Uncovering the Impact of Online Programs in Broadening Participation in Computer Science: An Experience Report Studying Graduation Rates of Black Undergraduate Students

Talia Goldwasser
tgoldwasser@sagefoxgroup.com
SageFox Consulting Group
Amherst, Massachusetts, USA

Tyler Clark, PhD
tclark@sagefoxgroup.com
SageFox Consulting Group
Amherst, Massachusetts, USA

Rebecca Zarch
rzarch@sagefoxgroup.com
SageFox Consulting Group
Amherst, Massachusetts, USA

Alan Peterfreund, PhD
apeterfreund@sagefoxgroup.com
SageFox Consulting Group
Amherst, Massachusetts, USA

ABSTRACT

This paper explores the growing prevalence of all-online degree programs and their implications for the Broadening Participation in Computing (BPC) movement in the United States. We relate our experience as educational researchers encountering this trend in nationally available data sets. We explore the process of using disconnected data to uncover the story of online education, including how it challenged our assumptions about place-based intervention, and concerns for serving the growing distance-learning population in future BPC work. Our findings emphasize the need to connect data to a broader understanding of the landscape in support of developing equitable approaches in addressing disparities.

CCS CONCEPTS

• **Social and professional topics → Computer science education**.

KEYWORDS

Computer science education, Online learning, Distance learning, Black students, Undergraduate students, Broadening Participation in Computing

ACM Reference Format:
Talia Goldwasser, Tyler Clark, PhD, Rebecca Zarch, and Alan Peterfreund, PhD. 2024. Uncovering the Impact of Online Programs in Broadening Participation in Computer Science: An Experience Report Studying Graduation Rates of Black Undergraduate Students. In *Proceedings of the 2024 RESPECT Annual Conference (RESPECT 2024), May 16–17, 2024, Atlanta, GA, USA.* ACM, New York, NY, USA, 8 pages. https://doi.org/10.1145/3653666.3656111

RESPECT 2024, May 16–17, 2024, Atlanta, GA, USA

ACM ISBN 979-8-4007-0626-4/24/05
https://doi.org/10.1145/3653666.3656111

1 INTRODUCTION

How many Black undergraduates do you think earn their degrees in computer science in the state of New Hampshire every year? Probably not very many, right? Well, according to national postsecondary education data collated by IPEDS, in 2022 that number was 135, or 1.47% of the all computer science bachelor's degrees awarded to Black students in the U.S. Not far off, maybe — until you realize that New Hampshire's Black population is just 0.07% of the national Black population [4]. In other words, New Hampshire in 2022 graduated twenty-one times its expected share of the United States' Black CS students. These and related findings startled our team at SageFox Consulting Group when we undertook an exploration of state graduation rates in computer science with a focus on Black students, leading us down a rabbit hole of research as we sought to understand the surprising data we were seeing. Ultimately, we found that the BPC numbers in primarily-white states as well as at the national level are being driven by online education programs, which were on the rise in the U.S. even before the explosive growth triggered by the Covid-19 pandemic. Now, the prevalence of online education raises new questions for the place-based policies, programs and practices that the BPC movement has relied on.

This paper explores the intersection of equity, representation, and graduation rates in computer science (CS) education across U.S. states. The study originated from a fundamental question: What does representation in the graduation rates in CS programs look like in each state, particularly for Black students? This inquiry holds significant importance to us as the evaluation partner for the BPC Alliance IAAMCS (Institute for African-American Mentoring in Computing Sciences), as a major goal of IAAMCS is to increase the number of Black/African American students completing the Ph.D. in computing fields through a national mentoring model. For IAAMCS, knowing where students are getting their undergraduate degrees can help improve recruitment and support mechanisms. Our interest in the question was amplified by our partnership with a second BPC alliance, Expanding Computing Education Pathways (ECEP), where states work to broaden participation at the K–12 level through equity-explicit policy, practices, and programs. Representation in graduation rates was of interest to ECEP as the data could show an impact on the number of students by state going into CS degree programs. As we explored the data new questions

emerged, and we found understanding the connection between graduation rates and BPC-focused initiatives to be increasingly complicated by incomplete or incongruent data.

As the research unfolded, the need to understand the impact of online degree programs on graduation rates emerged as a critical factor. Using New Hampshire as a case study, where the data revealed an anomalous overrepresentation of Black male CS graduates due to online programs, the investigation expanded into a broader exploration of online education and the data available to support this inquiry. For example, we learned that despite a large number of Black bachelor's awardees graduating from Southern New Hampshire University (SNHU), the 6-year graduation rate of Black bachelor's students from SNHU is only 14% — but we don't know how this rate varies across the university's programs of study. The examination touched upon various aspects of data disaggregation and the challenges associated with obtaining comprehensive demographic data for online programs. Most importantly, we have no insight into the lived experiences of the students who complete an online bachelor's degree program in CS.

The paper navigates through the rabbit hole of online education data with a focus on graduation rates, and probing into the residential status of students. The examination extends to issues of commuting at institutions like Georgia State University, where a large student population may be affected by distance-only enrollment, and the University of Maryland's Global Campus which serves a significant military and government population. The exploration concludes by considering the demographic composition of online students, their pathways and their lived experiences. Through this comprehensive investigation, the paper aims to contribute valuable insights into the intricate dynamics of CS education, emphasizing the imperative of equity in shaping the educational landscape.

2 DESCRIPTION OF PRACTICE

This research emerged organically out of work that SageFox does with two of our partners, the NSF BPC Alliances IAAMCS and ECEP. Both alliances aim to increase the participation of underrepresented students in computing, but IAAMCS's mentoring model engages individual (particularly Black and African American) students at the undergraduate and graduate levels with the goal of supporting them in pursuing and completing a Ph.D. in a computing field, whereas ECEP works at the state level to address the structural and institutional barriers to diverse student engagement and success in state K–12 education systems. These two projects together led us to consider how investments in broadening participation in K–12 computer science might connect to changes in who is participating in computer science in higher education. Many states started prioritizing computer science in their education systems more heavily following President Obama's 2016 push for CS for All. In 2018 alone, eighteen different states established statewide standards for K–12 computer science instruction [6]. As of now, many from the first cohorts that were affected by this accelerated investment are finishing or have finished their undergraduate degrees. This provided us with an exciting opportunity to examine the success of states' pushes toward CS education more directly than we typically can at the K–12 level, by investigating their rates of computer science undergraduate degree completions. While we are interested in the rates overall, we focus particularly on the diversity that is present within each state's CS graduate population.

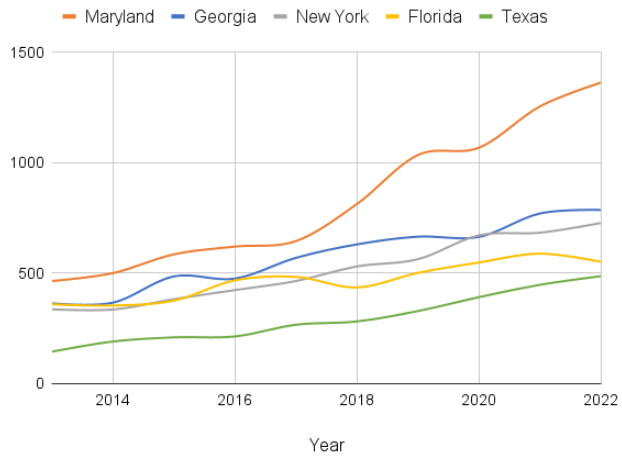

Figure 1: Black / African American CS bachelor's degrees by state (top five) 2013–2022.

As it happens, our work with IAAMCS recently involved collecting closely related data, on where in the U.S. Black students were earning the most CS undergraduate degrees. Some of the initial findings in this work surprised us. We expected states that were large *and* had significant African American/Black populations would top the list, and in fact the top states were Maryland, Georgia, New York, Florida, and Texas, all with large Black/African American populations. These states together accounted for 43% of Black CS bachelor's degrees in the U.S. in 2022. Yet, Maryland as a relatively small state outpaces all others with 1,363 degrees in 2022, 15% of the national total. Though we were surprised given the population of the state, we also know through our engagement with the ECEP state team that there has been significant investment in BPC in Maryland for over a decade [14, 15]. We were excited to see that this investment was apparently paying off.

Because of our work with ECEP and other projects with a national focus, members of our team were interested in expanding the degree completions dataset to look across all 50 states. Of course, many states have few Black CS degrees simply because their Black populations are small. To get a better picture of the CS success of Black students in these states, we decided to normalize our graduation data against the number of Black K–12 students in each state. While not a perfect measure, since many students go out-of-state for college, this would give us an idea of which states were successful at encouraging their young Black students into CS pathways, a question of interest to both our BPC partners. This analysis was performed on data published by the National Center for Education Statistics' (NCES') Integrated Postsecondary Education System (IPEDS), the federal repository of U.S. higher education data as reported by educational institutions, as well as its K–12 counterpart the Elementary Secondary Information System (ElSi). We decided to take a first look at data disaggregated by gender, since gender has a large impact on students' likelihood of going into a computer

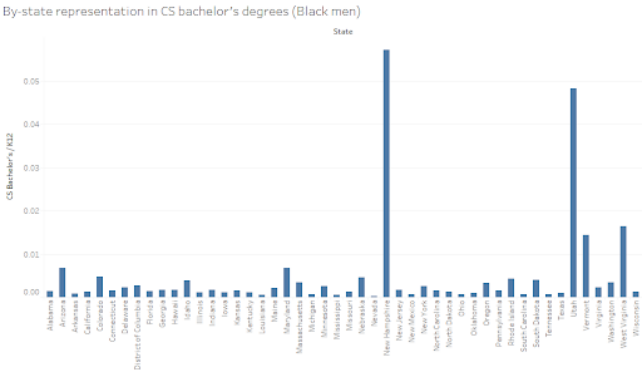

Figure 2: Initial visualization of Black men's representation in CS bachelor's degrees by state.

science major. As soon as we had produced the first visualization for male students, we saw very unexpected results. Two rather unexpected states stood out as having by far the most computer science bachelor's degrees earned by Black men, compared to their Black male K-12 populations — New Hampshire and Utah. We knew that there would be some noise in the measure due to small population size in some states, but these two were really exceptional, both over ten times the mean value. The raw data, when we checked to confirm what we were seeing, bore out our initial impression that something strange was going on. New Hampshire in 2022 had 155 Black male 12th graders [10] to 104 Black male CS bachelor's degrees [9], for a ratio of three to two.

Clearly, Black students were studying computer science in New Hampshire at truly disproportionate rates. It was one of our senior evaluators who figured out what was happening — they asked how many of those hundred and four graduates came from one particular school, Southern New Hampshire University. The answer? Ninety-four. In Utah, two hundred fifty-five out of two hundred seventy-six Black CS graduates (of any gender) came from Western Governors University. Both of these are large online programs that advertise widely around the country. We realized that New Hampshire's surfeit of Black CS undergrads weren't just not from the state originally — they might well have never even set foot there.

The next question to turn to, then, was how prevalent these online schools are overall and what share of CS degrees they account for. We quickly realized two things: that many students in the U.S. are getting degrees online (at institutions that offer some in-person programs as well as those that are entirely online), and that there is very little information available about these distance-only degrees. According to IPEDS, there were 17.6 million degree-seeking undergraduate students enrolled in U.S. institutions of higher education (IHEs) during the 2021–22 school year. Of these, 5.2 million — almost 30% — were enrolled exclusively in distance classes. However, IPEDS offers little in terms of ability to drill down into this number. No data on distance students' gender, ethnicity, program of study, or degree completion rate are available. IPEDS does allow us to find at which schools these students are enrolled, and therefore, in which states: the greatest absolute number were in California, but New Hampshire had the highest proportion at over

Table 1: Top states for distance education, 12-month enrollment 2021–22

State	Total distance students	Percent distance students
California	997,435	36.2%
Texas	411,479	26.5%
Arizona	366,754	54.6%
Florida	361,710	32.6%
Utah	190,606	50.3%
New Hampshire	184,275	80.6%
NATIONAL	**5,158,578**	**29.4%**

80% of the state's undergraduates. The vast majority of these were at Southern New Hampshire University. Additionally, the IPEDS Fall Enrollment category contains limited information on where distance students are located: in the same state/jurisdiction as the institution; in the U.S. but not in the same state/jurisdiction as the institution; in the U.S, state/jurisdiction unknown; outside the U.S.; or location unknown. In the fall of 2021, these were respectively 71.8%, 25.3%, 0.8%, 1.4%, and 0.7% of degree-seeking undergraduate distance students. For those 28.2% of students not in the same jurisdiction as their institutions, we currently have no way of knowing where they are located.

In addition to IPEDS, the National Center for Education Statistics (NCES) also publishes an annual Digest of Education Statistics that contains some information on distance education. The most relevant of the tables included is the Digest's Table 311.22, which shows "Number and percentage of undergraduate students enrolled in distance education or online classes and degree programs, by selected characteristics" [11]. These characteristics include gender, race/ethnicity, and undergraduate field of study, among others. This makes it a very useful supplement to the data available on IPEDS. Since it is a static table and not a database, however, these disaggregation categories cannot be combined; we cannot examine, say, computer science students who are Black. Furthermore, the publication of the Digest lags behind IPEDS data; the current most recent data available in this table are from the 2019–20 school year. This limits its usefulness at a time when distance education is changing rapidly. The table shows that as of that year, 28.0% of undergraduates studying computer and information sciences and 27.6% of Black undergraduates were earning their entire degree online, compared to 23.9% of undergraduates overall.

Other approaches include looking at the disaggregated statistics for just those institutions that offer online programs only. But many primarily online institutions (including Southern New Hampshire University) do have a small on-campus population, excluding them from this category. Additionally, many primarily in-person schools, such as Georgia State University, also offer large programs online [18]. In all, only 10% of distance-only undergraduate students in the U.S. are enrolled at distance-only institutions, not enough to glean reliable insight from. Georgia State is also notable for having a large commuter population of students who study on campus but do not live there. Such populations mean that measures based on campus residency, such as the Carnegie Classification's "Residential

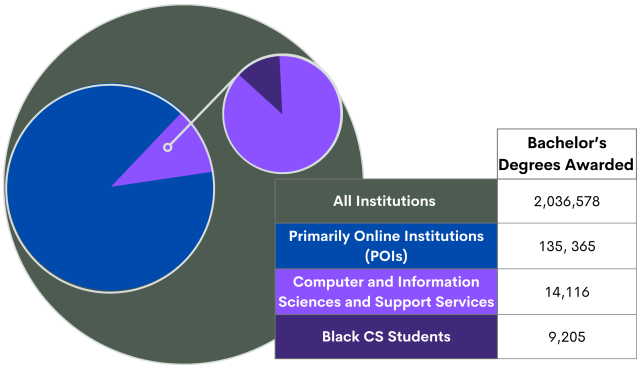

Figure 3: Drilling down from bachelor's degrees earned nationally in 2022 to those earned at primarily online institutions (POIs) in computer science by Black students.

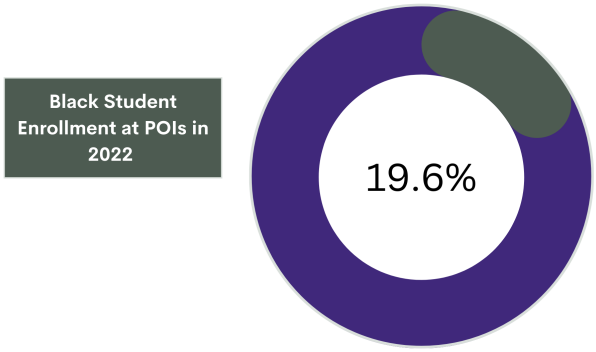

Figure 4: In 2022, 19.6% of degree-seeking undergraduate students at primarily online institutions were Black.

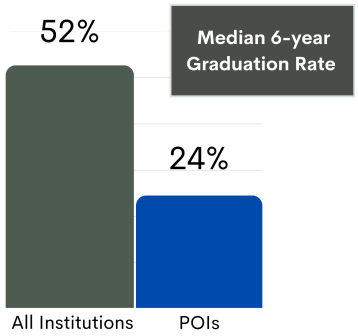

Figure 5: Primarily online institutions have notably lower 6-year graduation rates than typical (2022 data).

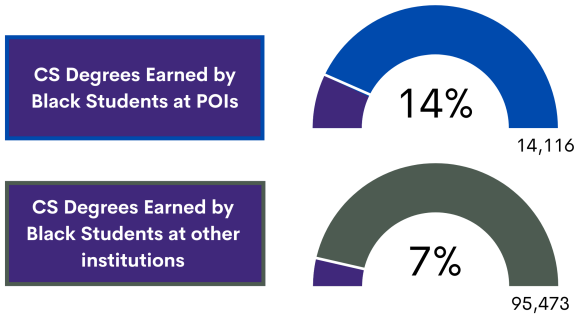

Figure 6: Primarily online institutions award a higher proportion of computer science bachelor's degrees to Black students than do other institutions (2022 data).

Character" categories [13], are not adequate for identifying distance students.

Our other option is to look at those institutions that, while not necessarily entirely online, offer mostly distance education. The Digest of Education Statistics offers some limited information on "primarily online institutions," which it identifies as institutions that "have more than 90 percent of students enrolled in exclusively distance education courses in the fall term [12]." For our purposes, we chose to slightly adapt that definition to look at institutions where at least 90% of, specifically, undergraduate degree-seeking students were enrolled exclusively in distance education courses. One hundred and seventy-three of the institutions on IPEDS fit this criterion for the fall of 2022. During that semester, these 173 institutions enrolled 867,108 degree-seeking undergraduate students, 98.2% of whom were taking only distance courses. This population accounts for 26.8% of the semester's online-only enrollment nationwide. Looking at IPEDS data for these primarily online institutions (POIs), we see:

- The 173 POIs awarded 135,365 bachelor's degrees in 2022, including 14,116 (10.4%) within NCES's CIP code 11, Computer and Information Sciences and Support Services.
  - By comparison, the other institutions listed in IPEDS awarded 1,901,213 bachelor's degrees, including 95,473 (5.0%) in CIP code 11.
  - 14.4% of CS degrees at POIs were earned by Black students, compared to 7.5% of other CS degrees.
- Of all degree-seeking undergraduate students enrolled at POIs for the fall of 2022, 19.6% were Black.
- As of 2022, the median 6-year graduation rate for POIs was 24%, compared to 52% for IPEDS institutions overall.

We must note that though the students at POIs are overwhelmingly enrolled online, they are not necessarily representative of the population of all online students, of whom they comprise only a quarter. Recall that 71.8% of distance students overall reside in the same state in which they are enrolled; for distance students at POIs, this number drops all the way to 17.1%, suggesting that these populations are very different in character. IPEDS' new Outcome Measures survey component shows other ways in which POIs' student bodies differ from those of traditional institutions; students at POIs are 1.4 times as likely as those at non-POIs to be enrolled part-time, and 1.9 times as likely to be non-first-time (e.g., transfer-in) students. (Though these comparisons are based on total enrollment, not just distance students.) Nevertheless, these data are

troubling. They indicate clearly that large numbers of CS students, particularly Black CS students, are enrolling in online programs, and that many of those who enroll do not go on to earn the degree they came for.

Our experience with uncovering the landscape of online education left us with more questions than answers. Important questions remaining are: Who is enrolling in online education? Are they students who might have gone to more traditional programs, or are they coming from a different population? What is the trajectory of students who successfully complete an online degree? The data are insufficient to form a coherent picture of who these students are and their lived experiences around distance education.

3 POSITIONALITY STATEMENT

SageFox Consulting Group works closely with equity-focused programs in the educational space, both as an evaluator to some projects and as an active participant in others. As such, it is the core of our practice to explore and interpret the educational landscape at both the large and the small scale. SageFox has a long history of collaboration in the Broadening Participation in Computing (BPC) space through Alliance efforts like IAAMCS and ECEP, and through smaller grants. Our work has given us a long-term view of the BPC space, from identifying indicators of equity early in the BPC movement [19] through more sophisticated landscape analysis [8] which is critical to contextualizing and understanding the dynamic landscape in which educational goals are pursued. We frequently make recommendations to both local and regional programs about how they can best support their students, particularly underrepresented students in STEM. All of this requires that we maintain a deep knowledge of the dynamics at play in the education system. Our project partners need to understand student needs in order to advocate for them.

In our research team at SageFox Consulting Group, we bring together diverse backgrounds, experiences, and expertise to address the multifaceted aspects of computer science education and workforce development. Our collective commitment to equity, diversity, and inclusion informs our approach to research and evaluation.

This paper was led by Talia Goldwasser, a junior member of the SageFox team who holds a bachelor's degree in Mathematics and a minor in Computer Science. While in college she spent one semester taking entirely online classes due to the Covid-19 pandemic, but otherwise studied in-person. Her academic background and work with young students enriches our team with practical insights into the educational landscape. The second member, Dr. Tyler Clark, holds a doctoral degree in Educational Research Methodology (ERM) with a focus on Program Evaluation. Having graduated from the University of North Carolina Greensboro and a two-time alumna of North Carolina Carolina Central University (a Historically Black College and University-HBCU), her academic journey reflects a deep commitment to equity and inclusion and its implications for discrimination contributes valuable insights to our study on online education, graduation rates, and representation in computer science. Our team is led by the organization's Director, Rebecca Zarch, who has worked in the BPC space for 15 years to build local capacity for using data to understand and inform change efforts. She holds an MBA with a Social Policy focus and an M.Ed, which unite education and complex change efforts. The final member of the team is the Executive Director, Dr. Alan Peterfreund, who has decades of experience exploring data in support of broadening participation in CS and Engineering and a doctoral degree in planetary geology. Together, our diverse team is poised to conduct a comprehensive examination of the intricate dynamics of computer science education. We recognize the importance of inclusive and equitable practices in education programs, emphasizing the need for informed discussions on equity in education. Our work may be limited by our relative inexperience in exploring the role of online education in the current educational ecosystem, particularly in light of the Covid-19 pandemic and in support of BPC. Yet we hope our collective commitment to challenging perspectives and promoting diversity ensures a holistic and well-rounded approach to the study at hand.

4 LIMITATIONS AND ASSUMPTIONS

4.1 Limitations of Scope

The population examined in this study is restricted to degree-seeking undergraduate students at IHEs in the United States. Only students who were taking exclusively distance courses during a given time window are considered as distance students, excluding those in partially-online programs or hybrid classes. The study also focuses on Black students, without examining other underrepresented groups. A fuller picture of distance education and its impacts on BPC would require expanding beyond these constraints.

4.2 Data Availability and Quality

The study confronts limitations associated with the availability and quality of data from various sources, particularly the Integrated Postsecondary Education Data System (IPEDS). The accuracy and reliability of our findings hinge on the assumption that the data collected from these sources, some of which are still in a provisional form, offer a comprehensive and accurate representation of the educational landscape. Potential inconsistencies or gaps in the data pose a challenge and could impact the study's overall robustness.

4.3 Online Program Demographic Data

A significant limitation emerges in the acquisition of detailed demographic data for online programs. The study grapples with challenges in obtaining comprehensive information on the backgrounds and characteristics of students engaged in online education. This limitation may impede a nuanced understanding of the diverse student populations within online programs. The assumption here is that the available data, such as enrollment figures, provide sufficient insights into broader trends within online education, notwithstanding potential gaps in demographic information.

4.4 Swirling

Even if better data become available, privacy concerns mean that they will be provided on the aggregate level. While sufficient for many purposes, aggregate data have difficulty addressing questions like: Do students who participate in distance education tend to spend their whole college careers there? How many people are transferring into distance education programs? How many are

transferring out? While we can find the transfer rate for a particular program, interchange between the world of distance education and the more familiar world of in-person learning is a gap in our understanding. When we talk about "distance students," are we discussing a population that will start, continue and finish their college education online, or one with more complex trajectories? This has important implications for our understanding of distance students' experiences and what forms of support they most need.

4.5 Causation vs. Correlation

While the study identifies correlations between online programs and graduation rates, a critical limitation lies in the inability to establish causation. The analysis does not delve into other potentially influential factors that might contribute to observed disparities in graduation rates. Caution is warranted in attributing outcomes solely to the presence of online programs. The assumption is that the correlations identified offer valuable insights into potential relationships between online education and graduation rates, recognizing the need for additional research to establish causative links.

4.6 Temporal Factors

The temporal dimension introduces another consideration, as the study relies on data available up to the knowledge cutoff dates imposed by our data sources, with the most recent data currently available being from the fall of 2022. Changes in policies or educational landscapes after this date may not be reflected in the analysis. The assumption is that the identified trends and patterns remain relevant and applicable to the research's timeframe, recognizing the potential for changes beyond the knowledge cutoff.

5 IMPLICATIONS

5.1 Equity in Computer Science Education

The study sheds light on the critical intersection of equity, representation, and graduation rates in computer science (CS) education across U.S. states. By emphasizing the disparities uncovered, particularly for Black students, it calls attention to the urgent need for understanding the role that online education has in fostering equitable approaches to CS education. Online education appears to be an important mechanism for increasing the number of Black students with a CS degree; however, these programs do not appear to be more successful in graduating most students who start the program. The findings underscore the importance of addressing systemic issues that contribute to uneven outcomes and adopting inclusive practices that prioritize underrepresented groups.

Although this paper focuses on African American/Black students because of our original question, this is not the only group to consider when taking an equity perspective. Gender, other racialized groups, people with economic disadvantage, English Language Learners and students with disabilities are all likely to uniquely experience online education. As online programs expand, the implications for students with disabilities in particular remain not fully understood, as noted by Bakia et al. [1]. Ensuring access for students with disabilities in online learning is a complex task, requiring adherence to universal design standards for both web and printed documents.

5.2 Online Programs and Graduation Rates

The study highlights the substantial impact of online programs on graduation rates. This underscores the necessity of a nuanced understanding of the challenges and opportunities posed by online education. Institutions and policymakers must critically assess the implications of online programs on student success, ensuring that strategies are in place to mitigate potential disparities. There has been significant scholarship in understanding the high-impact practices that support students in CS, but these often assume a place-based model and may not easily translate to an online environment [3, 16].

5.3 Cost of Offering Online Education

In addition to accessibility, there are also cost considerations necessary to acknowledge in this space. While a considerable body of existing literature argues that online education can lead to cost reductions [1, 5, 7], it is crucial to recognize that the cost dynamics in online education are multifaceted. Proponents of online education often emphasize factors such as reduced infrastructure costs, elimination of commuting expenses, and the potential for scalability in reaching a larger student population, but there is also a need to invest in licensing fees for educational technologies, faculty training, and the development of engaging digital content [2]. While online schools, typically more cost-effective, might be subject to less stringent regulation, it's important to clarify distinctions. For instance, Trump University, now-defunct, exemplifies the potential risks [17]. However, it's crucial to note that for-profit institutions often bear the brunt of criticism for lax oversight. We must acknowledge these distinctions between accredited and non-accredited, as well as public/non-profit versus for-profit universities as we ensure not to make blanket assumptions of lax regulation across all online programs.

6 NEXT STEPS AND CONCLUSION

The study's findings underscore the importance of broadening our conception of comprehensive interventions across policy, institutional practices, and ongoing research to foster equity in CS education. In terms of policy, it is imperative that policymakers prioritize equity, particularly by addressing graduation rate disparities affecting Black students. In our work as evaluators, we value the narratives of students who participate in the education ecosystem. This work has raised important questions about students graduating with CS degrees from online programs including:

- Where did they begin their educational journey? How might credits transfer between programs? Are students seeking an additional degree or first degree?
- What are the current life circumstances that make online education the best option?
- How do the marketing practices of online institutions potentially impact the demographic makeup of student enrollment?
- As higher education gets demonized politically, are people looking to online education environments as a safe and efficient avenue to an education credential and employment?
- What is the time to degree as compared to place-based CS programs?

- How do students build community and professional networks?
- What is the career trajectory of students who complete online CS degrees?

For each of the above questions it is important to understand the variation between students. The authors assume that there are a range of factors influencing individual student choice to go into an online program, their experience in that program and the resulting career opportunities.

Much of what we know supports students in their pursuit of a CS degree relies on quality data to help shine a light on potential areas of successes or challenges. Institutions must prioritize the collection and reporting of comprehensive demographic data for online programs to gain a nuanced understanding of their student populations. This information is crucial for identifying areas of improvement and implementing targeted support mechanisms to address disparities and promote inclusivity. Qualitative data to help understand the lived experiences can help shape better policy, programs and practices in support of students.

Prior experience through IAAMCS and ECEP underscores the importance of establishing comprehensive support structures to champion students' success. Many high-impact practices are highly relational, developing connection and community between students and with faculty. Understanding the dynamics of the relationships faculty form with students is crucial in terms of advocacy, as faculty members can serve as powerful advocates for students, influencing their academic journey and overall success. We pose the question: What does this relationship look like via an online platform? Can these connections be made? These questions highlight the necessity of fostering a collaborative and supportive ecosystem within educational institutions to ensure that both students and faculty are equipped with the resources and relationships essential for academic success of the students.

An area for further exploration involves identifying and implementing robust support mechanisms tailored to the specific needs of the students. This could include various support services, including academic advising, financial planning assistance, and career guidance. Recognizing that faculty play a pivotal role in shaping the student experience, there is a concurrent need to assess whether they require additional support and resources to effectively engage with and advocate for these students.

Our research agenda emphasizes the necessity for further investigation into the causal factors contributing to graduation rate disparities and the impact of online programs on student outcomes. A holistic exploration of students' experiences, support structures, and potential barriers in online education is recommended. Additionally, adopting a longitudinal approach will provide valuable insights into the evolving landscape of CS education and the effectiveness of interventions over time.

In terms of overarching recommendations, we propose three key themes: research, practice, and policy. In the realm of research, there is a call for investigations into the holistic factors influencing graduation rate disparities, the long-term impact of interventions, and a detailed exploration of online education's effects on student success. For institutional practices, a shift towards equity-centered approaches, including mentorship programs, targeted interventions, and robust support structures for online learners, is suggested. The collection of comprehensive demographic data for accurate institutional depictions is deemed imperative. Regarding policy, the study recommends the formulation and implementation of policies prioritizing equity in CS education, accompanied by guidelines for online programs to ensure inclusivity and address potential disparities in graduation rates. Increased investment in K–12 CS education is also urged, especially in states with identified disparities.

It is easy, when we discuss the education landscape, to think only about the familiar models that form the bulk of our prior experience. However, in the face of changing practices, we as researchers, educators, and policymakers must be aware of and responsive to the new challenges brought about by new modalities in education. The implications, next steps, and recommendations derived from this study underscore a collective responsibility to foster equity in computer science education. Through targeted research, informed practices, and equitable policies, the field can strive towards advancing inclusive education for all students, irrespective of their demographic backgrounds or mode of learning.

ACKNOWLEDGMENTS

This work was produced under NSF grant numbers 2216622 and 2137834. Any opinions, findings, and conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The authors would like to thank Mika Hurd for producing the visualizations.

REFERENCES

[1] Marianne Bakia, Linda Shear, Yukie Toyama, and Austin Lasseter. 2012. *Understanding the Implications of Online Learning for Educational Productivity.* Technical Report. Office of Educational Technology, US Department of Education.
[2] Sharon Jeffcoat Bartley and Jennifer H Golek. 2004. Evaluating the Cost Effectiveness of Online and Face-to-Face Instruction. *Journal of Educational Technology & Society* 7, 4 (2004), 167–175.
[3] Jayne E Brownell and Lynn E Swaner. 2012. Five High-Impact Practices: Research on Learning Outcomes, Completion, and Quality. *Peer Review* 14, 3 (2012), 29–30.
[4] United States Census Bureau. 2020. Table P1 | Race. https://data.census.gov/table/DECENNIALPL2020.P1?q=&y=2020&d=DEC%20Redistricting%20Data%20(PL%2094-171)
[5] Igor Chirikov, Tatiana Semenova, Natalia Maloshonok, Eric Bettinger, and René F Kizilcec. 2020. Online Education Platforms Scale College STEM Instruction with Equivalent Learning Outcomes at Lower Cost. *ScienceAdvances* 6, 15 (2020).
[6] Code.org. [n. d.]. State Tracking 10 Policies (Public). https://docs.google.com/spreadsheets/d/1YtTVcpQXoZz0IchihwGOihaCNeqCz2HyLwaXYpyb2SQ/pubhtml#
[7] Rita Day and Brian Mulligan. 2015. Making Free Online Learning Sustainable Through Reduction of Production Costs. *Higher Education in Transformation Conference* (2015), 273–280.
[8] Jordan Esiason, Phebe Palmer, and Alan Peterfreund. 2023. Engineering PLUS Data Landscape Framework. https://docs.google.com/document/d/1Ub84HIysJ9qv-83QmqofsGZCsRLgC5LJeIopFEriMow/edit#heading=h.vknvm8ffti2g
[9] National Center for Education Statistics. [n. d.]. Integrated Postsecondary Education Data System. https://nces.ed.gov/ipeds/use-the-data
[10] National Center for Education Statistics. 2022. Elementary / Secondary Information System (ElSi). https://nces.ed.gov/ccd/elsi/#:~:text=The%20Elementary%2FSecondary%20Information%20System,Private%20School%20Survey%20(PSS).
[11] National Center for Education Statistics. n.d. Digest of Education Statistics. https://nces.ed.gov/programs/digest/d22/tables/dt22_311.22.asp?current=yes
[12] National Center for Education Statistics. n.d. Digest of Education Statistics. https://nces.ed.gov/programs/digest/d22/tables/dt22_311.33.asp?current=yes
[13] Carnegie Foundation. 2024. Size & Setting Classification. https://carnegieclassifications.acenet.edu/carnegie-classification/classification-methodology/size-setting-classification/
[14] Megean Garvin, Michael Neary, Kayla Carrigan, and Marie desJardins. 2018. Maryland Computing Education Growth From 2011–2016. *RESPECT 2018* (2018).

[15] Megean Garvin, Rebecca Zarch, Jeff Xavier, and Sarah Dunton. 2020. Maximizing BPC through Maryland's Annual State Summits. *RESPECT 2020* (2020).
[16] Cindy A Kilgo, Jessica K Ezell Sheets, and Ernest T Pascarella. 2015. The Link Between High-Impact Practices and Student Learning: Some Longitudinal Evidence. *Higher Education* 69 (2015), 509–525.
[17] Steven Perlberg. 2013. New York Attorney General Sues Donald Trump and his Alleged 'Sham' 'University' – Says Students 'Defrauded' out of $US40 Million. *Business Insider Australia* (2013). https://web.archive.org/web/20160823134115/http://www.businessinsider.com.au/trump-university-sued-2013-8
[18] Georgia State University. n.d. Georgia State Online. https://online.gsu.edu/
[19] Rebecca Zarch, Alan Peterfreund, Burçin Campbell, Heather Wright, Monica M. McGill, Julie M. Smith, Talia Goldwasser, and Tyler Clark. 2024. *Building Shared Measures for Broadening Participation Initiatives.* Technical Report. https://doi.org/10.62572/jZamU35