

# **DIVERSIFYING UNDERGRADUATE COMPUTER SCIENCE: THE ROLE OF DEPARTMENT CHAIRS IN PROMOTING GENDER AND RACIAL DIVERSITY**

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*Broadening participation in computer science for women and underrepresented minority students remains an area of concern for many colleges and universities. Yet, little is known about the role of department chairs in initiating and leading efforts to recruit and retain women and students of color. Interviews with 15 department chairs participating in a nationwide effort to diversify computer science provide greater understanding about the change process and reveal insights about the barriers to and challenges in broadening participation. The findings illuminate the ways that department chairs grapple with both internal and external factors that impact their ability to diversify their departments.*

**KEY WORDS:** *gender, underrepresented minority students, computer science, organizational change, CS department chairs*

## **1. INTRODUCTION**

Increasing the representation of women and underrepresented minority (URM) students in the computer science (CS) major has been a focus of public discussion in recent years. The gender gap in particular has received significant attention, as the disparity between men and women in computing is highly visible. At the college level, more than four men earn a bachelor's degree in computing for every one woman (National Center for Education Statistics [NCES], 2015). Furthermore, the gender gap in CS has widened over the years: In the mid-1980s, more than 35% of CS bachelor's degrees were conferred to women (NCES, 2015). However, women's representation among CS degree earners quickly declined, hovering around 28% throughout the 1990s, and dropping to approximately 18% by 2012 (NCES, 2015).

Students of color are also underrepresented in CS. In particular, African Americans are awarded only 3.8% of all CS bachelor's degrees, despite constituting 9% of degree recipients across all fields (NCES, 2016a, 2016b). Further, the proportion of bachelor's degrees awarded to URM students in CS has remained stagnant at about 18% since 2006 (National Science Foundation, 2015). At the same time that computing fields suffer from pronounced gender and racial/ethnic inequity, there is growing demand for individuals trained in CS. The Bureau of Labor Statistics (2016) predicts that jobs requiring CS degrees will be some of the fastest-growing careers over the next 20 years.

Given growing inequities and economic conditions within computing, efforts to broaden the participation (i.e., to increase the recruitment, retention, and advancement) of women and URM students have become a priority for many undergraduate CS departments. Department chairs are

often tasked with spearheading departmental change efforts, and can become the lynchpin of diversity-related change initiatives at their institutions (Maton, et al., 2008; Byrne, 1997). Furthermore, research has highlighted the key role that department chairs play in initiating change to diversify CS (Cohoon, 2001).

However, departmental approaches to creating change may vary based on their perspectives of the problems and challenges at hand. Specifically, how faculty conceptualize the challenge of recruiting and retaining women and URM students in CS may shape the approach they take to broadening participation in their departments. Furthermore, exposure to and training on diversity issues in education is not the norm in most computer science departments and therefore department chairs may have varying levels of awareness around these issues and varying degrees of comfort around discussions of race. At the same time, there has been growing awareness of the need to increase the participation of women and students of color in the tech community (Frieze & Quesenberry, 2015). Thus, department chairs may deal with the tension of internal and external pressures to diversify their departments coupled with a lack of training about diversity-related change efforts. This study addresses this topic by focusing on the perspectives of department chairs involved in an initiative aimed at broadening the participation of women and URM students at 15 CS departments across the United States. This study fills an important gap in the literature by focusing on how these chairs conceptualize diversity and how that relates to their role in broadening the participation of women and URM students in computing.

## 2. LITERATURE REVIEW

In recent decades, researchers have examined efforts to broaden the participation of women and students of color in CS. Margolis and Fisher's (2002) groundbreaking book *Unlocking the Clubhouse* examines the gender gap in the CS major and reviews best practices for increasing women's representation in computing. Based on interviews with CS students at Carnegie Mellon University (CMU), Margolis and Fisher (2002) identify four issues relevant to women's lack of representation among CS majors, including the gap in computing experience between men and women, women's lack of confidence in their computing abilities, unaccommodating curricular requirements, and an unsupportive peer culture. Margolis and Fisher attribute much of the gender gap in CS to familial factors such as girls' lack of access to home computers growing up (we note, however, that this is an artifact of the timeframe for their study and that this particular condition has undoubtedly morphed in the present era of "ubiquitous computing" [McCoy & Heafner, 2004]). Margolis and Fisher note that educational reforms in the areas of faculty-student interactions, departmental culture, and classroom pedagogy can dramatically increase women's representation in the CS major, citing CMU's increase in the representation of women from seven to forty-two percent between 1995 and 2000. They also highlight the importance of women's early experiences in the college CS classroom, noting faculty encouragement and positive peer interactions as key to women's retention in the CS major.

More recently, Frieze and Quesenberry's *Kicking Butt in Computer Science* (2015) builds upon Margolis and Fisher's pioneering work by taking an in-depth look at the culture of the CS department at CMU in the years since *Unlocking the Clubhouse*. Frieze and Quesenberry highlight some of the positive changes that led to a healthy and thriving environment for women in computing at CMU, noting that women's representation has grown to over 40% in recent years.

Like Margolis and Fisher, their work focuses on the importance of culture change through programmatic interventions inside and outside of the classroom.

Other studies have yielded similar findings on the importance of faculty interactions and positive classroom environments to women's persistence in STEM majors (Seymour & Hewitt, 1997; Cohoon, 2001). Research also reveals the importance of positive faculty interactions in the recruitment and retention of URM students in the CS major (Newman, 2011). Further, while men tend to cite early childhood experiences as sparking their interest in computers, women often cite later exposure to computing (e.g., their interactions with college professors) as initiating their CS interests, a finding that holds true across different racial and ethnic groups (Varma, 2006).

Introductory computing courses can also play a key role in broadening (or limiting) participation in CS, though much of the research on the role of introductory courses has focused on STEM majors in the aggregate. Gasiewski and colleagues (2012) found that introductory courses are key to recruiting, retaining, and engaging students in STEM. Unfortunately, STEM faculty have historically seen introductory courses as a mechanism for "weeding out" students who they interpret to be less prepared for a STEM major (Gasiewski, et al., 2012). Scholars have posited that when faculty view introductory courses as an opportunity to weed students out of the major, retention decreases both generally and particularly for women and URM students (Graham et al., 2013; Watkins & Mazur, 2013; Roberts, Kassianidou, & Irani, 2002).

Fortunately, when faculty begin to view introductory courses as an opportunity to engage – and thus recruit and retain – students, we see significant increases to retention in STEM majors for all students but for women and URM students in particular (Watkins & Mazur, 2013). In CS in particular, changes to introductory courses (e.g., flipping the classroom, adding real-world examples, etc.) have shown to significantly increase enrollment, retention, and success among underrepresented minority students (Newhall, et al., 2014; Frieze & Quesenberry, 2015). Introductory courses can provide an opportunity for institutions to foster a positive and supportive peer culture among students. Reinforcing a positive peer culture through discussion and engagement with course content positively predicts retention for women of color in CS (Espinosa, 2011), though it is important to remember that peer interactions are not always supportive and inclusive of women and URM students (Seymour & Hewitt, 1997).

Many of the aforementioned findings on faculty and peer interactions and changes to introductory courses relate to the broader issue of departmental culture change. Literature on women and students of color in STEM majors has highlighted the importance of culture change in efforts to broaden participation of women and URM students in STEM, and more specifically in CS (Cohoon, 2001). Key to initiating and implementing changes to departmental culture is the CS department chair. While students, faculty, or staff sometimes initiate changes to departmental culture through grassroots efforts, the department chair often serves as the lynchpin for change efforts (Evans & Chun, 2015). Department chairs have the ability to encourage a cultural shift in their departments toward more positive student-faculty interactions and inclusive classroom environments. Their attitudes and actions can shape policies and practices among the faculty in their departments and the students whom they teach. Furthermore, achieving deep and systemic change (e.g., transforming the departmental culture to be more inclusive) can be extremely difficult without the support of those in formal leadership positions, such as the department chair (Kezar, 2009).

Evans and Chun (2015) recently examined how department chairs across fields conceptualize diversity-related change initiatives in their department. Interviews with department chairs revealed numerous impediments to change, with some department chairs perceiving

barriers to diversity to be more localized in the department (e.g., factions or cliques within the department) and others citing issues outside of the department (e.g., that recruiting diverse students is the responsibility of the institution). The fact that computer scientists have differing points of view on diversity in computer science is not surprising given that the research community also has inconsistent perspectives: some attribute the lack of diversity to larger societal problems while others call for more department-level change initiatives. For example, Herring et al. (2006) cite the masculine culture that is hostile toward women and people of color as the reason departments are unable to diversify their computing majors. Because of broader computer science stereotypes, Herring et al. posit that it is difficult to recruit women and people of color when the pipeline is so limited. However, Margolis and Fisher's (2002) study also highlights the role of classroom-level factors, suggesting that instructors in computer science ought to receive implicit bias training in order to be more inclusive. More research, this study included, is needed to examine the impact of these differing perspectives and determine how differences in department chairs' perceptions might influence their leadership within their department with respect to diversity-related change initiatives.

### 3. THEORETICAL FRAMEWORK

To gain a deeper understanding of the ways that department chairs can influence diversity-related change within their academic units, this study is guided by the theory of institutionalization (Curry, 1992; Kezar, 2007; Kezar & Sam, 2013). Institutionalization refers to policies and practices that become part of the underlying assumptions and norms embedded in the culture of an organization (Kezar & Sam, 2013). Curry (1992) advanced a typology for organizational change in three stages: (1) mobilization, or preparing for change; (2) implementation, or introducing the desired changes into the system; and (3) institutionalization, where the system is stabilized in its altered state. As Curry points out, "If an innovation is not institutionalized, either in its original form or in a modified form, it is terminated" (1992, p. 8). While most organizations are continually evolving and trying to improve practices, creating lasting change can be difficult and often requires insightful and dedicated leadership.

Kezar (2007) highlights the need for different leadership approaches during the three phases of institutionalization. During the mobilization phase, leaders should be focused on setting priorities, developing a vision, and communicating that vision to others. In the second phase, implementation, leaders need to inspire and persuade others to see the importance of the proposed change, and create opportunities and incentives for involvement. Finally, to realize institutionalization, leaders need to focus on value and meaning, and work to create cultural consensus by helping individuals work through conflicting views that could be barriers to lasting change. Organizational change happens over time, and the three stages of change in institutional theory occur on a continuum with one phase blending into the next (Curry, 1992; Kezar, 2007).

Institutionalization theory provides a useful framework for examining the role of department chairs in furthering the diversity goals of their CS departments. While some departments in this study are building on substantial ongoing efforts to encourage the enrollment, retention, and academic success of women and students of color, others are just starting to articulate a vision and build momentum. Creating a more inclusive and diverse environment within the field of CS has been an ongoing challenge; therefore, gaining new insight regarding the ways that academic leaders facilitate positive change within their departments is highly valuable and timely.

#### 4. OBJECTIVES

As the previous sections highlight, department chairs are uniquely positioned to initiate and nurture change efforts in their departments and at their institutions. While some research has started to examine the leadership role of department chairs in efforts to influence departmental cultures and create more inclusive academic environments (Evans & Chun, 2015), little is known about the ways that CS department chairs conceptualize diversity issues within their departments and how these perceptions might impact their efforts to broaden participation in STEM fields. This study builds on the work of previous studies that demonstrate that leadership and engagement of department chairs matters in efforts to diversify STEM fields (Fox, Sonnert & Nikiforova, 2009), and focuses on the department chairs as leaders and key gatekeepers for organizational change efforts in initiatives focused on diversity. Additionally, this study contributes to existing calls for research conducted on individual STEM fields, rather than studying them in the aggregate (Kanny, Sax & Riggers-Piehl, 2014).

This study seeks to gain a deeper understanding of the opportunities and challenges that CS department chairs face in trying to encourage more women and students of color to pursue a degree and career in computing. It aims to shed light on the challenges and benefits of departmental change for diversity, and the role of department chairs as leaders in the change process to close the sizeable gender and race gaps that exist in CS. Specifically, we utilize data from personal interviews with 15 CS department chairs participating in a diversity-related initiative in an effort to answer the following research questions:

1. How do department chairs make meaning of the underrepresentation of women and students of color in their CS departments?
2. How do department chairs think about broadening participation in their CS departments?
3. How do department chairs' ideas regarding broadening participation in CS influence their change-related initiatives?

#### 5. RESEARCH DESIGN

This research study employed a constructivist lens (Lincoln & Guba, 2013; Schwandt, 1994) to conduct a qualitative study of CS department chairs at 15 institutions across the United States. Bryant and Charmaz (2007) assert that constructivism assumes that both researchers and participants construct multiple realities that produce useful data. Therefore, a constructivist lens allowed the research team to interpret the meaning of the participants' experiences through a partnership between the participants and the researcher in which reality lies in how the participant makes meaning and the researcher interprets that meaning (Merriam, 2009). Additionally, qualitative studies are useful in focusing on how participants make meaning of experiences and allows for inductive and comparative data analysis, which highlights rich, descriptive themes or categories (Merriam, 2009).

#### 6. STUDY SAMPLE

This study is part of a larger, national, longitudinal research project designed to examine the process of diversifying CS departments. The Building Recruiting and Inclusion for Diversity (BRAID) project was initiated by Maria Klawe, president of Harvey Mudd College (HMC),

and Telle Whitney, CEO of the Anita Borg Institute for Women and Technology (ABI). In July of 2014, Dr. Klawe gave a talk at the biennial conference of the Computer Research Association (CRA) outlining strategies for increasing women's and URM students' participation in CS and encouraging CS faculty to implement these strategies at their own institutions. Dr. Klawe talked about four major strategies for increasing diversity in CS, including modifying introductory courses to make them more inclusive and inviting for underrepresented students, facilitating the development of a supportive and inclusive culture and sense of community within the department, increasing outreach efforts to high school students and teachers in the local community, and developing and/or promoting double majors in areas like CS and Biology to attract more underrepresented students.

In her address, Dr. Klawe offered to provide funding to support the first department chairs who contacted her with concrete plans to diversify their department. Corporate sponsors were identified for the project, including Facebook, Google, Microsoft, and Intel, and participating departments were provided with three years of funding (\$30,000 annually) to support their efforts. Participating departments provided a written statement of their commitment to diversify their CS departments by utilizing at least three of the strategies outlined by Dr. Klawe. Based on this framework, many of the BRAID departments are making efforts to enhance their introductory CS courses by incorporating real-world problems into the curriculum, considering the use of new programming languages, and finding other ways to make these courses more welcoming and attractive to diverse student populations. Several institutions are developing new double majors and partnerships with other academic units on campus, sponsoring students' participation in the conferences and meetings, developing mentorship programs and student organizations, and partnering with local K-12 schools to talk to students about computing and invite them to campus for summer programs.

This qualitative study focuses on interview data collected from the CS department chairs participating in BRAID. Participating institutions include 15 research universities located in various regions across the United States. Five of the institutions are located in the Midwest, three are in the Southwest, and the remainder are scattered throughout the Northeast, Mid-east, Great Lakes, Southeast, Plains, and Far West regions of the country. Thirteen of the 15 institutions in the study (87%) are public colleges and universities, with an average enrollment of 828 undergraduate CS majors across all BRAID institutions (Range: 115–2500). Four (27%) of the department chairs interviewed for this project were female.

## 7. DATA COLLECTION AND ANALYSIS

Data for this study were collected through qualitative interviews with 15 department chairs (Creswell, 2013; Fontana & Frey, 2005). The semi-structured interviews focused on several major themes, including participants' academic background, their goals for broadening participation within their department, and their perceptions of departmental culture for women and students of color at their institution. Interviews were conducted over the phone between a member of the research team and the participating department chair, and lasted approximately one hour. Interviews were audio recorded, with permission, and transcribed verbatim. Other data sources for this project included institution websites, NCES demographic data, and researcher notes.

Data were analyzed and coded by the research team in multiple steps, using both deductive and inductive methods (Creswell, 2014; Maxwell, 2013). Dedoose qualitative coding software was used throughout the process of data analysis. First, two members of the

research team each reviewed a small group of transcripts to establish an initial codebook that would guide further analysis. Data were ordered using organizational, substantive, and theoretical categories (Maxwell, 2013). Interview transcripts were then divided among the research team with the initial codebook helping to establish major categories and themes. During this subsequent round of coding, the codebook was expanded as necessary to incorporate new categories and sub-categories. Researchers paid particular attention to areas of agreement or disagreement between participants, and similar codes were collapsed into parent codes. Parent codes were defined and arranged into overarching themes illustrative of the participants' experiences with diversity and change efforts (Miles, Huberman, & Saldana, 2013). In order to ensure trustworthiness, codes were compared throughout the analysis to confirm consistency and triangulate data (Denzin, 1978). Members of the research team considered issues of positionality during data analysis, and challenged each other's perceptions and assumptions (Merriam, et al., 2001). Table 1 includes some codes and definitions from the codebook that were used in this manuscript.

## 8. FINDINGS AND DISCUSSION

Our findings reveal important themes related to underrepresentation in CS, broadening participation, and efforts to institute change. The research questions for this project focus on two main

**TABLE 1:** Examples of codes from codebook

<b>Code</b>	<b>Definition</b>
Barriers to Participation	Restraints, obstructions, boundaries, or limits perceived by participants to negatively impact the participation of women and underrepresented minority students in the computing field
External Challenges to Broadening Participation	Difficulties in creating or implementing changes related to broadening participation that is viewed as outward or outside of the control of participants
Internal Challenges to Broadening Participation	Difficulties in creating or implementing changes related to broadening participation this is viewed as inside of the department or within sphere of influence of participants
Preparing for Change	A stage in which participants are getting ready to implement initiatives or changes aimed at broadening participation
Implementing Strategic Changes	A stage in which participants are actively implementing initiatives to broaden participation and getting buy-in from important stakeholders at their institutions
Institutionalizing a New Culture	A stage in which initiatives have been implemented a new institutionalized culture has been created which is supportive of women and underrepresented minority students

Table 1 includes examples of codes taken from the codebook created by the research team and used for analyzing the data.

areas. First, we were interested in how CS department chairs make meaning of undergraduate gender and racial/ethnic diversity in their departments (research question one); the first two themes discussed below address this first research question. Next, we wanted to learn more about how department chairs think about broadening participation in CS (research question two) and creating departmental initiatives that focus on diversifying their departments (research question 3); the third theme is connected to these two research questions.

### 8.1 Differences in Barriers to Participation for Women and Students of Color

When the BRAID initiative was formally established, the mission explicitly focused on broadening participation in CS for both women and students of color. Still, some participants were engaged in diversity efforts more singly focused on women's participation in CS and were therefore able to more clearly articulate gender gaps in CS as compared to those present for students of color. Other departments took a more comprehensive approach to diversifying CS that included efforts to increase participation among both women and students of color.

Diversifying CS with regard to gender has been an area of particular interest to the field for many years, so it is not surprising that many of the participants in this study were more comfortable discussing gender disparities in their department than those related to race and ethnicity. When asked about women's participation in CS, one participant stated, "Like many computer science programs, it's a struggle to get women into the program. Women as scientists don't seem to – at least in large numbers – naturally come to computer science." Later, when asked about students of color, the same participant stated, "Our percentage of [students of color] is definitely increasing... in all of our programs," but was unable to provide specific data to support this assertion.

Several participants also commented that it was easier for them to articulate gender-related initiatives because they have thought about it for a longer period of time. While most of these department chairs were optimistic that their diversity-related efforts would help to attract and retain both women and students of color, at the time of these interviews they were more confident in discussing their department's gender related initiatives.

However, that is not the case for all of the participants. A few department chairs were clear in their thinking about diversity initiatives related to race and gender together. After talking at length about barriers to participation for women in CS, one department chair also discussed the underrepresentation of students of color and acknowledged the fact that there were "real barriers to participation for both women and students of color," but believed that "the computing community has the ability to remove those barriers." In her mind, there is no real reason that women and underrepresented students cannot succeed in CS.

*There are really no barriers based on gender or ethnicity to stop [all students] from excelling in computer science and computer engineering. It's just a matter of being aware of what's possible here.*

While clearly situating the challenge of diversifying CS in a national context, this participant is focused on recruitment and increasing awareness of CS to diverse communities as components of the department's diversity efforts.

Some institutions had already seen success in increasing participation among students of color and could provide more concrete examples of success. As one participant stated, "I think we were very proactive in trying to get into the community, creating opportunities for culturally



disadvantaged neighborhoods, providing scholarships for those students, and just making it clear that they are welcome here.” This department chair also reported that the percentage of students of color in the CS department had increased in recent years while female participation had stagnated. Thus, the challenges of diversifying CS were variable across the institutions in this study.

## 8.2 Challenges with Broadening Participation

Our findings indicate that the CS department chairs conceptualize disparities in the recruitment and retention of diverse student populations in various ways. Most participants articulated a range of external factors, or those outside the direct control of the department or institution, that influenced the composition of their student population. While some department chairs focused mainly on these external factors, others acknowledged such challenges but also discussed ways to work within these parameters to create change in their departments.

**External factors.** Department chairs articulated a range of external factors influencing their diversity efforts, including the nationwide challenge of recruiting and retaining underrepresented students in CS, the lack of female role models in the field, and the challenge of making computing more appealing and approachable for women and underrepresented students. For example, one participant raised concerns about the lack of underrepresented students who come to college planning to major in CS, and connected this to “a deeper problem that goes at least to high school.” For this department chair, the lack of effective computing instruction in schools and the limited exposure to computing that many underrepresented students receive is a major cause of the lack of diversity in CS at the university level. As this chair put it, “There are things which we can do here, but we can never graduate the student we don’t matriculate.”

Another participant commented on the challenge of “attracting a new group of people” and moving away from the “embedded cultural belief that computing is a male-dominated, unsuitable to females sort of environment.” For this department chair, it was difficult to focus on improving representation in CS departments in the face of deeply rooted cultural beliefs about computing. Another participant had similar concerns, stating that “our biggest obstacle” to diversifying CS is “finding a good way to communicate and change what people believe about computing... and changing that stereotype of the unshaved and unshowered, messy guy in a cubicle.” While these challenges are real, for some department chairs they served to limit the focus on concrete actions and solutions. As previously highlighted, the male-dominated culture of CS has been well documented by researchers such as Margolis and Fisher (2002). Their qualitative study not only paints a picture of the nerdy, male, computer geek as the ideal computer scientist but also discusses the ways in which that stereotype creates a barrier to participation among women. The male-dominated culture of CS was a large part of these department chairs’ perceptions of barriers to broadening participation. This is not surprising given that, nationally, pervasive stereotypes and the culture of CS are becoming a larger part of the conversation around broadening participation (Cheryan, Drury & Vichayapai, 2013; Cohoon, 2001; Espinosa, 2011; Margolis & Fisher, 2002; Seymour & Hewitt, 1997). However, many of our participants focused on the lack of control that they had over national trends in enrollment and thus viewed the lack of women and students of color in CS as something largely influenced by the available pool of students who are interested in CS. Simply put, the perspective is that one cannot recruit those who are not interested.

While many of our participants were primarily focused on the lack of women and under-

represented students in CS at a national level, they also connected that national issue to a lack of female role models (particularly among faculty) within their departments. Several department chairs commented that having more female faculty in their departments would positively impact female enrollment in CS because they would serve as role models simply by their presence and also by their engagement with students. However, many department chairs were concerned about the real challenges associated with recruiting female faculty to their departments.

In a department that had small numbers of female faculty, the chair who was hiring new faculty positions stated that the department had gone “out of [its] way” to recruit female candidates and had offered a position to a highly qualified woman to no avail. As this chair put it, “We’re missing the kind of role models that would speak to women [students] and... we need to start is aggressively [hiring] female professors. And we’ve been trying, but it’s actually not as easy as one thought.”

Recent literature suggests that, in addition to a lack of women in the pipeline to hire as CS faculty, when there are women with Ph.D.s in CS or a related field who could serve in these professorial roles they are often lured away by industry jobs that can offer higher salaries and resources for research (Saugani & O’Kelley, 2015). Further, female computer scientists are in high demand at institutions of higher education and may therefore receive several desirable offers. In this study, participants were eager to hire more female faculty but found it quite challenging. When potential candidates are lured away from academia to industry positions or choose to pursue a faculty post at another institution, participants viewed that as an issue that was out of their control.

**Factors that can be internally controlled.** While some department chairs had a difficult time moving past the national and institutional challenges that hindered their diversity initiatives, others were more interested in exploring those factors within their sphere of influence. Specifically, these faculty members talked about balancing departmental enrollments, recruiting diverse students from within the institution, and increasing the pipeline to CS through outreach efforts in their local community. All participants were cognizant of the external factors that influenced their efforts at broadening participation in their departments, but some were better equipped to challenge these barriers by focusing on their particular context and looking for innovative approaches to implement best practices in their department.

Participants often talked about balancing racial and gender gaps within their CS departments through high school outreach. For some, that meant partnering with local schools to plant the seed early and encourage students to start thinking about pursuing a CS degree while they were still in high school. One chair talked about female students in the department serving as ambassadors by “going to local schools and telling girls that computing is cool and that they can do it.” For this participant, it was important that outreach efforts were led by students in the department because they could connect with younger students and would have the greatest impact. Several participants also talked about offering summer camps for local students as an important recruitment tool. These programs often target underrepresented students to introduce them to CS and help them become familiar with the institution.

Some department chairs acknowledged that undergraduate recruitment and admissions were conducted at the institutional level and thus beyond their control, but that they aimed to balance enrollments despite these limitations. As one participant commented, “We are an academic program, so we don’t directly do undergraduate admissions... But we try to attract students.” This chair went on to highlight numerous recruitment efforts including department open houses, “discovery days” for local students, and events hosted for top students. In

general, these participants are committing to outreach programs in an effort to expose more young people to CS in hopes of getting more students into the pipeline.

Not all issues fit squarely in internal or external categories. In fact, internal and external barriers exist on a continuum, and participants often articulated issues that are somewhere in between the two ends of that spectrum. For example, several participants were concerned about the ways that CS is perceived more broadly and the need for strategies to attract more girls and students of color to the field at an earlier age. As one participant put it, “We’re trying to figure out how we can make the profession more attractive and better known to high school kids.” Making CS classes more accessible and, thus, more interesting to women and underrepresented minorities was one strategy mentioned by several participants. In response to broad stereotypes about CS and the lack of women and underrepresented students gaining exposure in schools, one participant commented that introductory courses that were welcoming and engaging were an important “alternative step” that would be “less intimidating” and “less stressful” for students, particularly if they were designed and advertised as such.

Making introductory CS courses more appealing to all students, including those without any background in coding from high school, was a popular idea among the majority of study participants. Yet, some department chairs were concerned about the notion of “gendering” CS in an effort to attract female students. As one chair noted,

*We are really not sure where to go with this. I had some naïve ideas about this, as in use examples and assignments that are more of female interest...but it's not the right thing to paint the computers pink to make it attractive.*

Thus, the notion of making CS more approachable and appealing is a complicated issue that falls at the nexus of internal and external barriers. On the one hand, these department chairs are trying to work around barriers to participation for women and students of color by developing more relevant curricula. At the same time, they want to think critically about the best ways to encourage broad participation without furthering misconceptions and oversimplifying the needs of underrepresented students.

### 8.3 Mobilizing, Implementing, and Institutionalizing Change

Returning to the framework for our study, Kezar (2007) outlines three stages in relation to change in STEM departments: mobilizing, implementing, and institutionalizing. The initial mobilizing stage is the point at which leaders, in this case department chairs, are preparing for future changes. Next, the departments would move to introducing, or implementing, the desired changes. Finally, the institutionalizing stage is the point at which the system, in this case the CS department, has stabilized in its desired state. Our findings in the following section will detail ways in which different diversity-related change initiatives are characteristic of each category. These categorizations are related to specific initiatives and do not reflect the status of overall diversity efforts in participating CS departments. At a single institution, the department chair may be guiding change efforts that fall within each of the three stages.

**Preparing for change.** In the previous section, we highlighted the fact that department chairs often consider both internal and external factors in conceptualizing the challenges associated with broadening participation in CS. External factors, or those perceived to be beyond the control of the department and institution, pose a particular challenge for department chairs interested in instituting change because they cannot be easily addressed or overcome. In this sense,

department chairs focused on these external issues are cognizant of the associated challenges and may be considering strategies to combat these barriers, or moving toward the mobilizing stage, but are not actively engaged in corresponding change efforts.

When department chairs mention the challenges of recruiting students into CS who don't gain admission to the institution or haven't been exposed to computing before enrolling in college, it is clear that they are considering these issues and may be planning future activities to combat them. These challenges may seem insurmountable, they may not have the necessary resources to tackle them at present, or they may be grappling with the best approach considering their institutional and departmental context.

Many department chairs were researching opportunities and trying to replicate efforts that have been successful in other departments and at other institutions. For example, one participant talked about the efforts put forth by the College of Engineering at their institution to recruit more women into their programs and "keep them in the pipeline" to graduate school. Alluding to the collaboration and preparations already taking place, this department chair stated, "We are planning to get more involved in what they are already doing...we haven't actually gotten involved with that yet but we will." This participant is clearly in the mobilizing stage but has not yet formulated a plan of action.

For many department chairs, there are several key people in their department and at their institution who may be involved in this planning process. Participants talked about faculty members who "provided a lot of leadership" for particular initiatives or support staff who "did an awful lot of planning and organization." At the same time, several faculty members commented on the obstacles to action, including the need to hire more faculty to meet the demands of growing enrollments, the lack of financial resources to support new initiatives, and the lackluster support from faculty members focused on their own research and graduate students. Factors such as these many contribute to department chairs' hesitation in moving beyond mobilizing, or preparing for action, to actually implementing change.

At the same time, many department chairs commented on the way that their participation in the BRAID initiative had helped to jumpstart their diversity efforts. One participant stated that, "it really focused our attention and made it a much more prominent and active priority.... I mean it's something we cared about but to be actively committed to doing things I think that BRAID is what really put a focus there and really got us moving." The accountability associated with the project, the sense of community and support among participants, and the financial resources for participating institutions helped many department chairs begin to move beyond the mobilization stage and start to thinking about implementing change.

**Implementing strategic changes.** Those department chairs who are no longer solely focused on perceived barriers and are finding creative ways to establish diversity initiatives within their departments have moved on to the implementation stage. These initiatives may be small pilot projects designed to test the effectiveness of innovative ideas, or broad policies that will affect all students and faculty. Change efforts that are in the implementation stage are more active than the mobilized stage.

Some participants, for example, were in the midst of implementing changes in their departments centered on creating community for women and students of color. One department chair talked about combating women's feelings of isolation in the department and in their courses by "getting women to connect with other women." Within introductory courses, many participants had implemented pedagogical strategies focused on group work and more applicable real-world situations in an effort to create more of a community in classroom settings. Others were work-

ing on designing new or modified introductory courses that are less intimidating for students with little programming experience. One department had established a new course sequence that would introduce students to computing and potentially put them on the path toward the major. In describing the new course, the chair stated,

*If you are curious about what this programming stuff is all about here's a course you can do this. And we make it a course that anybody with reasonable effort can certainly learn to program ... If they stop there that's fine, but if they get really excited about it and they want to go on, we have a transition step for them so they can get into the rest of the sequence and continue.*

This example highlights the role that a department chair can play in implementing a significant change within their academic unit. This new course sequence represents a major curricular change within this department that would not have been accomplished without careful planning, strategic leadership to garner faculty support, and a focus on increasing representation of women and students of color.

Additionally, some participants had initiated mentorship programs for women and students of color to encourage community and support networks among students. One participant talked about developing a new mentoring program that paired undergraduates with graduate students in the department as well as professionals from the local technology sector. As this department chair put it, "We always knew that some mentoring would be needed but we didn't really have a good framework for thinking about that... the whole creation of the project was a catalyst for speaking more deeply about how to [develop the mentorship program] and so that led to this idea of broader mentoring networks." Through careful planning that involved numerous stakeholders, this department chair implemented a new mentoring program that leveraged available resources to meet the needs of students in the department.

Another participant talked about the importance of undergraduate research and new efforts to "heavily promote" internships for students, despite this department's lack of large research groups and its focus on undergraduate education. As this chair stated, "We are constantly reviewing our system.... So there's a lot of diversity in terms of the nature of the things we work on... from robotics to computer games to [developing theory], to machine learning artificial intelligence." Instead of focusing on the challenges of implementing a robust research program for students, this participant worked within the existing structure to design a program that worked well for both students and faculty.

Many department chairs also focused on creating community by supporting student organizations and undergraduate networks. One department chair talked about establishing department chapters for several CS-related student organizations, including one focused on women in computing, pointing out that, "they are starting because I kicked the avalanche down on the hill."

These participants acknowledge that, while there is a lack of women and students of color and part of that is because of the culture of CS, they wanted to work within the boundaries of their discipline to find opportunities to create community. Our participants have found ways to work within their current context to make internal changes focused on broadening participation. While the changes in the previous mobilizing section were at the idea stage, efforts at this stage are more active. The changes are newly implemented, and the participants are eager to see what will come of the initiatives that they have put in place.

**Institutionalizing a new culture.** The final stage of change outlined by Kezar (2007) and used for this analysis is institutionalized change. Change initiatives reach this stage when the CS

departments have stabilized in their desired state. At this point in the research project, we do not have examples from participants in this stage of change. All of the department chairs opted into this program because they wanted to create change and broaden participation in their CS departments, but they needed support and guidance in doing so. It is important to note that this is the first year of this project; we anticipate that in the future, some participants will reach this stage. Many participants said that they will know that their initiatives are successful when they have the numbers to prove that they have broadened participation for women and students of color. As one participant put it, “Well, certainly, by the numbers... but also, just by attitude like, for example, what students are reporting about the welcoming environment of our group here.”

## 9. LIMITATIONS

This study is important as it builds on previous research about broadening participation in CS and extends our knowledge of the role of department chairs in creating institutional change. However, these findings should be viewed with important limitations in mind. First, the CS departments chosen for this study come from a specific initiative aimed at broadening participation at a select number of institutions in the United States. These participants were the first fifteen among a room of other CS chairs to volunteer to be part of the program. Nevertheless, the participants represent a broad range of institutional types and geographic locations. Further, this is an important group of people to study as the participants willingly joined the project, made a public commitment to supporting broadening participation, and are creating initiatives to support women and students of color at their institution. Second, this study is part of a multi-year study of diversity-related change in CS departments. The findings for this paper reflect data from the beginning of the three-year research period. We expect to see changes over the course of the study that will provide insight into broadening participation, which provide rich access to data for future research.

## 10. IMPLICATIONS

This study gives voice to the perspectives of CS department chairs who, as leaders of their departments, are in a unique position to effect change at their institutions, and as leaders in their profession, have the ability to effect change in the CS discipline. As we reflected on the myriad ways in which the department chairs conceptualized the gender and racial/ethnic gaps in CS, it became apparent that many of the participants were particularly concerned about a number of external factors that influenced their ability to institute positive change in their departments. As we discussed above, many of the department chairs attributed the lack of participation among women and URM students in CS to larger societal issues over which they had little or no control. Further, because some of the department chairs felt that student recruitment was handled at the institutional level without their input, many of them suggested that they had limited options for broadening participation in their major.

The belief held by many department chairs in our study that the lack of gender diversity in computing is the status quo is somewhat curious, given that women once constituted a sizeable portion of programmers. As described by Ensmenger (2010), women made up the majority of the earliest computer programmers; in fact, among the first programmers were six women at the University of Pennsylvania who were hired in 1946 to assist with the Electronic Numerical Integrator and Computer project.

Throughout the 1950s and 1960s, women continued to be well-represented in comput-

ing, as many saw coding work as clerical in nature, and therefore, believed it appropriate for women (Ensmenger, 2010). As scientists and corporations realized computing's scientific and commercial uses, programming came to be seen as a craft that required innate creative and mathematical abilities (Ensmenger, 2010). Hence, as the computing discipline has matured, it has become more exclusive (and more male). Thus, despite the sense that computing's masculine culture is a deeply engrained societal construct, in reality it stands in contrast to the historical origins of the computing field.

The perspectives of many our participants are consistent with the mobilization stage of organizational change where leaders are planning for change but have not necessarily fully embarked on change efforts (Curry, 1992; Kezar, 2007). As Kezar (2007) points out, in this phase leaders should be focused on setting priorities and communicating a vision of change to others. Yet, if department chairs are focused on factors perceived to be beyond their control, then it will be difficult for them to move on to the next stage of initiating change. We believe that this finding may be influenced by the department chairs' backgrounds and knowledge with respect to diversity issues. Faculty members in CS may not have received professional development training to prepare them to take on diversity or social justice work (Sorcinelli et al., 2006). In studies involving computer science courses at the high school level, providing high school teachers with professional development around diversity issues has been found to quickly and dramatically increase women's and URM students' participation in computer science courses (Goode, 2007; Margolis, Fisher, & Miller, 2000). In addition, for many department chairs, increasing participation of women and students of color in CS is one priority among many. They may feel that they lack the necessary skills and expertise, along with the resources and support, to engage in transformational change around diversity issues. Therefore, we believe that the department chairs involved in the BRAID initiative and other CS department chairs seeking to engage in this type of work would benefit greatly from professional development that would educate them about diversity issues and enhance their sense of agency around diversity work. Nearly all of the BRAID departments are affiliates of National Center for Women and Information Technology (NCWIT), which offers many professional development opportunities related to diversity for CS faculty, including institutional consultation through their extension services as well as through sessions at the annual NCWIT Summit. Further, organizations like the Association for Computer Machinery's (ACM) Special Interest Group on Computer Science Education (SIGCSE) offer professional development for CS faculty at their annual symposium and through pre-symposium events.

In addition to empowering department chairs to serve as change agents, we also believe that diversity training might move the department chairs forward in their thinking as they seek to develop initiatives to broaden participation in CS. For instance, several department chairs described somewhat superficial ways in which they were seeking to make the major more welcoming to women, such as by adding throw pillows to student lounge spaces to make them feel less institutional. At the same time, some department chairs voiced concern that engaging in such behavior might be problematic. Indeed, previous research has demonstrated that the design and messages conveyed in physical spaces are important to all students' sense of belonging in the CS major (Cheryan et al., 2009) and that gendering science can inadvertently reinforce stereotypes about women that ultimately undermine their success in STEM fields (Colatrella, 2011). Hence, exposing department chairs to training around diversity issues might help to educate them about how to develop a balanced approach to broadening participation in the CS major that welcomes all different types of

students, without reinforcing detrimental stereotypes.

Another key finding of our study was the way in which the BRAID initiative served as a change framework for the participants. As discussed above, each department chair focused on different interventions, from reimagining introductory CS courses to working to build a stronger sense of community among their students. No matter what specific initiatives a department chose to implement, all of them are participants in the broader BRAID initiative, which targets four overarching areas of change (revamping introductory courses, creating community, multidisciplinary offerings, and K-12 outreach).

Hence, the chairs discussed how their involvement in BRAID brought a sense of structure to their efforts, while still giving them a great deal of autonomy to develop initiatives that make sense within their particular departmental structure and culture.

Kezar (2007) points out that during the implementation phase of organizational change, leaders should be focused on building momentum by creating incentives and opportunities for more people to get involved. In a sense, the leaders behind the BRAID initiative are implementing change by helping the participants to move beyond the mobilization stage. For many department chairs, the accountability and support associated with the project was a motivating factor in leading change efforts at their own institutions. In addition, several department chairs mentioned that they were eager to engage with and learn from their peers at participating institutions to develop new ideas and best practices for broadening participation in CS.

Given this, the BRAID initiative may serve as an important model for non-profit and professional organizations that are committed to increasing the representation of women and URM students in CS. The BRAID initiative puts a great deal of power in the hands of the department chairs (whether or not the chairs themselves believe that they have this power). In lieu of adopting programs that target individual students, such as through mentoring programs or summer internships, organizations seeking to address gender and racial/ethnic inequality systemically should consider investing broadly in CS departments. Over time, replicating the BRAID model at more CS departments could increase the sense of agency among department chairs and also bring a united approach to broadening participation in the CS discipline at a national level.

## 11. CONCLUSION

In conclusion, this study highlights important findings related to computer science department chairs and their role in leading change efforts for broadening participation in CS. This study was necessarily limited in scope and focused specifically on the ways in which department chairs made meaning of the gender and racial/ethnic gaps in CS as well as the efforts that BRAID department chairs chose to employ to broaden participation within their department. There are several findings in this study that warrant further investigation in future research. First, the department chairs in our study tended to focus their efforts on increasing the representation of women in the CS major and were only beginning to expand their plans to increasing the participation of URM students. Hence, many of our findings focus specifically on gender, with less emphasis on race/ethnicity, and, furthermore, none of the department chairs discussed the intersection of gender and race/ethnicity or initiatives to recruit URM women specifically. Future research should focus more intentionally on the plans that department chairs develop with respect to addressing the racial/ethnic gap and the intersection of race and gender.

Second, in our initial review of our data, we were unable to analyze how the department



chair's own gender and racial/ethnic identities might play into the ways in which they articulated the problems and solutions related to women's and URM students' participation in CS. Future research should examine how various aspects of the chairs' identities and experiences might influence their approach to broadening participation. Additionally, future studies should focus more on understanding departmental culture and developing better metrics for learning about the experiences of women and students of color in participating CS departments.

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