13. An Asset-Based Approach to CS Equity

Ethnographic Research on Google igniteCS

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Abstract: The field of computer science (CS) struggles to expand the representation of women and minorities. To help strengthen a sense of belonging and confidence in the field for these underrepresented groups (URGs), Google launched igniteCS (iCS), an educational mentorship program run by undergraduate CS students in the United States and Canada. This paper presents a qualitative study of iCS that found the program exemplifies an "asset-based" approach that grows out of the unique strengths and interests of URGs. The program's peer support and leadership opportunities led to significant positive outcomes for undergraduates most at risk of dropping out of CS programs. These positive outcomes included: (a) psychological safety, (b) peer relationships in CS, and (c) identity transformation. The key design features that supported these outcomes included: (a) validating and sponsoring the strengths of youth from URGs, (b) supporting student autonomy and initiative, and (c) peer-to-peer and near-peer mentorship.

Introduction

Broadening participation in computer science (CS) requires expanding formal educational programs and career opportunities, as well as informal supports such as mentorship, peer friendships, and role models that reflect diverse identities and interests. Studies of CS programs in higher education show that a lack of mentors and peers whom they identify with can be barriers for students from underrepresented groups (URGs). URGs in CS refers to students who identify as female, Latinx, African American/Black, Native American, or Pacific Islander. Research on informal supports for learning emphasizes benefits of programs taking an "asset-based" approach that builds on the strengths that URGs bring to CS, rather than only orient toward remedying deficits. Integrating these findings, the connected learning approach to program design has documented how supportive relationships, meaningful projects, and a sense of belonging are essential for most young people to persist in challenging fields such as CS (Ito et al., 2013). This study examines key features of a Google-sponsored experiential learning program, igniteCS (iCS), through a connected learning lens to highlight features that broaden participation for students from URGs.

iCS was a Google-sponsored program designed to improve retention rates in undergraduate CS majors for women and other URGs. The program supported undergraduate volunteer clubs at colleges and universities in the United States and Canada from 2015 to 2018. Participation in iCS clubs centered on teaching CS and computational thinking to K–12 learners in local communities. Student volunteers had a high degree of autonomy in forming teams, designing curricula, and establishing relationships with community partners. Across all four years, the program included 155 clubs, 3,176 undergraduate volunteers, and more than 10,700 young students. The outcomes of this initiative were captured through surveys conducted by Google and in a qualitative study of the final program year conducted by the Connected Learning Lab (CLL) at UC Irvine. The CLL study complements Google's quantitative research by providing a textured, student-centered view of club experiences, focusing on students at risk of dropping out of CS programs.

Background

iCS is situated within a growing range of initiatives aimed at broadening access to CS careers, particularly for women and underrepresented minorities. Studies show a persistent and long-standing underrepresentation of women, Blacks, Hispanics, and Native Americans in CS courses and the workforce. The National Science Foundation (NSF; 2017) found a downward trend of women pursuing CS in the past decade, and by 2014, less than 20% of undergraduate degrees in computer science and engineering were earned by women. By contrast, the representation of women in other STEM fields is growing (e.g., women earn 59% of U.S. undergraduate degrees in biology), and nearly half of all law and medical graduates are women. The combined representation of Black and Hispanic students in CS was 19.5% by 2014 (NSF, 2017). Efforts supported by industry, government, and philanthropy address a range of settings and factors, including the K–12 system (Vogel, Santo, & Ching, 2017).

Even when they have access to CS programs in higher education, sociocultural influences such as stereotypes and lack of diverse mentorship can be barriers for youth from URGs in CS (Cheryan, Master, & Meltzoff, 2015; Cheryan, Plaut, Davies, & Steele, 2009; Choney, 2018; Cozza, 2011). Young women and students of color struggle to find role models and frameworks in which they imagine their future selves as computer scientists or engineers (Barton et al., 2013). Addressing these barriers can have a significant impact (Moghadam & Bates, 2017). For example, Project Rise Up 4 CS is a targeted CS program that helps high school students from URGs pass their AP CS exams through a combination of near-peer support, weekly seminars, and twice-weekly webinars (Ericson, Parker, & Engelman, 2016). Results show significant improvement in student attitudes toward CS and increased perception of their ability to pass the AP exam. A study of Black Girls Code found that CS programs tailored for Black and Latino girls supported confidence in computing and a desire to persist in the field (Rockman et al., 2017).

iCS builds on this prior research, targeting the undergraduate phase of CS learning and identity development to strengthen social and cultural supports for students who are interested in a CS undergraduate major. Among varied efforts to address equity in access to CS education, iCS stands out in its focus on providing a context for otherwise marginalized youth to connect their college experience to their authentic interests and identity. It goes beyond a specific curricular or mentorship intervention to support a holistic civic engagement opportunity that enhances a sense of purpose and expands social capital in CS for the most vulnerable of CS majors. It is particularly notable in taking an asset-based rather than a deficit-oriented approach. Rather than focus on direct aid such as mentorship, financial support, and instruction, the program provides a context for these youth to exercise power and leadership through civic engagement that grows out of their unique identities and assets. It recognizes and amplifies the strengths of youth from URGs in CS rather than seeking to "fix" a perceived deficit.

The program exemplifies an approach to learning and program design developed and refined by the Connected Learning Research Network and a broader network of partners (Ito et al., 2013). In a nutshell, connected learning is when a learner is engaged in a pursuit that grows from his or her interest and identity, is supported by peers and mentors who share that identity, and is tied to opportunities for success. In the case of iCS, the program was designed to legitimize the identities of students from URGs and connect their interests in social justice to a supportive set of relationships, which were in turn connected to opportunities for success in the field of CS. This research study investigates learner experiences and outcomes in iCS in order to extend our understanding of how connected learning approaches can best support broadened access to CS degrees and careers.

Research Methodology

Between February and April 2018, researchers from the CLL conducted interviews with 25 undergraduate volunteers, six Google employee mentors, and focus groups at two campuses. Interviews were designed to capture the backgrounds of undergraduate participants, their experiences in the program, and how these experiences contributed to their commitment and feelings of belonging in CS. Researchers also sought to understand which iCS features contributed to positive outcomes. The study was not designed to provide a comprehensive view of iCS participation, but rather focused on iCS features that contributed to positive outcomes for students most marginalized in CS. The program was sunsetted in 2018, but the underlying factors and design implications can inform other programs with similar goals and theories of action.

Research Questions

Research questions addressed in this study and report include:

1. Program Design: What are the intended design and key features of iCS?
2. Participant Characteristics: What are the characteristics of iCS student volunteers?
3. Experiences and Outcomes: How do student volunteers experience specific iCS features? Does participation in iCS affect student commitment to and belonging in CS and career aspirations?
4. Supports: What experiences and program features contributed to student commitment and sense of belonging to the field of CS and CS career aspirations?

iCS Program Background and Student Characteristics

iCS seeks to increase retention in undergraduate CS by increasing participants' sense of professional belonging. Many qualified, competent undergraduates leave CS because they perceive that the field "is not for them" (Cheryan et al., 2015; Choney, 2018). In iCS, undergraduates teach CS to K–12 learners within supportive peer networks with mentorship that might heighten their sense of purpose, affiliation, and ultimately, belonging in CS. iCS posits that through a shared mission to introduce K–12 students to CS concepts, undergraduate CS students will foster a deeper sense of belonging that also increases their chance of completing their degree. Likewise, iCS would inoculate students against feeling disconnected from their local communities through the practice of measurable, meaningful volunteer engagement.

Students already active in academic organizations working toward equity within CS are eligible to participate in iCS. The program is composed of undergraduates who assemble into teams of five or more volunteer students who identify and collaborate with K–12 community partners to address a particular community need for CS education. The curriculum has multiple entry points for differently aged students and is flexible so that undergraduates can tailor learning experiences to local needs. Google is a key component of the program, as it offers professional legitimacy, affiliation, and potential professional mentors. Additionally, Google provides iCS programs a curriculum, supporting materials, and in the first three years of the program, up to $10,000 to reimburse expenses.

Good programs include overlapping and reinforcing components. iCS program designers theorized that undergraduate CS students teaching K–12-age learners would deepen their understandings of CS and strengthen their identification with and commitment to the field. Although iCS was not designed to specifically address the high school-to-college pipeline, seeding successful undergraduate CS students with local partners could imbue these communities with

knowledge and experiences of what it is like to go to college and study in CS. K–12-age learners develop CS skills in addition to recognizing how people with backgrounds similar to theirs belong in a university CS program. This cycle could lead to a self-renewing pipeline of women and minorities in CS. As such the desired *outcomes* of iCS were:

1. Increased retention of women and underrepresented minorities in undergraduate CS;
2. Stronger connections to local communities and building a pipeline to university CS programs;
3. Improvement of faculty-student relationships in undergraduate CS;
4. Building community across campuses;
5. Increased interest and participation of students from URGs in university CS courses programs.

Participating students completed a survey about their background, their current academic status, and future career interests. The total survey sample is 41 out of 44 total participants (see Table 1). The majority of participants attended public universities that served between 11,000 and 30,000 students. This sample has an above-average representation of women, Black, Hispanic, and first-generation students compared to 2016 national statistics. Both universities where we conducted focus groups were commuter schools that predominantly served local students and were recognized as Hispanic-serving institutions.

Student demographics	Frequency (n=37)	Percentage
Average age	22.4	--
Female	17	46%
First-generation college student	7	19%
Computer science major	28	76%
STEM major	35	95%
Race	**Frequency (n=41)**	**Percentage**
African American/black	3	7%
Asian	19	46%
Caucasian/white	12	29%
Hispanic	7	17%

Table 1. Student demographics.

Data Collection

Data collection took place between February and April 2018. Interviews and focus groups were conducted by the lead author with the exception of one iCS staff interview conducted by another author. iCS staff were interviewed as part of the research design and helped describe the motivation, intended design, and objectives of Google iCS. Six Google employees volunteered as MentorNet mentors, and all of them were invited to participate in the study by iCS staff. Four out of six Google mentors participated in the interviews. Student volunteers were invited to participate in the study by program administrators at Google. These students were given information about the evaluation and self-selected to be contacted as a part of the study. Interview participants were recruited from the sample of students (n = 38) who responded to this call. We contacted each of the 38 student volunteers individually by email to schedule online video interviews over Google Hangouts. A total of 25 students from the initial sample were interviewed. Interviews lasted approximately 50 minutes. Focus group participants were selected by geographic proximity to the research team at UC Irvine, thus only iCS groups in California were considered. The proximity of the institutions allowed us to visit the student groups and observe their group interaction in person. The two groups who participated in the evaluation were indicative of the variety of ways iCS groups structured their programs in different institutions. The first group was affiliated with a Southern California institution, and a total of 16 active members participated in the two-hour

group interview. The second iCS group was affiliated with a Northern California institution and consisted of six active members, four of whom were participants in the group interview.

Analysis

This cultural and practice–based analysis is naturalistic, interpretive, and qualitative, seeking to understand and theorize participants' experiences of the program. A coding tree was developed to surface themes that responded to the original research questions, as well as to allow for emergent findings (a priori and emergent coding). Although codes were developed, code counts or saturation rates are not reported, as we are not attempting to characterize iCS or CS participation more generally. Rather, we identify specific cultural patterns and forms of social participation among target youth that suggest promising directions for program design that could be amplified. From this analysis, the following findings emerged.

Findings

Student volunteers who were interviewed for this study reflected varied backgrounds in relation to CS. They included students who were allies but not themselves from URGs, and many youth who already had substantial exposure to and supportive relationships in CS before entering college. The outcomes for youth who already had strong informal and relational supports in CS were less profound than for those youth who were newer to CS, had identities that did not conform to the dominant culture of CS, and had fewer CS friends and mentors before volunteering for iCS. Here we focus on this latter group of student volunteers, showcasing their voices and subjective experiences, and identifying the ways in which iCS contributed to outcomes that supported their persistence in CS.

Outcomes

Although young people engaged with iCS in varied ways, the positive outcomes of iCS hinge on this power shift from a deficit-oriented to an asset-based approach. Three student gains were identified as: (a) psychological safety, (b) peer relationships in CS, and (c) developing CS identities.

Psychological safety. Participation in an iCS team resulted in feelings of psychological safety, which spilled over to confidence in CS college courses. This sense of safety emerged from experiences of teaching and mentoring younger students in a lower-stakes setting, combined with a supportive team environment. Miriam, a junior CS major, described her developing feelings of confidence and safety:

> One thing I learned [by working with young students] was that I always expect it to be hard so I, like I tighten up my skin and tell myself that it is going to be hard, judging it before actually seeing the program. [My students] actually challenged that problem. They were like, okay, let's do this. And I learned that oh, you don't have to panic about it. They kind of told me like, hey, take it easy; it's okay.

Peer relationships in CS. Participation also led to peer relationships in CS that provided socioemotional and concrete support for academic success in CS. The team context created strong bonds and friendships, and students supported

each other in classes and in navigating other opportunities in the university and beyond. Leon, a senior CS major, explains, "If somebody needs notes, then we get the notes. If we need to study together, we know we can study together."

Developing CS identities. The most vulnerable student volunteers experienced profound identity transformation into someone who has unique value to contribute to CS. Volunteers who once thought they were marginal or did not fit in described how iCS helped them realize that they could provide value to the field of CS *without* having to conform to the dominant culture of CS. Diego, a junior CS major, describes how being part of iCS stretched what he thought he was capable of. "I never thought I would go on and teach students, but they got me to go out and teach students. I never thought I would learn to create different lesson plans but now I do."

Key Features

These outcomes are driven by three key features of iCS: (a) validating and incentivizing activities for students from URGs, (b) supporting student autonomy and initiative, and (c) peer-to-peer and near-peer mentorship.

Validating and incentivizing activities for students from URGs. By focusing on community service through mentorship and equity in STEM, iCS validated their interests in using their knowledge and experience to make a difference. iCS volunteers described a shared purpose in providing equitable access to CS education. Prisha, a senior CS major, joined iCS to help bring more young women into CS. She underscored the importance of active participation of volunteers from URGs, explaining how "if you see a lot of people who look like you doing something, then you feel more inclined to consider that as an option for yourself." In their interviews, 13 volunteers emphasized that making CS accessible to students with limited opportunities to develop computer literacy and programming skills was most important to them.

Previn, a sophomore CS major, notes how this sense of purpose infused his approach to CS more broadly: "What I'd say is I think teaching students how to do something and seeing a positive outcome of it motivates you to want to better yourself. And so indirectly I think it would motivate you to want to take computer science more seriously, which would make your attitude toward it a bit more positive." Participants describe how iCS helped improve their attitude toward CS, as well as how their connection to CS improved their sense of civic efficacy. As a commuting CS freshman who recently joined the club, Nina says, "Sure, politics and governments may be out of my scope, but being in ignite is saying that you can still contribute to closing that socioeconomic gap." In other words, iCS gave students who were not otherwise civically engaged an outlet for justice-oriented action connected to their STEM identities.

Enabling student autonomy and initiative. Student volunteers identified with the mission and purpose of iCS, affiliated with it as a program, repurposed materials with relative ease and confidence, and took ownership over their local clubs. Even when direct financial support was withdrawn in Year 4, students took pride in their clubs and did not report feeling exploited, undercompensated, or as if iCS wasted their time. Rather, iCS volunteers designed their club mission and objectives to address needs in their local communities and to reflect goals that were most meaningful to them. Participants iterated on their program design and expanded their social network to provide a more seamless and sustaining learning environment for CS fluency.

For example, three student volunteers said they helped local K–12 CS teachers as classroom aides, and two incorporated remote online support for students in CS classes. One student volunteer, who attended a small liberal arts college, opened her iCS classes to fellow undergraduate students, because the majority of her (liberal arts) peers had never had the opportunity to develop computer literacy or programming skills before. This fluidity is common to interest-driven connected learning communities, but less common in planned, organized groups with institutional sponsorship. Volunteers brought their interests and skills to their clubs and expressed pride in the cultures they cultivated.

Peer-to-peer and near-peer mentorship. The act of creating and running a club provides opportunities for formal and informal socializing, varying from the focused development of activities to the less formal "down times" between sessions. The ability to work with peers in this relatively unstructured setting enabled forms of formal and informal knowledge sharing. The professionally intimate nature of teaching and the open-ended nature of clubs helped students grow strong, trusting bonds around professional matters. Raquel, a senior CS student, told us how her relationships with iCS peers helped her persist in CS. "Once I joined iCS I started getting involved with my peers more," she told us as she described how her university experience changed after joining iCS. "We started taking classes together, we all see each other [as] equal on the team. We all help each other out. It has made me feel better about myself. I walk into class and there's a whole bunch of guys, but who cares, you know?"

By contrast, student volunteers described how they felt unmoored in the vast selection of courses in their program and that faculty often seemed inaccessible. Even when offered the option of industry mentorship via MentorNet, a portal to professional mentors provided by the iCS program, few took advantage of this opportunity. The fear of "not knowing enough" or being intimidated by a Google employee prevented most of the student volunteers from reaching out to available mentors. Yet all volunteers felt comfortable approaching peers for advice. Without diminishing the importance of supportive professional and faculty mentors, our findings point to great advantages in building strong ties between students in different levels.

Implications

iCS approached the problem of undergraduate retention in CS through a unique set of levers. The program reflected the strengths of experiential and project-based learning in nurturing efficacy and motivation, but it tailored these approaches to the identities and backgrounds of those most vulnerable to dropping out of CS degree programs. Rather than take the more typical approach of providing "disadvantaged" young people with more resources and support, iCS calls on these same young people to give *more with less*, in service of CS and communities that they identify with. While more researchers investigating educational equity have been pointing to the importance of an asset-based orientation, few programs have fully embraced this approach at the scale that iCS has. The case of iCS is an important addition to this growing body of research.

Programs that seek to increase a sense of efficacy and belonging in CS for students from URGs should consider validating and amplifying existing strengths, such as their commitment to activism and justice. Whether it is prior experiences of marginalization or other skills such as community organizing, youth who are not part of the dominant culture of CS bring unique assets to the field. Programs could encourage student agency by providing model projects, resources, and materials but allowing students to co-design the mission and focus of local sites, so that the interests, passions, and concerns of both volunteers and students are reflected in projects. Designers should be mindful about providing materials and funding in ways that could limit student initiative. Peer mentorship can form naturally from students who (a) self-selected into groups by interest, (b) engaged in teaching as a sustained purposeful activity, and (c) were in courses with one another.

While it is tempting to shower marginalized students with resources and powerful connections, charity has the unintended side effect of not only calling out deficits, but reducing initiative. In iCS, professional mentoring relationships occurred less regularly, naturally, or spontaneously than peer mentorship. Particularly with a population that has already made it so far as to declare a CS major, empowerment is a critical component to achieving a strong sense of belonging. In this context, the experience of leadership, self-determination, and being co-equal with other peers with shared identities conferred greater benefits than professional mentorship and material resources. Further, benefits of this approach accrue disproportionately to the most marginalized students, making it attractive to those

seeking to change the balance of representation, rather than simply distributing resources more equitably. Add to this the advantage of being a leaner way to support and scale programs, and the iCS approach stands out as an effort worth emulating.

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