Interviews and Quotes



Appendix K Excel Analysis and Data Cleaning

	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
58	Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
59	Agree	Agree	Agree	Agree	Agree	Agree	Neutral	Neutral	Neutral	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree
60	Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
61	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree
62	Agree	Agree	Agree	Agree	Agree	Agree	Disagree	Agree	Disagree	Agree	Neutral	Strongly Agree	Agree	Agree	Agree	Agree	Agree	Agree
63	Agree	Agree	Disagree	Agree	Agree	Agree	Agree	Neutral	Strongly Agree	Agree	Agree	Strongly Agree	Agree	Agree	Strongly Agree	Agree	Agree	Agree
64	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
65	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
66	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
67	Agree	Disagree	Disagree	Agree	Strongly Disagree	Neutral	Neutral	Agree	Disagree	Disagree	Neutral	Neutral	Disagree	Neutral	Agree	Agree	Strongly Disagree	Neutral
68	Disagree	Disagree	Agree	Agree	Disagree	Agree	Neutral	Agree	Disagree	Agree	Neutral	Agree	Disagree	Neutral	Agree	Strongly Agree	Strongly Agree	Neutral
69	Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
70	Strongly Agree	Agree	Disagree	Agree	Agree	Agree	Agree	Strongly Agree	Neutral	Agree	Agree	Strongly Agree	Agree	Agree	Agree	Agree	Agree	Agree
71	Strongly Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree	Agree
72	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
73	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
74	Agree	Agree	Disagree	Strongly Agree	Agree	Agree	Agree	Agree	Neutral	Agree	Agree	Neutral	Disagree	Neutral	Agree	Agree	Strongly Disagree	Strongly Disagree
75	Agree	Agree	Agree	Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
76	Agree	Agree	Agree	Strongly Agree	Disagree	Strongly Agree	Agree	Agree	Disagree	Agree	Neutral	Agree	Agree	Agree	Agree	Agree	Strongly Agree	Agree
77	Agree	Agree	Disagree	Agree	Agree	Agree	Neutral	Agree	Disagree	Agree	Neutral	Disagree	Agree	Agree	Agree	Agree	Neutral	Strongly Disagree
		Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages	Percentages
Strongly Agree	57.1428571	42.8571429	31.5789474	54.5454545	46.7532468	42.8571429	35.5263158	40.7894737	24.6753247	32.8947368	32.4675325	32.4675325	35.8974359	37.6623377	31.1668312	16.8831169	27.2727272	
Agree	37.6623377	42.8571429	39.4736842	38.961039	40.2597403	41.5584416	38.1578947	44.7368421	42.8571429	50	44.1558442	37.6623377	38.4815385	27.2727272	41.5584416	22.0779221	29.87012	
Neutral	2.5974026	0.07792208	11.8421053	3.8961039	2.5974026	11.6883117	21.0526316	11.8421053	16.8831169	11.8421053	16.8831169	20.7792208	16.6666667	29.8701299	24.6753247	23.7766234	19.46051	
Disagree	2.5974026	0.06493506	14.4736842	1.2987013	7.79220779	2.5974026	3.94736842	2.63157895	12.987013	3.94736842	6.49350649	6.49350649	7.89230769	5.19480519	2.5974026	19.4805195	12.9870	
Strongly Disagree	0	0	2.63157895	1.2987013	2.5974026	1.2987013	1.31578947	0	2.5974026	1.31578947	0	2.5974026	0	0	0	18.1818182	10.38961	

Appendix L Step-by-Step Interview Setup and Analysis Using Carol Warren's Methods

Preliminary Considerations:

Understanding the Research Topic: Define the topic and its fit with the interview method.

Literature Review: Consider existing research to determine the relevance and potential contribution of the new study.

Planning: Account for time, access to respondents, and the financial and emotional costs of the study.

Interview Design:

Thematizing: Develop a clear understanding of the themes to explore. - **Done through the research questions**

Designing Questions: Create main questions, probes, and follow-up questions to guide the interview. - **Done through the interview protocol**

Selecting Respondents: Use strategies such as a priori research design, theoretical sampling, or snowball sampling to find suitable respondents.

Conducting the Interview:

Setting Up: Choose a convenient time and place, obtain informed consent, and prepare necessary materials (questions, tape recorder, etc.).

Recording: Use audio or video recording to capture the interview, being aware of the potential impact on respondents.

Interaction: Focus on the interaction between interviewer and respondent, treating the unfolding social context as valuable data. Done with OtterAi **Post-Interview Process: (Interview**

Analysis)

Transcription: Convert the recorded interview into text.

Initial Analysis: Begin by familiarizing yourself with the data, noting key themes and patterns. In-

depth Analysis: Use coding to categorize and interpret the data, identifying significant patterns and themes.

Interpretation:

Contextual Understanding: Interpret the data considering both the respondent's and the interviewer's perspectives, acknowledging their historical and social contexts.

Ethnographic Linkages: Where relevant, combine interview data with ethnographic observations to enhance understanding.

Reporting:

Verification: Check the accuracy and validity of the findings.

Presentation: Report the findings, highlighting the interpretations and meanings derived from the interviews.

Appendix M Research Alignment Table

Title	Exploring the Use and Impact of AI-Assisted Programming Tools in Computer Science Education among African American, Latinx, and AfroCaribbean Students Shorten Title: <i>AI-Driven Programming Education for Black, Latinx, and Afro-Caribbean Communities</i>
--------------	--

Background of the Problem	
---------------------------	--

Programming and technology proficiency are essential in today's digital economy for career progression. Rapid technological advancements necessitate digital literacy as a foundational educational skill (Surtini, 2021; Balanskat & Engelhardt, 2015). However, significant disparities in educational access and quality persist, especially affecting African American, Latinx, and Afro-Caribbean communities. These groups often contend with low academic performance and limited programming experience, compounded by social and structural barriers that restrict their access to effective programming education (Albarakati, 2023). In the Caribbean, the situation is further aggravated by suboptimal educational settings, insufficient infrastructure, and a dearth of qualified teachers, leading to underdeveloped educational systems (Mohan, 2003). These challenges hinder the engagement and success of minority students in the technology sector, necessitating targeted strategies to foster an inclusive learning environment and enhance educational equity in STEM fields.

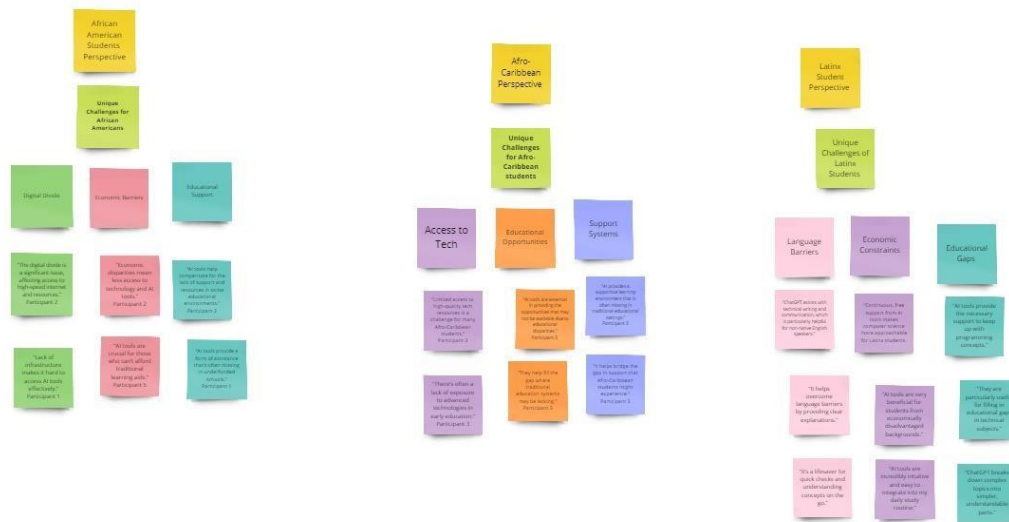
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Problem Statement (deficiency)	Currently, little attention in peer-reviewed literature has explored the <i>effectiveness</i> of AI-assisted tools in computer science education, particularly for underrepresented Black, Latinx, and Afro-Caribbean students, to <i>enhance</i> engagement and <i>retention rates</i> in these groups (Albarakati, 2023)
Purpose Statement (Positive)	The purpose of my thesis research is to examine (QUAN) and explore (qual) the <i>effectiveness</i> of AI-assisted tools in Computer Science education, particularly for Black, Latinx, and Afro-Caribbean students, <i>and</i> to understand how AI platforms may enhance engagement and retention rates in these underrepresented groups.
Research Question(s)	
RQ1 (QUAN)	How do African American, Latinx, and Afro-Caribbean students rate AI-assisted tools in terms of their effectiveness, learning engagement, and retention effort in programming education?
RQ2 (QUAN)	How will African American, Latinx, and Afro-Caribbean students describe AI-assisted tools' effectiveness on learning, learner engagement, and retention effort in programming?
RQ3 (QUAN)	How do African American, Latinx, and Afro-Caribbean students perceive the role of AI-assisted tools in reducing barriers to entry and success in computer science education?
Conceptual Framework	Educational Equity, AI For Learner Engagement, and Student Retention

Literature Review Topics (Draft Topics)	1. Educational Equity in Computer Science 2. AI for Learner Engagement
	3. AI-Driven Retention Strategies and Ethical Considerations in Technology Adoption 4. Cultural Implications of AI and ChatGPT 5. Research Gaps in Computer Science Education Intervention Methods
Research Methodology	Mixed
Specific Research Design	Explanatory Sequential Design QUAN ----> qual
Variables of Survey measured	effectiveness of AI-assisted tools in general <i>effectiveness of AI</i> tools on learner engagement Effectiveness of retention rates
Data Collection	
RQ 1,2,3	Survey- Completed
RQs 4, 5, 6	Interview - Completed
Data Analysis Methods	
RQ 1,2,3	Descriptive Statistics (Percentages of Responses , Mean, Mode, Median)

RQs 4, 5, 6, 7	Content Analysis to seek emergent themes (Open Coding → Categories → Themes)
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Appendix N Unique Challenges from Each Demographic (African American, Afro-Caribbean, and Latinx)



Appendix O

Frequency Distribution of Responses Regarding AI-Assisted Tools in Programming Education

The figure contains two tables showing the frequency and mode responses to various statements about the impact of AI-assisted tools on learning programming. Each table displays responses from 61 valid participants, with the mode response being predominantly 1.0 or 2.0 on a Likert scale for each statement.

		I believe AI-assisted tools could help me understand programming concepts, even if I have little to no programming experience.	I think using AI-assisted tools would make learning programming engaging.	The availability of AI tools makes me motivated to start or continue learning programming	I feel that AI-assisted tools could make learning programming accessible for beginners or those with limited programming experience	I believe that with AI tools, I would be equipped to overcome challenges when starting to learn programming
N	Valid	61	61	61	61	61
	Missing	2	2	2	2	2
Mode		2.00	1.00	1.00	2.00	2.00

Statistics

		I believe AI-assisted tools could enhance my engagement in learning programming, even as a beginner or non-programmer	I think using AI-assisted tools would make learning programming engaging	AI tools have the potential to make computer science interesting and enjoyable for someone with limited or no experience in programming	The use of AI-assisted tools makes me inclined to explore programming further.	I believe that with AI tools, I would be engaged to overcome challenges when starting to learn programming
N	Valid	61	61	61	61	61
	Missing	2	2	2	2	2
Mode		1.00 ^a	1.00 ^a	1.00	1.00	1.00

Appendix P

Frequency Distribution of Responses Regarding AI-Assisted Tools in Programming

Education

The figure contains two tables showing the frequency and median responses to various statements about the impact of AI-assisted tools on learning programming. Each table displays responses from 61 valid participants, with the median response being predominantly 1.0 or 2.0 on a Likert scale for each statement.

Frequencies

		Statistics				
		I believe AI-assisted tools could help me understand programming concepts, even if I have little to no programming experience.	I think using AI-assisted tools would make learning programming engaging.	The availability of AI tools makes me motivated to start or continue learning programming	I feel that AI-assisted tools could make learning programming accessible for beginners or those with limited programming experience	I believe that with AI tools, I would be equipped to overcome challenges when starting to learn programming
N	Valid	61	61	61	61	61
	Missing	2	2	2	2	2
Median		2.0000	1.0000	1.0000	2.0000	1.0000

		Statistics				
		I believe AI-assisted tools could enhance my engagement in learning programming, even as a beginner or non-programmer	I think using AI-assisted tools would make learning programming engaging	AI tools have the potential to make computer science interesting and enjoyable for someone with limited or no experience in programming	The use of AI-assisted tools makes me inclined to explore programming further.	I believe that with AI tools, I would be engaged to overcome challenges when starting to learn programming
N	Valid	61	61	61	61	61
	Missing	2	2	2	2	2
Median		1.0000	1.0000	1.0000	1.0000	1.0000

Appendix Q Frequency Distribution of Responses Regarding AI-Assisted Tools in Programming Education

The figure contains two tables showing the frequency and mode responses to various statements about the impact of AI-assisted tools on learning programming. Each table displays responses from 61 valid participants, with the mode response being predominantly 1.0 or 2.0 on a Likert scale for each statement.

Frequencies

		Statistics				
		I believe AI-assisted tools could help me understand programming concepts, even if I have little to no programming experience.	I think using AI-assisted tools would make learning programming engaging.	The availability of AI tools makes me motivated to start or continue learning programming	I feel that AI-assisted tools could make learning programming accessible for beginners or those with limited programming experience	I believe that with AI tools, I would be equipped to overcome challenges when starting to learn programming
N	Valid	61	61	61	61	61
	Missing	2	2	2	2	2
Mean		1.5082	1.2295	.8361	1.4098	1.2295

Statistics

		I believe AI-assisted tools could enhance my engagement in learning programming, even as a beginner or non-programmer	I think using AI-assisted tools would make learning programming engaging	AI tools have the potential to make computer science interesting and enjoyable for someone with limited or no experience in programming	The use of AI-assisted tools makes me inclined to explore programming further.	I believe that with AI tools, I would be engaged to overcome challenges when starting to learn programming
N	Valid	61	61	61	61	61
	Missing	2	2	2	2	2
Mean		1.1803	1.0000	1.2459	.8197	1.0984

Appendix R Chapter V Key Themes in the Effectiveness of AI tools in CS Education

The table below summarizes the five key themes identified through the analysis of both quantitative and qualitative data on the effectiveness of AI-assisted tools in CS education.

Theme	Reasons for Selection	Quantitative Data	Supporting Qualitative Data
Enhanced Learning and Engagement	Highlighted in both quantitative and qualitative responses as a significant benefit of AI tools in CS Education	High percentage of “Strongly Agree” and “Agree” responses across multiple questions	Frequent mentions of increased understanding and interest in CS/programming concepts
Confidence and Motivation	Identified as a key factor in student success and persistence in CS	Significant percentages of positive responses in related questions	Participants frequently cited AI tools as boosting their confidence and motivation
Support for Continuous Learning and Retention	Important for ongoing student engagement and reducing dropout rates	Positive survey responses indicating AI tools help in retention and continuous learning.	Qualitative feedback emphasized the role of AI tools in supporting ongoing learning and overcoming challenges
Addressing Learning Barriers and Bias	Critical for creating an inclusive and equitable learning environment	Responses showing AI tools help reduce intimidation and provide equitable access	Numerous mentions of AI tools helping to overcome biases and barriers in learning
Demographic Challenges	Reflects the specific needs and experiences of different demographics	Data showed varied responses based on racial/ethnic identity	Detailed insights into distinct challenges faced by African American, Afro-Caribbean, and Latinx students

Appendix S Standard Deviation Calculation for AI technologies contributed for creating an inclusive learning community that welcomes students from diverse backgrounds, including those new to programming

The graph below illustrates the frequency distribution of responses to the statement "AI technologies contribute to creating an inclusive learning community that welcomes students from diverse backgrounds, including those new to programming."

Key Points:

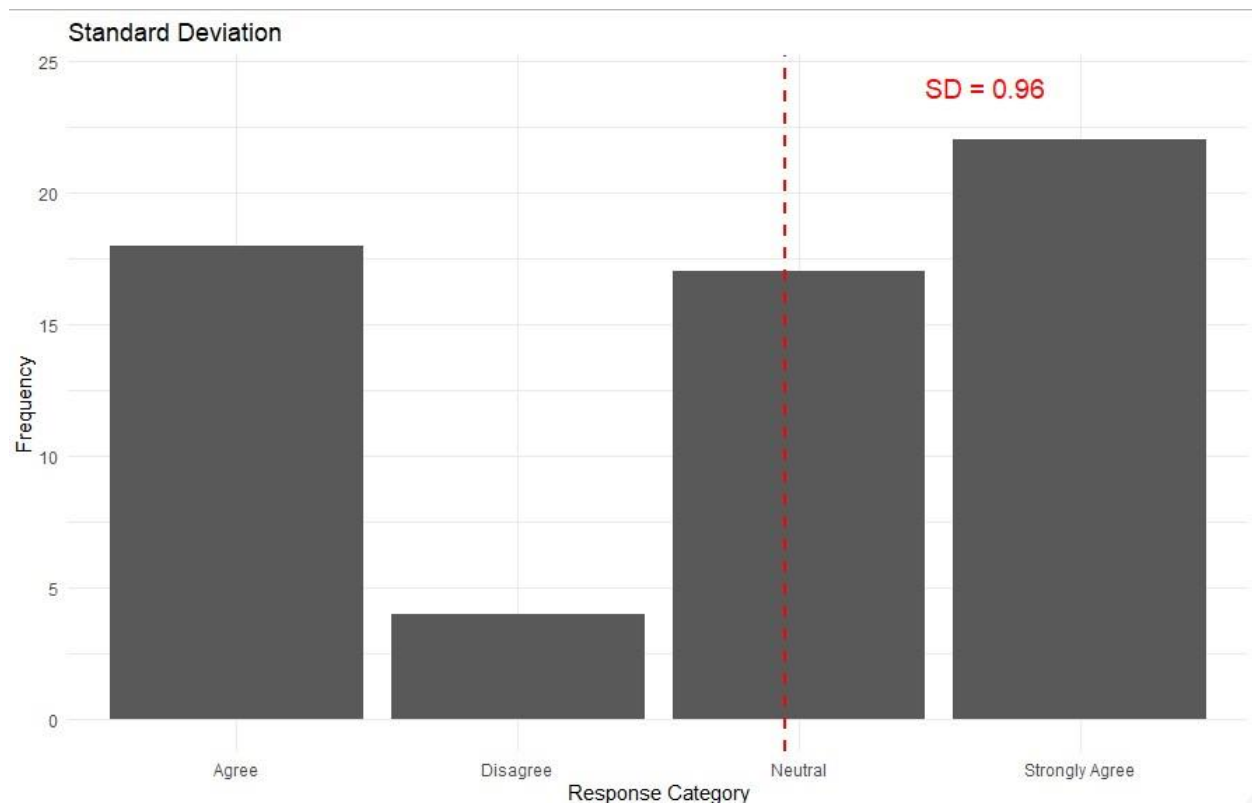
- **Response Categories:**
 - **Disagree:** 4 respondents (6.6%) ○
 - **Neutral:** 17 respondents (27.9%) ○
 - **Agree:** 18 respondents (29.5%) ○
 - **Strongly Agree:** 22 respondents (36.1%) ○
- **Total Responses:** 61 valid responses were recorded.

Graph Details:

- The **bar chart** shows the frequency of each response category.
- A **dashed red vertical line** is drawn at the mean value of the responses, indicating the average response.
- The **standard deviation** of the responses is annotated on the graph as a text label.

Standard Deviation:

- The standard deviation is a measure of the amount of variation or dispersion in the responses. In this case, the standard deviation is approximately .95. This indicates that the responses are relatively spread out around the mean, with most responses falling within one standard deviation of the mean.

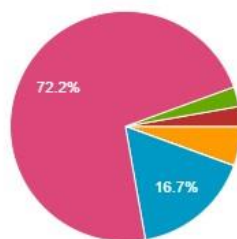


Appendix T Demographics of Participants - Education

6. What is the highest level of education you have completed or are currently pursuing? (Please select the highest level that applies.)

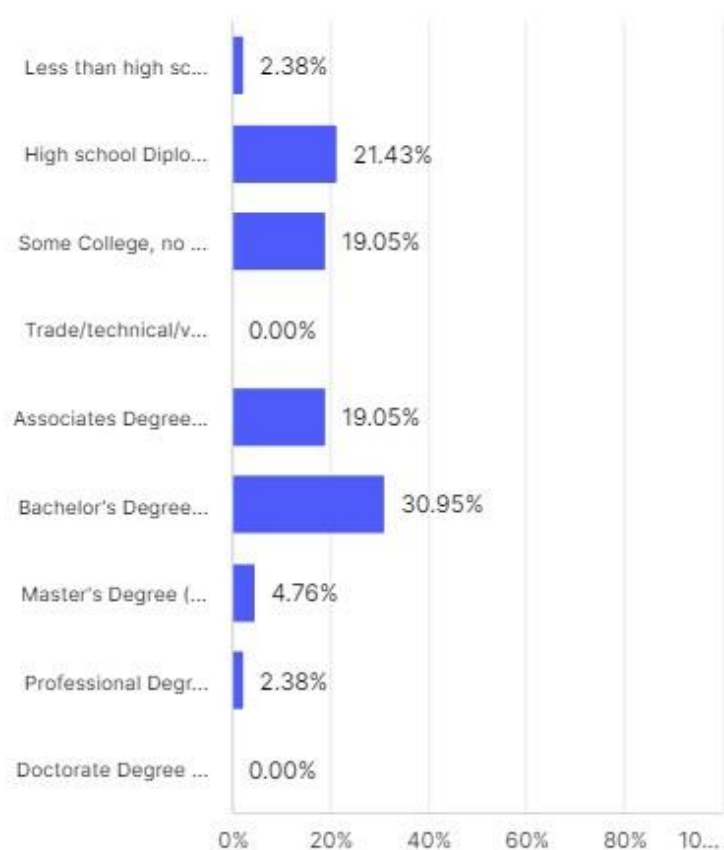
[Copy](#)

36 responses

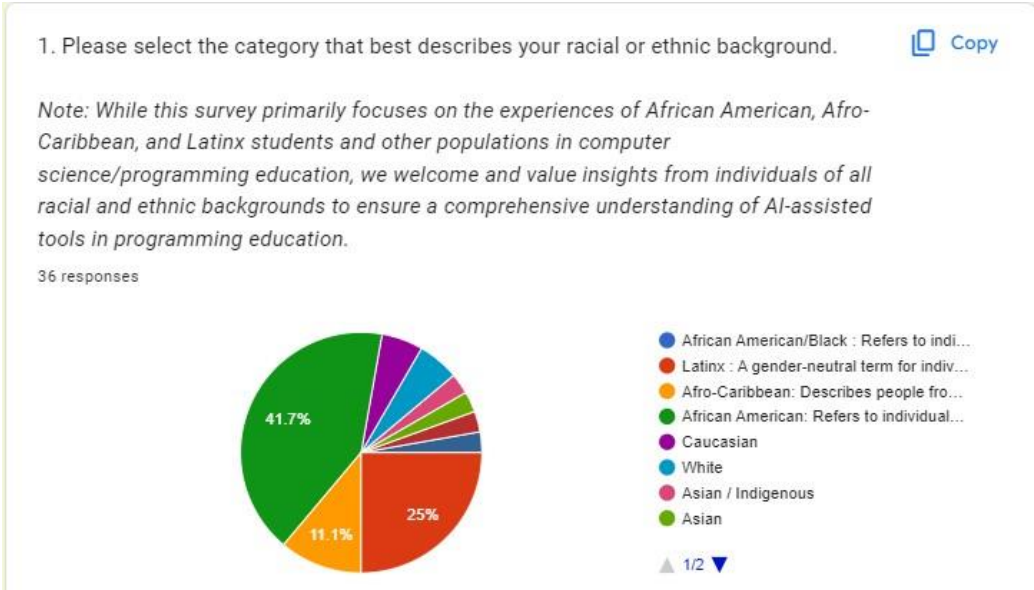


- Less than high school diploma
- High school diploma or equivalent (e.g., GED)
- Some college, no degree
- Trade/technical/vocational training
- Associate Degree (e.g., AA, AS) - com...
- Bachelor's Degree (e.g., BA, BS) - co...
- Master's Degree (e.g., MBA, MS, MEd...)
- Professional Degree (e.g., MD, DDS,...
- Doctorate Degree (e.g., PhD, EdD) - c...

What is the highest level of education you have completed or are currently pursuing?

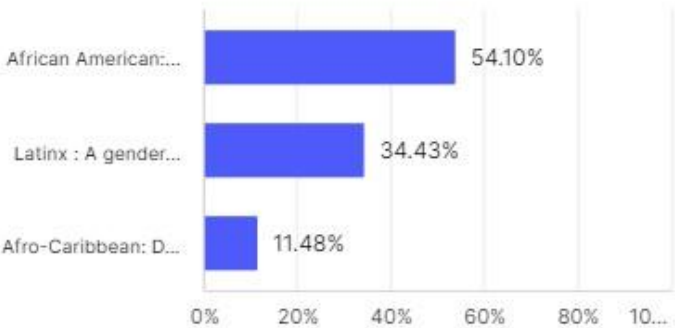


Appendix U Demographics of Participants - Racial Profile

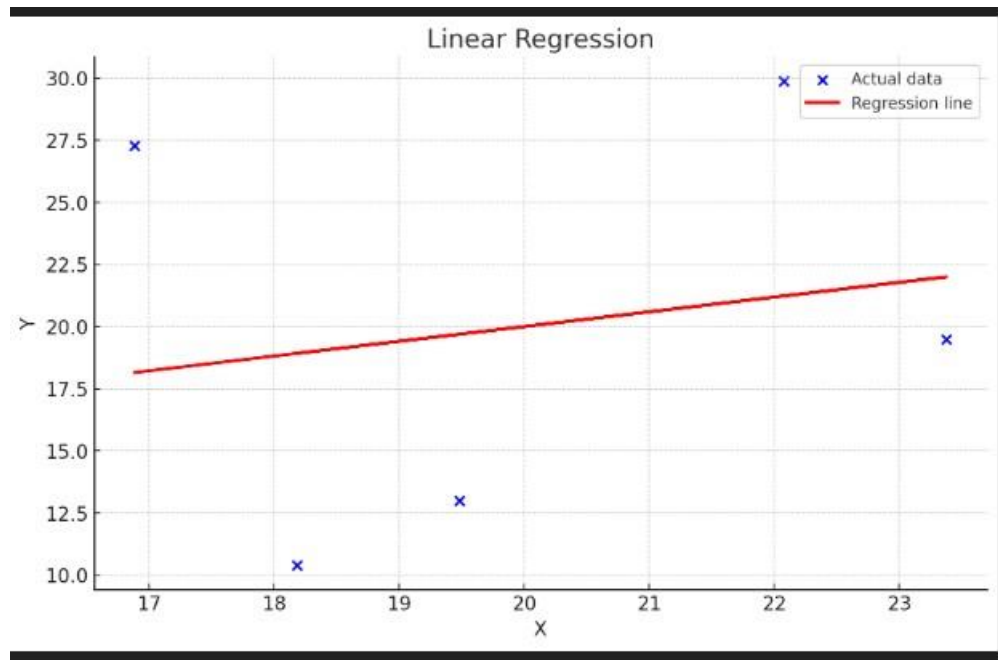


1. Please select the category that best describes your racial or ethnic background.

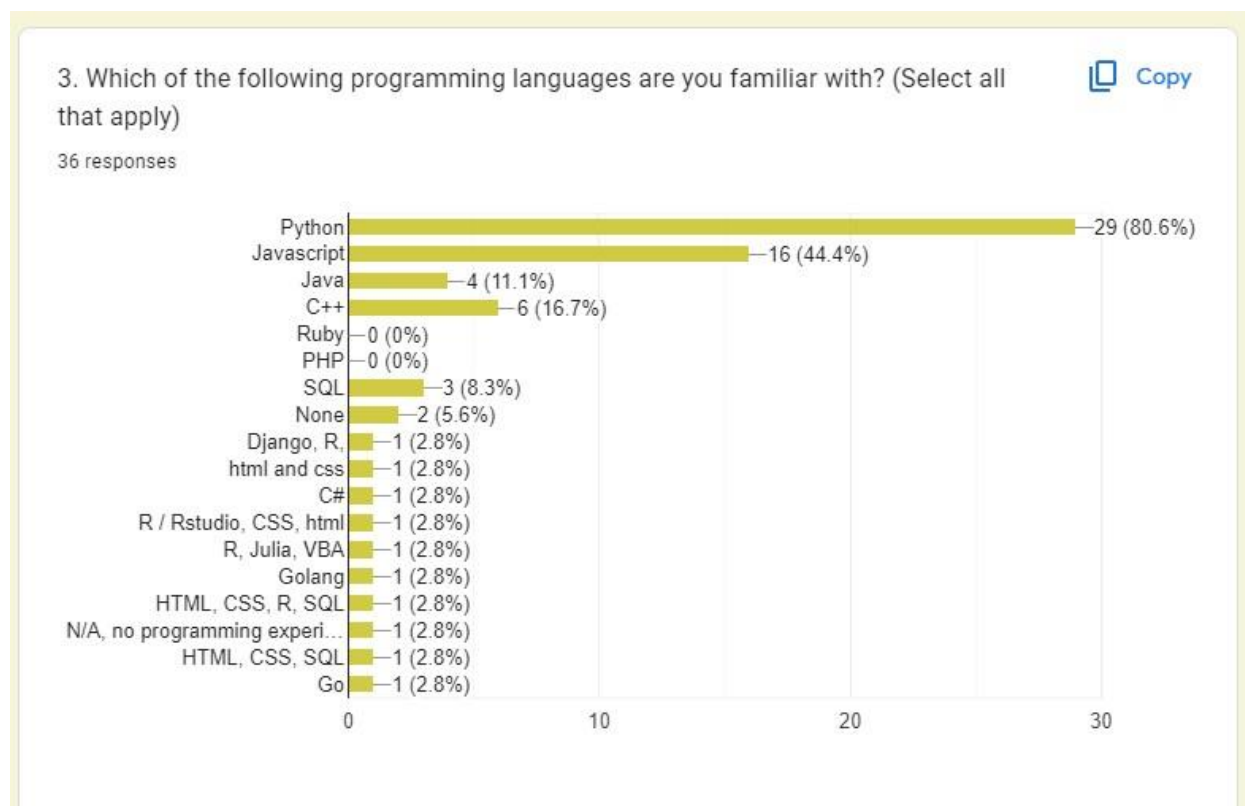
Note: While this survey primarily focuses on the experiences of African American, Afro-Caribbean, and Latinx students and other populations in computer science/programming education, we welcome and value insights from individuals of all racial and ethnic backgrounds to ensure a comprehensive understanding of AI-assisted tools in programming education.



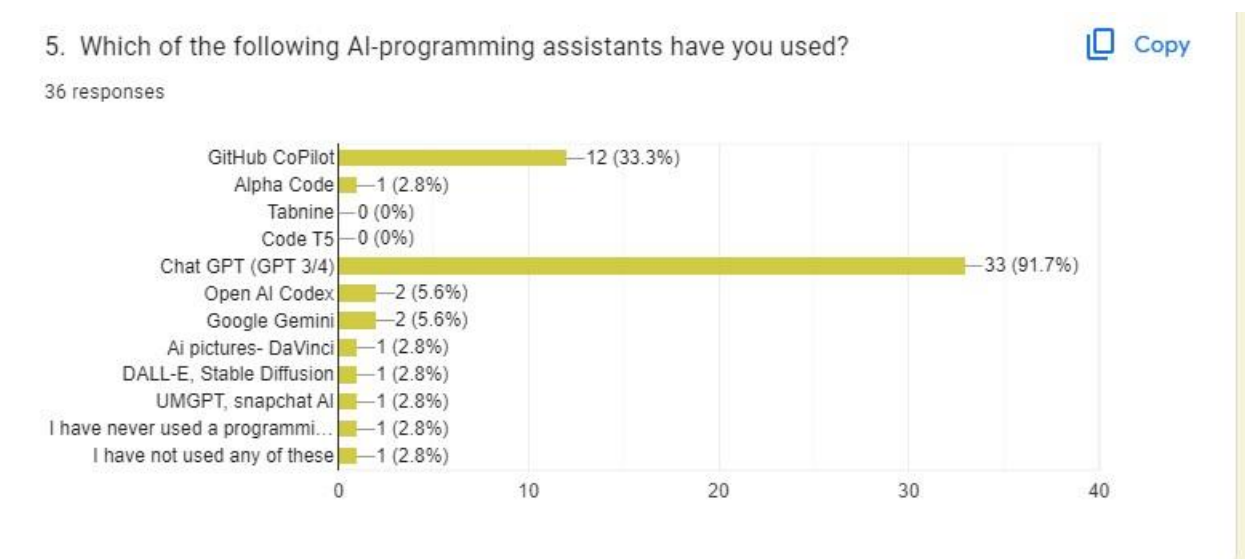
Appendix V Impact of Racial/Ethnic Identity on AI Tool Usage in Computer Science Education



Appendix W Familiarity with Programming Languages – University of Michigan and Other Educational Partners' Samples

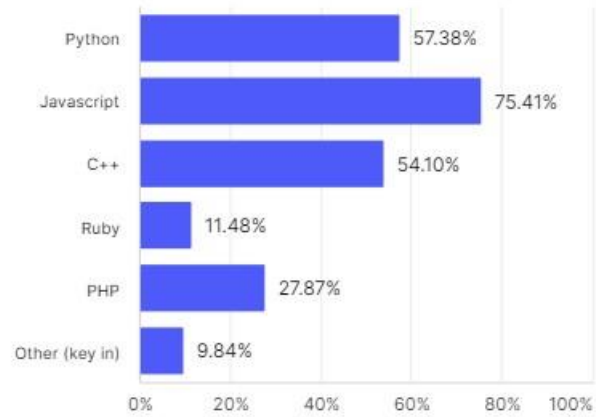


Appendix X Familiarity with AI Tools - University of Michigan and Other Educational Partners' Samples

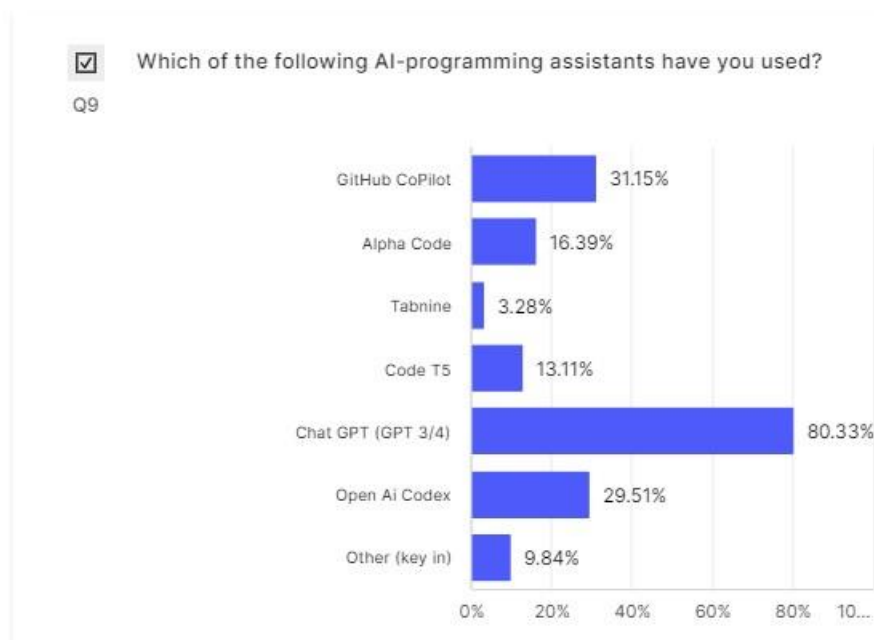


Appendix Y Familiarity with Programming Languages – External Sample

☒ 3. Which of the following programming languages are you familiar with? (Select all that apply) ...
Q7



Appendix Z Familiarity with AI Tools – External Sample



Appendix AA - Survey Messaging Communication and Screenshots

I hope you all are well and having a great week. I know you all seek to enhance the experiences of marginalized students pursuing computer science, computer engineering, and information sciences. I would love your feedback on a recent **survey** that dives into research on **AI**'s impact on programming education, specifically to support communities of **color**. Please take a moment to fill out the **survey** below that will directly influence tech education being more inclusive.

Plus, you'll get a chance to win a cool prize in our raffle! Here is the link below:

<https://forms.gle/YwEuGZHvVHKgCAQb7>

Thank you for your participation,

--

Karon Jáhmai "KJ" Green

UMSI Achievement Fellowship Scholar

MBA + MSI Candidate, Class of 2024

[Stephen M. Ross School of Business](#) | [School of Information](#)

karongre@umich.edu | [LinkedIn](#) || 340.344.5937

[Schedule a meeting with me on calendly](#)

Appendix BB – Research Question Definitions and Glossary

Effectiveness

Effectiveness in the context of educational tools, such as AI-assisted learning, is defined by how well these tools achieve their intended outcomes. This includes improving students' understanding, performance, and overall learning experiences. Effectiveness is measured through assessments of students' academic achievements, their ability to apply learned skills, and the overall impact on their educational journey (SpringerLink).

Chine et al.'s Work on Education Equity that Ties to the Effectiveness of AI Tools

Chine's work on educational equity through combined human-AI personalization evaluates the effectiveness of AI-assisted tools in narrowing achievement gaps among marginalized students. This study highlights the effectiveness of AI-assisted tools by demonstrating that the combination of human mentoring with AI tutoring significantly improves learning outcomes, particularly in mathematics. This effectiveness is seen through the provision of personalized learning opportunities and motivational support, which directly contribute to enhanced student performance and understanding (Chine et al., 2022).

Effectiveness of AI Code Generators

AI code generators like OpenAI Codex have been shown to significantly improve the learning experience for novice programmers by increasing task completion rates and correctness scores, while also reducing encountered errors and task completion time without decreasing performance on subsequent manual coding tasks (Kazemitabaar et al., 2023)

Impact of ChatGPT in Programming Education

Learner Engagement

Student engagement is a malleable, multidimensional construct that combines the three dimensions of behavioral, emotional, and cognitive engagement (Pedler et al., 2020). This construct is crucial for ensuring meaningful student participation in the learning process. Behavioral engagement refers to students' participation in academic, social, and extracurricular activities (Pedler et al., 2020). Emotional engagement encompasses students' emotional reactions in the classroom and their sense of belonging or connectedness to their school. Cognitive engagement involves the investment in learning, willingness to exert the effort needed to comprehend complex ideas, and mastering difficult skills (Pedler et al., 2020). Learner engagement in higher education refers to the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught. It encompasses behavioral, emotional, intellectual, physical, and social components. Engaged students attend classes, participate actively in discussions, exhibit enthusiasm, and demonstrate a high level of motivation towards their studies. Engagement is seen as a crucial factor in enhancing learning outcomes and overall academic success (EdGlossary).

Retention Efforts

Retention efforts in higher education are strategies and practices implemented to ensure that students remain enrolled and successfully complete their educational programs. These efforts include academic support services, mentoring programs, engagement initiatives, and other resources aimed at addressing the various barriers that might lead to student dropout. Retention rates are often used as a metric to gauge the success of these efforts, reflecting the percentage of students who continue their studies from one academic year to the next (SpringerLink).

Key Factors Influencing Retention in Computer Science

In computer science (CS) education, retention is particularly influenced by several key factors identified in research. Gains from studying CS, both cognitive (such as critical thinking and problem-solving skills) and non-cognitive (such as teamwork and personal development), play a

significant role. The learning environment, including supportive and challenging academic settings, is also crucial. Additionally, the perceived usefulness of the degree, which relates to students' beliefs about the value and applicability of their education in future careers, significantly impacts their intention to persist (Glannakos et al., 2016).

Barriers to Retention

Barriers to retention include negative personal values and feelings of not belonging, poor-quality teaching, and dissatisfaction with learning effectiveness. The eight-predictor model used in the study explained 39% of the variance in student retention, highlighting that a high level of perceived degree usefulness positively affects retention. Cognitive gains and a supportive environment also positively impact the perceived usefulness of the degree, whereas non-cognitive gains may hinder it (Glannakos et al., 2016).

Effective Retention Strategies

Effective retention strategies in CS education must address these factors to combat the high dropout rates. By fostering a supportive and engaging learning environment, enhancing the perceived value of the degree, and mitigating negative personal values and poor teaching quality, educational institutions can ensure that more students continue their studies to completion. These efforts are crucial for meeting the growing demand for CS professionals and ensuring a steady supply of skilled graduates to the workforce (Glannakos et al., 2016).

Intersection of Learner Engagement and Effectiveness

The intersection of learner engagement and effectiveness is critical in higher education. Engaged learners are more likely to benefit from educational tools and practices, thereby enhancing the overall effectiveness of these interventions. Engaged students are more likely to attend classes regularly, participate in academic activities, and exhibit a proactive attitude towards learning,

which in turn leads to better academic performance and a deeper understanding of the subject matter. Effective educational tools and strategies are designed to foster such engagement, creating a positive feedback loop where engagement enhances effectiveness, and effective tools further promote engagement (SpringerLink).