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A Characterization of Engineering and Computer Science Undergraduate Participation in High-impact Educational Practices at Two Western Land-grant Institutions

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A Characterization of Engineering and Computer Science Undergraduate Participation in High Impact Educational Practices at Two Western Land Grant Institutions

Introduction

To maintain its technological competitiveness and innovation leadership into the 21st century, the United States requires a robust engineering and computer science (E/CS) workforce with substantial diversity across gender and underrepresented racial and ethnic minority groups [1] [2]. However, there are growing concerns about the ability of U.S. educational systems to meet increasing demands to prepare and train a diverse E/CS workforce. Research shows that students from underrepresented gender, racial, and ethnic groups are less likely to complete their education, compared to their counterparts from dominant groups, due to a variety of institutional factors [3]. Also, first-generation college students (FGCS), who are the first in their family to pursue postsecondary education, are less likely to complete their education compared to students whose parents attended college [4]. Therefore, to encourage and enable diverse students to opt into E/CS fields and persist within them, there is a critical need to provide E/CS students with supportive and enriching opportunities from which to learn and grow within their chosen field.

Research indicates that undergraduate participation in specific activities, known as "high impact educational practices (HIP)," can have substantial positive impact on students' academic outcomes [5]. Kuh [6] identified eleven teaching and learning practices (i.e., HIP) that have been shown to positively impact the educational outcomes of students from a variety of backgrounds. While Kuh's work suggests that students, including those from diverse backgrounds and underrepresented groups, benefit from participating in HIP, the question of whether HIP participation leads to improved outcomes for E/CS students has yet to be fully investigated. To address these issues, more research is needed to understand how and why E/CS students choose to participate in HIP and how participation affects their academic outcomes.

Purpose

Funded by the National Science Foundation (NSF), a multi-institutional and interdisciplinary research team is conducting a two-phased, mixed methods research study to advance current knowledge about HIP access at rural public institutions and the impacts of HIP participation among diverse E/CS students enrolled at these institutions. Ultimately, this study will provide recommendations for improving participation of E/CS students, particularly those from underrepresented groups, in HIP at similar land grant institutions nationally. In the present study, we examine the HIP participation of E/CS undergraduates enrolled at two predominantly White, western land-grant institutions: Utah State University and Washington State University.

This paper focuses on the characterization of E/CS student participation across five HIP (i.e., global learning and study abroad, internships, learning communities, service and community-based learning, and undergraduate research) that have been shown to be effective for improving students' academic, personal, and practical outcomes. While opportunities to engage in these five activities are supported and/or provided by the engineering colleges and/or computer science departments at both institutions, these five activities can be considered to be *extracurricular* (i.e., optional or voluntary) in the context of engineering and computer science degree programs. That

is to say, these five activities are not linked to or included within required courses at these universities. To conduct the study, an online questionnaire was developed to explore how and to what extent E/CS undergraduates participate in HIP. The online survey was deployed via Qualtrics at both institutions in Spring 2020. This paper reports on the frequency distribution analysis of the survey data. Currently, findings from the frequency distribution analysis are being used to develop protocols for focus groups interviews with E/CS students who volunteered to participate in the interviews during the survey as part of the larger study.

Literature Review

HIP have been identified and studied for over a decade. Continuing HIP research, however, is still needed across varying activities and institutional contexts because HIP take different forms and are employed based on learner characteristics as well as institutional priorities [6]. Kuh [6] identified eleven high impact educational practices (HIP) as shown in Figure 1. Six of these practices (i.e., global learning and study abroad, internships, learning communities, senior culminating experiences, service and community-based learning, and undergraduate research) have been reported by students to provide personal and practical, career-related gains in addition to support for deep learning of academic content [7]. Based on their demonstrated ability to support student personal and professional development along with academic development, these particular HIP became a focus of our study.

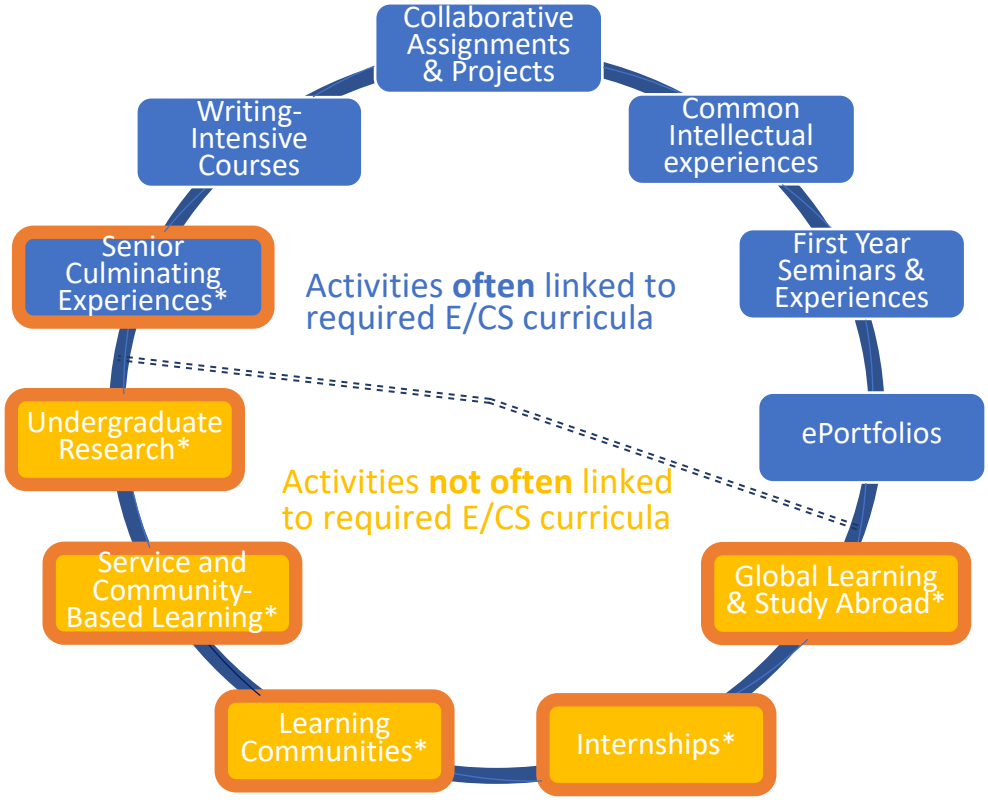

Figure 1. Eleven High Impact Educational Practices (HIP) as defined by Kuh [6]. " * " represents specific HIP reported by students to provide personal and practical gains in addition to deep learning gains [7]. "E/CS" stands for engineering and computer science.

Importantly, all of these six HIPs except one, senior culminating experiences, may be considered *extracurricular* (i.e., voluntary or optional) activities in the context of E/CS. Anecdotally, E/CS students choose whether or not to participate (outside of class) in these activities; these activities are not commonly included in required E/CS curricula. Moreover, within ABET accredited engineering programs, senior culminating experiences are provided as part of a required "senior design" course sequence that students complete during their final degree program year. In this way, students enrolled in ABET accredited engineering programs participate in at least one HIP (i.e., senior culminating experiences) by the end of their degree program. Since senior culminating experiences are required for the engineering students taking part in this study, we elected to restrict the focus of this study to the five, extracurricular HIP (i.e., i.e., global learning and study abroad, internships, learning communities, service and community-based learning, and undergraduate research) that students report as providing career-related gains. Doing so will ensure that the recommendations developed for improving E/CS student participation in HIP at land grant institutions will not require changes to E/CS curricula and, therefore, are more likely to be transferred and adopted at other institutions.

Researchers report that HIP engagement improves academic outcomes for undergraduates generally [6] and for students enrolled in science, technology, engineering, and mathematics (STEM) degree programs specifically [8]. Peters, Tisdale and Swinton [8] pointed out that universities recognize the importance of HIP and are beginning to establish mandatory requirements for student participation in one or more HIP prior to graduation. For example, Peters, Tisdale and Swinton [8] reported that students enrolled at University of Wisconsin-Eau Claire must participate in service learning as a requirement for graduation.

Other studies provide insights into the usefulness of HIP for underrepresented students. Service learning is reported to contribute to substantial improvements in underrepresented student outcomes. Song, Furco, Lopez and Maruyama [9], for example, analyzed the effects of service learning on underrepresented students enrolled at a Midwestern university. Their findings suggested positive relationships between STEM undergraduate participation in service learning and several academic outcomes, including cumulative grade point average and continued enrollment. Service learning has also been shown to effect student self-efficacy and self-concept [10]. Because service learning has been shown to produce several benefits, it is increasingly employed in E/CS, among other disciplines [11].

Like service learning, participation in undergraduate research activities is reported to positively impact underrepresented student outcomes [12]. For example, Collins et al. [13] found that students enrolled at a Hispanic-Serving Institution experienced gains in knowledge and skills, perceptions of institutional support (i.e., both academic and nonacademic support), overall satisfaction, grade point average (GPA), and perceptions of student-faculty interactions after participating in undergraduate research. Participation in undergraduate research has also been shown to help underrepresented students develop science identities [14]. More generally, participation in undergraduate research has been shown to increase retention for both STEM and Non-STEM freshman undergraduates [15], and researchers [16] have reported associations between participation in undergraduate research and high GPA.

Other HIPs, such as learning communities and study abroad programs, have been shown to positively impact student outcomes by increasing student engagement with peers and professionals from diverse backgrounds. For example, Russell [17] found that female undergraduates who participated in a freshman learning community completed more credits than students who did not participate in the learning community. Russell [17] also found that students from underrepresented racial and ethnic groups who participated in the learning community were more likely to major in STEM subjects than underrepresented students who did not participate in the learning community. Carrino and Gerace [18] suggested that learning communities may have psychological and academic benefits for STEM students. Psychological benefits include improvement in student's self-regulation, metacognition, self-efficacy, and professional identity development. Academic benefits include improvements in student interactions with faculty, administrators, and peers. According to Solanki, McPartlan, Xu and Sato [19], learning communities are beneficial for students from underrepresented groups because learning communities provide high degrees of social support.

Study abroad enables students to experience personal and cultural diversity first-hand. Because today's E/CS employers' value those employees who are able to collaborate effectively within diverse teams, E/CS students may improve their employability by participating in study abroad programs. Study abroad programs can be a source of intercultural development [20] and have a positive impact on how students rate their educational experiences [21]. Notably, Mazyck [22] points to a lack of underrepresented student participation in study abroad programs and suggests the need for better understanding of how to improve underrepresented student participation in study abroad programs.

Internships and cooperative learning experiences enable students to gain practical skills that complement the theoretical knowledge they learn in coursework. For E/CS students, internships can be valuable activities for discovering career paths, acquiring full time jobs, and gaining or improving professional career skills [23]. Internships may also positively affect outcomes within other HIP, such as capstone projects [24]. Internships have been reported to improve the autonomy and technology, methodology, and project management skills of computer science students [24]. In engineering, underrepresented students reported that internships supported their professional career goals by providing opportunities for them to apply theory to practice in authentic industry environments [25].

In engineering and computer science programs, it is important for students to envision the link between theoretical course work and real-world practice. Senior culminating or "capstone" experiences provide curricular opportunities for engineering undergraduates to synthesize this link [26]. Capstone experiences aim to "cap off" the academic and intellectual experiences of engineering students [27]. Typical engineering capstone experiences may consist of semester or year-long projects. Students most often work in teams as in done in practice. Capstone experiences are reported to improve undergraduate's professional skills, including critical thinking, design thinking, quantitative reasoning, teamwork, and communication information literacy [28]. Capstone experiences are also valued by students for preparing them for professional careers and/or graduate studies [29]. To emphasize the importance of capstone experiences, the Engineering Accreditation Commission of the Accreditation Board of Engineering and Technology (ABET) requires that engineering undergraduates participate in a

"culminating major design" (i.e., capstone) experience prior to earning their degree [30]. However, the ABET accreditation criteria for computing programs do not require a culminating computing experience for student enrolled in these programs [31].

Research Question

To develop deeper understandings of E/CS undergraduate participation in HIP at land grant institutions, we guided the current study by the following research question (RQ):

To what extent do engineering and computer science undergraduates enrolled at one of two western land grant institutions participate in extracurricular high impact educational practices?

Research Design

Research Context

U.S. land-grant institutions are federally funded, public institutions of higher learning founded under the First Morrill Act of 1862. The First Morrill Act was later expanded to ensure access for diverse groups under the Second Morrill Act of 1890, which provides federal land-grant funding for Historically Black Colleges and Universities (HBCU).

We chose land-grant institutions as the context for this study based on their fundamental mission to provide all Americans, regardless of gender, race, ethnicity, or social class, opportunities for social mobility via practical education in agricultural, engineering, science, and technology fields [32]. Today, over 70 public land-grant institutions (i.e., at least one institution in every state, U.S. Territory, and the District of Columbia) operate to provide local, affordable educational alternatives amid rapidly increasing costs of private higher education in the United States [33].

Institutional Context

Utah State University (USU) is a public land grant research institution for the state of Utah and is classified as Carnegie Level R2 – doctoral universities with high research activity. WSU is a public land grant institution for the state of Washington and is classified as Carnegie Level R1-doctoral universities with very high research activity**.** Both institutions are rural and predominantly White; WSU is an emerging Hispanic-Serving Institution (HSI) [34].

USU fulfills its land grant mission by operating a system of statewide campuses, comprising the original residential campus in northern Utah, two additional residential campuses in eastern and southeastern Utah and four non-residential campuses and 25 education centers located throughout the state [35]. With a total enrollment of almost 28,000 students across all campuses and centers, USU makes college accessible to every Utahn no matter where they live [36].

Similarly, Washington State University (WSU) is a land-grant institution that maintains a presence in every county in the state of Washington. WSU enrolls nearly 30,000 students across its main residential campus in eastern rural Washington and five regional campuses geographically located throughout the rest of the state [37]. In addition, WSU operates a Global

Campus that provides online-based instructional programs designed to bring higher education to a wider audience [38].

Participants

All E/CS undergraduates who were enrolled at either USU or WSU during the spring 2020 semester were invited to participate in the online survey. After the research team received institutional review board approval for conducting research with human subjects from both institutions, engineering and computer science college and departmental administrators at both institutions emailed a link to the online survey to all engineering and computer science students at their institution. Students were provided several email reminders spaced approximately two weeks apart prior to the researchers closing the survey.

Data Generation Methods

The online survey, which was administered in Qualtrics, required volunteers to confirm that they were at least 18 years of age and to provide their informed consent prior to allowing them view or answer the research survey questions. The full survey, designed to fulfill the objectives of the larger NSF-funded research study, included a total of 51 questions. These 51 questions comprised 16 demographic questions followed by 35 HIP-related questions. This paper reports on the analysis of participant responses to the demographic questions and two HIP-related questions that asked participants about their patterns (i.e., type, frequency, preferences) of engagement in extracurricular (i.e., optional) HIP during their time in their engineering or computer science programs. The final survey question asked respondents to provide their email address if they wanted to volunteer for the follow-on focus groups interview to be conducted during the Spring 2021 semester. Otherwise, the survey was conducted anonymously.

A total of 683 (USU = 301 and WSU = 382) students responded to the Qualtrics online survey, resulting in a survey response rate of 12.3% (USU), 11.4% (WSU) and 11.8% (combined). To ensure quality in our findings, we set criteria to determine whether individual participant responses would be included in the analysis. We analyzed only those survey responses which included both a) responses to all demographic questions and b) at least the first question in main survey. After cleaning the raw data according to these criteria, 576 (USU = 256 and WSU = 320) survey responses met the criteria and were included in the analysis.

Data Analysis Methods

For the purpose of analyzing E/CS student HIP participation, a frequency distribution analysis was carried out. Frequency distribution analysis provides a convenient way to organize categorical data in either tabular or graphical forms [39]. For the current research, this type of data analysis provided important insights into the trends of diverse E/CS student participation across varying HIP. The frequency distribution analysis was iteratively carried out by calculating and comparing different activity types, academic disciplines, demographic groups, first generation college students (FGCS), institutions, non-traditional students, year of study, and non-participation. Resultant HIP distributions were graphically represented and accompanied by a detailed description.

Limitations

This study is limited in at least three ways. First, the sample comprised E/CS students from two western public land grant institutions and was limited by the predominantly White composition of the student body at these institutions. However, despite these limitations, our sample did include a statistically reasonable representation (i.e., $n > 20$) of E/CS students who identified as women, Asians, Hispanic or Latinx, multi-racial, first generation college students, and nontraditional undergraduates. Thus, it provides a valuable dataset from which to begin to explore HIP participation among several underrepresented and/or underserved groups in E/CS.

Second, this study is limited in that gender was operationalized as being binary. Therefore, the results of this study cannot not characterize E/CS student participation in HIP with respect to diverse gender identities (i.e., those other than male, female, or prefer not to disclose). In this paper, we examine the results of respondents who identified as female in order to understand the participation trends of women, who are an historically underrepresented group in engineering and computer science. Future work should examine HIP participation of E/CS students based on a more diverse and inclusive conceptualization of gender.

Third, our study was limited by the timing of the data collection during the late spring 2020 when the effects of the COVID-19 pandemic were being felt among undergraduate students nationally. It is possible that participation rates would have been higher if the survey were deployed at another time. Conducting the same study again across a larger cross section of land grant institutions located within other regions of the United States could address and improve upon these limitations.

Findings

In the following sections, we present findings from the frequency distribution analysis, as well as our emergent interpretations that will be further explored and refined during the focus group interviews.

Sample Demographics

As depicted in Figure 2a), the combined sample included E/CS undergraduates from the following demographic groups: female (34%), Black or African American (2%), Native American or Alaska Native (1%), Asian (10%), Hispanic or Latinx (6%), White (81%), Native Hawaiian or other Pacific Islanders (1%) and more than one race (4%). Figure 2b) provides the break-down of these demographic groups as represented within each institutional sample. *We note that since each race, as well as being multiracial, was tracked in the survey, the combined percentage of respondents by racial/ethnic group in Figure 2a) and b) totals more than 100%.*

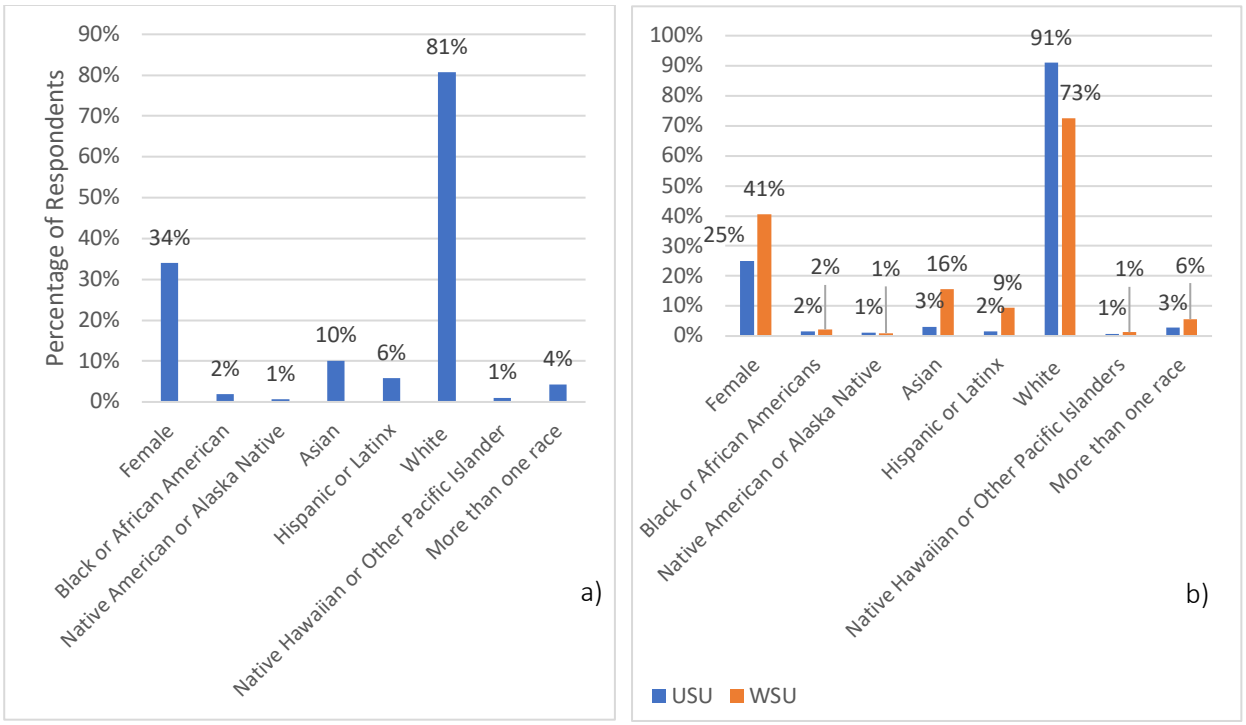

Figure 2. Gender, race, and ethnicity demographics within the a) combined and b) institutional samples.

While the majority of survey respondents from both institutions are White and male, our combined sample does include substantial representation of women (n = 196) as well as statistically reasonable representations (i.e., n > 20) of students who are Asian (n = 58), Hispanic or Latinx (n = 34), or from more than one race (n = 25). While all of these underrepresented racial and ethnic groups are represented within each institutional sample (Figure 1a), the WSU sample represents larger percentages of participants from these groups than the USU sample does (Figure 2b). We further note that the small number of participants who reported being Black or African American (n = 11), Native American or Alaska Native (n = 6), or Native Hawaiian or other Pacific Islander (n = 6) inhibit our ability to report on the participation trends of these participants as separate and distinct groups. *Therefore, we have combined the responses of all racial and ethnic groups with samples that number ~ 10 or less (i.e., Black or African American, Native American or Alaska Native, and Native Hawaiian or other Pacific Islander) into a group called "Other Non-White" and reported their combined responses as such.*

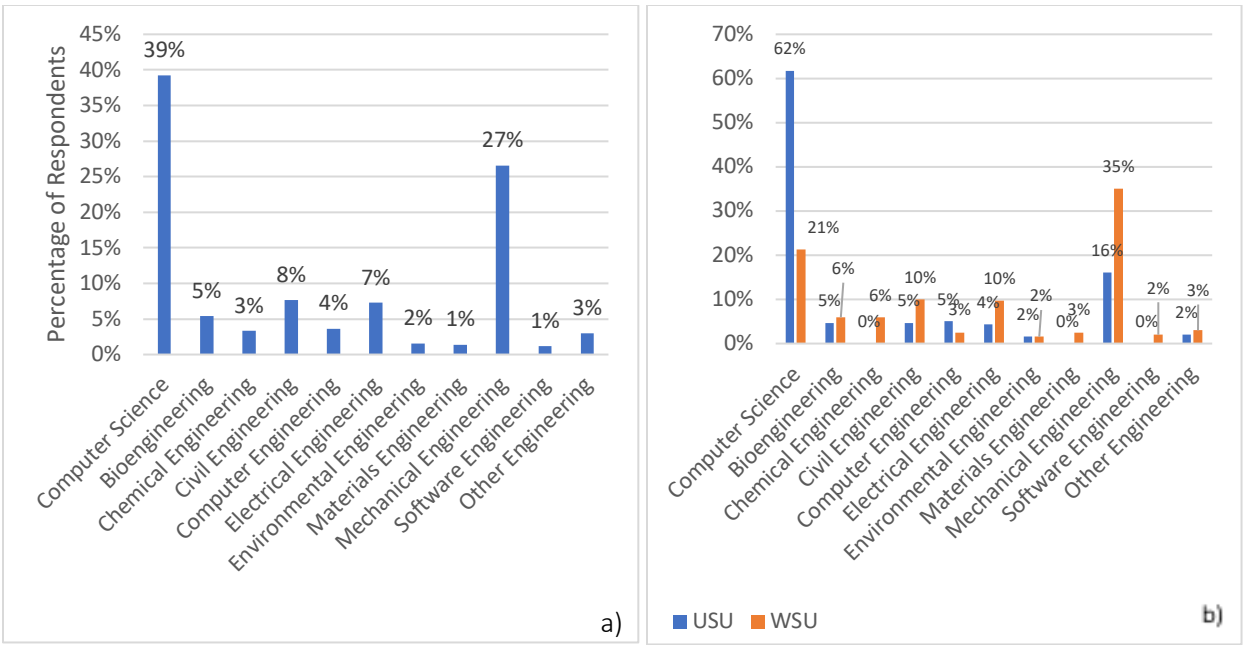

Figure 3. Percentage of respondents who reported majoring in each academic discipline within the a) combined and b) institutional samples.

As shown in Figure 3a, most combined sample respondents (61%; n= 351) reported that they were majoring in engineering, while 39% (n = 225) of combined sample respondents reported that they were majoring in computer science. Based on the sample size of each major, we consider this dataset to be sufficient for making comparisions between the responses of students majoring in engineering and computer science. Insitutional samples differed with respect to major, as more (62%) of USU respondents reported majoring in computer science compared to 21% of WSU respondents. Based on this result, we note that the trends in computer science student HIP paricipation may be more heavily influenced by the USU, rather than the WSU, insitutional context.

As shown in Figure 3, more respondents reported studying mechanical engineering than any other engineering subdiscipline in the combined sample (i.e., 27%), as well as in both institutional samples (i.e., 16% USU and 35% WSU). The engineering subdisciplines of materials engineering and software engineering were the least represented in the combined sample; we note that USU does not offer degrees in chemical, materials, or software engineering.

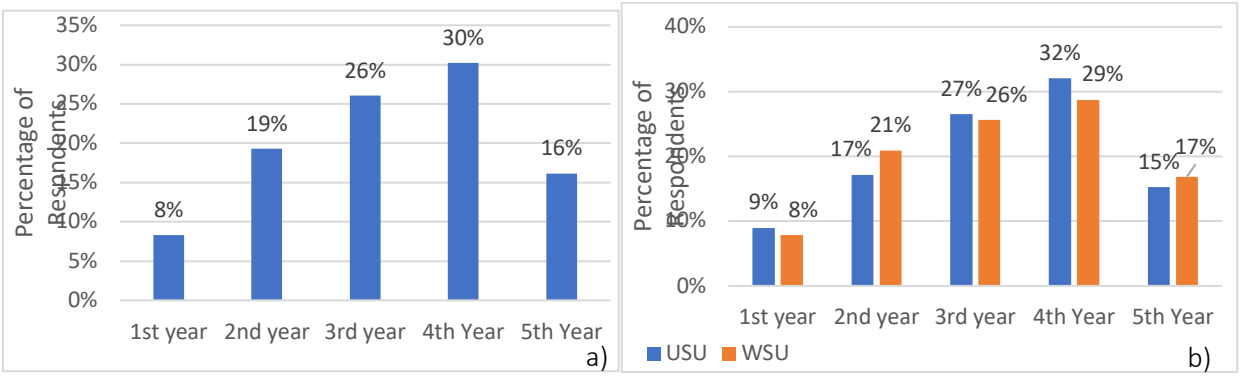

Figure 4. Percentage of respondents by years in program within the a) the combined and b) institutional samples.

As shown in Figure 4, the combined and institutional samples were weighted toward students in their latter years of study, as 72% of participants reported being in their 3rd, 4th, or 5th years of study in the combined sample. More participants reported being in their 4th year of study in the combined sample (30%) and in both institutional samples (i.e., 32% USU and 29% WSU). First year students (8%) were the least represented in the combined sample and in the institutional samples (i.e., 9% USU and 8% WSU). The representation of participants across year groups in both institutional samples was consistent.

HIP Participation by Institution

Along with similarities across the institutional sample demographics (Figures 2-4), we observed consistent similarities between the USU and WSU survey responses related to the level of E/CS student participation in HIP. As shown in Figure 5, USU and WSU respondents reported equivalent participation levels (7%, 9%, and 38%, respectively) across three HIP (i.e., service and community-based learning, learning communities, and internships). In the case of study abroad programs, participation of USU and WSU students is similar (i.e., 4% and 6%, respectively).

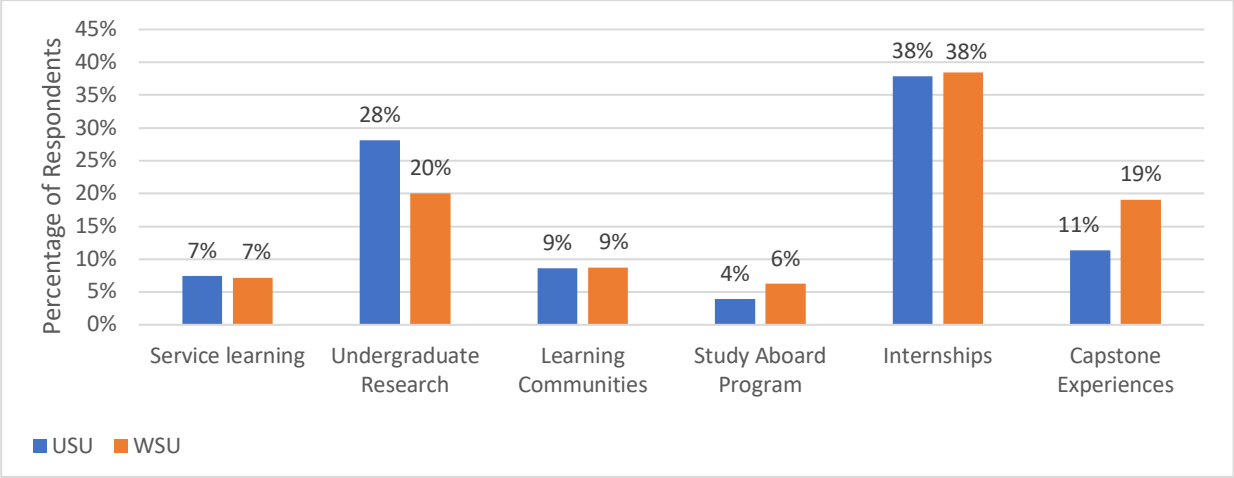

Figure 5. Percentage of respondents who reported engaging in HIP activities by institution.

Notable differences in HIP participation were found between the USU and WSU samples in participation in undergraduate research (28% and 20%, respectively) and senior culminating (i.e., capstone) experiences (11% and 19%, respectively). The lower percentage of USU participants who reported engaging in capstone experiences may be explained by the high percentage (62%) of USU respondents who were majoring in computer science, wherein capstone experiences are not required. For both the USU and WSU samples, more students reported participating in internships, followed by undergraduate research and culminating experiences. Participation in global learning and study aboard, learning communities, service and community-based learning were reported at much lower levels.

HIP Participation of the Combined Sample

Based on similarities between the participant demographics (Figures 2-4) and HIP participation (Figure 5) across the USU and WSU samples, we completed the remainder of the

analysis using the combined (i.e., USU and WSU), cleaned dataset. In addition, we focused the analysis on E/CS student participation in the five extracurricular HIPs (i.e., global learning and study abroad, internships, learning communities, service and community-based learning, and undergraduate research) shown to have substantial positive effects for both student learning and personal and practical gains. We excluded senior culminating (i.e., capstone) experiences during these analyses since a substantial (but unknown) portion of engineering student participants were likely to be/have been required to participate in a senior culminating experience due to the ABET accreditation of the USU and WSU engineering programs (See Figure 4).

Figure 6 shows the percentage of combined sample respondents who reported participating in each of the five extracurricular HIP. Respondents were more likely to participate in internships (i.e., 38%) over any other type of extracurricular HIP. After internships, participation was reported to be the highest in undergraduate research (24%).

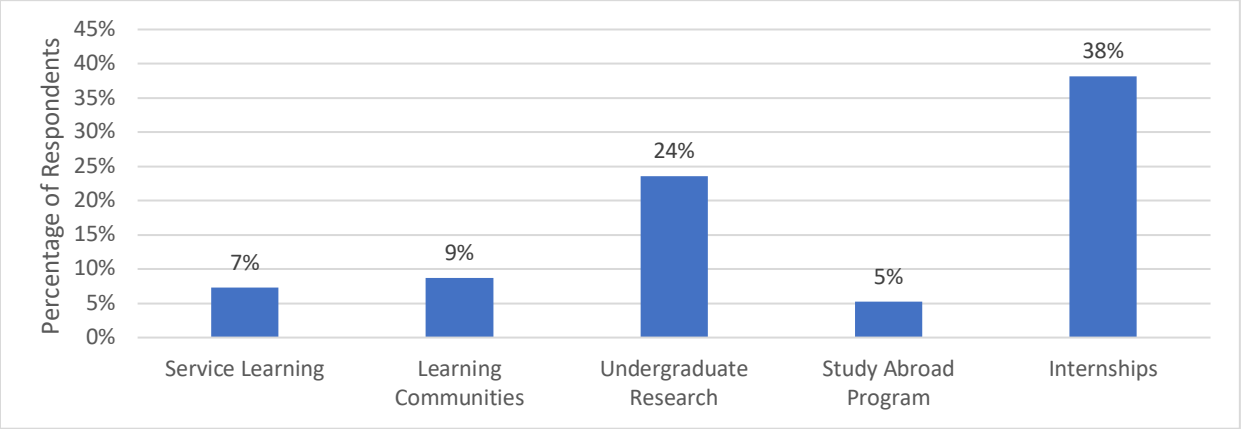

Figure 6. Percentage of combined sample respondents who reported participating in HIP by type.

E/CS student participation in learning communities and service and community-based learning was substantially lower than participation in either internships or undergraduate research (i.e., 7% and 9%, respectively). As a whole, participants were least likely to engage in study abroad programs (i.e., 5%).

HIP Participation among Underrepresented Groups

Women. Our analyses showed that female respondents reported engaging in all extracurricular HIP at higher rates than male respondents. As shown in Figure 7, internships engaged nearly half (42%) of female respondents, followed by undergraduate research activities (31%). The participation of women was markedly lower in learning communities (10%), service and community-based learning (12%), and study abroad programs (8%) as compared to their participation in internships and undergraduate research.

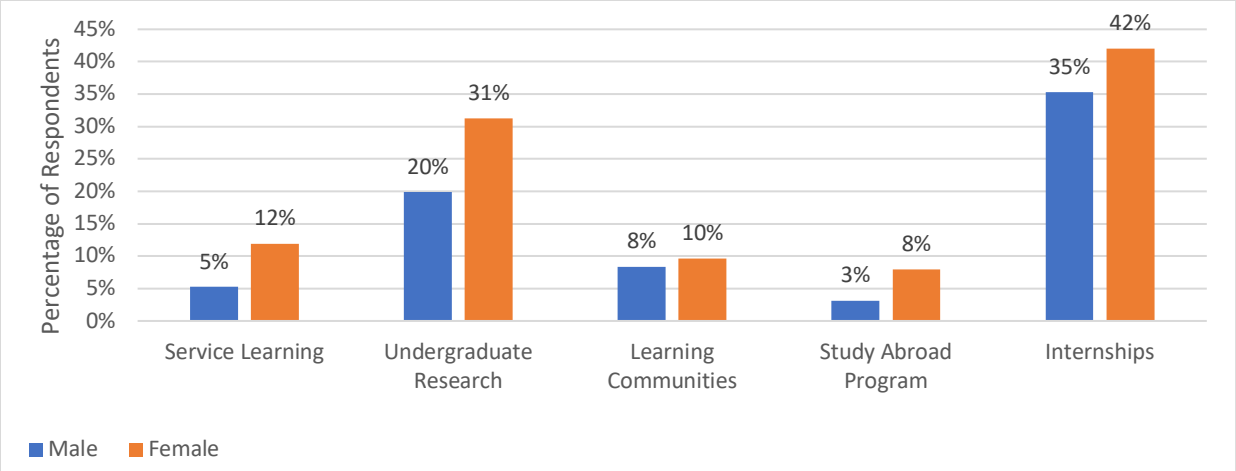

Figure 7. Percentage of combined sample respondents who reported engaging in HIP by activity type and gender.

Generally, female and male HIP participation followed similar trends as the overall sample (Figure 6), except that females reported participating at a slightly higher rate in service and community-based learning than in learning communities. The opposite was true for male respondents.

Underrepresented Racial and Ethnic Groups. As shown in Figure 8, participation in internships, learning communities, and undergraduate research was reported by respondents across all racial and ethnic groups. All groups except Other Non-White reported participation in all HIP; Other Non-White respondents reported no participation in service and community-based learning and study aboard.

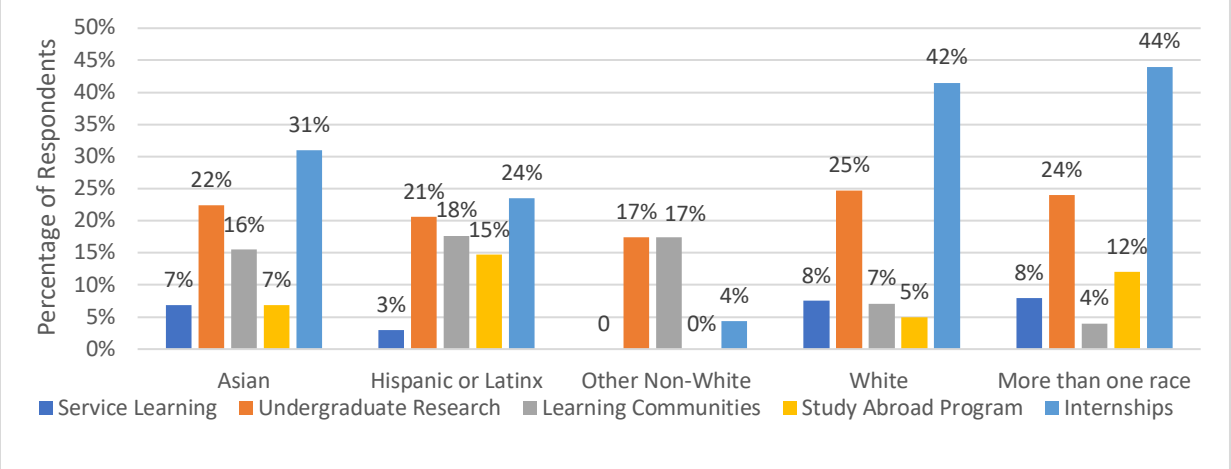

Figure 8. Percentage of combined sample respondents who reported engaging in HIP by activity type, race, and ethnicity.

As shown in Figure 8, participation in internships among Asian, White, and multiracial respondents was relatively high compared to their participation in other HIP. Participation in internships among Other Non-White respondents, however, was markedly low (4%) compared to the other groups; participation of Other Non-White respondents in undergraduate research and

learning communities measured at similar levels to the other groups. Hispanic or Latinx respondents participated in study aboard at the highest level of any group.

HIP Participation among First Generation College Students (FGCS)

As shown in Figure 9, FGCS were more likely to participate in internships (29%) and undergraduate research (25%) compared to other HIP. Only five percent of FGCS reported participating in global learning and study abroad. Overall, HIP participation of FGCS followed the same trends as the combined sample (see Figure 5).

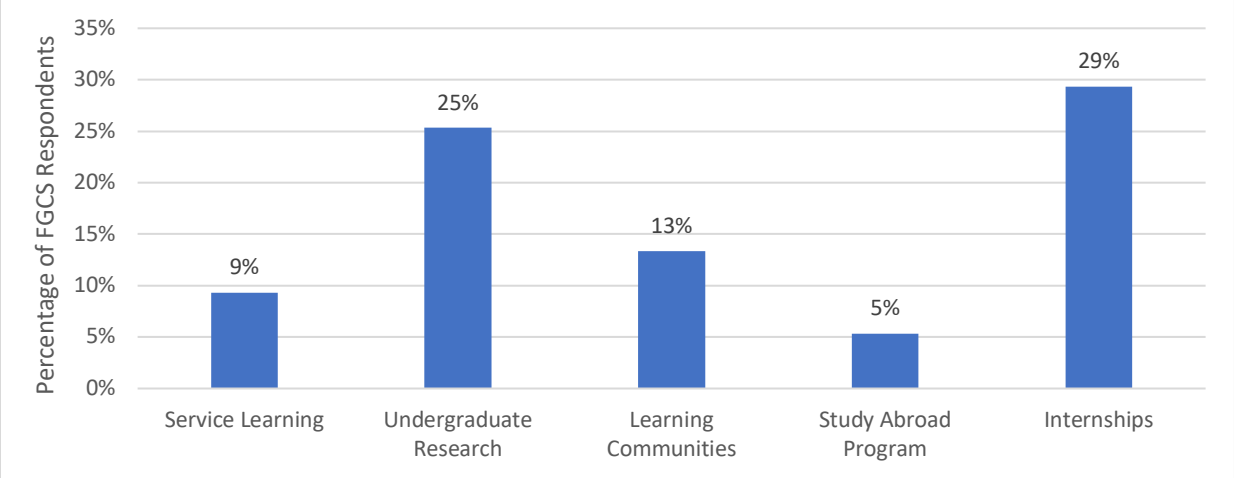

Figure 9. Percentage of First Generation College Student (FGCS) respondents in the combined sample who reported engaging in HIP by activity type.

HIP Participation among Nontraditional Students

The National Center for Education Statistics (NCES) identified seven characteristics that are used to differentiate nontraditional undergraduate students from those considered to be more traditional. These nontraditional student characteristics are 1) delaying enrollment into postsecondary education, 2) attending college part time, 3) being responsible for their own finances, 4) working full time while enrolled, 5) having dependents other than spouse, 6) being single parents, and 7) obtaining high school credentials (i.e., GED) other than a standard high school diploma [40]. Importantly, these characteristics were developed from statistical risk factors for undergraduate degree noncompletion. According to NCES [40], undergraduates who have none of these characteristics are considered "traditional." Otherwise, students having one characteristic are considered "minimally nontraditional," those with two or three characteristics are considered "moderately nontraditional," and those with four or more characteristics are considered "highly nontraditional."

Due to an oversight during survey development, survey questions were developed to inquire about all seven nontraditional characteristics except one (i.e., whether participants had dependents other than their spouse). To track the number nontraditional characteristics for each participant, those who reported having any one of the six characteristics that were included in the survey were assigned one point for each characteristic. Therefore, participants who did not report possessing any nontraditional characteristics were considered "traditional" and assigned a score

of zero. Other participants were assigned scores of one to four based on the number of nontraditional characteristics reported. (We note that none of the participants reported having more than four nontraditional characteristics.) Using the data from the 576 survey responses included in the analysis, 189 (32.8%) participants were considered traditional, 223 (38.7%) participants were considered minimally nontraditional, 159 (27.6%) participants were considered moderately nontraditional, and 5 (0.17%) participants were considered highly nontraditional.

Figure 10 presents HIP participation based on respondents' nontraditional student scores (i.e., Score 0-3). We note that all participants who were considered highly nontraditional by reporting four nontraditional characteristics (i.e., Score 4) also reported that they did not engage in any of the five extracurricular HIP and were excluded from Figure 10.

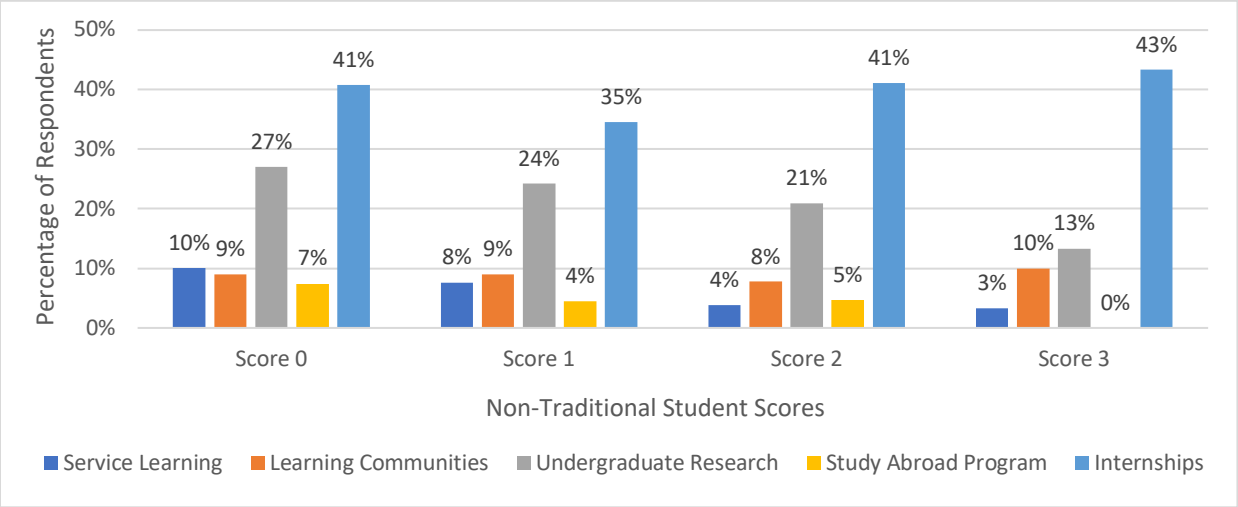

Figure 10. Percentage of combined sample respondents who reported engaging in HIP by nontraditional student score (Score 0-3) and activity type.

As shown in Figure 10, nontraditional student respondents (i.e., participants with Scores of 1, 2, or 3) reported participating in internships and learning communities at similar levels as traditional students (i.e., respondents with a Score of 0) did. However, nontraditional student participation in service and community-based learning and undergraduate research appear to decrease with an increasing number of nontraditional characteristics, while participation in internships and learning communities remains consistent. Participants with three nontraditional characteristics did not participate in study abroad, yet maintained a high participation rate (i.e., 43%) in internships.

HIP Participation within Engineering and Computer Science Disciplines

As shown in Figure 11, differences in participation between E/CS student participants were most notable for undergraduate research and service and community-based learning activities. In both cases, computer science students participated in these activities at lower rates compared to engineering students.

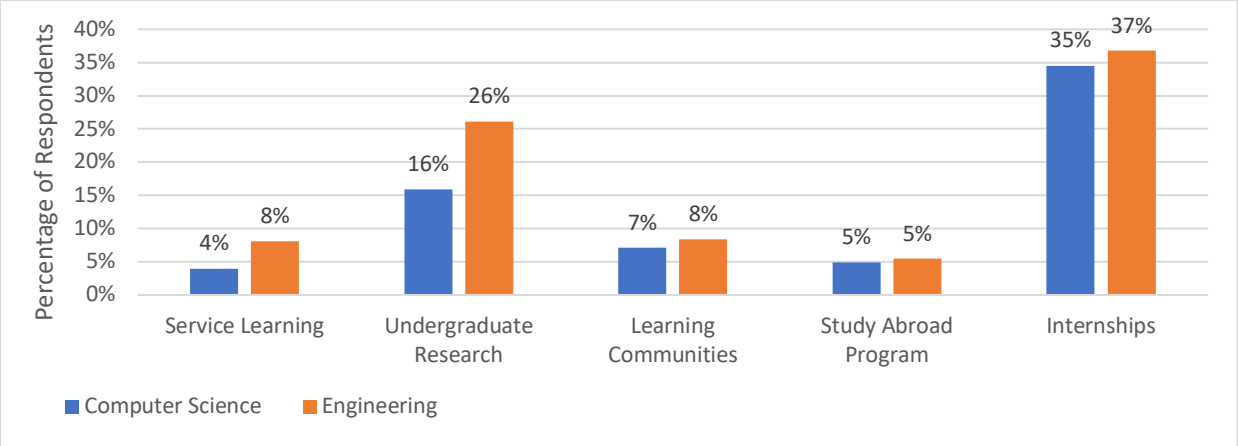

Figure 11. Percentage of combined sample respondents who reported engaging in HIP by academic program and activity type.

Figure 11 also shows that engineering and computer science student participants reported engaging in internships at the highest rates of any HIP. Otherwise, participation of E/CS students in other HIP (i.e., global learning and study aboard, internships, and learning communities,) were equivalent and followed similar trends in relation to one another (Figure 11) and the combined sample (Figure 6).

HIP Nonparticipation

As depicted in Figure 12a), a substantial number of respondents (43%) reported not engaging in any HIP. A smaller group (38%) reported participating in one HIP and 19% percent reported participating in two or more HIP.

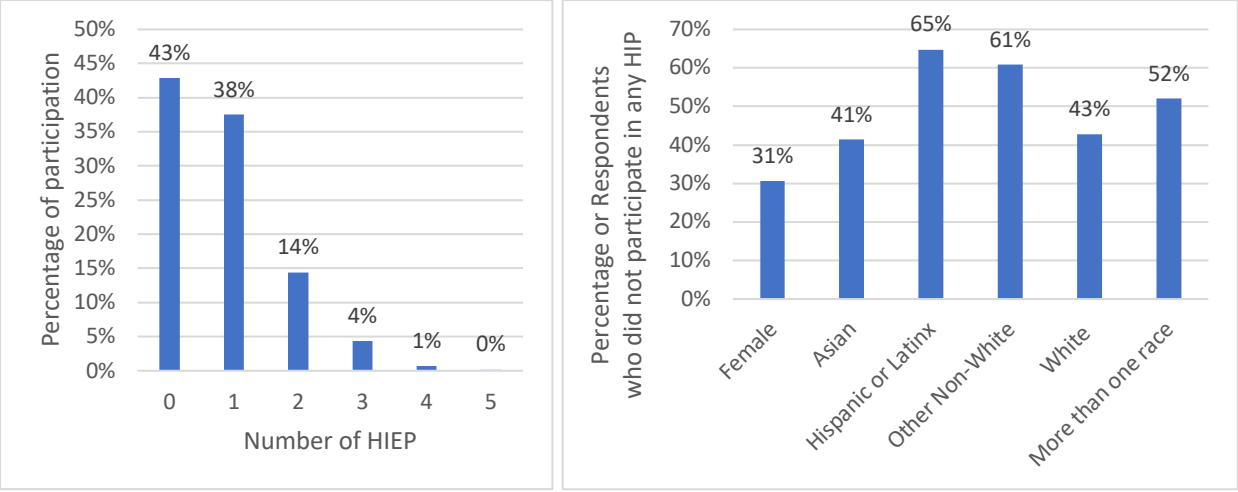

Figure 12. a) Percentage of combined sample respondents by the number of different HIP activities they participated in and b) percentage of combined sample respondents that did not participate in any HIP by demographic category.

The percentage of participants from each demographic group that did not engage in any HIP are shown in Figure 12b). Hispanic or Latinx (65%) and Other Non-White (61%) respondents reported that they did not participate in HIP at the highest levels of any group; females (31%) reported that they did not participate in HIP at the lowest levels of any group.

Participation in Multiple HIP

Also shown in Figure 12a), there was a substantial decrease in participation between those respondents who reported participating in one HIP (38%) and those who reported participating in two (14%) or more HIP (i.e., a total 19% of respondents reported participating in two or more HIP). Further analysis showed that engagement in internships substantially led engagement in other HIP for participants who reported engaging in only one HIP. More (although not all) participants who reported engaging in two HIP chose internships and/or undergraduate research. Participation in internships and undergraduate research was less dominant among those who reported engaging in three HIP.

Discussion

Our findings examine the participation trends of diverse E/CS students in extracurricular HIP at the two western, predominantly White (one institution is an emerging HSI), land grant universities. Importantly our data provide insights into the HIP participation trends of computer science students; to our knowledge, data related to computer science student HIP participation is not currently tracked in national reports on HIP participation (see e.g., [7]).

Internships

Our results indicate that the E/CS respondents engaged in internships and undergraduate research activities at substantially higher rates than service and community-based learning, learning communities, and study abroad opportunities. Internships, in particular, were found to engage E/CS participants at the highest rates of any HIP in general (38%), as well as among women and across most racial and ethnic (excluding Other Non-White), first generation, and nontraditional student groups. This result is consistent with those reported by Kuh [7] that showed national engineering student participation level in internships (55%) to be larger than any other HIP.

The relatively higher level of participation of E/CS students in internships may reflect the value that E/CS students place on internships for the purposes of discovering appropriate career paths, gaining professional skills and experience, and acquiring full time jobs [23]. It may also be that E/CS students are motivated to participate in internships because they are often paid to participate in engineering or computer science internships. In our data, nontraditional students (of all types) reported internship participation rates similar to, if not greater than, those of traditional students. Nontraditional student participation rates in other HIP (i.e., other than internships) were much lower, especially for moderately and highly nontraditional students. Given the large percentage of nontraditional student respondents (61%) (who often work while going to school), it is understandable that both money and future career benefits could become factors when deciding to participate in an HIP.

Despite a higher level of participation among E/CS respondents in internships, their recorded participation rates in internships were lower than nationally reported levels, both within engineering (55%) and across all demographic groups. Kuh [7] reported internship participation levels to range between 41-53% across all race and ethnicities (including Hispanic, Black and Other groups), women, First-Generation College Students, and less selective and public

institutions. This comparison suggests that barriers to participation in engineering and computer science internships may exist at USU and WSU, especially for the most severely underrepresented racial and ethnic groups in our sample, including Hispanic or Latinx (24%) and Other Non-White (4%), and First-Generation College Students (29%).

Undergraduate Research

The participation rates of E/CS respondents in undergraduate research were the second highest of all HIP (i.e., below internships) across all groups we examined. Only for Other Non-Whites did the participation in undergraduate research merely equal (and not exceed) participation in another HIP (i.e., learning communities). Engineering respondent participation rates in undergraduate research (26%) was slightly lower than nationally reported level within engineering (29%) [7]. Across all demographic groups except highly nontraditional students (13%), participation levels in undergraduate ranged between (17-31%) and compared well to or exceeded national participation levels (18-24%) reported by Kuh [7] across all race and ethnicities (including Hispanic, Black and Other groups), women, First-Generation College Students, and less selective and public institutions. Notably, E/CS female respondents (31%) exceeded national levels of participation in undergraduate research in engineering (29%), by females (19%), and across all demographic groups (18-24%). These comparisons suggest that USU and WSU have strong cultures of undergraduate research in engineering and that other public, land grant institutions may benefit from learning about USU's engineering undergraduate research policies (i.e., required pay for undergraduate researchers) and programs.

The data also show that participation in undergraduate research by computer science respondents (16%) noticeably lagged that of engineering respondents (26%). Since the majority of computer science respondents were USU students, this finding may indicate a need for improving undergraduate research opportunities for computer science students there. It is difficult to know if this finding aligns with national levels of participation of computer science students in undergraduate research, since computer science student participation in HIP is not frequently reported in the literature (see e.g., [7]). Kuh [7] reported participation levels in undergraduate research among business (10%) and other professional (15%) majors, which do compare more closely with our computer science data. Since computer science majors enter and participate in the technical workforce across a variety of career fields and disciplines, nationally reported numbers for business and other professional majors may, in fact, be a more appropriate comparison than those of engineering majors.

Learning Communities, Service and Community-Based Learning, and Study Abroad

Both E/CS institutional samples (i.e., USU and WSU) reported low (i.e., single digit) participation rates in learning communities, service and community-based learning, and study abroad. Similar results (i.e., single digit participation rates) were found when the data were grouped by engineering-only and computer science-only respondents. These results are striking when compared to national levels of participation in these HIP among engineering students: learning communities (19%), service learning (34%), and study abroad (12%) [7]. Particularly with regard to service learning, our data indicate that USU and WSU respondents are participating at very low levels. It cannot be determined from our data if the reason for these

results is more due more to a lack of opportunity to participate in these activities, more to a lack of interest, or more to other reasons.

The potential for there to be limited opportunities for E/CS students at USU and WSU to participate in these HIP, particularly learning communities and study abroad, is gravely concerning since our data show that severely underrepresented racial and ethnic groups (i.e., Hispanic or Latinx and Other Non-White) participate in these HIP as much as or more than internships and undergraduate research. This finding suggests that one way to encourage underrepresented students to participate in extracurricular HIP is to emphasize learning communities and study within colleges of engineering and computer science and to grow the number of opportunities for underrepresented students to participate in these activities that are perhaps more compelling, interesting, or important to them.

Kuh [7] reports that service learning is the only HIP to have experienced a modest increase in the percentage of participating students at the national level since 2006. When comparing our E/CS student data to national reports of participation in service learning across of variety of groups, such as engineering (34%), business (40%), professional other (64%), less selective (50%) and public (47%) institutions, women (51%), and underrepresented racial and ethnic groups (48-53%), it is clear that E/CS student participation in service learning at USU and WSU is lagging behind. More research is needed to determine and remedy the precise reasons for these outcomes.

Non-participation

Last, our findings show that a substantial portion (43%) of E/CS respondents did not engage in any of the five extracurricular HIP, and that only 19% reported participating in two or more HIP. These findings are important to consider, given the current emphasis placed on multiple HIP participation for improving student educational outcomes [6-8, 10, 15]. Moreover, our data showed that more respondents from severely underrepresented racial and ethnic groups, including Hispanic or Latinx (65%) and Other Non-White (61%), reported that they did not participate in any HIP.

On a positive note, our data revealed that women (31%) had the smallest percentage of respondents, of any group, who reported that they did not participate in any HIP. In addition, female respondents reported participating in HIP at higher rates than male respondents *across all HIP activities examined*. Taken together, these findings suggest that female E/CS students at these institutions may be poised to take a prominent role in promoting access to and participation in HIP at their institutions. More research at these institutions is needed to understand the motivations and actions of female E/CS students how these motivations and actions can be effectively transferred within and across gender boundaries at these and other land grant institutions.

However, the fact that there is substantial percentage of participants who did not engage in any HIP (43%), and that those who do not participate include members of all of the underrepresented and underserved groups we examined, suggest that systematic or institutional barriers to HIP participation may exist at USU and WSU. Continued research is needed to understand why E/CS

students choose not to engage in HIP, and the ways that extracurricular HIP can be made more accessible and inclusive for all E/CS students at these institutions.

Conclusions

The United States advocates for a robust and diverse E/CS workforce in order to maintain its technological competitiveness and position as an innovation leader across a global landscape. A growing body of literature indicates that participation in one or even multiple HIP contributes positively towards student outcomes, especially among underrepresented groups. Our results show that a large portion of underrepresented and underserved E/CS undergraduates enrolled at two western land grant institutions participated in these important activities at levels considered low nationally, and that many are not participating in any HIP at all. As public institutions continue to develop programs for improving retention and educational outcomes, stronger and more targeted emphasis on improving access to and participation in HIP across all demographic groups—particularly those underrepresented and underserved in engineering and computer science—is needed. Our findings provide a detailed look at E/CS student HIP participation at land grant institutions and provides insights for directing future research in this important area.

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