Google

Student Perspectives of Community College Pathways to Computer Science Bachelor's Degrees

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This report was commissioned by Google Inc. and authored by Louise Ann Lyon and Jill Denner of ETR.

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Additional reports from Google's Computer Science Education Research are available at g.co/cseduresearch.

Executive Summary

Student Perspectives of Community College Pathways to Computer Science Bachelor's Degrees is one in a series of Google reports designed to explore the pathways and experiences that community college students — especially those from underrepresented groups — follow to a bachelor's degree in computer science (CS) and the opportunities that exist or that might be created to ensure successful career advancement. Community colleges are an untapped resource for increasing diversity in CS, with 57% of Hispanic and 52% of Black undergraduates educated at community colleges.[1] While a companion report, *A Longitudinal Analysis of Community College Pathways to Computer Science Bachelor's Degrees*,[2] investigates the national landscape of CS students at community colleges in order to better understand how student behaviors and institutional characteristics affect the likelihood of obtaining a CS bachelor's degree, this report takes a complementary in-depth and qualitative look at the experiences of students from underrepresented groups at two community colleges in California, a state that enrolls one quarter of all community college students in the U.S.[3] The goal of this study was to better understand the supports and challenges community college students face when attempting to transfer and complete bachelor's degrees in CS.

Key findings in this report

» **Community college students struggle to efficiently move through the CS prerequisite chain of classes in preparation for transfer.** CS pathways through postsecondary institutions are complex, unclear, and inconsistent. In most cases classes must be taken in a preset order such that any delays in course-taking sequences require increasingly drawn-out time at an institution. This can be particularly challenging to community college students who reported family and financial responsibilities, trouble enrolling in classes filled to capacity, and low confidence to obtain needed grades along with anxiety about math. Increasing the availability of classes along with increased one-on-one course assistance could help students to complete and excel in required courses. In addition, financial support is critical to helping students stay in school.

» **Community college students are confused about computer science transfer pathways from their community college to their target four-year institution.** Many students report that even with counseling and online resources, they have difficulty knowing which classes meet the requirements for transfer to a 4-year institution with a CS major, what course grades they need to earn to successfully transfer into a CS major, and which CS major at the four-year institution to select. Strengthening the CS transfer pathway and improving available resources could help larger numbers of students move more effectively and efficiently towards obtaining bachelor's degrees.

1 http://www.aacc.nche.edu/AboutCC/Documents/FastfactsR2.pdf

2 Jaggars, S. S., Fink, J., Fletcher, J., & Dundar, A. (2016). *A Longitudinal Analysis of Community College Pathways to Computer Science Bachelor's Degrees.* Mountain View, CA: Google Inc. Retrieved from http://goo.gl/Eiz33G.

3 Foundation for California Community Colleges (2015). Facts and Figures

- **Community college students have limited knowledge of how CS is applied in professional settings and how to prepare for a career in CS.** Results from our interviews suggest that students are enthusiastic about entering a growing job market that includes many diverse fields, and their interest increases as they progress to higher-level CS classes and participate in internships. However, student perceptions of what is required to obtain CS-related jobs, the differences between job types, and the training and educational credential they will need is often insufficient. Partnerships between industry and community colleges that engage students in practical work experiences can help them gain greater understanding about CS as a chosen field, possibly increasing the likelihood of successfully completing a CS bachelor's degree.

This study suggests that to increase the number of community college students — particularly from underrepresented groups — who successfully transfer to a bachelor's degree in CS, institutions should offer more financial and planning support, flexibility, and better information about transfer pathways. To tap into the diverse resource of students that community colleges already reach, universities and industry must work with the colleges to ensure that the unique needs of community college students are met.

Introduction

The underrepresentation of women and some minority groups in computer science (CS) continues to be a topic of discussion, concern, and research. Community colleges are often overlooked in efforts to increase diversity at the postsecondary level despite the fact that these institutions serve large numbers of traditionally underrepresented students. Half of all Hispanic students who earn bachelor's degrees start at a community college, and in the U.S., 43% of community college students are non-white and 42% are the first in their families to attend college.[4] The contribution of community colleges is often excluded from resumes, which list only bachelor-degree granting institutions. In fact, over half of women who earn a STEM (Science, Technology, Engineering, and Math) degree started out at a community college,[5] and 43% of people who earned a degree in computer or mathematical sciences in 2010 attended a community college.[6] We are at an inflection point where community colleges will be a vital and viable pathway for the many women and minority students who are already engaged at their institutions to consider CS and successfully transfer to complete a bachelor's degree in the field.

Community colleges are public institutions that provide higher education to regional populations. Established to build a local workforce with pre-baccalaureate credentials for jobs, community colleges now commonly focus on the general education requirements of postsecondary education as well as technical and continuing education. They offer certificates, diplomas, and associate's degrees along with transfer preparation for bachelor's degree granting institutions; an increasing number also offer bachelor's degrees in some fields. Community colleges offer an open access,[7] less expensive option for students to complete their general education and lower division classes compared to universities. Thus, for students interested in pursuing a bachelor's degree in computer science (CS) who are unable to enter directly into a four-year institution for financial, academic, or personal reasons, community colleges offer a more accessible gateway into the field. However, the potential of populations to transfer and complete CS bachelor's degrees is not being fully realized. Finding ways to encourage and support students to persist and continue their CS education beyond community college has the potential to positively affect not only the field, but many diverse students' long-term educational and labor market outcomes.

Prior studies have identified factors that influence intention to transfer and study CS at a four-year institution. These factors include prior programming experience and support from professors (for men), and peer encouragement, confidence, and interest in CS (for women).[8] While large, quantitative studies can help us explore *what* is happening with many participants in community colleges across the U.S., the reasons *why* students are/are not following certain pathways in CS can better be understood by asking students in-depth questions and by investigating the contexts in which students are making choices. For this study, we focused on students at community colleges in California. One-quarter of all U.S. community college students are enrolled in one of California's 113 community colleges[9] and the state is the home of Silicon Valley, making it an appropriate location for this work. This study focused on the candidates who are most likely to be interested in pursuing a bachelor's degree

4 American Association of Community Colleges, 2013.

5 Institute for Women's Policy Research, 2012.

6 http://www.nsf.gov/statistics/infbrief/nsf11317/

7 Open to anyone, with no application necessary

8 Denner, J., Werner, L., O'Connor, L., & Glassman, J. (2014). Community College Men and Women A Test of Three Widely Held Beliefs About Who Pursues Computer Science. *Community College Review,* 0091552114535624.

9 Foundation for California Community Colleges (2015). Facts and Figures

in CS: students who were or had been at a community college and had enrolled in a CS class. Our goals were: (1) to better understand the supports and challenges for community college students from underrepresented groups who are interested in transferring and completing bachelor's degrees in CS, and (2) to investigate how their experiences influenced their choices to pursue CS. The findings from this study provide a valuable student perspective on this issue and suggest strategies that community colleges, universities, and industry can implement to strengthen the transfer pathways to a bachelor's degree in CS.

This cross-sectional study was conducted with two groups of participants: (1) students enrolled in introductory programming or data structures classes during 2015 at two community colleges in California with high populations of students traditionally underrepresented in CS and that included CS departments that emphasized and encouraged transfer, and (2) students who had been enrolled in an introductory programming class at a community college in California five years earlier during 2010 (see Table 2 for the CC region of these students; none had attended either of the two community colleges that students from group 1 were attending).

Students from group 1 were invited to complete an online survey. Among the 321 students surveyed (out of 429 students enrolled in the classes), a subgroup of students from underrepresented groups[10] who intended to transfer and obtain a bachelor's degree in CS was identified and invited to be interviewed later in the semester. Details about the 321 students surveyed are in Appendix A. Table 1 provides details about the 24 currently enrolled students who were interviewed for this study.

The two schools partnering in this study included a rural and an urban community college and were targeted based on their high numbers of students traditionally underrepresented in CS in order to increase the likelihood of finding participants from these groups for the study. The rural school was about 10 miles from the closest public 4-year institution, while the urban school was about 6 miles from the closest public 4-year institution. Both were Hispanic-Serving Institutions, indicating that they have over 25% Hispanic students; the rural community college was over 59% Hispanic, while the urban community college had almost 17% African American students and over 48% Hispanic students. Both CS programs had an emphasis on transfer and completion of bachelor's degrees for students and offered tutoring to support students in introductory classes. At the urban community college, CS was housed with the mathematics department, while at the rural community college it was housed with other technology majors (e.g., Agricultural Business Technology). The colleges offered academic counseling to help students choose classes and prepare for transfer. Both community colleges had MESA (Mathematics, Engineering, Science Achievement) programs designed to provide educationally and economically disadvantaged students with the skills and resources to succeed in school and in careers

10 Due to the self-selecting nature of participation and the nature of qualitative studies, participants may not be representative of the general population of underrepresented students studying computer science at community colleges.

Table 1.

CURRENT CC INTERVIEW PARTICIPANTS

GENDER	RACE/ETHNICITY	BIRTHPLACE	CS CLASS
7 females	**1** white	U.S.-born	**4** Introductory programming
	3 Latina		
	1 Asian American/Pacific Islander	U.S.-born	**3** Data structures
	2 white	Immigrant	
17 males	**11** Latino	U.S.-born	**7** Introductory programming
			4 Data structures
	6 Black	U.S.-born	**5** Introductory programming
		Immigrant	**1** Data structures

in science, technology, engineering and math (STEM) disciplines. Several students in this study mentioned this program offers tutoring and STEM-specific career information.

The rural community college had several programs that student interview data indicated encouraged students to pursue and persist in CS that were not present at the urban community college. These programs should be further investigated as promising practices. The CS department had a close partnership with a nearby four-year institution such that students were familiar with the possibility to complete a bachelor's degree in CS, many knowing friends or acquaintances who did so. The department had a staff member who actively reached out to high schools and gave presentations on CS and the job market prospects for CS graduates. Several students reported that these presentations had inspired them to consider majoring in CS. CS teachers at the rural community college reflected the diversity of the classrooms, discussed personal knowledge of and experience in industry during class, and also invited outside speakers from industry to provide insights on job prospects. In addition to tutoring, the rural college offered a peer-led CS teaching program in which students worked together on assignments in groups of about four.

In the CS classes surveyed at both community colleges, just over 75% of the students were male, over 85% were traditionally-aged students who were 25 years old or younger, and the largest race/ethnicity was Hispanic/Latino at over 46%. Over 31% of all students had been raised in other countries in addition to or instead of the U.S., and 46% spoke a language other than English at home. The most common reason that students had enrolled in a CS class was because the class was "required for my major." Almost 60% of students enrolled in CS classes were intending to transfer to a 4-year university and major in CS or computer engineering (CE). Using parent educational levels as a proxy for socioeconomic (SES) status, many students were low SES, with almost 75% of students' mothers and almost 69% of their fathers having never attended a four-year institution. Students' most common funding source for schooling was "grants/scholarships," with close to 40% of students relying on grants or scholarships; other sources of funding are detailed in Appendix A. (See Appendix A for details of results from all 321 students surveyed, including variation by gender and race/ethnicity.)

Almost 60% of students enrolled in CS classes were intending to transfer to a 4-year university and major in CS or computer engineering (CE).

As part of this study, we also interviewed 14 students from underrepresented groups who had been enrolled in introductory programming five years prior at various community colleges across California and who had intended to transfer and obtain a bachelor's degree in CS (see Table 2).

All interviews were transcribed for a word-for-word record of participants' responses. A subset of these transcriptions were then open coded by the interviewer and a research colleague independently. Codes were discussed and revised to create a common set of codes, the rest of the transcriptions coded, and codes combined into shared themes. Themes amenable to interventions are reported here. (See Appendix A for more detail on study methods and coding.) All names given in this report are pseudonyms. Quotes have been edited for readability.

Table 2.

POST-CC INTERVIEW PARTICIPANTS

RACE/ETHNICITY & GENDER	DEGREE/CERTIFICATION RECEIVED	CURRENT JOB IN TECH?	CC REGION
Asian American female	None: currently working on BS in CS	No	San Francisco Bay Area
Asian American female	BA in Film and Media Studies	No	San Francisco Bay Area
Asian American female	Certification in C/C++ Programming; working on an accelerated Master's/Bachelor's program in CE	Yes: internship at company that makes databases	San Francisco Bay Area
Black female	None	No	San Francisco Bay Area
Black/Asian/white male	AA in Information Technology System Security (from University of Phoenix)	No	Southern CA
Black/Latino/white male	AA in Computer Information Science: currently working on BS in Network Communication Management	Yes: works at a startup	Northern CA
Black/white/Native American male	None (tech training through a nonprofit)	Yes: Senior Engineer	San Francisco Bay Area
Latina female	AA in Liberal Studies and Economics	No	Northern CA
Latino male	AA Computer Support Specialist	Yes: Computer Technician Manager	Northern CA
Latino male	Certifications: Java Programming, Android Programming	Yes: Programming position	San Francisco Bay Area
Latino male	CC Linux certification, industry Red Hat System Administrator and Red Hat Certified Engineer certification	Yes: Systems Engineer	Northern CA
Latino male	Certificate in Computer Programming; AA in CS: working on BS in CS	Yes: internship as IT Manager	Southern CA
White female	BS in CS	Yes: Software Developer	Northern CA
White female	AAs in CS, Social & Behavioral Sciences, Natural Sciences: BA in Technical Management	Yes: Test Engineer	Northern CA

Institutional CS Support and Flexibility

Students interested in CS can be delayed in their pursuit of an education at the community college level when necessary prerequisite classes are over-enrolled, the math requirements are daunting, they lack confidence to succeed in needed courses, or competing responsibilities interfere. Additional institutional support and flexibility can help students stay on a pathway toward realizing their CS educational goals.

Students in our study gauged their interest in CS based on their level of enjoyment of CS classes, and most described programming classes as "fun," "exciting," and "fascinating," which may have encouraged their persistence.[11] Students reported enjoying problem solving and the challenge of learning to program. When struggling with class content, students said that they turned to teachers, tutors, or online resources for help. Students noted that teachers were "approachable," "knowledgeable," "enthusiastic," and "welcoming for coming to their office hours." The tutoring that was available both through the department and the MESA (Mathematics, Engineering, Science Achievement) program was cited as a resource for assisting in understanding class content, although there were not always enough tutors to meet demand.

Despite the interest and enthusiasm that students show for CS, progress through the community college can be delayed for many reasons. CS has a traditionally rigid and ordered set of prerequisite classes, and when early prerequisite classes fill up, students' progress can be hindered. Students at both community colleges reported difficulties in being able to enroll in classes they needed. (See "Institutional CS Support and Flexibility" sidebar.) Carlos (at the rural community college), for example, was challenged by the lack of classes. He noted: "sometimes you have to wait a whole semester to take another class." Asenath (at the urban community college) described a

Institutional CS Support and Flexibility: Esperanza's Story

Esperanza was a young Latina woman attending the rural community college. Upon graduating from high school, Esperanza had gone to the local community college even though she had been admitted to a California State University because she wanted to save money. At the time, she had wanted to study computer science, but she was "afraid of the math classes like calculus."

She took a different path, studying social science and transferring from community college to a four-year institution, but during her first semester at the four-year institution she realized that she would rather do something that she knew she had "always loved to do. That's when [she] switched to computer science."

Her change in major had repercussions both financially and in her choice of educational institution, since an associate's transfer agreement in social science requires students to "finish out the course of study" at the four-year institution, yet completion of an associate's degree meant that she could not receive financial aid from the community college when she returned to study CS. Esperanza reported that, luckily, she was able to get a Board of Governor's waiver when she came back to the community college to change majors to CS, because if she had not received the waiver "it would have been more of a struggle to see whether [she went to] work or back to school."

Now back at the community college, her progress was again being delayed. She noted that the most difficult part of attending the community college to study CS was that there were "not enough classes for computer science. Right now, [Data Structures] is already full and that's the class [she] need[ed] for next semester and they're only offering two classes. They're all full so [she] wish[ed] there [were] more classes or at least online classes."

11 Packard, B. W. L., Gagnon, J. L., LaBelle, O., Jeffers, K., & Lynn, E. (2011). Women's experiences in the STEM community college transfer pathway. *Journal of Women and Minorities in Science and Engineering,* 17(2).

similar experience, noting: "you have to be the first person to be registering, or have the first day of registration, or you won't get classes that you want." These prerequisite chains include not only CS but also math, and fears of or dislike of math can hinder some students. (See "Institutional CS Support and Flexibility" sidebar.) This was true for students in this study even though over 84% of students surveyed had taken advanced math classes at the time of the survey. In California at large, many students arrive at community college below the math level required for CS.[12] As one student noted:

> **"I was really intimidated when I started the Computer Engineering course working toward transfer, because I remember seeing that you needed to go up to Linear Algebra and Differential equations, and that just sounded really scary to me because I started off with remedial math, so I thought that was just unattainable. When we got to calculus I remember doing the first integral, and it felt so cool. I'd seen that symbol on TV all the time and it was always, like, 'Wow, that is just for geniuses; I'd never be able to do it.' And then you are just able to solve it, and it just got me. I wanted to do more math after that — just wanted to get as far as possible. I think the biggest thing [I would advise young people about getting a CS degree] is don't feel like you are not capable of making it that far."**
>
> *– Pablo*

Students could also be delayed at the community college when they felt pressured to drop and re-enroll in classes to keep a high grade point average (GPA) in anticipation of transfer application. High drop rates in CS classes not only interrupted students who had to take a class at a later time, but also discouraged the students who remained in half-empty classrooms. Marcos reported on this phenomenon when asked what about his CS class had been discouraging. He cited the fact that "a lot of people dropped." When his class went from forty to fifteen students, he found it "scary" and began to question his feelings of confidence. He had two friends in the class who dropped, and he reported they had told him that they dropped because the class was "difficult," and "they said that they weren't confident they were going to get a decent grade, so they said they don't want to start off their academic career getting a low grade in a class that's in their major." These issues of over-enrolled classes and GPA concerns are particularly acute in CS with insufficient class sections at some community colleges and low transfer acceptance rates at universities due to high CS enrollments and little space in California,[13,14] similar to the situation in the U.S. at large.

Most students in this study had chosen to enter community colleges and transfer instead of enrolling directly in a four-year institution because they believed they could get the same education at a lower cost and because it allowed them to stay near their families. Yet being stalled at community college meant extra semesters of paying tuition and school costs while delaying entrance into the CS workforce and earning a salary.

In addition to juggling school schedules, community college students also reported needing to balance competing outside responsibilities, which has been found to possibly delay their progress through community college.[15] Students expressed particularly strong concerns about balancing educational costs with supporting themselves and/or their families. This financial balancing act of school and home or family can delay transfer[16] (see "Institutional CS Support and Flexibility" sidebar) and, as found in other studies, extend the time students spend at community college.[17]

Students in this study cited the Board of Governors out which pagewaiver,[18] financial aid, and the ability to live with parents or family who provided room and board as mitigating financial burdens so they could attend community college (see "Institutional CS Support and Flexibility" sidebar). In some cases, students had dropped out of community college for weeks or semesters at a time when family or other outside responsibilities interfered, resulting in longer time spent at community college as

12 http://californiacommunitycolleges.cccco.edu/Portals/0/reportsTB/2013StrategicPlan_062013.pdf

13 https://www.calstate.edu/sas/documents/impactedprogramsmatrix.pdf

14 http://talk.collegeconfidential.com/university-california-general/1071944-impacted-majors-at-each-uc-schools.html

15 Fishman, R. (2015). Community College Online. *New America Foundation.*

16 Packard, B. W. L., Gagnon, J. L., LaBelle, O., Jeffers, K., & Lynn, E. (2011). Women's experiences in the STEM community college transfer pathway. *Journal of Women and Minorities in Science and Engineering,* 17(2).

17 Monaghan, D. B., & Attewell, P. (2015). The community college route to the bachelor's degree. *Educational Evaluation and Policy Analysis,* 37(1), 70–91.

18 http://home.cccapply.org/money/bog-fee-waiver

others have found.[19] Rodrigo reported that "stuff at home" could prevent him from attending community college and studying computer science. He noted that when his brother was in a car accident, he had to "drop off for like a year just to work and pay off the bills." Sofia noted her father's ill health led her to miss classes.

> **"[I would stop attending community college and studying computer science] if my dad gets sick. Because there was this one week that I didn't go to classes; my dad just felt really stressed because he has arthritis and has other stuff and he's working. Now that it's cold he can't really work on the mechanics, and he's the only one who pays the bills and stuff. My mom sometimes too; she works in the fields. My dad gets more money so we expect him to get the money. When he feels bad, I feel like I need to work, because my brother is more focused and he's already in his second year, so I feel like we shouldn't bother him, or my older brother, well, he's doing his job but he's not really good at managing money, and my mom only gets a little bit of money. I'm out of high school and I could do college later."**
>
> *– Sofia*

These delays and outside pressures can make CS students' pathways through community college in preparation for transfer less straightforward than those of other students.

Recommendations

To encourage more students to continue on to transfer, community colleges could maximize course-taking flexibility by minimizing course prerequisites as well as increasing available student slots in course sections offered on a varied schedule. Community colleges could also encourage students in CS by offering intensive math options that allow remedial students to catch up quickly and motivate students with projects and homework related to CS.[20] Community colleges should continue, implement, or expand tutoring resources and educational resources that can help with successful STEM transfer.[21] And, colleges could consider ways to prevent discouragement for students by offering pass/fail options as well as training teachers to implement inclusive learning environments. Colleges can also provide social supports by connecting students with similar CS transfer goals through cohorts or social media and following up with students who drop classes with actions to encourage them to continue. In order to give low-income students the financial means for success,[22] Board of Governors waivers and financial aid should be continued or even expanded. Industry could also effectively support community college students through scholarships or paid internships.

19 Monaghan, D. B., & Attewell, P. (2015).

20 Hagedorn, L. S., & DuBray, D. (2010). Math and science success and nonsuccess: Journeys within the community college. *Journal of Women and Minorities in Science and Engineering,* 16(1).

21 Costello, C. B. (2012). Increasing Opportunities for Low-Income Women and Student Parents in Science, Technology, Engineering, and Math at Community Colleges. Report# C388. *Institute for Women's Policy Research.*

22 Costello, C. B. (2012).

CS Transfer Pathways

Community colleges' CS course pathways designed to prepare for application and transfer to four-year universities are not always straightforward or clearly aligned. Students seeking help with the process use counseling and online resources with mixed success. Improvement of these resources could support students in effective planning. Alignment with nearby universities is most important, as students are mainly targeting "local" schools for transfer.

Most students in this study already had ideas on possible transfer schools. Some mentioned specific California State and University of California (UC) schools that they were targeting for transfer. Most planned to remain in the local area (consistent with the findings in *A Longitudinal Analysis of Community College Pathways to Computer Science Bachelor's Degrees*), but a few were targeting universities based on proximity to tech jobs, a school's ranking in CS, or the availability of a specific concentration (e.g., game design). Only Marcos mentioned a four-year institution outside of California, saying "obviously the one everyone dreams of is MIT." He was uncertain, however, whether he would actually apply to transfer there. Only one other student mentioned a private college, and it was located in California near his community college. Students said that they used online research to determine the rankings of schools in CS and the majors at particular universities. In some cases, students reported that their CS teachers were an important source of information concerning the differences among universities. For those students who were interested in staying "local," the urban community college had many more choices of universities than the rural one. Silicon Valley can also loom large in the minds of students interested in CS in California. Students who were targeting a school in that location reported that they were planning to apply to San Jose State University "since it's so close to Silicon Valley" (Santiago). CS students at the rural community college appeared to have a clearer pathway to transfer that was being modeled by Hispanic/Latino young men and women through an established pipeline from the community college to the four-year institution.

Students who were targeting more than one school for possible transfer had found that it was confusing for them to determine which classes they needed to take at the community college to successfully transfer to schools with different transfer application requirements. Jadyn, for example, noted "we just want a straight linear path from point A to point B to transfer into a school," and goes on to explain how this is not the case.

> "What's most difficult? I would say the courses and the courses in relation to what schools require, because it's such a pain figuring out what classes that I need to take. It's a game trying to figure out what class I should take for what because, at least the way I figured it out after talking to the counselor and then trying to figure out on my own, the first thing I have to do is decide what colleges are my top goals and from that I have to decide what classes I need from each college and what overlaps and what doesn't. Let's say I wanted to go to [UCX1] and [UCX2] and then [Cal State], for example. [UCX1] might want chemistry, but [UCX2] won't even have that as a requirement for transfer, but might have it as a recommended course. That's just for chemistry. Then you have to do the same process for physics, math, everything like that. I know for a fact that for [UCX1] the minimum required transfer is just [C++ Programming class], but at [UCX2] I think it's both [C++ Programming class] and [Data Structures]. Then [UCX1] wants physics A, B and D, but at [UCX2] they want only A and C or A, C and D. It's a matching game, and then I have to make sure I get the courses in alignment with how I prioritize each school and then I have to make sure I'm doing well in those classes and not having to repeat, because if I repeat one that's a prerequisite for another that pushes back the whole line. That could push me back a year and a half."
>
> *– Jadyn*

Students cited community college counselors as the best qualified to provide information and guidance for planning their classes in preparation for transfer, but another study shows that students noted their experiences with counselors had mixed results.[23] Some students stated that the counselors were critical in helping them develop an educational plan that prepared them for transfer. Asenath, however, noted that the counselors "need to be more aware of their computer science students — what you need and what help you can get. They need to have more outside information." Some students at the urban community college experienced difficulties in getting appointments with or the necessary attention from counselors, who were overwhelmed with high student loads, as found in other studies.[24] The urban students reported that there was a transfer counseling center with knowledgeable staff and STEM-specific counseling available through the MESA center. Esperanza (see sidebars), who had transferred from the rural community college to a four-year institution and then returned to the community college when she changed majors, had the foresight to email the counselors at the four-year institution she was targeting for transfer to ask about requirements for CS transfer. Another student at the rural school had been discouraged by incorrect advice from counselors and had turned to the ASSIST.org transfer website to plan his classes. Luis, a student from the second group of interviewees, had almost been prevented from transferring due to poor counseling advice that left him short one English class.

> "I was applying for schools everywhere and all the schools were rejecting me because [the community college] sent me a letter saying I couldn't take any more classes with them; I had maxed out what I could take with them. I was still missing a couple courses. The counselors at the community college kind of messed up my academic plan years ago. They had thought I only wanted to get an Associate's Degree, but I wanted to transfer out. When I actually went to apply for transfer to schools, they wouldn't take me because I was missing one class; I was missing an English class."
>
> *– Luis*

23 Packard, B. W. L., Gagnon, J. L., LaBelle, O., Jeffers, K., & Lynn, E. (2011). Women's experiences in the STEM community college transfer pathway. *Journal of Women and Minorities in Science and Engineering,* 17(2).

24 Fishman, R. (2015). Community College Online. *New America Foundation.*

Recommendations

CS departments at community colleges and universities should continue to work together to streamline pathways to transfer in order to help students navigate the system, including following best practices in articulation agreements.[25] Students in this study were struggling to figure out transfer pathways[26] and many reported needing well-informed counselors who understand CS classes and transfer pathways specifically. Since students report seeking assistance from, and relying on, counselors for class and transfer information, the cut in funding for community college counseling[27] is potentially detrimental for California students. Because counseling has been found to improve outcomes for students,[28] the state should strive to increase funds and lower counseling student loads.[29] Online resources such as ASSIST.org[30] — an "online student-transfer information system that shows how course credits earned at one public California college or university can be applied when transferred to another" – and the University of California admissions website[31] were reported to be helpful, but required students to combine information from various sources.

25 Mattis, M. C., & Sislin, J. (Eds.). (2005). *Enhancing the community college pathway to engineering careers.* National Academies Press.

26 Bailey, T. R., Jaggars, S. S., & Jenkins, D. (2015). *Redesigning America's Community Colleges*. Harvard University Press.

27 http://californiacommunitycolleges.cccco.edu/Portals/0/reportsTB/2013StrategicPlan_062013.pdf

28 Hagedorn, L. S., & DuBray, D. (2010). Math and science success and nonsuccess: Journeys within the community college. *Journal of Women and Minorities in Science and Engineering*, 16(1)

29 Costello, C. B. (2012). Increasing Opportunities for Low-Income Women and Student Parents in Science, Technology, Engineering, and Math at Community Colleges. Report# C388. *Institute for Women's Policy Research.*

30 http://www.assist.org/web-assist/welcome.html

31 http://admission.universityofcalifornia.edu/transfer/preparation-paths/

CS Careers

Students are pursuing CS degrees because they believe it will help them obtain jobs in a variety of fields that they find meaningful and lucrative. Students are motivated by the availability of CS jobs and relatability of CS to their interests. However, students have only a vague understanding of the skills and knowledge necessary for particular careers and fields where CS can be applied. Partnerships between community colleges and industry could offer first-hand experiences and applications to increase understanding of career potential and requirements and help encourage students to persist along the pathway to a bachelor's degree in CS.

Participants in this study were enthusiastic about the CS field, not only because of their enjoyment of the coursework, but also because of the job prospects and high salaries. The broad nature of CS and the use of technology in many fields and products meant that students had a variety of visions for jobs they would like to pursue. Two women anticipated working in non-tech fields — one in medicine and the other in forensics — and using their CS skills in those fields. Several students wanted to own their own businesses or work independently, although they recognized that they would probably need the training and expertise that would come from working in industry first (see "CS Careers" sidebar). Students who had started studying CS due to their interest in gaming hoped to work for their favorite gaming companies. Another student, Rontay reported that he wanted "to be able to help people in [his] community with, basically, programming and everything else. [He] just wanted to learn how to do [CS] so [he] can make a business out of it and try to just, basically, make websites and different programs." Although students had a general idea of where they were headed with their anticipated CS degree, their knowledge of what subfields of study might be appropriate and the tasks they might be performing on the job was unclear. Jadyn, for example, noted that he planned to study either CS or computer engineering, after which he will "immediately apply for computer science positions or computer programs positions; that point's a little bit hazy." Kylie, who had successfully transferred and was completing her accelerated BS/MS degree while working, was using internships to explore CS careers. She notes that she "tr[ies] to find as many interesting internships as possible so [she] can see what [job she] wants to do."

CS Careers: Esperanza's Story

Once Esperanza finishes school, she hopes to start her own business. Alternatively, if she does get a job, it would be "maybe with the county because right now I work for the county. I work in the parks department and they tell me they have really good IT positions there so I was thinking maybe I could apply to that." Esperanza and her boyfriend were motivated to pursue CS by a friend who had shared that CS is "a really fun job and you get to meet different people and the pay is really good." In considering what might encourage more women to pursue computer science, Esperanza suggested that perhaps community colleges could provide: "an orientation class on CS and have students talk about the jobs you could get and people that do have those jobs could come and speak and say why they love their job so much and the opportunities they have. I think it would especially encourage females to pursue a computer science degree."

Recommendations

Clearer degree pathways and job goals would assist students in planning their pathway through transfer to a bachelor's degree and into the workforce and would also help motivate them to pursue their dreams. A student who had had an internship, for example, indicated that

he was better able to gauge his fit in, and enjoyment of, a CS job because he had done "real" CS and realized how much he liked it. Establishing partnerships between community colleges and industry is another strategy that could help students better understand the field and feel more involved in the professional community. Stronger relationships between community college instructors and industry experts could assist faculty in devising "real-world" assignments and projects that would be more meaningful to students. It could also provide opportunities for industry experts to share their experiences with students, either in the classroom or virtually. Programming class content could also be extended to provide students with more information on the broadness of the field, job availability, and differences in job requirements and salaries. Connections to professionals through on-campus student organizations, industry professional organizations such as the Association for Computing Machinery (ACM),[32] or social media are another strategy to inspire students to see themselves as future workers. Community colleges could also implement exchanges between community college students and CS professionals through such mechanisms as job shadowing or mentoring to give students a more realistic idea of the workplace and CS options. Increasing the number and types of internships open to community college students could help students build more in-depth knowledge of the field and could give technology companies additional opportunities to help shape the future workforce.

32 https://www.acm.org/

Conclusions

Many challenges were revealed through interviews with underrepresented students in California who want to earn bachelor's degrees in CS via a community college. The results suggest strategies for community colleges, four-year institutions, and industry that could help facilitate the persistence of students on the CS pathway. Strategies that are effective for CS at four-year institutions should also be extended to community colleges. Pulling together the strategies mentioned in the report, we can conclude that providing increased institutional support and flexibility, clearer pathways and help in navigating those pathways, and improved CS career knowledge and experience for students are three strategy areas to help underrepresented students transfer from community college to complete a bachelor's degree in CS.

Strategies for Creating Institutional CS Support and Flexibility

At the two California community colleges in this study, students found almost all teachers and tutors were helpful to their success in CS classes. They struggled, however, to move smoothly through coursework citing full classes, hesitation about meeting math requirements, and the the daunting prospect of needing near-perfect GPAs by transfer institutions as delaying their progress. These delays could be eased by increasing capacity — particularly for classes early in the prerequisite chain — and allowing more flexibility in course-taking order. It is critical to find ways to motivate students in math and to quickly bring them up to required levels. Community colleges may want to foster social cohesion among students in CS who intend to transfer. Community colleges should also find ways to support students in maintaining high GPAs without needing to drop and re-take classes. Financial support is critical in keeping community college students in school, and industry could provide new scholarships to enhance the current community college waiver and financial aid that already assist students.

Strategies for Developing Clear CS Transfer Pathways

Most students did not see a clear pathway of courses and application for transfer to a bachelor's degree in CS. Students mostly planned to attend local universities. This meant that the confusion about necessary courses was increased for the urban students who had more nearby four-year institutions to choose from, indicating that transfer planning is more complicated when more transfer institutions are targeted. Students most often used community college counselors or online resources for assistance, but, as students in this study reported, benefits gained from these resources were limited. Community colleges could help students navigate the pathway by increasing counselor training in requirements and pre-requisites for transfer into four-year CS programs and by increasing the number of counselors available. A centralized online repository of transfer information specifically targeted for computer science students would also be helpful in providing additional support, especially given the current workload of many counselors. Overall, community colleges and universities should strive to streamline transfer pathways — a strategy also suggested by the findings in *A Longitudinal Analysis of Community College Pathways to Computer Science Bachelor's Degrees*.[33]

Strategies for Building Knowledge of CS Careers

The promising career opportunities for CS graduates combined with their enjoyment of classes encourage students studying CS at community colleges to persist in the field. Good teachers for these classes can also make a positive impact.[34] Strengthening the ties between industry and community colleges would bring these students more

33 Jaggars, S. S., Fink, J., Fletcher, J., & Dundar, A. (2016). *A Longitudinal Analysis of Community College Pathways to Computer Science Bachelor's Degrees.* Mountain View, CA: Google Inc. Retrieved from http://goo.gl/Eiz33G.

34 Google Inc. (2014). Women Who Choose Computer Science—What Really Matters. Retrieved from https://goo.gl/rLX6ax.

"real world" contact and context and would help them refine and clarify their planning for the future. The tech industry could provide "real world" projects for community college students and provide information about and experience in the field by also opening up their programs and internships for university students to include community college students.

It will take additional commitment and investment from colleges, universities, and industry to build a more diverse CS workforce. Industry should keep in mind that community colleges are exceedingly diverse institutions that are often the most accessible for underrepresented groups and therefore support a large future diverse workforce. By presenting insights on the challenges and opportunities from the CS students' perspective, this study hopes to increase the likelihood that these investments will succeed.

About Google

Google's core mission is to organize the world's information and make it universally accessible and useful. Google creates products to increase access to opportunity, break down barriers and empower people through technology. To help reach these goals, Google works to inspire young people around the world not just to use technology but to create it. There is a need for more students to pursue an education in computer science, particularly girls and minorities, who have historically been underrepresented in the field. More information on Google's computer science education efforts is available at g.co/csedu.

About ETR

Education, Training, Research (ETR) is a nonprofit organization that aims to enhance the lives of children, youth, and their families. Since 2002, that work has included a focus on increasing diversity in Science, Technology, Engineering, and Math fields. Our multi-disciplinary staff does applied research and evaluation, professional development, and program development. We work with federal agencies, universities, community colleges, schools, foundations, and businesses to design and disseminate science-based services, solutions, and programs. For more information, visit www.etr.org/areas-of-focus/it-diversity/.

Appendix A: Methods

In the first phase of the study, a survey was given to all consenting students enrolled during 2015 in either introductory programming or data structures classes at each of the partner community colleges. All instructors from the two community colleges agreed to give access to their students. Recruitment was in-person during class time by the research team (all white women) in the middle of the academic semester, and $15 gift cards were given to students who chose to fill out the survey. Most of the surveys were completed online during class or laboratory time. Survey results are in Appendix B. From the survey results, a list of women, Hispanic/Latino men, and Black/African American men was compiled, and all these students were invited to participate in an interview and offered a $35 gift card as an incentive; 24 students agreed to be interviewed. In-person interviews held at the library or in a classroom at the community college lasted from about 45 minutes to one and a half hours and were conducted by a white, female researcher and audio recorded.

In the second phase of the study, a list of participants from underrepresented groups who had filled out a survey as part of a previous study[35] was gathered, and those 40 participants who had indicated in 2010 that they were "probably" or "definitely" planning to pursue a computing-related major at a 4-year university were invited to participate in an interview and offered a $35 gift card for participation; 14 students agreed to be interviewed. Interviews were conducted by the same researcher and were held over the phone and audio recorded. Interviews lasted from about 20 minutes to an hour.

Data analysis consisted of descriptive tables of the survey data for all participants and separated by race/ethnicity and college class. Interviews were transcribed for a word-for-word set of data and open coded by interview question using Dedoose software. Four of the interview question responses were coded by two researchers to create an agreed-upon coding scheme, then the rest of the data were coded individually. Codes were grouped by similarity into themes and the themes amenable to strategies for change are reported on in the body of this report. Codes that were used to make up the themes reported on here are in the following table.

COMMUNITY COLLEGE INTERVIEW CODES

THEME	CODE
Institutional CS Support and Flexibility	Hard to get *in* and *through* class
	Math experience/attitudes
	Tutoring/Peer-led teaching
	Financial
	Personal or family crisis
	Family/other commitments
	Teachers
	MESA
	GPA worries
CS Transfer Pathways	Counselors
	Easier to try out majors
	University choice basis: location
	University choice basis: CS ranking
	University choice basis: majors
	Clear pathway
	ASSIST.org
CS Careers	Closer to my goals
	More authentic
	Inspiring outside speakers
	Next step to finalize decision about job
	Goal besides/beyond software engineering
	Gaming
	Pro-social/Intrinsic reward
	Entrepreneurship
	Internships

35 Denner, J., Werner, L., O'Connor, L., & Glassman, J. (2014). Community College Men and Women A Test of Three Widely Held Beliefs About Who Pursues CS. *Community College Review,* 0091552114535624.

Appendix B: Survey Descriptives

A total of 321 students enrolled in introductory programming or data structures class during one semester were surveyed as part of this study. Below are results from the survey.

Part A

INTRODUCTORY PROGRAMMING AND DATA STRUCTURES CLASS SURVEY

DEMOGRAPHICS		TOTAL
Gender (n=314)	Male	(236) 75.2%
	Female	(78) 24.8%
Age (n=317)	25 and Younger	(271) 85.5%
	26 and Older	(46) 14.5%
Race (n=315)	Black/African American	(14) 4.4%
	Asian American/Pacific Islander	(82) 26.0%
	Hispanic/Latino	(146) 46.3%
	White	(38) 12.1%
	Mixed	(33) 10.5%
	Other	(2) 0.6%
School (n=319)	Rural	(163) 51.1%
	Urban	(156) 48.9%
Class (n=319)	Intro to Programming	(226) 70.8%
	Data Structures	(93) 29.2%
Home Country (n=317)	Unites States Only	(218) 68.8%
	Other	(99) 31.2%
Language Spoken at Home (n=316)	Mostly or Only English	(172) 54.4%
	½ English, ½ Other Language	(73) 23.1%
	Mostly or Only Other Language	(71) 22.5%

Part B

INTRODUCTORY PROGRAMMING AND DATA STRUCTURES CLASS SURVEY

STUDENT CS INTENTIONS	BLACK		ASIAN AMERICAN/ PACIFIC ISLANDER		HISPANIC/ LATINO		WHITE		MIXED		OTHER	
	M n=12	F n=2	M n=56	F n=25	M n=105	F n=40	M n=30	F n=7	M n=28	F n=4	M n=2	F n=0
Current Major												
CS/CE Major	91.7%	-	78.6%	72.0%	87.6%	82.5%	66.7%	57.1%	82.1%	75.0%	100%	-
Other STEM Major	8.3%	100%	17.8%	20.0%	8.6%	10.0%	13.3%	14.3%	7.1%	-	-	-
Other Non-STEM Major	-	-	3.6%	-	1.0%	7.5%	13.3%	14.3%	7.1%	25.0%	-	-
Un-decided	-	-	-	8.0%	2.8%	-	6.7%	14.3%	3.6%	-	-	-
Transfer to a 4-Year University												
And Major in CS/CE	75.0%	-	57.9%	60.0%	63.8%	57.5%	46.7%	57.1%	69.0%	25.0%	100%	-

Part C

INTRODUCTORY PROGRAMMING AND DATA STRUCTURES CLASS SURVEY

PARENTS	BLACK		ASIAN AMERICAN/ PACIFIC ISLANDER		HISPANIC/ LATINO		WHITE		MIXED		OTHER	
	M n=12	F n=2	M n=57	F n=25	M n=105	F n=40	M n=30	F n=7	M n=29	F n=4	M n=2	F n=0
Parent Working in Computing Field												
Mother	-	-	-	-	1.0%	-	3.3%	14.3%	10.3%	-	-	-
Father	8.3%	-	5.3%	16.0%	1.9%	-	10.0%	-	13.8%	-	-	-
	M n=12	F n=2	M n=53	F n=25	M n=103	F n=38	M n=30	F n=7	M n=28	F n=4	M n=2	F n=0
Mother's Education Level												
Less than High School Diploma	-	-	11.3%	8.0%	56.3%	50.0%	3.3%	-	32.1%	-	-	-
High School Diploma, Trade School, or Community College	66.7%	-	43.4%	44.0%	34.0%	42.1%	50.0%	85.7%	53.6%	50.0%	50.0%	-
Some University Schooling or Higher Degree	33.3%	100%	45.3%	48.0%	9.7%	7.9%	46.7%	14.3%	14.3%	50.0%	50.0%	-
	M n=11	F n=2	M n=53	F n=24	M n=93	F n=36	M n=26	F n=7	M n=28	F n=4	M n=2	F n=0
Father's Education Level												
Less than High School Diploma	-	-	15.1%	8.3%	65.6%	58.3	-	-	17.9%	-	-	-
High School Diploma, Trade School, or Community College	36.4%	-	26.4%	33.3%	28.0%	38.9%	53.8%	57.1%	46.4%	25.0%	-	-
Some University Schooling or Higher Degree	63.6%	100%	58.5%	58.3%	6.5%	2.8%	46.2%	42.9%	35.7%	75.0%	100%	-

**Students who selected that they did not have a father/father figure and/or a mother/mother figure are not included in this table and were coded as missing.*

Part D

INTRODUCTORY PROGRAMMING AND DATA STRUCTURES CLASS SURVEY

PRIMARY SOURCE OF FUNDING	BLACK		ASIAN AMERICAN/ PACIFIC ISLANDER		HISPANIC/ LATINO		WHITE		MIXED		OTHER	
	M n=12	F n=2	M n=57	F n=25	M n=104	F n=40	M n=30	F n=7	M n=29	F n=4	M n=2	F n=0
#1 Funding Source												
Loans	8.3%	-	5.3%	-	2.9%	2.5%	3.3%	-	6.9%	-	-	-
Grants/ Scholarships	25.0%	-	17.5%	24.0%	55.8%	60.0%	16.7%	57.1%	48.3%	75.0%	-	-
My Work	33.3%	-	12.3%	-	10.6%	17.5%	20.0%	14.3%	20.7%	-	-	-
My Savings	-	-	8.8%	4.0%	6.7%	5.0%	6.7%	-	3.4%	-	50.0%	-
Family	33.3%	100%	50.9%	68.0%	16.3%	10.0%	53.3%	14.3%	27.6%	25.0%	50.0%	-
Other	-	-	5.3%	4.0%	7.7%	5.0%	-	14.3%	-	-	-	-

Part E

INTRODUCTORY PROGRAMMING AND DATA STRUCTURES CLASS SURVEY

EXPERIENCE	BLACK		ASIAN AMERICAN/ PACIFIC ISLANDER		HISPANIC/ LATINO		WHITE		MIXED		OTHER	
	M n=12	F n=2	M n=56	F n=25	M n=105	F n=40	M n=30	F n=7	M n=29	F n=4	M n=2	F n=0
Prior Programming Experience (Before Intro to Programming)	33.3%	-	35.7%	44.0%	34.3%	47.5%	53.3%	42.9%	31.0%	50.0%	50.0%	-
	M n=12	F n=2	M n=57	F n=25	M n=105	F n=40	M n=30	F n=7	M n=29	F n=4	M n=2	F n=0
Higher Math Class Previously Taken (i.e., trig, calculus, and/or stats)	91.7%	100%	91.2%	100%	75.2%	90.0%	83.3%	85.7%	82.2%	75.0%	50.0%	-

**This table represents the percentage of students who selected "Yes" for the questions above.*

Part F

INTRODUCTORY PROGRAMMING AND DATA STRUCTURES CLASS SURVEY

TOP REASON FOR CLASS ENROLLMENT	BLACK		ASIAN AMERICAN/ PACIFIC ISLANDER		HISPANIC/ LATINO		WHITE		MIXED		OTHER	
	M n=12	F n=2	M n=57	F n=25	M n=105	F n=40	M n=30	F n=7	M n=29	F n=4	M n=2	F n=0
Top reasons students enrolled in class												
#1 Required by Major	100%	50.0%	82.5%	88.0%	82.9%	80.0%	76.7	85.7%	75.9	75.0%	100%	-
#2 Personal Interest	75%	50.0%	78.9%	72.0%	81.0%	57.5%	86.7%	42.9%	89.7%	75.0%	50.0%	-
#3 Potential for High Paying Job	100%	-	54.4%	56.0%	73.3%	60.0%	53.3%	57.1%	79.3%	50.0%	50.0%	-

**These are the top 3 reasons for enrolling for the total population of students.*