Breaking Down Barriers: Supporting Minoritized Learners in Undergraduate Computer Science Courses

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ABSTRACT

This work addresses the structural inequities that prevent minoritized learners from succeeding in introductory Computer Science (CS) courses at two liberal arts colleges in the Northeastern United States. In this work, we conducted a literature review and surveyed students in introductory CS courses. We were able to survey 43 students with various backgrounds, identities, and experiences in CS courses at those institutions. We found that first-generation and low-income students reported feeling under-prepared for CS1 and had significantly lower ratings of self-efficacy. More broadly, minoritized students struggled with finding a sense of belonging and persisting in the CS major. Many students felt supported by the TAs, but a significant portion of students reported not having a support system beyond their peers. A number of students reported that CS1 was too difficult, time consuming, not taught clearly, and inaccessible due to classroom policies. Based on these findings, we make the following recommendations: implementing CS0, standardizing CS1, preparing CS peer educators, ensuring equitable access to information, and shifting the departmental culture. Following through on these changes will make CS more inclusive, accessible, and welcoming toward minoritized students.

CCS CONCEPTS

• **Social and professional topics** → **Computer science education**; **CS1**; **Computational thinking**; **User characteristics**; *Race and ethnicity*; *Gender*; *Sexual orientation*; *People with disabilities.*

KEYWORDS

CS0, self-efficacy, minoritized learners, diversity, accessibility, belonging, Asset-Based Pedagogy, Culturally Sustaining Pedagogy

1 INTRODUCTION

Minoritized learners are those who have been socially, politically, and/or economically disenfranchised by systems of power and privilege in our society. In this work, we have chosen to highlight the experiences of women, transgender and gender non-conforming (GNC), BIPOC (Black, Indigenous, and People of Color), FGLI (first-generation and/or low income), neurodivergent (Autistic, ADHD, dyslexic, etc.), Disabled, and LGBTQ+ CS students. While members of any of these groups may have vastly different experiences in the classroom, minoritized identities can result in compounding and intersectional experiences of oppression [4]. Addressing their needs is essential to diversify our field, as only 18% of CS degrees go to women, Black, and Latino students [22]. This diversity is paramount because it introduces new perspectives, ways of solving problems, creativity, and innovation. However, it also means that we must adapt CS courses to embrace different ways of learning, knowing, and being. In higher education, this work starts with CS1.

This work is necessary because minoritized students are not being served by existing introductory CS courses. Issues like preparedness for CS1 [15, 26, 27], retention of minoritized students [8, 29] and the lack of qualified, diverse faculty [11] are pervasive in CS. While addressing these issues is necessary to improve the experiences of all CS students, it is particularly necessary for minoritized students. Given a state of institutional failure of minoritized CS students, this work proposes the following research questions:

(1) How do students perceive their success in CS1? How is self-efficacy impacted by prior exposure to CS concepts and/or support from advisors, instructors, and peers?
(2) What factors keep students from continuing in CS? How can they be mitigated?
(3) How might minoritized students experience CS1 differently than their peers? What factors impact their decision to continue taking CS courses?
(4) How can we improve the course content, structure, delivery, support, and/or resources to support minoritized students?

These questions emphasize the collective responsibility of instructors, peer educators, and university-level support staff to acknowledge the different experiences that students have in their courses. Additionally, they call for an active commitment to making learning spaces safe, supportive, and welcoming to all.

1.1 Background and Related Work

1.1.1 CS0 and CS1. The typical entry point to the CS major is CS1, an introduction to programming in languages like Python or Java. This experience is intended to teach critical thinking and problem solving skills that are necessary to create an algorithm [21]. While programming plays a significant role in modern CS, the design and logic of the code are just as important. Learners may benefit from alternate entry points that do not rely on "learning by doing."

Entry points to consider include CS0 and CS1X. CS0 would be taken before CS1 by students with little CS experience and non-majors. It would cover high-level material from sub-fields such as HCI and AI/ML, prioritizing computational thinking, logic, and problem solving. CS0 courses are "breadth-first" CS courses that survey the discipline as a whole, with exposure to but not an emphasis on programming. These courses have been shown to increase success rates in CS1 and interest in the CS major [7]. Another approach is to create sections of CS1 to help students without prior experience transition directly into the major, such as Cohoon and Tychonievich's CS1X [8]. This course covered the same content as CS1 and allowed students to enter the same CS2 course, but significantly improved the enrollment and retention of minoritized

students. CS1X was "designed to encourage the interest and retention of a diverse community" [8]. These approaches can help even the playing field for students by the time they reach CS2 [17, 26].

1.1.2 Retention and Self-Efficacy in CS. Some of the biggest concerns in the literature have been the failure and retention rates in CS. In 2006, many U.S. CS1 courses reported drop rates between 30-50%, and 1/3 of those who remained would fail [16]. As of 2017, the failure rate had decreased to 28%, which was believed to be "not alarmingly high." [1]. Despite what many believe, CS is not more inherently difficult to teach or learn [5]. Instead of asking why our students are failing, we must ask how we can best set our students up for success. We can make them more comfortable asking questions, re-explain concepts, and reduce their anxiety around the course [27]. We can add smaller identity-based sections, which has been shown to improve retention, confidence, and collaboration [29]. We can offer supplemental material and support for students without prior math and CS background, which can improve student dispositions and outcomes [15, 26, 27]. Finally, we can increase their persistence and resilience by building their self-efficacy, or "judgment of their ability to execute tasks or achieve mastery" [12].

1.1.3 CS Pedagogies. Many pedagogical practices have been applied to CS education to improve student pass rates [25] as well as encourage interactivity, collaboration, and communication amongst students [19]. These include the flipped classroom [20], problem-based learning [10], pair programming [19], project-based learning [3], feedback surveys [15], and more [23].

One approach that has not been sufficiently researched in CS education is Asset-Based Pedagogy and its successor, Culturally Sustaining Pedagogy (CSP) [2]. These theories are designed to for educators to take an active role in recognizing students' strengths and "make teaching and learning relevant and responsive to the languages, literacies, and cultural practices of students" [18]. This work has been applied to CS summer programming for youth, demonstrating that CSP improves agency/ autonomy, relationality, and embracing many "ways of knowing" in CS [9].

1.2 The XYCo

In order to answer our RQs, we considered the case of College X (CX) and College Y (CY). These small liberal arts colleges in the U.S. Northeast make up the XYCo. Both serve about 1400 undergraduate students on wealthy suburban residential campuses. While CX is coeducational, CY is a Historically Women's College (HWC) which admits women and GNC students. While students in the XYCo may take courses or major in CS at either college, CY CS students are predominantly women and GNC. Both colleges have struggled to maintain enough faculty to meet demand for CS courses, resulting in the elimination of CX's CS0 course. Other paths to entry in the CS major include CX's CS1+2 course for students with extensive programming experience and CY's CS1X approach taught in Processing, with a focus on computational creativity and computer graphics [28]. CS students can seek peer support with peer educators (TAs and peer tutors) at no cost.

1.2.1 The Fall 2020 Strike. CX and CY have legacies of student activism on their campuses, including the Fall 2020 Strike. During this time, a group of BIPOC students in the XYCo "organized the Strike 'in response to the continued racism and anti-Blackness perpetrated by... administration.'" [24]. The majority of students on campus publicly supported the Strike by not attending classes, jobs, or extracurriculars. Instead, they attended teach-ins, rallies, and met with administration to fund initiatives for minoritized students.

Many departments across the XYCo took time during and after the Strike to offer events to address anti-racism within their fields. At one town hall, a CY CS faculty member and students developed a set of goals for the department to work toward. These included increasing the number of underrepresented students taking CS courses, declaring a major or minor, participating in CS-related extracurricular activities, finding jobs or internships, as well as feeling welcomed, valued, and supported in the department. They identified numerous challenges to achieving these goals including students' preparation before college, how time-consuming CS courses are, impostor syndrome, the lack of representation in the department, inaccessible course policies, the lack of communication about opportunities, and students feeling that they did not have a voice in decisions made by the CS department. Despite these issues being brought to the CY CS department, no action was ever taken.

1.2.2 Project Reboot. At CX, many CS students are involved in CodeX, a student organization dedicated to the technology field. In Spring 2022, as a result of longstanding issues in the CX CS department, they distributed a survey and compiled a list of recommendations entitled Project Reboot, summarized below [13].

CodeX first addressed a shortage of faculty which resulted in CS1 being taught primarily by new instructors. This prevented students from getting solid foundational material, which carried over into higher-level courses. CodeX also addressed CS1 over-enrollment, which they claim led "to many students having to abandon [CS] as a major" [13]. They questioned the necessity of CX's CS1+2 course, claiming students should go into either CS1 or CS2. CodeX noted that an "uneven distribution of experience in classes... can lead to imposter syndrome" [13]. This particularly affected students with Java experience, since the placement test was in Python. Additionally, the CS website listed outdated course numbers, forcing students to contact instructors individually to enroll in their courses. CodeX argued that "channels for students to provide direct feedback" to the department are needed [13].

Next, CodeX addressed issues faced by peer educators. They detailed the lack of training, orientation, and resources available to TAs. Although CX TAs grade assignments, this is done "without expectations or examples of what performing these tasks well looks like" [13]. Peer tutors do not have any access to course materials except what is sent by their tutees, which impedes their ability to prepare for sessions. Peer tutors' lack of guidance and preparation may detrimentally impact student experiences in CS1. This particularly impacts first-generation students, who are less likely to understand the "hidden curriculum" or seek resources like instructor office hours when they are struggling [14].

2 METHODS

In this study, eligible XYCo students were surveyed about their experiences in CS1. The study received IRB exempt status from CY as protocol number 24-048. No compensation was provided to the participants. Participants were recruited using the CS department

mailing lists (which includes all CS students), flyers, word-of-mouth, and snowball sampling. The first author utilized their personal connections with tutees and CS majors in the recruitment process. All students were encouraged to give their honest feedback and were not pressured or obligated to participate. The survey was open to students who had completed at least two weeks of a XYCo CS1 course (the end of the add/drop period). We attempted to mitigate survivorship bias by incorporating feedback from students who were unable to complete CS1.

The survey included demographic questions, Likert scales, and short-answer questions. Students were asked about the workload, difficulty, grading, and support systems in CS1. They were also given the option to discuss their personal experiences, challenges, learning needs, and their opinions on a hypothetical CS0 course. The questions chosen for the self-efficacy scale were adapted from the New General Self-Efficacy Scale (NGSE) [6]. Self-described demographic factors were coded into categories to ensure anonymity. For race, the final categories were: white, BIPOC, and two or more races. For gender, the categories were women, men, and GNC. For those who decided to self-describe their disability, they were categorized as psychological (anxiety, depression, Autism, ADHD), physical, and learning disabilities.

All statistical tests were performed in Jamovi using a significance level $\alpha = .05$ and non-directional hypotheses. The short-answer responses were meticulously reviewed by the authors to identify statements based on shared sentiments by the participants. For example, students were marked in agreement with the statement "I found the TAs helpful" if they said something like "the TAs helped me get the information MUCH clearer" (P24) or "I went to enough TA hours to get all my questions answered" (P25). While responses tended to align with short-answer questions on those topics, all written feedback was considered, including several "elaborate as desired" responses. Written data was reviewed at least twice per participant to ensure that information was not taken out of context or conflicting. These estimates are conservative as the authors did not indicate agreement with responses that were not clearly in favor. It is important to note that percentages were calculated out of all participants who answered a minimum of one short-answer question and most participants did not answer every question.

3 RESULTS

In this study, 43 students opted to participate out of ≈ 600 XYCo students who took CS1 in Fall 2020-Spring 2024, indicating a 7.17% response rate. Most participants (83.72%) responded to at least one short-answer question. All answers were considered in the results.

3.1 Demographics

For the class years 2024-2027, CY students made up 18.60%, 9.30%, 13.95%, and 4.65% of respondents. Similarly, CX students made up 13.95%, 4.65%, 23.26%, and 11.63% of respondents. The other identity-based demographics are as follows:

- Race: white (58.14%), BIPOC (25.58%), two or more (11.63%)
- Gender: women (44.19%) GNC (30.23%), men (20.93%)
- LGBT: yes (51.16%), no (37.21%), unsure/ questioning (6.98%)
- FGLI: no (69.77%), yes (25.58%), unsure/ questioning (2.33%)

A chi-square test of association was used for BIPOC and FGLI identities, $\chi^2(1, N = 40) = 8.03, p = .005$. This result is significant and suggests that BIPOC and FGLI identities were correlated.

Additionally, 20.93% of respondents identified as disabled and 9.30% were unsure or questioning. Of those who felt comfortable identifying their disabilities (noting some had multiple disabilities), 72.73% had a psychological disability, 36.36% had a physical disability, and 9.09% had a learning disability. Participants also indicated a number of mental health conditions, including anxiety (34.33%), depression (26.87%), ADHD (11.94%), Autism (7.46%), and dyslexia/ dyscalculia/ dysgraphia (1.49%). Only 16.42% of those who chose to answer experienced no mental health conditions during college.

3.2 CS Experiences

Most of the participants in this study (62.79%) were CS majors or minors, with the remaining participants being another major, undecided, or undeclared. Most students came into CS1 with very little (41.86%) or some (39.53%) CS experience; only (18.60%) had significant experience. There was no observed correlation between major intention and preparation. Of the students who reported their CS1 course, 44.19% took CS1 at CY, 27.91% took CS1 at CX, and 18.60% took CS1+2 at CX. Outside of class, students spent:

- 1 hour reviewing the textbook (IQR = 1.55)
- 1 hour creating meaning via study sheets/ tools (IQR = 1.90)
- 2 hours working with peer educators (IQR = 2.43)
- 5 hours completing programming assignments (IQR = 2.55)

An ANOVA test was conducted to understand the effect of prior experience in CS with time spent on programming assignments, $F(2, 24.1) = 3.62, p = .042$. A Games-Howell post-hoc test found that the mean difference between those with little and significant experience was 2.17, $p = .033$. These results indicated that students with significant, some, and little programming experience spent about 3-5, 4-6, and 5-7 hours on assignments each week, respectively. It is important to note that 13.95% of participants reported spending 10 or more hours per week on their programming assignments.

Students also rated their agreement with statements about their CS1 course. The majority found CS1 time-consuming (30.00% agree, 27.50% strongly agree). 42.11% of students felt that CS1 was more difficult than introductory courses in other departments. 37.21% reported that the content was not taught in a way they understood.

While all students who responded felt that they had been supported by at least one person on campus, 34.15% reported that their sole support was friends and/or peer educators. This finding indicates that many students are not being reached by their advisors and instructors. Only 38.89% of students agreed that there was a community in XYCo CS for students with their identities.

A self-efficacy score was created based on an average of participants' ratings on the following scales (reverse-coded as necessary): I cannot be successful in CS, I received enough support to do well in CS, I am less capable than my peers in intro CS, It took me more time to understand concepts than my peers in intro CS, and I felt confident in my ability to overcome challenges in intro CS. The reliability analysis indicated a Cronbach's α coefficient of .89, suggesting high internal consistency among the items. The average score was 3.38 ($SD = 1.19$). This score was significantly different

for students who identified as FGLI. An independent samples t-test found that the self-efficacy was significantly different between FGLI ($M = 2.56, SD = 1.39$) and non-FGLI ($M = 3.67, SD = 1.05$) students, $t(39) = -2.87, p = .008$, Cohen's $d = -0.99$. This indicates that FGLI students had significantly lower ratings of self-efficacy, associated with a large effect size, which is shown in Figure 1.

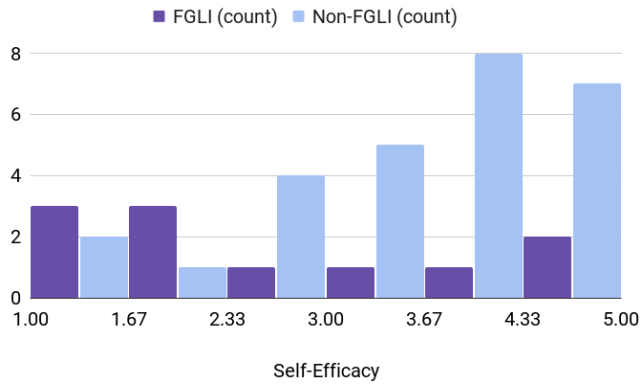

Figure 1: Self-Efficacy Score by FGLI Status

Additionally, independent samples t-tests were conducted on self-efficacy in relation to other demographic factors. Self-efficacy was significantly different between students without prior computing experience ($M = 2.72, SD = 1.23$) and those with some or significant experience ($M = 3.86, SD = 0.91$), $t(41) = -3.51, p = .001$, Cohen's $d = -1.08$. This result indicates that students with experience had significantly higher self-efficacy, which was associated with a large effect size. Self-efficacy was slightly lower for BIPOC students ($M = 3.03, SD = 1.26$) compared to their white peers ($M = 3.65, SD = 1.12$), but this difference was not statistically significant, $t(39) = -1.64, p = .110$. Self-efficacy had negligible correlation with other demographic variables.

3.3 Short Answer Responses

3.3.1 Course Content, Structure, and Grading. 41.67% of students struggled with the pace and workload in CS1. They claimed it "felt like a constant cycle of work" (P27) due to the number of assignments, their complexity, and the time required to complete them. Additionally, students felt that different CS1 sections covered different material, leaving them frustrated and confused in CS2.

Students listed a multitude of policies and practices which might impact their experiences in CS1. These include flexible extensions, ensuring clear guidelines on collaboration, making the slides legible from anywhere in the classroom, and distributing course materials online for accessibility. Students appreciated timely feedback which allowed them to resubmit and/or improve subsequent assignments. Participants expressed frustration when instructors lectured by reading the slides, asking instead for examples and in-depth explanations. They preferred typed feedback due to difficulties reading handwritten comments. Additionally, some instructors gave feedback in a manner where other students could see or hear it, which students disliked as it increased embarrassment and self-doubt.

Another theme brought up by 30.56% of participants was frustration with the grading of assignments, exams, and the course overall. Students felt that the grading was "unfair" (P7) and "too harsh, as there were no rubrics or guidelines on grading" (P14). They did not like losing many points for the same mistake in a test suite or because they did not write their name on an assignment. Students also lamented the exam time limits, calling them "stressful and arbitrary" (P16). P24 stated,

> The exams were a joke. Nobody finished on time, people were crying and cheating. The instructors knew this going into the second exam and changed nothing, despite most of the class completely failing.

Despite how hard students felt that they were working, some felt that their effort was wasted when they received their grade. P9 wrote, "my grade was an insult to all the work I put into this class."

At a higher level, students expressed issues transitioning through the introductory sequence. Of students who took an additional CS course after CS1 (81.40% of participants overall), 34.48% expressed that they struggled transitioning to other CS courses. Some expressed wanting a course between CS1 and CS2 to bridge this gap. Students like P26 who took CS1X at CY were disappointed by the lack of creative expression in in future courses. Students who took CS1+2 had mixed reviews, with some saying it did not cover the CS1 material enough and others expressing that it took too much time on CS1, leaving them under-prepared for future courses. It is evident that students appreciate having easy access to course materials, fair grading policies, a clear and consistent structure, and feeling adequately prepared for future courses.

3.3.2 Preparation, Resources, and CS0. Students listed preparation as one of the primary reasons they felt either insecure or confident in their course standing. Students with prior experience noted understanding concepts "quicker than peers" (P37), and also helping explain concepts to one another. From the perspective of students with less experience, they felt isolated, confused, and frustrated that they weren't understanding the material. Some students such as P20 attributed this to their lack of "opportunities... to take higher level math courses." To address issues of inadequate preparation for CS1, participants were asked about CS0. According to P15,

> For non-CS majors, a lot of the intro content is not relevant to what they hope to gain from the course, and the jargon only serves to confuse and deter them... it would also greatly benefit people considering the CS major who may not have any experience [coding].

Simply put, students thought that this concept "would be AMAZING!!" (P3). Of the students who answered the question about CS0, there was **unanimous** support for its creation.

3.3.3 Support from Instructors and Peer Educators. CS1 could not function without the collaboration of instructors, peer educators, and students. Students praised instructors who prioritized interactivity, "explain[ed] concepts well and intuitively" (P36), offered extensions as needed, and helped students stay the course. In contrast, some instructors were absent from their office hours, were not responsive over email, and steered students away from completing work in a way that was intuitive to them. Sentiments about CS1 being "poorly taught" (P24) were shared by 33.33% of respondents. This made students feel that the class was "not worth going to" (P14), leading them to turn to outside resources. Additionally, some

students chose not to participate due to their instructor "mocking and picking on students who had questions" (P43).

Students such as P9 expressed immense gratitude for "the incredible time and commitment [their] CS tutors took to ensure we could navigate [CS1]." Overall, 60.98% of students listed peer educators as part of their support system and 19.44% of students cited them as a key part of their performance. However, some felt that "it was a REQUIREMENT to meet with tutors rather than an available resource" (P9). P27 became a TA after taking CS1 and expressed that they never "received a good enough rubric to grade fairly." Access to supportive faculty, peers, and support staff can improve student experiences in CS1. On the other hand, some students were less likely to seek support after having harmful interactions.

3.3.4 Motivation and Sense of Belonging of Minoritized Students. 20.00% of minoritized students felt that they did not belong in CS1 or the department. Several of them felt that the culture of the department resulted in unreasonable expectations, such as working "10+ [hours] a week" (P43). The workload made CS1 feel like an upper-level course, which affected students' persistence and made it "difficult... to push through" (P43). Of those who remained, they expressed frustration and despair at the state of the department. Some expressed that they would not have chosen a CS major, despite their interest in CS. Minoritized students felt that they did not belong in CS and were alone in their struggles, especially when their identities were not represented in their peers and faculty.

FGLI students expressed struggles with CS1 and the department as a whole. They felt that they were not allowed to ask questions and that CS1 required prior experience that was not available to people with their "ethnicity and income" (P5). P38 struggled to fit into CS after struggling with the "financial burden" and access to "nutritious food." Similarly, P16 was "told to quit [their] job" to attend TA sessions, despite needing that job to afford their education.

Additionally, 22.22% of students faced challenges with their mental health in CS1. These included feelings of depression, anxiety, self-consciousness, and insecurity. P5 stated that their mental health "made it difficult" for them to perform well as a student and their CS instructors "have been hit or miss in terms of willingness to work with" them. Similarly, P10 felt forced to continue working through depressive episodes. P16 felt that CS "destroyed" their health. They claimed that sleep deprivation and the "toxic" culture resulted in their peers being "constantly on the verge of a breakdown." These feelings were pervasive and impacted student retention.

Likewise, neurodivergent students discussed their struggles in CS1. P37 noted that their performance was impacted by the people, sound, and light in the classroom. Similarly, P18 said they felt stressed because they struggled to "outreach" and work in groups in addition to their "ability to manage/stay on top of assignments." Neurodivergent students also struggled with directions being "vague" and "[requiring] too much interpretation" (P16).

Minoritized students such as P16 also expressed circumstances where they were "discriminated against" and felt "ostracized" due to their gender or time accommodations. P32 stated that "boys had a tendency to speak over me, so I didn't share ideas." P16 summarized their experiences by stating,

> I have been constantly misgendered in my CS courses, more than any other department. I have never felt like I belonged in CS... most of the professors have been hurtful, unresponsive, and unreasonably harsh.

In conclusion, minoritized students struggled with their sense of belonging, isolation, and persistence in CS1 courses. There were reports of discrimination due to aspects of participants' identities as well as struggles with mental health and neurodivergence.

4 DISCUSSION

From these results, we have identified five strategies that we believe will improve the experiences of minoritized CS students:

4.1 The Need for CS0

Implementing CS0 would provide another entry point to the major and fulfill STEM domain requirements. Students unanimously supported CS0 because they are interested in learning about relevant technology such as AI and building skills that transcend disciplines.

We recommend that the duration and order of sub-fields covered in CS0 should be shaped by the instructor's expertise and student interests. We envision the course as discussion and project-based. It could use pseudocode to get students accustomed to computational thinking. Opportunities to write code could be included as extra credit or guided labs. While this course may contribute to diversity in CS, we must also consider how to retain these students.

It is true that CS0 could increase CS1 over-enrollment by reducing availability of CS1 sections and increasing student interest in CS. However, many CS1 students are expecting the course to be like CS0, where they can explicitly build problem solving skills without code. CS0 addresses their needs and gaps in experience which prevent CS1 from functioning effectively. One might also contend that CS0 adds a semester to the major, creating additional barriers to graduation. However, putting minoritized students directly into CS1 is keeping them out of the discipline altogether. As long as students are properly advised and given the option to enroll directly in CS1, we believe CS0 will improve rather than detract from major completion. Additionally, computational thinking can benefit students from all majors and class years.

4.2 Standardizing CS1

Next, standardizing CS1 structures and policies across the XYCo will improve student experiences and alleviate the burden of CS2 instructors to manage students with different foundations. These courses should cover the same core concepts if they are considered equivalent. Implementing a flipped classroom model would allow students ask questions while working through difficult labs and reduce the time for students to learn the same information. Comprehensive and clear rubrics should be created, emphasizing partial credit and reduced penalties for small or repeated errors. Utilizing trained human graders with anonymized assignments will support this approach and limit bias. Most students would benefit from increased accessibility of course materials, hybrid or recorded lectures, take-home exams, and extension policies. These accommodations are provided to some Disabled students, but should be extended so everyone can benefit. Recognizing that students have busy schedules and off days, we must encourage them to utilize their resources and advocate for their needs. These are the skills that our students will need as they transition into the workforce.

4.3 Peer Educator Resources

Additionally, providing comprehensive training, rubrics, and resources for peer educators will allow them to support their students. Without sufficient instruction, guidance, or an understanding of teaching and learning styles, it is no wonder that some peer educators struggle to succeed. Instead of learning on the job, peer educators could practice with more experienced tutors, practice teaching scenarios, learn effective communication and pedagogical strategies, and more. Additionally, peer educators need open communication channels with instructors and access to the assignments/ learning goals in advance to best support their students.

4.4 Equitable Access to Information

Many of the previous issues stem from a lack of communication and coordination. CS students and their advisors need accurate course information, especially for study abroad or 4+1 programs, to ensure their preparedness and major progression. This is particularly important for first-year and minoritized students, who may not feel comfortable reaching out to their advisors. In consortiums such as the XYCo, it is important to offer the same placement test, complementary courses, and ensure that course changes do not disrupt major requirements at the other college. Clear communication and collaboration will allow for smoother transitions, clearer prerequisite pathways, and equitable access to information.

4.5 Shifting Departmental Culture

These changes lead to the final, most comprehensive recommendation: shifting the departmental culture to incorporate Culturally Sustaining and Asset-Based pedagogies. In other words, we must prioritize the needs that students have expressed and embrace their strengths in our teaching practices. Tangible changes include starting a working group, updating mission statements, creating department-level systems of accountability, training staff, and including students in department meetings. Ultimately, a culture of exclusion and seemingly unattainable expectations will continue to prevent minoritized students from succeeding in CS.

5 CONCLUSION

It is evident that students had different experiences and opinions about how to improve CS1. The recommendations here are made in the interest of supporting all students, without compromising the rigor of the courses. Adding CS0, standardizing course material and policies, ensuring our instructors and peer educators are prepared, maintaining equitable access to information, as well as giving students a voice will ensure that we continue to critique and improve our department. It is clear that minoritized students tend to struggle in CS1 as it currently exists in the XYCo. In addressing the research questions, we found the following:

(1) Minoritized learners have lower self-efficacy than their peers and often have limited support systems. Students who had less prior experience in CS, particularly FGLI and BIPOC students, felt that they could not be successful in CS.
(2) Factors that contribute to students retaining CS include: course structures, support systems, and sense of belonging.
(3) Minoritized students have less preparation, self-efficacy, and motivation to continue CS.
(4) Solutions include introducing CS0, standardizing CS1, training peer educators, clear communication, and improving departmental culture.

Addressing the issues facing minoritized students in CS0 and CS1 will benefit all students by increasing the diversity of ideas and perspectives in their learning spaces.

While this study had many meaningful findings, it was limited by sampling and offers a narrow view of the experiences of CS1 students. The demographic results are unique due to the racial and gender demographics of CY and CX. This partially explains the over-representation of white, female, and GNC respondents. This difference could also be attributed to the sampling methods and demographics of students who choose to take CS1 courses. It is also important to note that many of the analyses relied on coding self-described variables, which may not capture the full range of participant experiences. This choice was made to ensure that participants could express their identities without being restricted to non-representative categories, such as "other."

Future research is necessary to understand self-efficacy in FGLI students. Sampling more BIPOC and minoritized students will allow for a fuller understanding of their experiences. Further studies could examine the benefits and challenges of strategies proposed in this work in the XYCo and beyond. Strategies without much existing literature, such as applying Culturally Sustaining Pedagogy to STEM and CS, are especially important to prevent further harm to minoritized students. Finally, research is necessary to quantitatively assess CS0, CS1X, CS1, and CS1+2 approaches.

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