ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #45250

Work-in-Progress: Development of an HBCU/Research 1 Collaborative to Increase African American Semiconductor Manufacturing Researchers

Dr. Laura Sams Haynes, Georgia Institute of Technology

Dr. Laura Sams Haynes is faculty and Director of the Office of Outreach in Electrical and Computer Engineering at the Georgia Institute of Technology in Atlanta. Laura is passionate about developing and launching various outreach initiatives for K12 Atlanta Public Schools (APS) partners, including students and school counselors, as well as fostering HBCU partnerships, collaborations, and pathways, often with a focus on NSF grant funding or industry partnerships.

Dr. Kinnis Gosha, Morehouse College

Dr. Kinnis Gosha (Go-Shay) is an Assistant Professor in the Department of Computer Science and Director of the Culturally Relevant Computer Lab at Morehouse College. Dr. Goshaâ€™s research interests include conversational agents, social media data analyt

Mrs. Talia Capozzoli Kessler, Georgia Institute of Technology

Talia Kessler, MSPP is a research associate at The Center for Education Integrating Science, Mathematics, and Computing (CEISMC) at Georgia Tech. As a research associate, she works on research and evaluation projects centering on K-12 STEM education. She has a Master's degree in Public Policy from the Georgia Tech and is currently studying towards a PhD in Educational Policy Studies at Georgia State University.

Mr. R. Christian Ford, Georgia Institute of Technology
Whitney L Nelson

©American Society for Engineering Education, 2025

Work-in-Progress: Development of a Morehouse College/Georgia Tech Collaborative to Increase African American Semiconductor Manufacturing Researchers

Laura Sams Haynes
School of Electrical and Computer Engineering
Georgia Institute of Technology
Atlanta, USA

Kinnis Gosha
Department of Computer Science
Morehouse College
Atlanta, USA

Whitney Nelson
Department of Computer Science
Morehouse College
Atlanta, USA

Talia C. Kessler
Center for Education Integrating Science, Mathematics, and Computing (CEISMC)
Georgia Institute of Technology
Atlanta, USA

R. Christian Ford
School of Electrical and Computer Engineering
Georgia Institute of Technology
Atlanta, USA

I. Introduction

In August 2022, the 52.7-billion-dollar bipartisan CHIPS and Science Act was passed to strengthen the United States' position in the global chips and semiconductor industry, enhancing scientific research and promoting technological innovation [1]. In January 2023, Sethuraman Panchanathan, director of the National Science Foundation (NSF), forecasted the following: "Future semiconductors and microelectronics will require transdisciplinary research spanning materials, devices, and systems, as well as the engagement of the full spectrum of talent in the academic and industrial sectors" [2]. Relative to interdisciplinary and the transdisciplinary research referenced above by Panchanathan, Computer Science and Computer Engineering are dual contributing disciplines crucial to the body knowledge critical in chips and semiconductor research and technological innovation.

While the responsibility for semiconductor and chips manufacturing research resides in various departments within different academic institutions, at the Georgia Institute of Technology (Georgia Tech) [3], Computer Engineering is one of the primary areas. Georgia Tech Computer Engineering has various labs, facilities, researchers, experience, relationships, and funding. However, to meet the technology demands of our nation, as mentioned in the NSF director's previous quote, there must be more transdisciplinary research and the development of a full spectrum of American talent, which require such partnerships as Georgia Tech Computer Engineering engaging in an NSF-funded collaborative project with Morehouse College Computer Science [4]. Developing the full spectrum of American talent is particularly relevant

when considering the African American population, given its underrepresentation in technology, comprising 14.4% of the total population [5], but only 4% of the technology workforce [6]. In academe the lack of African American representation is also notable with only 10.7% of all bachelor's degrees and only 1.4% of all doctoral degrees in Computer Science awarded to African Americans [6]. Like the field of Computer Science, similar disparities exist and reinforce the need to attract and retain more African American students in the field of Computer Engineering [7] as well, given the necessity to engage the full spectrum of talent in academic and industrial sectors related to chips and semiconductor research and development.

The intervention highlighted here has been established to address the disparity and lack of African Americans exposed to interdisciplinary and transdisciplinary semiconductor research and features Georgia Tech Computer Engineering, with less than 8% African American undergraduate enrollment, partnering with the Computer Science department at nearby Morehouse College (which does not offer Computer Engineering), to construct a collaborative program for more African American students to gain both Computer Science and Computer Engineering exposure specifically related to semiconductor manufacturing research. This collaborative program is designed to leverage the greater number of African American Computer Science majors at Morehouse College and provide them with training and access to Georgia Tech state-of-the-art semiconductor research labs and research projects. Also, the collaborative program will broaden the Morehouse College students' interdisciplinary and transdisciplinary exposure to Computer Science software and Computer Engineering hardware subject matter knowledge related to semiconductor research — and will, thereby, bolster the students' competitiveness pursuing industry and/or graduate education opportunities.

The new program's activities include the following short-term outcomes: a stronger cohort of incoming first-year Computer Science students, via a pre-first-year summer bridge program and collaboration between Morehouse College Computer Science as well as Georgia Tech Computer Engineering on research proposals. Medium-term program outcomes include increased retention of African American Computer Science majors and an increase in the number of African American Computer Science majors at Morehouse College interested in and able to participate in more undergraduate research through collaboration with Georgia Tech Computer Engineering. In the long-term, Morehouse College's Computer Science majors will also have an opportunity to consider a newly designed Morehouse Computer Science to Georgia Tech Computer Engineering (CStoCompE) dual-degree pathway. If the newly designed CStoCompE pathway is successful, ultimately students starting their college experience in Computer Science at Morehouse could end with a dual degree in Computer Engineering at Georgia Tech, which is where they can gain noteworthy semiconductor manufacturing research experience.

While the program's main goal is to increase research opportunities for Morehouse College Computer Science majors, a secondary benefit could result in increased enrollment in African American Computer Engineering students at Georgia Tech via the partnership and the newly developed CStoCompE dual-degree pathway. However, whether or not Morehouse College students elect to exercise the newly developed CStoCompE dual-degree opportunity, undergraduates completing Morehouse College's Computer Science bachelor's program with added exposure to Georgia Tech research labs and projects through this partnership, as mentioned, will nonetheless graduate better qualified to address the national semiconductor

workforce demand and/or be well-positioned to continue educational pursuits in graduate programs related to the semiconductor stack and chips research and development.

As a work-in-progress submission, this manuscript presents a descriptive overview of the program's institutional partners, contents of collaboration, key stakeholders from each institution, program goals and activities, and results of the collaboration to date. As the student programming is currently ongoing and data collection is not yet complete, data from student stakeholders will be addressed in future publications of the program.

II. Institutional Overview

Situated less than three miles from Georgia Tech and with a total enrollment of approximately 2,200, Morehouse College is an undergraduate institution and is home to a Computer Science department renowned for the number of African American students it sends to doctoral programs in computing across the nation [8]. The department has five full-time faculty, with three tenured or tenure-track. The institution offers both a B.S. in Computer Science and a B.S. in Software Engineering. As of fall 2024, there are approximately 210 students majoring across both programs. Currently, none of the faculty have any active research projects in the area of semiconductor manufacturing.

Georgia Tech is a locally neighboring institution with an enrollment of approximately 48,000 (approximately 20,000 undergraduate students and approximately 28,000 graduate students). Electrical and Computer Engineering (ECE) at Georgia Tech has over 120 faculty members, with over 100 tenured or tenure-track. Georgia Tech's ECE program is recognized as one of the most competitive related to chips and semiconductor research and, according to 2025 undergraduate rankings, its Computer Engineering program ranks first among public universities [3]. As well, Georgia Tech, according to Diverse magazine, is the second largest producer of African American engineering graduates at the bachelor's level, second to North Carolina A&T [9]. Although a national leader in producing diverse engineers, Georgia Tech's African American engineering student enrollment is currently 8%, while African Americans represent 14.4% of the national population [4]. Georgia Tech's ECE department currently enrolls approximately 1,500 undergraduates, also with less than 8% African American student enrollment. As such, further work is necessary to increase African American student enrollment in both ECE as well as in Georgia Tech's engineering program writ large. Georgia Tech's enrollment data, however, does not necessarily diminish its high African American student graduation rate which is attributable to well-established student support programs, such as the Center for Engineering Education and Diversity (CEED); Black, Latino, and Indigenous in ECE (BLIECE); and EMBARC in ECE — all key contributing factors to successful African American completion rates, providing resources, support, networking, and a critical sense of belonging for Georgia Tech's African American Computer Engineering students [10]-[12].

The Morehouse College Computer Science department and the Georgia Tech Computer Engineering department are interested in collaborating due to the intersecting nature of both disciplines related to chips and semiconductor research and are further incentivized to explore the array of funding opportunities spurred by the bipartisan US Chips and Science Act as well as a host of corporate funding opportunities related to chips and semiconductor research,

manufacturing, and workforce development to address the national demand in consumer goods and products as well as national security technology innovation and advancement.

Although the CStoCompE dual-degree pathway is an innovative new offering rooted in the nation's need to produce more semiconductor research and development, this is not the first instance of Morehouse College and Georgia Tech collaborating in a dual-degree partnership. Both institutions are, in fact, linked to a pre-existing consortium designed for students to obtain bachelor's degrees from both institutions: the HBCU degree in a STEM area and an engineering degree from Georgia Tech. The pre-existing traditional dual-degree program provides a summer bridge program, tutoring, scholarships, internship access, and support for student organizations. Throughout the course of the traditional dual-degree partnership established in 1969, Georgia Tech ascended as a top-4 undergraduate engineering program [3], while Morehouse College experienced a decline in students participating in the traditional dual-degree program — noting that the majority of Morehouse College participants were historically Applied Physics or General Science majors — and not Computer Science majors transferring to Georgia Tech exclusively as Computer Engineering majors, which is the targeted, focused track for the newly developed CStoCompE dual-degree pathway.

III. Program Stakeholders

Key stakeholders include NSF collaborative planning grant PIs from Morehouse College, [Kinnis Gosha], Endowed Professor of Computer Science, and from Georgia Tech, [Laura Sams Haynes], Faculty and Director of Outreach in ECE, with both PI program directors serving as the research leadership team; Morehouse College Provost, [Kendrick Brown], and Georgia Tech College of Engineering, former Associate Dean of Academic Affairs, [Mitchell Walker, II], who executed the Memorandum of Understanding (MOU) establishing the new CStoCompE dual-degree pathway between both institutions; Georgia Tech ECE, Associate Chair of Undergraduate Affairs, [Elliot Moore], and Georgia Tech College of Engineering, Academic Program Manager Transfer Specialist, [Cedric Trice], who works in conjunction with both program directors and Morehouse College and Georgia Tech registrars to determine the CStoCompE dual-degree curriculum and designate the number of required transfer credits; Morehouse College postdoc, [Christopher Thomas], who serves as a program instructor and tutor; Morehouse College instructors, [David Cherry] and [Whitney Nelson], who manage the Summer Bridge Program curriculum and teach pre-first-year student summer sessions; Georgia Tech ECE PhD graduate assistant, [Christian Ford], who serves as tutor and mentor in the Morehouse College Undergraduate Student Support Lab; and Morehouse College students enrolled in the 2024 Pre-First-Year Computer Science cohort, who will also have access to Morehouse College Computer Science student programing and the newly developed CStoCompE dual degree pathway in partnership with Georgia Tech.

IV. Program Activities

A. Regular Meetings to Discuss Program Goals and Collaborative Funding Opportunities

The research leadership team meets monthly 1.) to discuss program goals, including establishing the pre-first-year summer bridge program, the undergraduate student support lab, and the CStoCompE dual-degree pathway; as well as planning participation in the graduate visitation

program, research lab tours, and conference and event travel; and also 2.) to discuss collaborative funding opportunities to expand research capacity at Morehouse College and research exposure for Morehouse College Computer Science majors through access to facilities and projects at Georgia Tech. Part of these virtual 1-hour monthly meetings focus on opportunities to support research collaboration. Monthly meetings may include guest attendees to discuss prospective collaboration goals. While these meetings concentrate on new proposal opportunities, they do not include meetings dedicated to the development of specific research proposals. Program leads also share opportunities to learn more about the research at Georgia Tech Computer Engineering through research talks, articles, and manuscripts. Introductions to Georgia Tech faculty members are made, as necessary. The results of the meetings are shared with the Morehouse College's Office of Research and Sponsored Programs.

B. Conference and Event Travel

To create a supportive environment, develop strategic collaborations, and identify resources for students interested in pursuing careers in Computer Engineering, the program's directors and the Georgia Tech ECE PhD graduate assistant will attend multiple conferences and events, including the National Society of Black Engineers (NSBE) annual convention. At conferences, the leadership team will share with companies and graduate programs the collaboration between Morehouse College and Georgia Tech and identify resources to share with student stakeholders. The same goals will be achieved by attending the Black Engineer of the Year Awards (BEYA) STEM Conference in future years of the program. Also, the leadership team will attend the IEEE SoutheastCon to learn from and expand the visibility of the collaboration to a wider selection of engineering academics and professionals in 2025. In 2024 and 2025, the PhD graduate assistant and the postdoc researcher are scheduled to attend the largest annual gathering of minority doctoral scholars in the world, the Southern Regional Education Board (SREB) Institute on Teaching and Mentoring, which provides underrepresented scholars strategies necessary to survive the rigors of graduate school, earn doctoral degrees, and succeed in the professoriate.

C. Georgia Tech's Research Lab Tours

Morehouse College students majoring in Computer Science will have access to lab tours visiting Georgia Tech Computer Engineering researchers. Two visits are planned for 2025 and are scheduled so multiple lab tours can occur during each visit. Labs interested in collaboration are prioritized.

D. Participation in Georgia Tech's Graduate Visitation Program

The Georgia Tech Graduate Visitation Program attracts highly competitive, diverse students from across the nation to campus, and the annual graduate recruitment three-day event provides an overview of Georgia Tech's graduate degree programs, including information on financial resources, application advice, and insight into decision-making when selecting graduate schools. Guest speakers present research talks and offer their knowledge about the graduate school application and selection process, graduate school funding, and how to present scientific research. The program directors will attend the event in year two of the grant. Event exposure will enlighten the Morehouse College program director regarding Georgia Tech's graduate degree offerings, including visits to academic units and research labs. The Graduate Visitation

Program offers a highly efficient engagement opportunity for the Morehouse College program director, streamlining meetings with potential Georgia Tech collaborators.

E. Summer Bridge Program

While Computer Science and Computer Engineering are interconnected disciplines in the field of semiconductor research and development, and research indicates a lack of African Americans trained in each discipline — additional research also reveals access to Advanced Placement (AP) Computer Science courses for African American high school students is limited and unequal compared to their white peers [13]. This lack of access is a contributing factor to the underrepresentation of African American students in Computer Science and Computer Engineering academic programs and careers. Studies have found African American students are less likely to attend high schools which offer AP Computer Science courses, and when they do, they are less likely to enroll in these courses compared to white students, with African Americans comprising only 3.8% of all AP Computer Science students nationally [14]. Additionally, research shows African American students who do enroll in AP Computer Science courses often receive lower scores than white students, indicating there may be disparities in the quality of instruction and/or resources available to African American students. With such a large population of incoming Morehouse College Computer Science majors potentially lacking the necessary coding experience to thrive as Computer Science majors, there is a diminished likelihood these students will persist and/or excel in fundamental coding courses, assignments, and group projects as Computer Science majors. Preemptively addressing this possible coding deficit, the Summer Bridge Program, piloted in 2024, focuses on bolstering coding skills and knowledge-base to increase the academic success and retention of incoming Morehouse College Computer Science majors and features the following curriculum: Introduction to Programming, Basic Python Syntax, Variables and Expressions, Conditional Code, Functions, Loops and Strings Iteration, Lists, Dictionaries, and Object-Oriented Programming. Summer Bridge Program student data was gathered in 2024 and will be addressed in 2025.

F. Undergraduate Student Support Lab

The Undergraduate Student Support Lab will provide academic support for students participating in undergraduate research and coursework for Morehouse College Computer Science entry-level programming courses (Programming I, Program II, Data Structures & Algorithms). The lab will also support students who have questions about Computer Engineering or graduate programs in computing. Students interested in cross-registering for Computer Engineering courses at Georgia Tech while at Morehouse College, via joint participation in the state-wide ARCHE cross-registration system, can seek advice in the Undergraduate Student Support Lab which, in addition to other lab staff, will also be staffed by the Georgia Tech ECE PhD graduate assistant who will provide tutoring and mentoring support. Additionally, the lab will serve as a resource for students interested in learning more about social events and research labs in the Georgia Tech Computer Engineering program accessible to Morehouse College Computer Science students beginning 2025.

V. Program Evaluation

An external evaluator is contracted to evaluate the program activities. Various evaluation activities will occur to collect the data needed to conduct the evaluation. Several evaluation activities are being undertaken with an aim toward understanding not just how many participants have been impacted but also to measure the effectiveness of the interventions, such as the Summer Bridge Program. The first evaluation tool utilized is "Project Fidelity Tracking." This evaluation will help create and populate a system of metrics associated with proposed program milestones, their proposed dates, target numbers, and responsible parties. The information in this system will be periodically updated throughout the program with careful attention to the context and reasons for deviations related to an examination of scholar outcomes. In year two of the program, the evaluation team will work with program leaders to submit a simple data request to the Morehouse College institutional research office. The purpose of this request will be to compare retention among first-year Computer Science students in the new cohort versus cohorts from prior years (who have not had the benefit of program activities).

The second evaluation activity is a "Post-Program Follow-Up Survey." Specific program events will be followed by a student feedback survey. These surveys will focus on formative feedback from students and will also examine the extent to which participants believe events' specific goals were met. These surveys will most notably be used for the Summer Bridge Program.

The third evaluation activity is an "Annual Scholar Focus Group." To obtain a richer understanding of the transformative nature of the program and how it may affect scholars, a subset of scholars will be asked to participate in an annual focus group. These interviews will revisit many of the areas explored in the survey, probing more deeply into issues related to academic and career impact and how the program could be made more supportive and effective.

The fourth and final evaluation activity is to interview program leads. All program leaders involved in program collaborative meetings and dual-degree structure decisions will be asked to participate in annual interviews. These interviews are intended to learn more about the impact on the program leads' research as well as any developments they think may be occurring within their institutions related to Computer Science and Computer Engineering research and research capacity.

VI. Current Status

Throughout 2024, both Morehouse College Computer Science and Georgia Tech Computer Engineering program directors met monthly with specific program stakeholders to discuss various related activities. Since the fall 2023 funding of the grant, a newly formed alliance led by Georgia Tech has emerged to support HBCUs pursuing semiconductor manufacturing funding opportunities. Additionally, in January 2024, the program directors and the program postdoc toured the Georgia Tech cleanroom laboratory, the largest in the southeastern US. Regarding conference and event travel, the Georgia Tech Computer Engineering program director attended the 7th Annual Collaborative Network for Engineering and Computer Diversity (CoNECD 2024) Conference, February 2024 in Crystal City, VA and the 50th Annual National Society of Black Engineers (NSBE) Convention, March 2024 in Atlanta, GA. Both Morehouse College and Georgia Tech program directors attended the HBCU CHIPS Network Kickoff, February 2024 in Washington, DC and the 2024 NSF CISE-MSI Research Expansion Grantees Meeting, hosted by NSF and managed by ASEE, May 2024 in Denver, CO and gave the following technical session

presentation: “An HBCU Program Strategy for Broadening Participation in Computing through Local Collaboration to Increase CHIP Related Professions.” The program directors also attended The SemiFoundation and Micron Semiconductor Curriculum Summit, September 2024 in Boise, ID and the Tapia Celebration in Computing Conference, September 2024 in San Diego, CA. They have also registered to attend the Southern Regional Education Board (SREB) Institute on Teaching and Mentoring, October 2024 in New Orleans, LA.

Completing a major program goal, the planning team launched the 2024 Summer Bridge Program, partially funded by Morgan Stanley, hosting thirty-five students in July 2024 for three weeks. In addition to Python programming instruction, the Summer Bridge Program also provided incoming first-year Computer Science majors at Morehouse College access to African American researchers who shared information about research opportunities at Georgia Tech. Four Georgia Tech African American featured guest speakers discussed: 1.) Georgia Tech and HBCU initiatives related to the US CHIPS and Science Act; 2.) the range of dual-degree engineering opportunities available at Georgia Tech; 3.) Georgia Tech’s cleanroom laboratory as the largest in the southeastern US with over 15,000 square feet of lab space situated in local proximity to Morehouse College; and 4.) Georgia Tech Research Institute with 1-billion-dollars in research funding and more than 200 clients in industry and government [15]. Intentionally targeting Georgia Tech African American research faculty as guest speakers for the Summer Bridge Program provided a clear vision for the African American pre-first-year participants to see themselves reflected in the image of the Georgia Tech African American guest speakers and thereby possibly envisioning themselves successfully engaging in the Morehouse/Georgia Tech CStoCompE dual degree pathway, ultimately helping increase the number of African American semiconductor manufacturing researchers [16]-17]. Student data collection and analysis for the Summer Bridge Program is currently ongoing, and future research will focus on findings of the student programming made possible through this collaboration.

VII. Acknowledgment

This program was funded by NSF Award #2318703 and Morgan Stanley.

References

[1] The White House, "Fact sheet: Chips and science act will lower costs, create jobs, strengthen supply chains, and counter china," Aug. 9, 2022. [Online]. Available: https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/. [Accessed: Aug. 26, 2024].

[2] S. Panchanathan, “Future semiconductors and microelectronics will require transdisciplinary research spanning materials, devices, and systems, as well as the engagement of the full spectrum of talent in the academic and industrial sectors,” NSF LinkedIn profile, Jan. 31, 2023. [Online]. Available: https://www.linkedin.com/posts/drpanch_nsf-launches-centers-for-pandemic-prediction-activity-7232500404146651136-gBa3?utm_source=share&utm_medium=member_ios. [Accessed August 22, 2024].

[3] U.S. News & World Report, “America’s best colleges 2025 edition,” Sep. 2024. [Online]. Available: https://www.usnews.com/. [Accessed: October 22, 2024].

[4] U.S. News & World Report, "2024 Best hbcus," Sep. 2023. [Online]. Available: https://www.usnews.com/best-colleges/morehouse-collge-1582. [Accessed: August 22, 2024].

[5] M. Moslimani, C. Tamir, A. Budiman, L. Noe-Bustamante, and L. Mora, "Facts about the u.s. black population," Pew Research Center, Jan. 18, 2024. [Online]. Available: https://www.pewresearch.org/social-trends/fact-sheet/facts-about-the-us-black-population. [Accessed: October 26, 2024].

[6] J. Margolis, R. Estrella, J. Goode, J. J. Holme, and K. Nao, *Stuck in the Shallow End: Education, Race, and Computing*, updated ed. Cambridge, MA, USA: MIT Press, 2017.

[7] S. M. Lord, R. A. Layton, and M. W. Ohland, "Trajectories of electrical engineering and computer engineering students by race and gender," *IEEE Transactions on Education*, vol. 54, no. 4, pp. 610-618, Nov. 2011.

[8] M. T. Nietzel, "Hbcus lead nation in african american baccalaureates who later earn doctoral degrees," *Forbes*, August 2022. [Online]. Available: https://www.forbes.com/sites/michaeltnietzel/2022/08/19/hbcus-are-nations-leading-institutions-for-African American-baccalaureate-graduates-who-Later-earn-a-phd/?sh=165151218903. [Accessed August 22, 2024].

[9] R. V. Sharpe, "Top producers of african american graduates in engineering," *Diverse: Issues in Higher Education*, vol. 35, iss. 1, pp. 15-19, 2021. [Online]. Available: https://diverseeducation.com/top100/. [Accessed August 22, 2024].

[10] J. A. Henderson, W. Junqueira, L. S. S. Benjamin, E. M. Hines, J. D. Alarcon, J. L Davis, and S. Cavazos. “Circle of success—An interpretative phenomenological analysis of how african american engineering students experience success,” *Journal of Engineering Education*, vol. 112, iss. 2, pp. 403–417, 2023. [Online]. Available: https://doi.org/10. 1002/jee.20509. [Accessed August 22, 2024].

[11] E. Knaphus-Soran, T. D. Pan, E. A. Riskin, S. Cunningham, S. K. Tanguay, and E. Litzler, "Who benefits most from a holistic student support program in engineering?," presented at the Collaborative Network for Engineering and Computing Diversity (CoNECD), Virtual, 2021. [Online]. Available: https://peer.asee.org/36141. [Accessed August 22, 2024].

[12] E. Litzler and C. Samuelson, "How underrepresented minority engineering students derive a sense of belonging from engineering," in Proc. ASEE Annual Conf. Expo., Atlanta, GA, USA, 2013. [Online]. Available: https://doi.org/10.18260/1-2-19688. [Accessed August 22, 2024].

[13] J. Wang and S. Hejazi Moghadam, "Diversity barriers in k-12 computer science education: Structural and social," in Proc. of the 48th ACM Technical Symposium on Computer Science Education, March 8-11, 2017, Seattle, WA, USA, pp. 615-620.

[14] J. Wang, H. Hong, J. Ravitz, and S. Hejazi Moghadam, "Landscape of k-12 computer science education in the us: Perceptions, access, and barriers," in Proc. of the 47th ACM Technical Symposium on Computing Science Education, March 2-5, 2016, Memphis, TN, USA, pp. 645-650.

[15] Georgia Tech Research Institute, “GTRI 2023 Annual Report,” Georgia Institute of Technology, Atlanta, GA 2024. [Online]. Available: https://gtri.gatech.edu/newsroom/gtri-2023-annual-report. [Accessed August 22, 2024].

[16] C. C. Samuelson and E. Litzler, "Community cultural wealth: An assets-based approach to persistence of engineering students of color," *Journal of Engineering Education*, vol. 105, no. 1, 2016, pp. 93-117.

[17] O. Villalpando and D. G. Solorzano, "The role of culture in college preparation programs: A review of the research literature," in *Preparing for College: Nine Elements of Effective Outreach*, W. G. Tierney, Ed. Albany, NY, USA: SUNY Press, 2005, pp. 13-28.