Enhancing Diversity and Inclusion in Computer Science Undergraduate Programs: The Role of Admissions

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ABSTRACT

Despite continued efforts to further the participation of women in Computer Science (CS), progress has been limited during the past decades. Recent efforts have been focused on recruitment and retention, with a notable gap in exploring the impact of admissions processes on diversity and inclusion. Through an extensive literature review, contextual analysis of public admissions data from 40 universities across four regions around the world, and qualitative and quantitative analysis on surveys and interviews, we explored the role of admissions in enhancing diversity and inclusion in CS undergraduate programs. Our findings highlight the role of financials, the possible positive effects of explicit advocacy for diversity and inclusion, and the imperative to cultivate a more welcoming and inclusive culture in CS programs.

CCS CONCEPTS

• **Social and professional topics → Computer science education**.

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KEYWORDS

Computer Science, CS, undergraduate admissions, equity, diversity, and inclusion, EDI, gender diversity

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1 INTRODUCTION

Computer Science is set to shape the future for a diverse set of technology users. A significant increase in demand for computing professionals in the workforce is expected in the upcoming years. In the meantime, despite numerous efforts towards broadening participation, the number of women in Computer Science, and related technology professions remains low. Undergraduate CS programs, often the main entry point to the discipline and the workforce, observe continued low registration from women, at about 20% [102] across different regions of the world. Understanding the importance of closing the observed gender participation gap, many CS programs pursue initiatives aimed at fostering diversity and inclusion. However, despite the continued efforts by the computing education community, little improvement is observed [79].

While all indicators agree on the need for a cultural shift to achieve proper inclusion, practical strategies to broaden women's participation in Computer Science have focused on two main categories: recruitment and retention [5, 36, 51]. Recruitment efforts include early exposure [110], introducing role models [34, 45], and outreach activities [44, 58, 121] to increase awareness about CS programs among young women and girls. Retention efforts include peer mentoring [34], social support [84], and fostering long-term cultural change within a community [51]. However, there is a disagreement on whether retention rates in CS programs differ between men and women [35], with many studies reporting no gender gap [28, 54, 55, 108, 124], and variation between departments [35].

Although admission to a CS program is an important step toward a career in technology, fewer published studies are available in the literature on the effects of admission processes on gender diversity. Much of the work in admission focuses on indicators of success, including those used by admission offices [26, 64, 81, 93, 107, 128, 130]. Patitsas et al. [86] argue that admission changes are needed to further the participation of women in computing, including changing general admissions criteria to focus on "non-numerics". However, beyond exploring the effect of affirmative action [25, 103], we are not aware of work that analyzes how admission policies may affect gender diversity in Computer Science.

Motivated to explore this knowledge gap, we studied the admission procedures for CS undergraduate programs. We investigated procedures, looking for factors resulting in more diverse student populations, including factors affecting the decisions made by women to apply to an undergraduate CS program, and the factors affecting their final decision to attend a program. We asked:

- **RQ1:** What are common approaches to admissions in Computer Science (CS) undergraduate programs?
- **RQ2:** What are the indicators of success considered in such admissions procedures?
- **RQ3:** What are the different outcomes of current admissions processes in terms of cultivating diversity and inclusion in admitted student populations?
- **RQ4:** How can admissions processes promote diversity and inclusion?

We centered our efforts on gender-diversity in answering these questions, due to the scope of work as well as availability of data; though we considered intersectionality when possible.

We used a combination of quantitative and qualitative methods to learn about the admission procedures from different sources: university websites, students, administrators, and CS program faculty in decision making positions. We performed contextual analysis on the websites of 40 universities across four regions around the world [i]. We surveyed and interviewed students, and interviewed people within roles in administrative and decision making roles in Computer Science and affiliate programs. We performed quantitative and qualitative analysis on survey data, and narratated interviews.

We found subtle differences among men and women in exploring their options when they apply to CS programs, and in the major parameters they consider in their choices. The majority of students indicated prestige, location, environment, program structure, and cost as their most important deciding factors. We also observed more financial concerns among women of color, compared to women who did not identify with a minoritized race or ethnicity.

Our findings suggest significant differences among gender identities in their assessment of culture in CS programs and their expectations from their prospective universities in terms of diversity and inclusion. During the application and university selection process, student participants who identified as women, non-binary, and self-identified gender identities preferred universities that explicitly promote diversity and inclusion. These students also indicated that they neither found the culture of CS programs welcoming to different gender identities nor did they find it welcoming to different ethnical and racial identities. These students expressed the need for cultural change in these programs to improve diversity and inclusion in the discipline.

We present our work in four major sections: a comprehensive literature review on diversity and inclusion, a study of admission procedures, a student survey, and interviews. We incorporate our methodology for study design, data collection, and analysis within each section and follow with the major findings, a discussion, and the threads to validity. We then conclude all of our findings in a final analysis and provide recommendations. The rest of this paper is organized as follows: In section 2, we explore the works and recommendations for increasing participation of women in Computer Science through recruitment, retention, and admission. In section 3, we present our process of choosing 40 universities within four different regions across the globe and explore their admission processes. Section 4 presents our student survey design, participant recruitment, and results. Section 5 follows the discussion with interviews. We discuss the threats to validity of our work in section 6. Section 7 summarizes our findings and discusses our recommendations for inclusive admission processes. Section 8 presents the future directions the authors would like to explore.

2 GENDER GAP IN COMPUTER SCIENCE: LITERATURE REVIEW

Concerns about the enrolment and involvement of women in CS educational programs, and the Computer Science discipline and workforce in general, began to appear in the literature from the 1990s [67, 88]. In recent years, these concerns have been further compounded by the declining enrollment of women in CS undergraduate programs. To delve into this ongoing issue and examine implemented solutions, we conduct a comprehensive literature review on initiatives aimed at enhancing diversity in CS programs.

Kallia and Cutts [62] considered inequalities in participation in Computer Science in terms of Bourdieu's sociological theories of capital, habitus, and field. Capital determines ranking within a field, while habitus is related to disposition towards the field. There is an alignment with the student journey of recruitment, admissions, and retention. Grades where used in admissions processes are an aspect of cognitive capital, while recruitment and outreach interventions can affect the habitus of potential students. Kallia and Cutts assert that capital and habitus are not enough and that the Computer Science field may be an additional factor that affects participation. A field consists of a structure and its agents, which include policies and procedures as well as teachers and students. The Computer Science field can encompass a range of interventions to support retention over a period of time as well as policies and agents related

[i]Website data and survey analysis codes are accessible at https://osf.io/5jxk8/

to admissions. Understanding the influence of admissions in this context may provide insights into ways of changing the field.

Interventions have been reported in relation to each of these aspects of the student journey which align with Bourdieu's framework. The approaches for recruitment include early exposure [110], outreach for recruitment of historically marginalized groups [6], considerations in admissions processes [51], pathways [19], financial support [24, 63], and changes in culture for enhanced student success [51]. The approaches for retention [12, 33] include introducing role models for igniting interest [34, 45], creating support networks [10] , initiative for design of inclusive curriculum and change in teaching practices [76], and living learning communities [131]. In this section, we conduct a thorough literature survey as a step towrds answering RQ4, possible ways in which admission processes can promote diversity and inclusion. Our review includes outreach, recruitment, and retention as interdependent processes, highlighting the need for furthering diversity and inclusion efforts in undergraduate admissions procedures. We start our review with recruitment, and continue with retention. We conclude this section with a thorough review of current studies on admission procedures, highlighting the knowledge gap on the impact on admission procedures on diversity and inclusion.

We base our research on self-expression of gender identities: Man, Women, Self-identifying/Non-binary (SI/NB). However, in this section, we maintain allegiance to language precision in the literature, which might be affected by either research-related definitions or the structure of available data.

2.1 Recruitment

Efforts to reduce the gender gap are focused on two important directions: recruitment and retention [5, 36, 51]. A recent study from 2021 conducted by Chan et al. [28] from the Government of Canada explored the roles of academic performance and preparation in gender differences in STEM enrolment and graduation. The study noted that even if male and female students aged 15 - 16 performed equally well with respect to academic achivement in Grade 10 (high school) STEM-related subjects, more men (57.9%) than women (36.9%) were ready for enrolling in post-secondary STEM programs (i.e., completed all courses needed) by the time they graduated high school. Female high school graduates are less likely to enroll in STEM post-secondary programs and Bachelor's degrees (29.8% and 36.4% respectively) compared to male graduates. The study indicated no difference in retention of men and women in STEM programs, highlighting that the gap occurs at the enrolment stage.

We present the literature review on recruitment efforts for diversity and inclusion in the following subsections: practices, early exposure, support networks, and outreach programs.

2.1.1 Recruitment Practices. Alexander et al. [5] present seven case-studies of CS undergraduate recruitment practices based on data collected from several universities in Canada, USA, Ireland, UK, Spain, and Sweden. They concluded that while prior success in earlier studies is a prediction of success in the mathematical part of the curriculum, the entry qualifications themselves do not appear to be an indication of successful program completion.

Cohoon [37] stated that actively recruiting women into CS majors is the "single most effective" method to increase women's participation, and provided six recommendations: (1) working with high school teachers, (2) communicating with high school guidance counselors, (3) using role models to actively recruit high school students, (4) developing relationships with community colleges, (5) establishing contacts with the local community and (6) recruiting first and second year students from within the institution.

Frieze and Quesenberry [51] note that successful enrollment rates at Carnegie Mellon University (CMU) are the result of a cultural approach rather than a gender difference approach. An important change in recruitment at CMU is the dropped programming/CS requirement from the admissions criteria (since 1999) and the added leadership potential requirement.

A prominent success story in recruitment of women in CS is that of Harvey Mudd, a private liberal arts college located in Claremont, California, that offers exclusively bachelor degrees in STEM fields, including computer science [40]. In 2005, the college implemented three innovative strategies to correct the trend of sluggish female enrollments in the CS major [66]:

(1) The focus of the introductory CS course (CS5) was shifted from learning basic programming skills to computational problem solving. This allows students to quickly gain an understanding of the potential and breadth of computer science as they tackle problems in different fields. The course also sorts students in two sections, according to their programming experience, reducing the risk of inexperienced students finding themselves in an intimidating environment.
(2) The college offers to every first year female student who expressed interest in CS the possibility to attend the Grace Hopper Conference [50]. The college reports that this experience is very motivating for attending students [66].
(3) Students who have completed the first year in the CS major can partake in summer research opportunities organized by the college. This experience is motivating for students who, having only completed one or two programming courses, may otherwise struggle finding internships.

The enrollment of women in the major climbed from 10% in 2005 to the current 50%. The success story of Harvey Mudd is certainly worthy of attention and praise. It may however be difficult to replicate by other institutions: the college currently enrolls only 905 undergraduate students *across all majors* (roughly 6% of them are enrolled in computer science) [40], and requires an annual tuition of $65,954 [39], well above the national average of $37,600 reported by the US department of education for other private nonprofit institutions [48]. This puts the college and its students in a uniquely favorable position to tackle the issue of inequitable enrollment.

2.1.2 Interest and Early Exposure. According to Chan et al., as high school academic achivements explain only a small portion of the gender gap, consideration should be given to other factors like confidence, early exposure to Computer Science, interest, role models, and societal norms [28].

Childhood activity choices and experiences inform future career interests and could create a gender divide [127]. For example, a majority of male undergraduate CS students report prior computing experience, but the same is not true for women [10]. Liben found a correlation between spatial thinking and engagement, persistence and success in STEM[69]. Computer exposure, playing computer games and facilitating children's spatial thinking through play could reduce the gender divide [47, 69, 113].

Social factors and norms are especially important as these can create a deterrent to women's participation in CS and more generally in other STEM fields. Shapiro and Neuberg [101] identified a set of six qualitatively distinct stereotype threats based on the source of the threat (self, outgroup members or ingroup members) and the target of the threat (self or group). Cheryan et al. [31] researched undergraduates' stereotypes of the students studying computer science, and revealed that media has an impact on perpetuating and, also could potentially change these stereotypes.

The outcome of these influences is the lack of interest and participation of women in computing education, resulting in what methaforically is described as a "leaky pipeline". The "leaky pipeline" problem is complex and presents several factors [17]. One of these factors is the lack of readiness for post-secondary STEM education. Chan et al. [28] revealed a drop in women's interest in STEM-related subjects during their high school senior years (grades 11–12).

2.1.3 Support Networks and Role Models.

Support groups are important and beneficial for female CS students. The CS department at Truman State University created a women's social and academic student group that provided mentoring role models and outreach experiences. Creating the support group needed only a modest initial expenditure of time and money, and it became soon a formally recognized university student organization [10].

Women often lack parental and mentor support; however, with proper support they can be successful in male-dominated professions [52]. Roberts et al. [95] recommended providing female role models for undergraduate women at every level of their education.

Drury et al. [45] argued that while female role models can be effective in the retention of women, they are not as effective for recruitment. Their analysis suggested that the gendered negative stereotypes that avert recruitment (feelings of not belonging) are different from those that avert retention (concerns related to ability). Studies also demonstrated the effectiveness of male role models, as the negative stereotypes about women's abilities are less of a concern for candidates who have yet to identify with the STEM domain [45]. However, the most effective recruitment strategy is simply to include role models (whether male or female) who provide perceived similarities and traits that are compatible with how women see themselves [45].

2.1.4 Outreach programs and activities.

Outreach activities can take the form of standalone activities such as awareness initiatives (college fairs, school visits), partnerships, workshops, campus visits and open houses. Alternatively, they may comprise part of an integrated program that could combine scholarships, and/or the use of ambassadors, such as in the University of Pennsylvania's Advancing Women in Engineering Program. Morreale et al. [75] suggest that general outreach programs can improve overall recruitment to CS degrees by up to 10%. However, Dodds and Karp [44] and Mackroy et al. [72] found that for a targeted initiative, the results on recruitment were inconclusive. In contrast, a study from Vachovsky et al. [121] evaluating Stanford University's SAILORS initiative targeted at high school girls showed a strong increase in the likelihood of the participants studying Computer Science or Artificial Intelligence degrees at the conclusion of the program. Gutica's [58] study, including coding activities mentored by undergraduate students acting as role models, also shows similar outcomes. This suggests that focused and specifically designed outreach programs may be an effective method for increasing female recruitment.

2.2 Retention

A substantial body of literature investigates solutions to retain the women who choose to study CS, or explore the reasons for their decision to leave. Campbell and McCabe reported that successful completion of the beginning year of a CS program represents a useful indicator of successful completion [26]. We present the literature review on retention efforts in the following subsections: differences in retention rates between genders, factors affecting retention, and interventions to improve retention.

2.2.1 Differences in retention rates between genders.

Cohoon [38], in a study of eighteen CS departments across the United States, found that women comprised around 24% of undergraduates enrolled in CS programs from 1994 to 2000, but were disproportionately represented in the attrition rate, comprising 32% of students who discontinued their CS program and switched to a different major. In an earlier study, Cohoon [35] analyzed universities in Virginia and found attrition rates of 16% for men and 21% for women, but that across departments, women's attrition rate varied more than men's (standard deviation of 24% vs 14%).

Not all universities retain women at a lower rate than their male counterparts. Research by Chen [30] shows that while roughly half of students who enter STEM programs transfer out before completing their degree, the average predicted probability of women dropping out of the program was 5 percentage points lower than that of male students. An ACM committee formed in 2018 which analyzed retention rates using data from the National Center for Women and Information Technology (NCWIT) reported overall attrition rates of about 21%, with no significant difference between that of men and women (20.98% vs. 20.19% respectively) [108]. Several other studies also reported no gender gap in persistence rates [28, 54, 55, 124] suggesting that recruitment is the most imporant factor that needs to be adrresed in terms of diversity and inclusion, and to a lesser extent retention. The overall variation across studies suggests that differences in departmental policies are worth investigating.

2.2.2 Factors affecting retention.

There have been efforts in many regions to study factors affecting retention and how they differ across genders [83]. These include individual factors related to lack of experience affecting self-efficacy and social belonging, and cultural issues like stereotypes affecting the classroom climate.

Lack of experience has been stressed by many [22, 23] as a reason why retention rates are lower in women. For example, Roberts et al. [97] conducted a survey in an Australian university ICT program and found that lack of expected background knowledge was the most common reason women provided for withdrawing; women are more likely to believe that they do not have the expected background knowledge for an ICT program [96]. Powell [89] surveyed

14 women planning to major in CS and identified lack of prior experience and social isolation as challenges. A survey from Biggers et al. [16] of Georgia Tech CS graduate "Stayers" and non-CS graduate "Leavers" found a statistically significant difference in their prior preparation between the two groups.

Prior experience is associated with self-efficacy [14]. Milesi et al. [74] found an association between feelings of being skilled in CS and persistence. Lishinski and Rosenberg [71] found significant gender differences in CS1 students' week-to-week momentary experiences throughout the program, but those differences reduced significantly when controlling for self-efficacy; they suggest that "gender gaps could instead be self-efficacy gaps".

Both lack of prior experience and self-efficacy tie to women's sense of social belonging. In Powell [89], women perceived male students as more knowledgeable, and these perceptions affected their social isolation. The survey conducted by Redmond et al. [94] showed that women were more confident asking questions in CS classes than men; men also reported higher course enjoyment of the CS1 course. In a separate U.S. multi-institutional study, Barker et al. [9] found student-faculty interaction, collaboration, and classroom climate to be predictors of retention. In an Australian survey, Roberts et al. [96] found that women students in ICT mention the lack of women in classes, the male-oriented content, and lack of encouragement from male staff to be reasons contributing to attrition. In Biggers et al. [16], women were more likely than men to leave the CS major due to feelings of non-belonging.

Cultural perception and stereotypes are seen as reasons why computer science has a larger gender gap than other STEM fields [32]. The effect of stereotypes are complex; Cheryan et al. [31] had students meet role models who did and did not embody stereotypes in CS, and found that exposure to the stereotypical role model had negatively affected women's interest in CS, irrespective of the gender of the role model. The institutional culture was also recognized as very important in several studies [36, 51, 70]: in Cohoon [36], same-gendered faculty and peer support (having at least one woman faculty and a sufficient amount of women students) is associated with departments retaining women at similar rates to men.

Importantly, Wall [124] stressed that attrition rate is *not* due to lower grades or lower math ACT scores [109]. In fact, Katz et al. [64] found that women with higher grades (than 'B') in an introductory CS program were less likely to persist compared to men with lower grades. More generally, Beyer and Bowden [15] show that for tasks considered "masculine", women's self-evaluation of performance is inaccurately low compared to actual performance. The intersection of cultural perception and prior experience affecting self-efficacy is at the heart of retention, and not ability.

2.2.3 Interventions to improve retention. Broadly speaking, most interventions aimed at improving retention center around supporting the *individual* or reconfiguring the *policy/curriculum*. Berry et al. [12] also identify *promotion and engagement* as a possible category for such initiatives.

Interventions to support individual women include, for example, peer-mentoring (e.g., assigning freshmen female engineering and CS majors to upper-division female peer mentors) [34], faculty mentoring [36], and faculty positive attitudes for their female students' abilities and work styles [36]. Pantic and Clarke-Midura [84] identify four different types of social interactions that support the retention of women in CS courses: peer support, faculty support, clubs, and tutor support. They also identify retention-supporting practices such as *gaining legitimacy* (i.e., situations in which women felt acknowledged), *establishing work-life balance*, and *finding a job*, and emphasize the importance of building community within the academic environment to provide educational and emotional support for women. They recommend that faculty implement initiatives aligning with these retention-supporting practices, such as encouraging women to search for jobs early in their program.

Khan [65] surveyed first-year CS students at the University of Minnesota, Duluth, to establish the outcome of two possible interventions on the retention of women in CS programs. They concluded that providing students with greater opportunities for social networking (such as online discussion platforms) and using more practical, "real world" problems in teaching materials could potentially increase women's interest in studying CS. A larger scale study administered across fourteen U.S. institutions also found that using assignments that required student collaboration and providing relevant and meaningful examples in curriculum content were both strong predictors of retention in CS programs [9]. Lancaster and Smith [68], too, explore the importance of making the link between academic learning and real world value when it comes to retaining women in CS courses, in their study which demonstrates how participation in cooperative educational experiences can build the confidence of female students.

While the studies reviewed identified a broad range of different interventions, evaluation of these interventions is challenging, since most studies do not have a control group and a number of actions may be implemented simultaneously. However, addressing these challenges requires a comprehensive approach that may include initiatives or interventions aimed at fostering an inclusive and equitable environment, promoting diversity among faculty and leadership, providing mentorship and support networks, and creating flexible academic structures to accommodate diverse needs and responsibilities.

2.3 Admissions

Continuing increases in computer science registrations keep the question of admission procedures into these programs relevant for students, educators, and industry. Interested students try to understand the admission procedures to increase their chances of admission, while programs try to improve their admission procedures, reaching diversity and inclusion across admitted populations. In the late 90s, Nielsen and Campbell [81] explored the factors considered in admitting computer science undergraduate students into graduate programs in the US. Their study surveyed 108 programs and provided a brief review of how admission committees weigh different parts of an application, such as GPA (Grade Point Average), GRE (Graduate Record Examinations), recommendations, work experience, and student statement towards the admission decision. This comprehensive study was limited to graduate admissions, and did not consider diversity and inclusion in the student population.

For undergraduate admissions, Massoud and Ayoubi [73] used data from the UK Higher Education Statistics Agency from 2010 to 2015, showing that institutions with higher flexibility in the admissions process have higher overall student enrollment. While they studied international and domestic students, their study was not specific to Computer Science and did not consider the enrollment for marginalized groups, or historic declines in registration of women in STEM fields such as Computer Science. Alexander et al. [5] studied the admissions processes of seven different undergraduate programs from Canada, Ireland, Spain, Sweden, UK, and USA, and concluded, with weak evidence, the relevance of high school mathematics to relevant areas of the undergraduate degree.

Patitsas [85] conducted a survey of Computer Science faculty in North America about enrollment increase in CS programs and argued that separation of gender diversity efforts from main Computer Science admissions decisions affects the enrollments. Her 2015 work [86] highlights the changes needed for furthering the participation of women in computing, which includes changing admissions criteria for CS majors, affecting all students.

Frieze and Quesenberry [51] discuss how Carnegie Mellon University's admissions decision to include leadership potential, keep high SAT scores, and drop the programming and computing background requirement from the admissions criteria in 1999 together with following cultural changes helped increase the participation of women in CS program to reach 50% in 2018. Their conclusion highlights cultural change, and not curriculum change, as the most effective parameter in attracting more women to the program.

In 2002, Cohoon [37] suggests practical steps for the recruitment and retention of women in computing. Two of the recommendations touch on admissions processes, including creating multiple entry points, and removing the prior experience with computing as an admission criteria. Interventions at admission are essential as "higher female proportions of enrollment were more likely to retain women at comparable rates to men" [36, p. 112]. Similarly, referring to graduate admissions, Cuny and Aspray recommend broadening the admissions criteria and flexibility [43].

Many UK universities make use of contextualized admissions, in which admission requirements are adjusted based on data from the application or information from, for example, personal statements or references, or in which outreach activities are provided prior to application [78]. Boliver et al. [18] argue that these approaches provide meritocratic equity of opportunity, in contrast to meritocratic equality, within a highly selective and stratified university system. Contextual admissions are attractive for policy-makers as they make some progress towards equity possible within the existing admissions model, although in doing so they may inhibit changes to the hierarchical nature of that model [77].

2.3.1 Success Indicators. Admission requirements are intended to determine applicants who are likely to succeed in a program. The last few decades saw an increase in interest in determining what factors contributed to a student's success in a CS major. Several studies pointed to strong mathematical and verbal skills [26, 64, 93, 107, 128, 130] and high school ranking [26] as predictors of success.

Reports on the impact of previous Computer Science coursework are mixed. A positive correlation between success in Computer Science courses and prior Computer Science coursework, either in high school or in college, was found in 1989 by Taylor and Mounfield [110], and, in 1994, a new study by the same authors found that prior formal computing education was a positive predictor for female students [111]. The authors attributed this difference to the higher exposure of male students to informal computing activities, while female students would often have their first exposure to computing in a school course. Katz et al. [64] found that success in an undergraduate CS program was correlated with the number of Calculus courses taken and prior computing experience, but also with having home access to a computer and a mentor or role model during high school years. This study also found that male students who earned a grade of B or less in the introductory programming course were more likely to enroll in the subsequent course than female students with the same grade. Chen et al. [29] found that having taken AP calculus or regular calculus in high school was positively correlated with success in an introductory college CS course, as well as having taken AP CS (but not regular CS).

Students' attitude has been reported as having a significant impact. In 2001, Wilson [130] focused on identifying factors correlated to success in a CS major and found that the biggest contributor was comfort level with the courses, identified as, among other things, the ability to ask questions in class or during office hours, and the perceived difficulty of material and assignments. A solid math background was the second most important factor for success, while the attribution of one's success to luck was found to have a negative correlation with success in the course (an older study on attribution styles [59] also found students' success to be correlated with their perception of their own abilities). Similar results were reported in [129] in 2002, which also analyzed gender differences. No differences between male and female students were found in these three factors; however, the author warns that the female population in a computer science course tends to self-select for high self-confidence and skills. Another study on sex and age as predictors for success found no significant correlation [11].

Simon et al. [104] explored cognitive, behavioral, and attitudinal factors. They found that spatial visualization and reasoning and the ability to articulate strategies for commonplace search are correlated with success in introductory programming courses. In addition, through a qualitative analysis of short interviews, they identified the qualities that students themselves regarded as essential to success in programming, such as logical thinking and problem-solving.

2.3.2 Admissions Advertisement. As part of the decision-making process, students are actively seeking out information about their university and/or program where they plan to apply [61, 87]. During this process, students are likely to visit admissions information websites. The material presented on those websites has been studied for readability [112] but we are unable to find research on the specific effects of diversity language on those websites. However, literature on job recruitment advertisements shows that recruiting organizations are more attractive to minorities when they advertise diversity in job recruitment materials [7, 8, 123].

2.3.3 Funding and Scholarship Model. The influence of funding on university and college admissions is traditionally considered primarily from an access and affordability perspective. Funding opportunities, such as scholarships [63] , grants, and financial aid, can significantly impact access on the ability of students from economically disadvantaged backgrounds to, firstly, consider higher education and, secondly, to remain in higher education once admitted [20, 116]. However, colleges and universities often use funding opportunities to recruit and attract top-performing students. Offering generous scholarships, financial aid packages, or research opportunities can entice high-achieving students to choose a particular institution over others. A smaller proportion of funding opportunities are used to enable Equity, Diversity, and Inclusion (EDI) or widening participation initiatives on admissions college or university wide or for specific academic programs. Studies report mixed levels of effectiveness of such schemes: Bruce and Carruthers [21] suggest there is limited impact, whereas others studies do report an impact [63, 100, 125]. There are various funding resources for scholarships to encourage women's participation in Computer Science [24]. Specific funding aimed at increasing the participation of women in CS programs is also often divided between direct scholarships and outreach and recruitment initiatives, examples of which include the University of Pennsylvania's Advancing Women in Engineering Program.

2.3.4 Alternative Pathways. Kar et al. [63] follows the education path of 39 NSF-Scholarship awardees entering computer science through alternative pathways. Seibel and Veilleux [99] discuss the sense of intimidation associated with considering computer science career paths in women without exposure to the field. While the work is focused on entry to workforce, similar analysis applies to high school students' consideration of the field for undergraduate studies. Therefore, exploring alternative pathways like internal transfers seem like a viable solution. However, authors' efforts to find literature on the topic yielded limited results.

In summary, Studies which have looked at Computer science admissions have considered success indicators, admissions advertising, funding models, and alternative pathways. Admissions advertisements and language on university websites, especially regarding diversity, are considered to have the ability to sway students' decisions. Funding, scholarships, and financial aid have been employed to influence access, but evidence suggests these have had mixed effectiveness in promoting gender balance. Based on previous efforts, our study further explores admissions from the perspective of a prospective student.

3 ADMISSIONS PROCESSES

In this section, we present our contextual analysis of publicly available information regarding CS programs' admissions and enrollment processes. The analysis contributes to answering our research questions RQ1 and RQ2, the approaches to admissions in computer science programs, and indicators of success considered in such admission processes. We also report the percentage of Women in the studied programs, as a limited quantitative measure contributing towards answering RQ3, the outcomes of admission processes in terms of cultivating diversity and inclusion in the admitted student populations.

For each of the four regions we selected a set of 10 universities with highly ranked CS programs where data indicating the percentage of women enrolled was publicly available [ii].The choice of ranking as a selection criterion stemmed from the assumption that higher-ranking universities are more likely to attract a large and diverse pool of applicants, providing a setting where admission processes play an important role in the diversity of the admitted student populations. We considered only CS standalone programs as opposed to combined programs (e.g., CS and engineering or CS and information systems). Our data was collected from universities' websites, as well as publicly available data from government organizations. For the universities selected from each region, we present two tables. The first table includes the percentage of women enrolled in the CS programs (most recent available data) and additional details related to EDI and scholarship content visibility. The second table includes the admission process selection basis that is specific to each region, the admission requirements, and any other relevant information on admission for each region.

Our criteria for content visibility follows Web Content Accessibility Guidelines (WCAG) guidelines' first principle — "perceivable" [1]. While many universities provide scholarships and support for students relating to equity, diversity, and inclusion, the extent to which this information is prominent or easily accessible can vary. For each university, we viewed both the program's website and the program or school's admissions page. We recorded whether links to scholarship information or EDI initiatives were *immediately visible*, *visible*, or *not visible* on either of these pages. *Immediately visible* included links for which the user did not have to scroll down or access navigation menus on a page. *Visible* included links in navigation menus, e.g., in the top or right/left menu bar, or in the footer. Content/links only available through overlay or popup menus were recorded as *not visible*.

We considered EDI initiatives broadly (e.g., student clubs for women), but we did not consider testimonials, photos, or showcases of individual members of their community since these do not provide resources for incoming students. We also excluded news items on websites as they change frequently and do not provide resources for incoming students. To reduce bias, two separate authors viewed the websites collaboratively and came to a consensus.

In the next subsections, we will present our data collection process for each region and highlight any regional characteristics and differences.

3.1 Australia

3.1.1 Selection of universities. For Australia, the ten universities chosen were all public universities which offer full-length specialized undergraduate Computer Science programs (Table 1). We selected those universities with the highest Times Higher Education ranking for Computer Science in 2023 [115], excluding the University of Melbourne, as that institution's generalized undergraduate degree model does not allow for us to capture data relating only to students majoring in CS programs. The ten universities range across five different states/territories in Australia (New South Wales, Victoria, Queensland, South Australia, Australian Capital Territory), and also include seven of the top ten highest ranked universities in Australia according to the QS World University Rankings 2023 [91].

Among the universities we selected, the percentage of women in CS varied from 15% (Griffith University and QUT) to 28% (University

[ii]In the preliminary stages of our study design, we considered the inclusion of other regions (e.g. France, Germany and Italy); however, we opted against including other regions due to lack of uniform criteria for university selection and data collection, and impediments in the analysis of non-English data.

of Sydney). These figures were taken from data published by the Australian Government's Department of Education from the year 2021 (the most recent data available) [82], and were calculated as a percentage of the total number of commencing students in Bachelor degrees in the field of Information Technology (which is the terminology used to refer to CS programs in Australia).

While many of these universities provide scholarships and support for students, all but two had links to scholarship information from the CS program admissions page (four have immediate visibility). By contrast, visible links to EDI initiatives from the school or faculty homepage were only present in two of the universities analyzed (Table 1). These two universities, however, were not among those with the highest percentage of women in their CS programs.

3.1.2 University admissions in Australia. Australian residents apply to attend university via the relevant post-secondary admissions office, which differs in each state and territory. These admissions offices are responsible for processing applications for admission to university courses, calculating an Australian Tertiary Admissions Ranking (ATAR) for each prospective student based on their secondary school results, and contacting successful applicants with offers. Most offers are made over the Australian summer period from December to January, after students have received their year 12 results, and before the university academic year begins in late February.

In Australia, admission to university courses is primarily based on the prospective student's ATAR. This is a percentile ranking from between 0.00 and 99.95 provided to all Australian students who successfully complete high school. Mature-age students who have completed their high schooling in an earlier year can also apply for an ATAR, which is calculated based on their previous results. All the universities selected in our study require the following prerequisites for entry into a Bachelor's degree in Computer Science:

- Successful completion of year 12 (and therefore eligible to receive an ATAR, or equivalent internationally recognized result such as International Baccalaureate).
- Completion of English at year 12 level.
- Completion of Mathematics at year 12 level.

Among the pool of prospective students who completed these minimum requirements, selection is competitive based on ATAR. Each university has their own procedure for generating a 'selection ranking' where a student's ATAR is adjusted based on a range of different factors.

Some of these adjustment factors are applied by the relevant state's post-secondary admissions office, and are designed to account for certain categories of disadvantage that a student may have experienced while studying. The Victorian Tertiary Admissions Centre (VTAC), for example, provides students with the option to apply for the Special Entry Access Scheme [122], which grants special consideration for course selection based on four different categories: personal information and location, financial disadvantage, disability or medical condition, and difficult circumstances. Similarly, the University Admissions Centre (UAC), the relevant office in NSW and ACT, provides the Educational Access Scheme [117], which lists nine different categories of disadvantage that students may apply on the basis of. The Queensland Tertiary Admissions Centre (QTAC) provides their own Educational Access Scheme [92], and the South Australian Tertiary Admissions Centre (SATAC) provides the Universities Equity Scheme [98]. International students are not eligible to apply for access schemes run through the state admissions offices.

Other internal adjustments are often applied by the universities directly. These may be equity-related and designed to meet diversity aims, or may be designed to attract students who show evidence of academic excellence. Each state's admissions office publishes the lowest selection rank (i.e., ATAR with adjustment factors applied) accepted into each course in the most recent intake. In Table 2 we present this information, as well as a summary of the types of ATAR adjustment factors (internally or externally applied, equity or non-equity related) listed by each university.

While domestic students apply for courses through their state's post-secondary admissions office, international students must apply directly to each university, providing their academic record and evidence of English proficiency. These applications are assessed individually by the universities to determine whether the student has completed studies equivalent to the Australian prerequisites, and whether they have done so to a competitive standard.

For students who do not fulfill the minimum requirements for course admission, some universities offer bridging programs (e.g. intensive summer study courses or diplomas) to allow them to meet the required level of knowledge. Some of these programs may be targeted at minority or otherwise disadvantaged groups (e.g., Aboriginal and Torres Strait Islanders).

3.2 Canada

3.2.1 Selection of Universities. For the Canadian region we selected the top universities based on a combination of Maclean's and Times Higher Ed ranking for CS programs [13, 27], but excluding from the analysis those universities for which data by gender was not available. These universities are shown in Table 3.

The selected universities are from the provinces of British Columbia (The University of British Columbia and Simon Fraser University), Quebec (McGill University) and Ontario (all the others). The selection of more Ontario universities is consistent with the fact that most universities are in Ontario, as the Ontario province is the most populous in Canada. Moreover, enrollment data by gender is available for all Ontario universities through the Council of Ontario Universities (CUDO) [42], so none were excluded. Table 4 shows that selected universities reported enrollment of women ranging from 17% to 37%.

These numbers are consistent with general statistics on women's enrollment in CS in Canada. According to the Government of Canada, women make up 28.4% of students registered in Mathematics and Computer and Information Sciences as of 2020–2021 [53]. This number is similar in British Columbia (BC) according to the BC Provincial Government, with women in Bachelor programs in Computer and Information Science making up approximately 25% of students [27]. However, both of these figures include programs that are outside CS.

For Ontario universities, we used the percentage of female students' enrollment in CS programs that was made publicly available by CUDO [42], and chose the highest percentage in the last 3 available years (2019, 2020, 2021). Based on CUDO data, women make up

Table 1: Australian Universities Explored

University	Abbreviation	Women in CS*	EDI link[iii]	Scholarship link[iv]
University of Sydney	**USyd**	28%	-	-
University of Technology Sydney	**UTS**	26%	-	✓
Monash University	**Mon**	25%	-	✓✓
Australian National University	**ANU**	24%	-	-
University of New South Wales	**UNSW**	23%	-	✓
University of Queensland	**UQ**	21%	✓	✓✓
Swinburne University of Technology	**SUT**	17%	✓	✓✓
University of Adelaide	**UA**	16%	-	✓✓
Griffith University	**GU**	15%	-	✓
Queensland University of Technology	**QUT**	15%	-	✓

* Based on publicly available from the Australian Government's Department of Education [82].

Table 2: Australian Universities: Admission details — ATAR & Listed ATAR Adjustment Factors

University	Lowest adjusted ATAR for CS[1]	State-based equity adjustments	Internal equity adjustments	Other adjustments
USyd	90.60	EAS (NSW/ACT)[3]	Indigenous, educational disadvantage, rural/remote students	Elite athletes/performers, high academic achievers, school leaders
UTS	80.05	EAS (NSW/ACT)	Indigenous, refugees/asylum seekers, educational disadvantage, students leaving formal care	Elite athletes/performers, school recommendation, special interest in IT (questionnaire-based)
Mon	82.05	SEAS (Vic)[2]	Indigenous, financial or educational disadvantage	Elite athletes/performers
ANU	85.50	EAS (NSW/ACT)	None listed	Elite athletes/performers
UNSW	90.10	EAS (NSW/ACT)	None listed	Elite athletes/performers, high academic achievers, school leaders
UQ	86.00	EAS (Qld)[4]	Rural/remote students	Elite athletes/performers, completed specific subjects or university-level enrichment programs
SUT	62.30	SEAS (Vic)	Rural/remote students	Completed university-level enrichment program
UA	65.00	UES (SA)[5]	None listed	None listed
GU	82.00	EAS (Qld)	None listed	Elite athletes/performers, completed specific subjects or university-level enrichment programs, student is a local resident (for certain campuses)
QUT	70.00	EAS (Qld)	Rural/remote students, first generation to attend university	Completed specific subjects or university-level enrichment programs

1 This information is published each year by the relevant state admissions offices.
2 Special Entry Access Scheme, provided by Victorian Tertiary Admissions Centre (VTAC).
3 Educational Access Scheme, provided by the University Admissions Centre (UAC) in NSW and ACT.
4 Educational Access Scheme, provided by the Queensland Tertiary Admissions Centre (QTAC).
5 Universities Equity Scheme, provided by the South Australian Tertiary Admissions Centre (SATAC).

20% of students enrolled in a CS programs in Ontario as of 2021; this number has slowly increased in the last decade from 14% in 2012. As the other provinces do not have similar provincial government data sources, we used the universities' own published data.

Canadian universities are committed in principle to equity, diversity, and inclusivity [119], and all selected universities report this commitment. However, we found that just two of the selected universities (University of Waterloo and Simon Fraser University) had immediately visible links to EDI resources, and four others (McGill University, University of British Columbia, Queens University and York University) had visible links. Nonetheless, all Canadian universities have visible links to scholarship resources (University of British Columbia has immediate visibility).

3.2.2 *University Admissions in Canada.*

Admission at Canadian universities requires graduation from high school and good academic standing, and is typically grade-based; however, some universities consider other factors in a broad-based admission system. All prospective students must demonstrate English- or French-language competency (in Quebec, which is a French-speaking province) prior to admission. Universities' websites include specific information for domestic (same province or other provinces) and international students, as the process of admission has different paths.

Most universities admit candidates based on grades from select (grade 11 and 12) high school courses (e.g. math, sciences), and on average grades in the top final year high school courses. High school CS courses are not ubiquitous in Canada, and most CS programs do not require such a course for admission. In some universities with broad-based admission, other materials may be used for admission decisions, for example, supplemental materials detailing extra-curricular activities and math and CS competition standings. Additional pathways exist in the form of internal and external transfer. Even if there are special paths for admission for minorities and under-represented groups (e.g., including bridging courses), these paths were not visible on the universities' websites. Admission procedures differ between Canadian provinces. Some provinces (e.g. Ontario) have centralized application systems for universities within the province. Other provinces require potential students to apply to each university individually.

Table 4 summarizes the requirements for each selected university. All selected Canadian universities require mathematics, and English or French. Science courses are required by McGill University, University of British Columbia, University of Waterloo, Simon Fraser University and McMaster University. Social sciences courses are required at University of British Columbia and Simon Fraser University. All universities have competitive admission with GPA averages in mid 80% or higher. (Some universities post minimum high school GPA requirements which are lower, however actual requirements vary from year to year.)

Several selected universities use broad-based admission, also known as *holistic admission*, meaning that evaluation of students for admission includes aspects other than academic. We found that the following universities include requirements for broad-based admission: McGill, University of British Columbia, University of Waterloo, University of Toronto and McMaster University. Each university requires different kinds of supplementary materials:

- **McGill University**: The university website states that the "admission review process may take into account your complete academic record (including marks for failed or repeated courses) as well as any other required supporting documents/information".
- **University of British Columbia**: Admission is broad-based and requires students to create personal profiles that include significant achievements, what was learned from experiences, and challenges.
- **University of Toronto**: The University of Toronto requires a supplemental application for the main campus only (St. George Campus), as each campus maintains a separate application process.
- **University of Waterloo**: Admission includes participation in non-academic activities and math contests. The website includes recommendations for participation in Canadian Computing Competition, Canadian Senior Mathematics Contest (CSMC), and/or the Euclid Mathematics Contest to enhance the student's admissions status.
- **McMaster University**: Admission requirements include a supplementary application described as an extra component that accompany program application.

3.3 United Kingdom

3.3.1 *Selection of universities.*

The ten selected universities are all in the top 20 for Computer Science in the Complete University Guide 2023 rankings [57]. Data on the percentage of women enrolled is available for virtually all UK universities through the Higher Education Statistics Agency (HESA). Universities are required to return to HESA a detailed dataset relating to students, staff, graduates, finances, etc. A set of tables and charts is made available by HESA as open data [3] although this is limited to the predefined queries that HESA choose to provide. For customised datasets a more in-depth business intelligence service based on the full HESA data is available as a service (Heidi Plus) [4] which is provided by HESA as a paid subscription.

Classification of an individual degree course within a subject area is based on the Higher Education Classification of Subjects (HECoS) codes, and the Common Aggregation Hierarchy (CAH) which provides a standardised hierarchical grouping of HECoS codes [60]. The classification of a specific course into a code is decided by individual universities themselves, but any allocation is based on set principles to ensure comparability between courses. Note that university league tables such as the Complete University Guide [57], Guardian University Guide [56] and Times Higher Education rankings [13] use their own subject aggregations, and reference [60] shows the CAH codes and league table subject codes for each HECoS code.

Data on percentage of women enrollments were derived from a dataset of Student Headcount by Institution, Subject and Sex, obtained from one of our own institution's strategy and planning team from HESA. This data was filtered by the Computing CAH code (11) and year 2021/22, and the selected universities represented a range including the highest five (27-35%) and lowest five (20-23%) of the high ranking institutions. It should be noted that both criteria for selection were based on aggregations which in most cases included a number of other related courses. In particular this means that the percentage of women on the specific program may differ somewhat from the stated figure. Disaggregated data was unfortunately not available to us.

Within each university we looked at a single program, typically named Computer Science. The data in tables 5 and 6 are based on the contents of the program web page for each university and the home page for the department that owns the program. The format of the program pages predominantly covers a standard information set, with all universities including information on program content/structure, entry requirements, career prospects and fees and funding. Funding information refers to government loans and

Table 3: Canadian Universities Explored

University	Abbreviation	Women in CS	EDI link[iii]	Scholarship link[iv]
McGill University	**MG**	37%	✓	✓
University of British Columbia	**UBC**	32%	✓	✓✓
Queens University	**QU**	30%	✓	✓
University of Waterloo	**UW**	26%	✓✓	✓
University of Toronto	**UofT**	25%*	-	✓
University of Ottawa	**UO**	25%	-	✓
Western University	**WU**	21%	-	✓
McMaster University	**MMU**	20%	-	✓
Simon Fraser University	**SFU**	19%	✓✓	✓
York University	**YU**	17%	✓	✓

* 30% in the main campus.

Table 4: Admission Requirements: Canadian Universities

University	Admissions Process	Courses				Specifications	Other	
		English	Math	Science	Social Sciences		Essay	Contests
MG	grade/broad-based	✓or French	✓	✓		Minimum grade ranges over the last three years: 90% in math/science	✓	-
UBC	grade/broad-based	✓	✓	✓	✓	At least six academic/non-academic Grade 12 courses. recommended, not required	✓	-
QU	grade-based	✓	✓			Minimum average required: mid 80s	-	-
UW	grade/broad-based	✓	✓			Admission average - Individual selection from the low to mid-90s	✓	✓
UofT	grade/broad-based	✓	✓			Approximate Admission Range: Low 90s	✓*	-
UO	grade-based	✓or French	✓			Required averages: Low to Mid 90s	-	-
WU	grade-based	✓	✓	✓(or more math)		Admission Average Guideline: Mid-80s	-	-
MMU	grade/broad-based	✓	✓	✓		Anticipated Admission Range: min. 90%	✓	-
SFU	grade-based	✓	✓	✓	✓	Minimum of five approved grade 12 courses	-	-
YU	grade-based	✓	✓			Academic average should be in the high 80s to low-90s	-	

* main campus only.

tuition fee support where appropriate, and often to additional scholarships and bursaries that students may apply for. The final column in table 5 indicates whether there is an explicit reference to the availability of scholarships in the program page. All but one university (University of Oxford) had EDI visibility with four universities including immediately visible links (University of Glasgow, University College London, University of Durham and University of St. Andrews). The links to scholarship resources were not visible for four universities: University of Edinburgh, University of Oxford, Imperial College London and University of Warwick. The rest presented visibility, and in one case (University of Bristol) immediate visibility. Universities with prominent information on EDI and scholarships on their websites are mostly among those with the higher percentages of women.

All of these universities are Athena Swan Charter members [2] and all except Bristol and ICL display a logo indicating the achievement of Silver or Bronze awards in recognition of advancing

Table 5: UK Universities Explored

University	Abbreviation	Location	Women in CS	EDI link[iii]	Scholarship link[iv]
University of Glasgow	**UG**	SCO	35%	✓✓	✓
University College London	**UCL**	RUK	34%	✓✓	✓
University of Edinburgh	**UE**	SCO	30%	✓	-
University of Bristol	**UB**	RUK	28%	✓	✓✓
University of Durham	**UD**	RUK	27%	✓✓	✓
University of St Andrews	**UStA**	SCO	23%	✓✓	✓
University of Oxford	**UO**	RUK	22%	-	-
University of Bath	**UBa**	RUK	21%	✓	✓
Imperial College London	**IC**	RUK	21%	✓	-
University of Warwick	**UW**	RUK	20%	✓	-

Table 6: Admission Requirements: UK Universities

University	Admissions Process	Standard Entry A Levels	Required Subjects	Adjusted Entry for Diversity
UG	grade-based	AAA-ABB	Maths and/or Computing	Guaranteed adjusted offers
UCL	grade-based	A*A*A	Maths	Adjusted offers
UE	grade-based	A*A*A* - AAB	Maths	
UB	grade-based	A*AA	Maths	Contextual offers
UD	grade-based	A*AA	Maths	
UStA	grade-based	AAA,-ABB	Maths and one of Biology, Chemistry, CS, Geography, Physics, Psychology	Gateway - supported entry where grades narrowly below minimum
UO	exam-, grade- and interview-based	A*AA		Access program, support but no adjustment
UBa	grade-based	A*AA	Maths	Contextual offers
IC	grade-based, post-application test	A*A*A	Maths	Guaranteed access to post-application test
UW	grade-based	A*A*A	Maths	Differential offers

gender equality in relation to careers. This is not directly relevant to students but indicates an institutional/department commitment.

3.3.2 University admissions in the UK. Applicants resident in the UK apply to universities through the Universities and Colleges Admissions Service (UCAS) [114]. An applicant can apply for up to five programs, which may include more than one program from any one provider. The applications are then passed on to the universities to make offers or reject. Offers can be either conditional or unconditional, with conditional offers depending on the applicant achieving specified grades if these have not yet been achieved at the time of application. Conditional offers may be made based on grade predictions made by schools through UCAS. Applicants can then choose to accept up to two offers, one as first choice, the other as an "insurance" choice in case the conditions for the first choice are not met.

The UCAS system manages the end-to-end process of making applications and accepting offers. It does not manage the process of making admissions decisions, which is owned by the individual universities. For CS most universities base decisions on grades, or a UCAS tariff which is calculated from those grades. Admissions are therefore primarily grade-based, although candidates applying through UCAS must include a personal statement which is narrative of up to 4000 characters. Two of our selected universities are exceptions and additionally require interviews or post-application tests for CS applicants.

While the UCAS system is UK-wide, there are significant differences in the education systems between the four constituent countries of the UK, which have implications for admissions. Most notably, there are different qualifications frameworks [90]: Qualifications and Credit Framework/National Qualifications Framework for England, Wales and Northern Ireland; Credit and Qualification Framework for Wales; and The Scottish Credit and Qualifications Framework. Given the similarities, we will refer to Scotland specifically, and England, Wales and Northern Ireland as the Rest of the UK (RUK). The selected universities that are RUK are in fact all in England, as no universities in Wales or Northern Ireland met the criteria. All the universities include at least entry requirements in terms of the English A Level qualification in their published data so we use this for the Standard Entry column in Table 6.

The requirements are often qualified by specifying subjects that must be included or pairs or groups of subject from which one must be included. As shown in Table 6, our selected universities almost all require mathematics. Computing or Computer Science is not mandatory in any of the universities.

The final column in Table 6 summarises information on the program web pages on contextualised admissions. Note that contextualised admissions schemes are generally targeted at applicant's with circumstances which may have prevented them achieving standard entry requirements, for example domicile within areas of deprivation, care experience and refugee status, and are not targeted specifically at women or underrepresented groups.

As an aside, we note here that there has been a significant growth in recent years of work-based degrees, known as Degree Apprenticeships in England and Graduate Apprenticeships in Scotland [118]. The admissions processes for these programs are distinct from the standard processes as in order to be accepted a student must attain a job role with an employer who is willing to support their study before applying to the university. There is some evidence that these apprenticeships have an impact on gender imbalance and social mobility in CS [105, 106]. Degree/Graduate apprenticeship programs are outside the scope of this work and are not included in the data but are an interesting area for further study.

3.4 United States

3.4.1 Selection of universities. The NSF-funded National Center for Science and Engineering (NCSES) publishes regular statistics for Science and Engineering by gender, however, only the number of degrees granted is reported [49]. The Center's data indicates that the percentage of bachelor degrees awarded to women has declined over the last three decades. In 2014, it was 18.1% of the total. However, more recent data collected through the Taulbee survey in 2022 shows that the number of bachelor degrees awarded should be now closer to 22% [132]. There is no centralized US data source that tracks undergraduate enrollment for CS programs by gender. We, therefore, had to rely on our own data collection utilizing institutional reporting on publicly available websites from individual universities.

We selected top universities based on the Times Higher Education ranking for CS programs [46]. We searched publicly available information on gender distribution at CS undergraduate programs' websites and institutional reporting portals. The selected universities reported between 24% and 49% women enrolled in their CS programs. Data regarding student enrollment demographics was publicly available for all universities included this way. As shown in Table 7, we found that all but one of the universities selected (Harvard University) had visible links to EDI information, with two (MIT and Stanford University) showing immediate visibility. All universities had visible links to scholarship information.

3.4.2 University admissions in the United States. Most prospective students will apply to a University/College to be admitted into a CS undergraduate program. Applicants typically submit personal information, an essay, teacher recommendations, academic records and standardized test scores, and need a high school diploma (or equivalent) and a minimum 2.0–3.0 GPA. Most programs also require freshman applicants to submit SAT or ACT scores. Additionally, candidates may need high school prerequisites in English, natural sciences, social sciences, foreign languages, and math.

The selected universities are extremely competitive, with acceptance rates as low as 4% for Harvard and Stanford [80, 120]. Application requirements are stated on university level websites, with some schools also having additional requirements from the relevant college or school. All programs selected in this study use a broad-based (holistic) approach in their selection process, so the applications also require candidates to write short answer essays to specific questions. Those questions typically invite the student to explain either their choice of university and/or program. A summary of the admission requirements for all universities included in our study is shown in Table 8. Here are a few more details that stood out in the admission processes we reviewed:

- 7 of the 10 universities included (see Table 8) use the Common App for their application process. Common App is a non-profit organization with the declared goal of facilitating the application process for students worldwide. The organization represents more than 1000 institutions, both public and private [41].
- Some universities such as MIT and Georgia Tech particularly encourage students to discuss in their application package activities and contributions to the community.
- Georgia Tech is the only university in our analysis to explicitly mention a review of institutional fit on their application page. Students' selected majors are evaluated for alignment with the institution's priorities.
- Johns Hopkins University requires early applicants to sign a binding agreement to attend if admitted.

3.5 Discussion

We found several commonalities, which is not surprising given these regions have strong cultural and language similarities. Firstly, women are underrepresented. The institutions with the most representation (above 40%) are in the US (Carnegie Mellon University 49% and Massachusetts Institute of Technology 44%).

Admission procedures differ between the four regions; however we found a number of processes, requirements, and related terminology that are common to two or more regions. Alongside this there are many specific details that are different between regions, and even within regions. It is important to note that for domestic students the admissions processes and criteria depend on and align with the high school/secondary school systems.

In Australia and UK, the overall admission process is administered centrally, but the final decisions are made by the individual universities. In contrast, for Canada and US, admission is solely the responsibility of individual universities. All regions admit students based on similar grades, generally English language proficiency (French in the province of Quebec, Canada), mathematics and sciences (some Canadian universities include social sciences courses). Students are admitted at Australian universities based solely on grades, and this is true for some Canadian universities. Admission in UK, US and in some Canadian universities is broad-based, although there is evidence that for most subjects the process in the UK is in practice grade-based.

In Australia, it is worth noting that (a) the three universities with the highest recorded percentages of women all advertise internally applied equity adjustments, and (b) the university with the highest

Table 7: US Universities Explored

University	Abbreviation	Women in CS	EDI link[iii]	Scholarship link[iv]
Carnegie Mellon University	**CMU**	49%	✓	✓
Massachusetts Institute of Technology	**MIT**	44%	✓✓	✓
Princeton University	**PU**	37%	✓	✓
Stanford University	**SU**	34%	✓✓	✓
University of Washington	**UW**	34%	✓	✓
Harvard University	**HU**	28%	-	✓
Georgia Tech	**GT**	27%	✓	✓
John Hopkins University	**JHU**	27%	✓	✓
University of California at Berkeley	**UCB**	26%	✓	✓
University of California LA	**UCLA**	24%	✓	✓

Table 8: Admission Requirements: US Universities

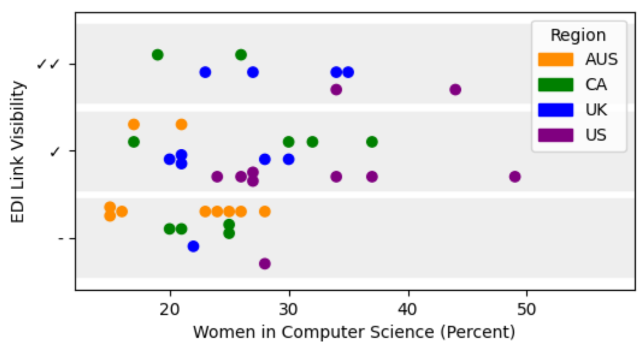
University	**GPA**	**Courses**				**Exams**	**Other**			**Common**
	Requirement	English	Math	Science	Other	SAT/ACT	Essay	Activities	Letters[2]	**App**
CMU	-	✓	✓	✓	✓[3]	✓[1]	✓	-	✓	✓
MIT	-	-	-	-	-	✓	✓	✓	✓	-
PU	-	-	-	-	-	✓[1]	✓	-	✓	✓
SU	-	-	-	-	-	✓[1]	✓	-	✓	✓
UW	-	-	-	-	-	-	✓	✓[4]	-	✓
HU	-	-	-	-	-	✓[1]	✓	-	✓	✓
GT	-	✓	✓	✓	✓[3]	✓	✓	-	✓	✓
JHU	-	-	-	-	-	✓[1]	✓	✓	✓	✓
UCB	3.0	-	-	-	-	-	✓	✓	-	-
UCLA	3.0	-	-	-	-	-	✓	✓	-	-

[1] Currently waived due to COVID (Test optional)
[2] Letters of recommendation from teachers
[3] Foreign Language
[4] Additional question to describe circumstances

percentage of women, University of Sydney, also requires the highest selection ranking for admission into the CS program (as listed in Table 2). In Canada, although broad-based admission criteria differ between institutions, we found that four out of the five institutions with the highest percentage of women in CS considered factors other than grade in their admission process (see Table 3). In UK, we found that two of the top universities with higher percentage of women had immediately visible EDI initiatives (see Table 6).

Based on our analysis of admission processes we did not find a common feature, requirement or aspect of a process that affect the number of women that are recruited to CS programs in all four regious. There is a suggestion of correlation between the visibility of EDI and percentage of women in CS, shown in Figure 1. However, it is important to note that generally, EDI links on programs' webpages tend not to be visible without requiring some browsing beyond the department or program home page. By contrast, links to scholarship information are more readily available and easily visible. Overall though, the number of univerities where EDI and scholarship resources were *immediately* visible is small (eight and six, respectively). Based on our findings, and confirming the literature on possibility of swaying student decision with information presented at admission advertisement, we suggest that universities pay close attention to the visibility of information on the web pages that applicants are most likely to visit.

Figure 1: EDI Link Visibility[iii] on Program Websites versus Percentage of Women in the Computer Science Program



4 STUDENT SURVEY

We decided to approach answering our RQ4, possible ways in which admission processes can promote diversity and inclusion, through student surveys and interviews. We designed and implemented an anonymous survey to better understand the students' experiences with admission processes to Computer Science majors, the factors influencing their decision in university selection and application, and their ideas towards improving diversity and inclusion.

We designed the survey questions for (a) high school students in the process of applying to a computer science program, (b) high school students considering or planning to apply to a computer science program who had not started their research or application process yet, (d) high school graduates starting a computer science program in the upcoming academic year, and (e) university students registered and studied in a computer science programme for at least one semester, and (f) participants in any other category. We designed and reviewed the questions multiple times collaboratively. The survey included 33 closed and open-ended questions and scale items (the complete list of Survey Questions (SQs) can be found in Appendix E). Our ethics approval process enforced limitations on the populations we could contact. Therefore, our targeted recruitment was only towards groups (d) and (e). We are aware that the recruitment process may introduce bias to our results.

Following our ethics approval guidelines, we found CS department contacts at each of the 40 universities included in our study. During the working group period, the survey link was sent to the CS department contacts included in our study, who were asked to disseminate it to students recently enrolled in the major. We heard back from a subset of the universities we contacted. We also encountered additional ethics requirements for recruitment in some of the universities who responded to our request. The majority of our recruited participants were from CS departments of Canadian universities. While the survey was inteded to be shared with students recently enrolled in the Computer Science major, it appears that the survey was shared beyond this cohort, possibly by the students themselves, therefore we have received responses by other types of students (e.g. high school students or students trying to transfer into the major). The survey design allowed us to record these answers and to identify the type of student responding, and we were able to include these responses in our analysis. Not all respondents answered all of the survey questions, therefore the number of respondents per question (N) varies.

The survey has received 311 responses from three out of the four regions studied. The composition of the respondents can be summarized as follows:

- 282 responses from Canada, 17 responses from US, and 12 responses from Australia
- 227 students registered in a CS program for at least one semester, 1 CS minor, 9 students currently enrolled in other majors but interested in transferring to a CS major, 6 students previously rejected from entering a CS major, 2 students with college experience who have been accepted in a CS major, 6 recently graduated from a CS major, 53 high school students accepted to CS majors, 3 high school student currently applying to university, and 4 other majors.
- 77 students who identify as people of color, 71 students who do not identify as people of color, 23 unsure. 6 students indicated they prefer not to answer and 114 students chose not to answer this question.
- 103 men, 59 women, and 11 self-identifying/non-binary students (SI/NB). 4 students indicated they prefer not to answer and 113 students chose not to answer this question.

Before proceeding with the qualitative and quantitative analysis, we decided to keep only entries coming from current or previous CS students and high-school students with confirmed enrolment. We did so because the survey was originally sent to enrolled students, and we had concerns that the other respondents did not have enough experience with the CS academic environment, or may confound their answers with their experiences in their current major. This reduced the number of entries to 288.

4.1 Quantitative Analysis

4.1.1 Methodology. The distribution of the responses to the Likert-scale questions is shown in Figure 2. Not all respondents provided an answer for every question, thus the number of responses received in each question is different and is shown as N in the figure.

We were particularly interested in examining possible differences in responses between men, women, and self-identifying/non-binary students. The overall average response by question, as well as the average response of each group, is visible in Table 9. We used the Wilcoxon-Mann-Whitney test to evaluate differences in the students' responses to the seventeen 5-point Likert scale questions: each Likert scale answer was turned into an ordinal value (from 1 - Strongly Disagree, to 5 - Strongly Agree), and responses from each gender were compared to the other two groups (e.g. women with men and self-identifying/non-binary, men with women and self-identifying/non-binary, and self-identifying/non-binary with men and women). Responses with missing information for gender were excluded from this analysis. Furthermore, we decided to limit this analysis to the 261 responses coming from Canada. The number of responses from the US and Australia was too small in comparison, and the resulting sample was not representative of all regions.

Because we performed multiple hypothesis testing, we applied a Bonferroni correction [126] to reduce the chance of false positives. A test was considered statistically significant if the corresponding p-value was lower than 0.05/51 = 0.00098, where 51 is the total number of hypotheses tested. For this reason, some small p-values that would normally be considered significant, are not marked as such in Table 9 (SQ8 and SQ23). The analysis yielded three statistically significant results ($p < 0.00098$).

4.1.2 Results: Gender-diversity. When asked if they find the culture of Computer Science programs accepting of people of all genders and sexual orientations (SQ4), men expressed more agreement than women and self-identifying/non-binary students. The complete distribution of responses to this question, grouped by gender of respondents, is presented in Figure 3.

4.1.3 Results: Racial and ethnic diversity. When asked if they find people of different races and cultures accepted among Computer Science students (SQ5), men expressed more agreement than women and self-identifying/non-binary students.

Figure 2: Distribution of responses to Likert scale questions. N indicates the number of nonempty responses per question.

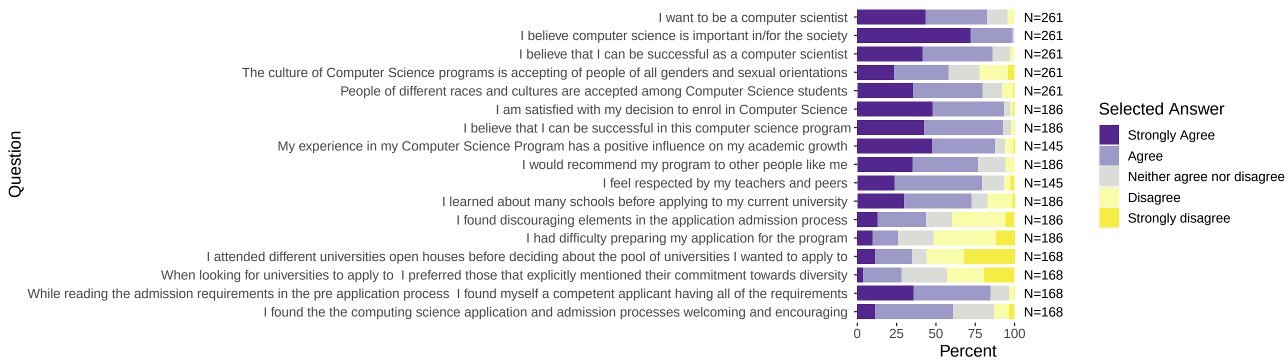


Table 9: Response to Likert scale questions by gender (mean and standard deviation). The * indicates a significant difference between that group and the other two groups combined ($p < 0.00098$)

	Overall	Man		Woman		SI/NB	
	Mean±SD	Mean	p-val	Mean	p-val	Mean	p-val
SQ1	4.21±0.84	4.27±0.76	0.96	4.21±0.89	0.91	4.36±0.67	0.76
SQ2	4.70±0.49	4.79±0.41	0.13	4.73±0.49	0.90	4.27±0.79	0.008
SQ3	4.24±0.76	4.36±0.65	0.30	4.18±0.73	0.38	4.18±0.87	0.72
SQ4	3.55±1.15	3.89±1.03	0.00004*	3.15±1.11	0.0005*	3.09±1.30	0.16
SQ5	4.06±0.92	4.28±0.83	0.0004*	3.81±0.97	0.005	3.73±0.90	0.11
SQ7	4.37±0.74	4.40±0.66	0.88	4.46±0.61	0.54	4.27±0.65	0.39
SQ8	4.32±0.70	4.43±0.63	0.01	4.15±0.75	0.03	4.18±0.75	0.45
SQ9	4.28±0.86	4.39±0.76	0.47	4.38±0.66	0.83	3.90±1.37	0.36
SQ10	4.06±0.87	4.08±0.91	0.67	4.10±0.77	0.97	3.81±1.08	0.45
SQ11	3.93±0.89	4.01±0.87	0.25	3.90±0.73	0.30	3.80±1.13	0.79
SQ12	3.83±1.07	3.98±1.02	0.04	3.58±1.16	0.04	3.82±1.08	0.90
SQ13	3.11±1.18	3.22±1.14	0.06	2.85±1.21	0.06	3.09±1.22	0.97
SQ14	2.72±1.16	2.76±1.13	0.46	2.67±1.22	0.62	2.54±1.21	0.62
SQ21	2.58±1.43	2.62±1.48	0.93	2.61±1.42	0.84	2.36±1.36	0.59
SQ22	2.69±1.15	2.45±1.09	0.0009*	3.06±1.11	0.006	3.18±1.33	0.20
SQ23	4.16±0.79	4.05±0.77	0.03	4.25±0.81	0.13	4.45±0.69	0.15
SQ24	3.55±0.94	3.59±0.87	0.66	3.60±0.91	0.99	3.18±1.33	0.39

Figure 3: Distribution of responses to SQ4, divided by gender.

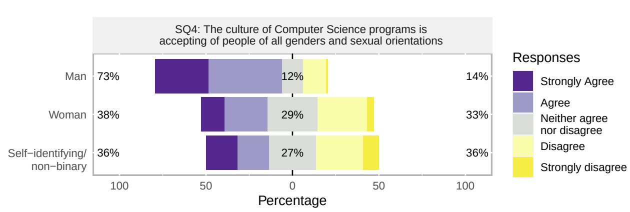
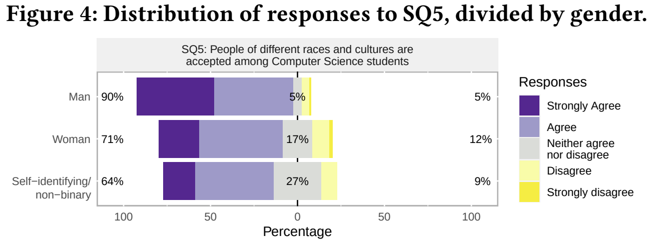
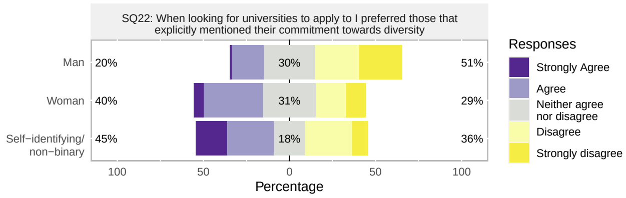


Figure 4: Distribution of responses to SQ5, divided by gender.



4.1.4 Results: Preference in the application process. Men expressed a lower level of agreement than women and self-identifying and non-binary students when asked if they preferred universities that explicitly mentioned their commitment to diversity (SQ22). The complete distribution of responses to this question, grouped by gender of respondents, is presented in Figure 5.

Figure 5: Distribution of responses to SQ22, divided by gender.



4.2 Qualitative Analysis

4.2.1 Methodology. We used thematic analysis to code the five open-ended responses. We began by inductively coding the open-ended question SQ18 in a bottom-up manner. This question asked the students why they decided not to apply to particular programs or universities. For this question, two coders began by open-coding an initial sample of 127 student responses (some of which were blank). They then conferred to discuss the coding and converged upon an initial codebook including 5 themes, described in detail in the next section. The entire 127 responses were then collaboratively re-coded using this codebook.

We followed the same procedure for SQ16 ("What did you consider when deciding which programs and universities to enroll in?"), using a combination of bottom-up and top-down approaches: creating new themes and reusing themes from the previous question. The two coders coded independently, then conferred to discuss the coding and agree upon a codebook. During this process, the coders combined smaller codes into a total of 10 themes. The entire 127 responses were then collaboratively re-coded using this codebook.

The two coders used the same codebook with 10 themes in SQ19 ("Do you remember any detail that made your current university stand out in the application process? ") and SQ25 ("What did you consider when deciding which programs and universities to apply to? "). They independently coded 40 samples from SQ25 and computed an Inter-Rater Reliability Cohen's Kappa score of $\kappa = 0.79$ across these 10 themes, indicating strong agreement. The coders then split the remaining responses.

For the final question (SQ26: "What is the one thing that if done could improve diversity, equity, and inclusion in admissions procedures?"), the two coders developed a new codebook. They began by open-coding responses, then conferred to discuss the coding and agree upon a codebook. The entire set of responses was collaboratively recoded.

We discuss our results with first emphasizing the key findings related to decision factors from Q16, Q17, Q19, and Q25. We then explore the intersectionality within our participant population and the variations in their decision factors. We then delve into Q26, where participants propose solutions for enhancing Equity, Diversity, and Inclusion (EDI).

4.2.2 Results: Decision Factors (Q16, 18, 19, 25). This section discusses the main themes that emerged in the open-ended questions about the factors that are considered when deciding where to apply and enroll, and how respondents' answers differ by gender.

Table 10 presents the codebook for these questions, sorted by frequency, and Table 11 compares the themes and their frequencies that occur across *all four questions*. The most frequently mentioned factors that prospective students report to have considered are the *prestige* and the *location* of the institution. Both academic concerns like the *program* structure and non-academic concerns like the campus *environment* are also factors that students consider. The general occurrence and the prominence of these themes are similar between men and women. However, women are more likely than men (11% vs 4%) to consider the diversity of the institution in their decision-making process. Moreover, respondents who are non-binary or self-identified discussed the cost of the program more than other groups (45% vs overall 34%). None of these differences are statistically significant.

Table 12 analyzes theme occurrence separately for each of the four survey questions. This analysis helps us understand how the themes emerge differently in the different stages of the application and enrollment process for men and women.

For example, women mention environment *more* than men when discussing decisions about where to apply, but *less* than men when discussing decisions to enroll and about their current institution. Similarly, women and SI/NB respondents discuss the diversity of the institution as factors for deciding where to apply, but less so when discussing their current institution.

In the discussion about where students chose *not* to apply, women are more likely than men to mention the location of the institution. Men are more likely than women to discuss the attainability and cost of the program. However, none of these results are statistically significant.

4.2.3 Results: Intersectionality. Our survey asked demographic questions about ethnicity and disability, as we are interested in how the intersectionality of these factors may affect the genders differently. Our sample size supported a limited amount of such analysis, and one result we noticed is that women who self-identify as a person of colour (POC) are almost twice as likely to identify cost as a factor in their application and enrollment decisions compared to women who do not (9/29 vs. 3/21). We do not see the same trend for men (16/41 vs. 16/40). These numbers are small, but they corroborate the evidence that intersectionality is an important aspect to consider when developing EDI initiatives.

4.2.4 Results: Suggestions to Improve EDI (Q26). This was perhaps the most contentious question for our respondents, and highlights the some of the sensitivities involved in running and messaging EDI initiatives related to admissions. Although many responses provide both general support for EDI and specific suggestions, many students spoke out against diversity/equity/inclusion initiatives. The codebook is presented in Table 13, with theme occurrence breakdowns by gender shown in Table 14.

There was a range of responses both in support of and against EDI initiatives. 10% of respondents reported that no change should be made to the admission system. This included 13% of the men

[iii] Visibility of link to EDI initiatives on the School/Program home page or admissions page of the Computer Science major (✓✓Immediately visible / ✓visible / -not visible).
[iv] Visibility of link to available scholarships on the School/Program home page or admissions page of the Computer Science major (✓✓Immediately visible / ✓visible / -not visible).

Table 10: Codebook for Q16, 18, 19, 25, including the definition of each theme, examples, and the overall occurrence frequency.

Theme	Definition	Example Quotes	Frequency
Prestige	The institution's ranking, reputation, prestige, research output, or faculty reputation	"how good their cs program is", "prestige", "university ranking"	64%
Location	Explicit mention of the city, country, region, or physical distance or proximity of the location of the institution to another location	"distance to home", "proximity to a city", "location of school", "Canada vs the US"	61%
Environment	Social and non-academic related factors like the campus environment, amenities, friends, culture, work-life balance	"campus appearance", "university life", "Ability to do ballet and other dance", "quality of life", "trans-inclusion"	45%
Program	The structure availability of the academic program, including the availability of certain specializations and co-op programs	"freedom of course selection", "co-ops", "study abroad programs", "transfer credits", "ability to double major"	43%
Cost	Tuition costs, cost of living, and availability of scholarship	"cost", "scholarship amounts", "The fees at [institution] was much more affordable compared to the others"	34%
Future	Future career or research opportunities afforded by the institution	"employability after graduation", "making connections in the industry", "what future they would offer me", "I felt that my choice would benefit me more in the long run"	32%
Attainability	Whether the program was attainable for the student, based on their self-assessment	"acceptance rate", "whether it's easy to get in", "GPA requirements", "how confident I was in my abilities"	21%
Interest	The alignment of the program or institution with the respondents interests	"personal fit", "being related to my ability and personality	19%
Application	The challenges and steps involved in the application process	"ease of application", "what each application required"	15%
Diversity	Explicit mentioning of the diversity of the institution	"diversity of students", "a very high percentage of non-male identifying students"	7%

Table 11: Themes occurrence in SQ16,18,19,25, by gender. The *n* row counts the number of responses assigned at least one theme. The percentages show the proportion of respondents of that gender who provided a response in that theme.

	All	Woman	Man	SI/NB	Empty
Prestige	64%	62%	65%	55%	68%
Location	61%	57%	59%	55%	79%
Environment	45%	46%	46%	55%	36%
Program	43%	46%	40%	55%	39%
Cost	34%	27%	38%	45%	29%
Future	32%	29%	35%	45%	21%
Attainability	21%	18%	26%	0%	18%
Interest	19%	21%	21%	18%	11%
Application	15%	14%	19%	9%	4%
Diversity	6%	11%	4%	9%	4%
n	195	56	100	11	28

and 6% of the women respondents. A similar number of people responded that admissions should not be changed to promote EDI initiatives. Most responses (69%) were in favour of EDI initiatives, but this response differed by gender, with women being more favourable towards EDI initiatives (p=0.040).

Specific suggestions about approaches to EDI included using a holistic or broad-based approach to admission that considers factors outside of grades. For example, one person writes, "As someone who has mental illness, comes from an ethnic background and someone who belongs to many other visible and invisible minority groups, I can say that the fact that in today's world universities only focus on GPA is disappointing." Some responses highlight that race or gender should not be used as a proxy for disadvantage: "...I think that the disadvantages faced by those who are less economically well-off need to be taken into account when assessing the true ability of an applicant...". In our data set, men and women are approximately equally likely to suggest this change.

Conversely, 25% of responses reported that academic factors should be the only factors considered in admission. These responses are not necessarily against EDI measures: "In my opinion, gender, race, sexuality, etc should not be considered at any point during admissions procedures, neither in favour of minority groups or majority groups. Only then, can we truly achieve equality", "Remove the ability for evaluators to see metrics like race, gender, etc. With only grades/ECs, inherent biases should go away." These responses suggest a belief that treating every student equally is sufficient

Table 12: Themes appearing in individual questions, by gender. The percentages show differences in the stage of the application process from which the themes emerge: Q16-Enroll, Q18-Not Apply, Q19-Current, Q25-Apply.

	All				Women				Men				SI/NB			
	Q16	Q18	Q19	Q25	Q16	Q18	Q19	Q25	Q16	Q18	Q19	Q25	Q16	Q18	Q19	Q25
Prestige	50%	-	32%	50%	50%	-	33%	51%	49%	-	28%	51%	45%	-	33%	33%
Location	44%	17%	40%	38%	44%	26%	33%	43%	43%	13%	37%	36%	36%	0%	50%	44%
Environment	27%	-	28%	31%	18%	-	19%	38%	31%	-	31%	28%	36%	-	33%	33%
Program	27%	23%	21%	29%	34%	26%	25%	30%	22%	18%	21%	28%	36%	100%	17%	33%
Cost	26%	29%	14%	20%	28%	26%	11%	22%	24%	32%	12%	20%	27%	0%	33%	33%
Future	23%	9%	5%	27%	18%	11%	3%	22%	26%	8%	6%	28%	36%	0%	17%	44%
Attainability	10%	20%	5%	13%	6%	11%	3%	11%	13%	24%	7%	16%	0%	0%	0%	0%
Interest	12%	-	4%	11%	14%	-	8%	8%	11%	-	3%	12%	18%	-	0%	11%
Application	1%	27%	7%	1%	2%	21%	8%	0%	1%	34%	7%	1%	0%	0%	17%	0%
Diversity	-	-	3%	7%	-	-	6%	14%	-	-	3%	3%	-	-	0%	11%
n	174	66	126	127	50	19	36	37	87	38	67	76	11	2	6	9

Table 13: Codebook for Q26, including the definition of each theme, examples, and the overall occurrence frequency.

Theme	Definition	Example Quotes	Frequency
Status Quo	No change should be made to the admission process to support EDI.	"Diversity and equity level seems fine to me", "Unsure, admission procedures are quite inclusive", "I think it's fine as is "	10%
Support EDI	Response express support for EDI goals explicitly or implicitly via concrete suggestions.	"Be more inclusive to women", "encourage others to apply to more diversity scholarships"	69%
Against EDI	Response express resistance against EDI goals explicitly or implicitly via suggestions.	"a lower focus on meeting diversity requirements and more on academic merit...", "Personally I don't think diversity should be a main concern for programs..."	10%
Wholistic	The admission process should consider non-academic factors.	"Opportunity to write about your own upbringing, background, past, and experiences in and out of academics", "Consideration of one's socio-economic background"	19%
Academics Only	The admission process should only consider academic factors.	"I would say admitting people based only on their academic performance...", "Assess solely based on performance and who the best of the best are"	25%
Process	Other admission process related suggestions not covered above.	"...grade inflation being taken into consideration...", "I found that some universities required high school credits in computer science for admission... [and] these requirements were not inclusive"	30%
Advertise	Information, transparency, and outreach could help improve EDI.	"actively encourage minorities to apply", "Be more transparent in their application process as to how students are evaluated", "more diversity reports on the admission demographics of the years before"	21%
Culture	The culture of the field is problematic, not the admissions process.	"No matter how inclusive the application process is, if the students in the program have biases, marginalized students will continue to feel ostracized"	9%

in promoting a fair admissions practice (i.e. equality vs. equity). Fewer women (6% vs. 33%) made this suggestion compared to men or SI/NB (p=0.029).

Responses provided a range of other suggestions for improving the admissions process. Some of these are not explicitly or directly related to EDI: for example discussing the application website interface, grade-inflation, prerequisite courses, and issues affecting students with mental health issues, international students, and low-income students. Socio-economic diversity was mentioned in a few responses, and scholarships and application fees were also discussed. Diversity amongst the admissions officers or the admissions panel was yet another process-oriented concern raised by students.

Outreach and transparency are also discussed by both men and women respondents. Outreach included both information surrounding the application process (e.g. "Increase some of the information available around this process, as I recall being very confused about the requirements for a bit before the application deadline", "Sessions for female-identifying prospective students") and much earlier on

Table 14: Response to SQ26 by Gender. The percentages show the proportion of respondents of that gender who provided a response in that theme.

	Overall	Woman	Man	SI/NB	Empty
None	10%	6%	13%	0%	0%
Support EDI	69%	88%	60%	67%	100%
Against EDI	10%	6%	13%	0%	0%
Wholistic	19%	18%	20%	0%	50%
Academics Only	25%	6%	33%	33%	0%
Process	30%	41%	24%	67%	0%
Advertise	21%	24%	20%	0%	50%
Culture	9%	24%	4%	0%	0%
n	67	17	45	3	2

("start encouraging more young women to have interest in math and science").

Finally, 24% of women mentioned culture as a major factor adjacent to admissions. Although this is a small number (4/17), it is more than those who identified as men or SI/NB (p=0.036). "The admissions themselves weren't intimidating, but rather the culture around the degree seems to only be welcoming to certain types of people." Specific suggestions pointed to clubs and mentorship to help foster this culture, but noted that "...no amount of work can replicate the effect of having an even split of gender identities in the program."

5 INTERVIEWS

We designed three sets of interview questions: interviews for people in chair and decision-making roles, interviews for registrar offices and affiliate programs, and interviews with interested students to follow up on their survey entries. The questions were open-ended and provided a chance for further exploration. All interview questions are listed in Appendix F, Tables 16, 17, and 18. We designed and reviewed the questions collaboratively. The goal was to further our understanding of answering RQ4, the possible ways in which admission processes can promote diversity and inclusion. Although we approached all participants indicating initial interest, we could finally schedule less than five interviews in each category. We do not include the exact number of interviews in our reporting to protect against the identifiability of our participants.

We contacted 13 students who showed interest in a follow-up interview in their survey. We were able to conduct interviews with a subset of interested students, including men and non-binary student participants. There were no women among the participants. Student interview questions are listed in Appendix F, Table 18. We transcribed, de-identified, and linked our student interviews to survey data and applied thematic analysis on student interviews using the codebooks developed for open-ended survey question SQ26 (Table 13). The codebook is applicable to answers explicitly provided to further elaborate participant's answers to SQ26 in the survey, or when participants were discussing suggestions for improving diversity, equity, and inclusion in admission procedures as part of their answer to the question asking for any additional comments. However, the limited number of participants prevents us from publishing percentages in each category. We breifly narrate student suggestions for improving diversity and inclusion.

The main themes that emerged in student interviews, ordered by popularity, included satisfaction with the status quo, showing support for EDI activities, and suggestions for cultural shift, academics-only admissions, wholistic admissions, process improvements, and advertising for better inclusion of minoritized populations. There was significant pushback on explicit implementation of procedures for furthering diversity and inclusion in Computing Science admissions processes, while participants were in favour of diversity and inclusion in the student population as a strength they observed in their institution. Students also shared their concerns about the practicality of diversity and inclusion efforts, ranging from protective viewpoints against populations with superior performance to the exclusion of non-visibly minoritized populations. Arguments against holistic admissions processes mainly included the burden of writing multiple essays with personal life stories, describing the process as "dehumanizing" given the limited effect they have on admissions decisions.

Suggestions for improving EDI efforts included further emphasis on the cultural and process changes and further support resources for different types of minoritized populations, which might not be visibly categorized within marginalized groups. Examples included people with different sexual orientations. All student interviewees showed support for the general concept of diversity and inclusion in the student populations. Even when protective viewpoints were expressed against implementing such initiatives in the admissions processes, the positive impacts of diversity in the student population in the personal lives of the participants were noted.

We also conducted interviews with people in chair or decision-making roles, and administrative roles in registrar offices or affiliate programs, including men and women participants. We used questions listed in Appendix F, Table 16 for Chairs and Decision Making Roles, and questions listed in Table 17 for administrative roles within Registrar Offices and Affiliate Programs. All interviewees were pro-EDI, with considerable background in implementing programs in support for EDI initiatives. All participants viewed themselves in an advocacy role (not a decision-making role) in terms of diversity and inclusion efforts in the design and operation of the admissions processes. The main themes that emerged in these interviews included the need for culture change and problems associated with the process and practicality of EDI solutions. While interviewees generally agreed on the general openness of program cultures to EDI initiatives, they expressed the need for further cultural change. Interviewees recommended the need for better accessibility solutions, work-life balance, moving away from masculine definitions of work culture, protection for whistleblowers, and moving away from assigning extra work to marginalized faculty and staff to support EDI efforts as examples of practical efforts that could potentially support the institutional culture change contributing to recruitment and retention of diverse populations.

In terms of process, participants discussed the need for effective measures for evaluating outreach and recruitment programs in the admitted target populations and their retention. They also emphasized the necessity of furthering the knowledge about diversity and inclusion among the responsible positions to support the expressed general openness to EDI efforts. Important suggestions for admissions processes included removing requirements that are not easily accessible for all high school students, and the implementation of general admissions with the possibility of choosing Computer Science in later years. The latter was suggested based on the argument that exposure to the field for a diverse set of students will enable them to identify their interest in the field, which is not possible in direct high-school admissions processes with a large population without any early exposure to computer science.

6 THREATS TO VALIDITY

Our analysis only considered four regions, all of which are English-speaking: Australia, Canada, the UK, and the US. Additionally, only ten renowned universities are considered per region, and these universities may not be representative of all universities within the region. There are variations between regions, and our criteria for selecting the universities (percentage of women in the CS program and overall regional acclamation) and in establishing methods of reporting differences in their admission criteria and websites may not result in generalizability of our results for the regions.

In particular, the website structures of universities differ between regions and institutions, so the selection of webpages to include in our analysis was not straightforward. We mitigated this challenge by having two authors for each region collaboratively identify websites and the presence of EDI/scholarship links on those sites, with at least one of the authors residing and working in the region.

While most people's first exposure to a university might be through the admissions website or the first page of the university, other means such as open days, school visits, and word of mouth also play an important role in a student's exposure and choice. This study only considers websites as a possible point of exposure.

Our survey data is from three of our target regions, but the majority of our entries are from Canada, and the sample size is still small. Results could vary with the inclusion of additional regions and a larger sample of responses. The survey is retrospective: undergraduate students are recalling their past experience applying for and selecting universities, which could introduce recall bias. Some respondents included are those who applied but were not accepted to a computer science program. The survey was voluntary, and not all respondents completed every question, thus the sample may not be representative of all undergraduate CS applicants.

7 DISCUSSION AND CONCLUSIONS

In this study, we investigated Computer Science admissions. We explored common approaches to Computer Science admissions (RQ1), indicators of success in admissions procedures (RQ2), outcomes of admissions processes in terms of diversity and inclusion (RQ3), and how admissions processes can promote diversity and inclusion (RQ4). We dedicated our attention to gender diversity and the details within admissions processes that affect the decision of women to apply to CS programs around the world. We explored 40 universities in four regions around the world, chosen based on the overall regional acclamation, availability of EDI initiatives within the program, and percentage of women in the program. We analyzed details of the admissions procedures of these universities through the lens of a prospective student.

Our review of university websites reveals that while many of the programs do have EDI initiatives, the resources are not always presented in a way that is easy to find for prospective students. Our quantitative analysis on student survey data shows that students of different gender identities have different opinions regarding the importance of explicit committment to diversity and inclusion initiatives as a deciding factor when choosing their target institutions. Women, non-binary, and self-identified gender identities indicated higher preference toward universities that explicitly mentioned their commitment to diversity. These two findings combined suggest that increasing the visibility of explicit commitment toward diversity and details of EDI initiatives could help attracting a more diverse population.

Our quantitative analysis also shows significant differences among different gender identities in the assessment of culture in CS programs. Women, non-binary, and self-identified gender identities agree less than men that the culture of CS programs is inclusive of different gender identities. There are similar differences in agreement with respect to the culture being welcoming towards ethnic and racial backgrounds.

Our qualitative analysis of survey data indicates only subtle differences between gender identities when it comes to the main decision factors in the application process, which are prestige, location, environment, program, and cost, respectively. However, we found that women of color were almost twice as likely to indicate cost as a factor, compared to women who did not identify with a racially minoritized background. The numbers are small, but they further corroborate the evidence for importance of intersectionality in developing EDI initiatives.

Our qualitative analysis of surveys, as well as student interviews, suggests that considering diversity in the admissions procedures is a divisive topic, particularly among those who would be seen as belonging to majority groups. These respondents expressed the belief that they will be unfairly disadvantaged by diversity initiatives, especially those that consider gender or demographic factors rather than socioeconomic factors.

In conclusion, and in response to our RQ4, we believe that the following changes in admission processes may lead to better inclusion of women and non-binary individuals:

(1) Provide explicit indicators for inclusion of all gender identities on the program websites. This may include promoting the use of pronouns and preferred names, and explicit welcoming messages to different gender identities. Make sure that this content is visible and immediately accessible on the university website.
(2) Provide more information about the kind of culture the university is trying to support and develop, and the kind of environment the students may expect to find when joining the program. This may include references to EDI efforts and support resources.
(3) Provide visible pointers to financial resources, such as scholarships for prospective students. While this third recommendation may not relate only to inclusion of women, many students, and particularly students from underrepresented

backgrounds, express concerns about the cost of their education. Providing a clear answer to these concerns may make a university more attractive to these demographics.

The recommendations outlined above may produce positive effects beyond gender diversity, and facilitate a cultural shift toward a more inclusive environment for all underrepresented minorities.

8 FUTURE WORK

While these findings come only from a small survey data and mostly from Canada, we believe they provide valuable insight to the admissions processes from a prospective student's perspective. In the future, we would like to collect additional data, and extend the current work in the following ways:

(1) Given the importance of location as a deciding factor for students in the application process, we would like to extend our data beyond Canadian students, to learn about possible differences related to the importance of location among our selected regions.
(2) Our interview data, paired with anectodal evidence, points at a possible disconnect between EDI efforts and elements within admission policies that may render them ineffective. We would like to take a closer look at general admission compared to program-specific admissions procedures, and see if they may inadvertently create obstacles to achieving a more diverse population. we believe this information will be helpful for administrators in their advocacy efforts.
(3) In line with the initial goals of our current research, we would like to investigate the decision process in the design and implementation of EDI initiatives and their implication on adoption and success of such programs. This will help us better understand how our interviewees relate to their position as advocates. Additionally, this would allow us to evaluate the concern that more EDI initiatives result in extra work and an undue burden on faculty and staff who identify with a historically marginalized identity.

Readers interested in applying and expanding our current work may want to consider the need to explore EDI efforts beyond gender diversity. This will add to the current body of knowledge and increase the positive impact on different underrepresented populations.

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[AUS135] University of New South Wales. 2023. Bachelor of Science (Computer Science) Admissions. https://www.unsw.edu.au/study/undergraduate/bachelor-of-computer-science
[AUS136] University of New South Wales. 2023. School of Computer Science and Engineering homepage. https://www.unsw.edu.au/engineering/our-schools/computer-science-and-engineering
[AUS137] University of Queensland. 2023. Bachelor of Computer Science Admissions. https://study.uq.edu.au/study-options/programs/bachelor-computer-science-2451
[AUS138] University of Queensland. 2023. University of Queensland: Faculty of Engineering, Architecture and Information Technology. https://www.eait.uq.edu.au/
[AUS139] University of Sydney. 2023. Computer Science (Science) Admissions. https://www.sydney.edu.au/courses/subject-areas/major/computer-science-science.html
[AUS140] University of Sydney. 2023. School of Computer Science homepage. https://www.sydney.edu.au/engineering/schools/school-of-computer-science.html
[AUS141] Queensland University of Technology. 2023. Bachelor of Information Technology (Computer Science) Admissions. https://www.qut.edu.au/courses/bachelor-of-information-technology-computer-science
[AUS142] Queensland University of Technology. 2023. School of Computer Science homepage. https://www.qut.edu.au/about/faculty-of-science/school-of-computer-science
[AUS143] Swinburne University of Technology. 2023. Bachelor of Computer Science Admissions. https://www.swinburne.edu.au/course/bachelor-of-computer-science/
[AUS144] Swinburne University of Technology. 2023. School of Science, Computing and Engineering Technologies homepage. https://www.swinburne.edu.au/about/our-structure/organisational-structure/schools-departments/school-science-computing-engineering-technologies
[AUS145] University of Technology Sydney. 2023. Computing Science Admissions. https://www.uts.edu.au/study/find-a-course/bachelor-computing-science
[AUS146] University of Technology Sydney. 2023. School of Computer Science homepage. https://www.uts.edu.au/about/faculty-engineering-and-information-technology/computer-science
[AUS147] Australian National University. 2023. Computer Science Major Admissions. https://programsandcourses.anu.edu.au/major/csci-maj
[AUS148] Australian National University. 2023. School of Computing homepage. https://comp.anu.edu.au/
[AUS149] Griffith University. 2023. Bachelor of Computer Science - 1534 Admissions. https://www.griffith.edu.au/study/degrees/bachelor-of-computer-science-1534
[AUS150] Griffith University. 2023. School of Computer Science homepage. https://www.griffith.edu.au/study/engineering-it-aviation/computer-science
[AUS151] Monash University. 2023. Computer Science - C2001 Admissions. https://www.monash.edu/study/courses/find-a-course/computer-science-c2001
[AUS152] Monash University. 2023. Faculty of Information Technology homepage. https://www.monash.edu/it/home

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[CA153] University of British Columbia. 2023. Admissions | Computer Science at UBC. https://www.cs.ubc.ca/students/undergrad/prospective/how-apply
[CA154] University of British Columbia. 2023. Computer Science Majors | Computer Science at UBC. https://www.cs.ubc.ca/students/undergrad/prospective/switching/computer-science-specializations
[CA155] University of Ottawa. 2023. Bachelor of Science in Computer Science | Degree in Computer Science | Undergraduate Degree Program | Ottawa University. https://www.ottawa.edu/academics/degree-programs/undergraduate/computer-science
[CA156] University of Ottawa. 2023. Computer Science | Faculty of Engineering. https://www.uottawa.ca/faculty-engineering/undergraduate-studies/programs/computer-science
[CA157] University of Toronto. 2023. Computer Science - Future Students. University of Toronto | University of Toronto. https://future.utoronto.ca/undergraduate-programs/computer-science/
[CA158] University of Toronto. 2023. Computer Science Admission Category | Faculty of Arts & Science. https://www.artsci.utoronto.ca/future/ready-apply/admission-categories/computer-science
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[CA160] University of Waterloo. 2023. Computer Science | University of Waterloo. https://cs.uwaterloo.ca/
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[CA162] McMaster University. 2023. Computer Science - Future Students - McMaster University. https://future.mcmaster.ca/programs/computer-science/#:~:text=Computer%20Science%20takes%20theory%20and,design%2C%20systems%20and%20theoretical%20foundations.
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[CA164] McMaster University. 2023. Department of Computing and Software – FACULTY OF ENGINEERING. https://www.eng.mcmaster.ca/cas/
[CA165] McGill University. 2023. McGill School Of Computer Science. https://www.cs.mcgill.ca/
[CA166] Queen's University. 2023. Computing | Undergraduate Admission, Queen's University, Canada. https://www.queensu.ca/admission/programs/computing
[CA167] Queen's University. 2023. Queen's School of Computing. https://www.cs.queensu.ca/
[CA168] Queen's University. 2023. Undergraduate Admissions | Queen's University, Canada. https://www.queensu.ca/admission/
[CA169] Simon Fraser University. 2023. Admissions - Computing Science - Simon Fraser University. https://www.sfu.ca/computing/prospective-students/undergraduate-students/admissions.html
[CA170] Simon Fraser University. 2023. Computing Science - Simon Fraser University. https://www.sfu.ca/computing.html
[CA171] Western University. 2023. Admissions | Western University. https://welcome.uwo.ca/next-steps/
[CA172] Western University. 2023. Computer Science and Ivey - Computer Science - Western University. https://www.csd.uwo.ca/undergraduate/current/programs/cs_ivey.html
[CA173] Western University. 2023. Undergraduate Students - Computer Science - Western University. https://www.csd.uwo.ca/undergraduate/index.html
[CA174] York University. 2023. Computer Science | Lassonde School of Engineering. https://lassonde.yorku.ca/academics/computer-science
[CA175] York University. 2023. Computer Science| Future Students | York University. https://futurestudents.yorku.ca/program/computer-science

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[UK176] Imperial College London. 2023. Computing BEng | Study | Imperial College London. https://www.imperial.ac.uk/study/courses/undergraduate/computing-beng/
[UK177] Imperial College London. 2023. Imperial College Department of Computing. https://www.imperial.ac.uk/computing/
[UK178] University College London. 2023. UCL Computer Science BSc. https://www.ucl.ac.uk/prospective-students/undergraduate/degrees/computer-science-bsc
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[UK184] University of Durham. 2023. Durham Department of Computer Science. https://www.durham.ac.uk/departments/academic/computer-science/
[UK185] University of Durham. 2023. Durham University Computer Science G400. https://www.durham.ac.uk/study/courses/g400/
[UK186] University of Edinburgh. 2023. Edinburgh Computer Science. https://www.ed.ac.uk/studying/undergraduate/degrees
[UK187] University of Edinburgh. 2023. Edinburgh School of Informatics. https://www.ed.ac.uk/informatics
[UK188] University of Glasgow. 2023. Glasgow School of Computing Science. https://www.gla.ac.uk/schools/computing/
[UK189] University of Glasgow. 2023. University of Glasgow - Computing Science. https://www.gla.ac.uk/undergraduate/degrees/computingscience/
[UK190] University of Oxford. 2023. Computer Science | University of Oxford. https://www.ox.ac.uk/admissions/undergraduate/courses/course-listing/computer-science
[UK191] University of Oxford. 2023. Oxford Department of Computer Science. https://www.cs.ox.ac.uk/
[UK192] University of St. Andrews. 2023. Computer Science BSc - Subjects - University of St Andrews. https://www.st-andrews.ac.uk/subjects/computer-science/computer-science-bsc/
[UK193] University of St. Andrews. 2023. St Andrews School of Computer Science. https://www.st-andrews.ac.uk/computer-science/
[UK194] University of Warwick. 2023. Warwick Computer Science BSc (UCAS G400). https://warwick.ac.uk/study/undergraduate/courses/computerscience/
[UK195] University of Warwick. 2023. Warwick Department of Computer Science. https://warwick.ac.uk/fac/sci/dcs/

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[US196] UC Berkeley. 2023. Berkeley, Admissions Overview. https://www.berkeley.edu/admissions/
[US197] UC Berkeley. 2023. Berkeley, Electrical Engineering and Computer Science homepage. https://cs.berkeley.edu/
[US198] University of California Los Angeles. 2023. UCLA, Samueli Computer Science homepage. https://www.cs.ucla.edu/
[US199] University of California Los Angeles. 2023. UCLA, Undergraduate Admissions. https://admission.ucla.edu/
[US200] Georgia Institute of Technology. 2023. Georgia Tech, College of Computering homepage. https://www.cc.gatech.edu/
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[US202] Massachusetts Institute of Technology. 2023. MIT, Admissions. https://mitadmissions.org/
[US203] Massachusetts Institute of Technology. 2023. MIT EECS, Computer Science homepage. https://www.eecs.mit.edu/research/computer-science/
[US204] University of Washington. 2023. University of Washington, Apply. https://www.washington.edu/admissions/
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[US206] Carnegie Mellon University. 2023. Carnegie Mellon, School of Computer Science homepage. https://www.cs.cmu.edu/
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[US210] Johns Hopkins University. 2023. Johns Hopkins, Department of Computer Science homepage. https://www.cs.jhu.edu/
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[US214] Stanford University. 2023. Stanford, Engineering - Computer Science homepage. https://cs.stanford.edu/
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Appendix E SURVEY QUESTIONS

Please see table 15 in the next page.

Appendix F INTERVIEW QUESTIONS

Please see table 16, table 17, and table 18 in the next pages.

Table 15: Survey Questions: Students

No.	Question	Question Type
	Observations about Computer Science	
SQ1	I want to be a computer scientist.	5-Point Likert Scale
SQ2	I believe computer science is important infor the society.	5-Point Likert Scale
SQ3	I believe that I can be successful as a computer scientist.	5-Point Likert Scale
SQ4	The culture of Computer Science programs is accepting of people of all genders and sexual orientations.	5-Point Likert Scale
SQ5	People of different races and cultures are accepted among Computer Science students.	5-Point Likert Scale
SQ6	I currently am ... (a) a high school student who is in the process of application to a computer science program. (b) a high school student who is considering or planning applying to a computer science program, but has not started my research or application process. (c) a high school graduate who will start a computer science program in the coming academic year. (d) a university student registered and studied in a computer science program for at least one semester. (e) Other (please specify)	Multiple Choice
	Admissions and Program Experience	
SQ7	I am satisfied with my decision to enrol in Computer Science.	5-Point Likert Scale
SQ8	I believe that I can be successful in this computer science program.	5-Point Likert Scale
SQ9	My experience in my Computer Science Program has a positive influence on my academic growth.	5-Point Likert Scale
SQ10	I would recommend my program to other people like me.	5-Point Likert Scale
SQ11	I feel respected by my teachers and peers.	5-Point Likert Scale
SQ12	I learned about many schools before applying to my current university.	5-Point Likert Scale
SQ13	I found discouraging elements in the application/admission process.	5-Point Likert Scale
SQ14	I had difficulty preparing my application for the program.	5-Point Likert Scale
SQ15	Other than the program that I ultimately enrolled in, I considered these other programs and universities:	Open-ended
SQ16	What did you consider when deciding which programs and universities to enroll in?	Open-ended
SQ17	Were there programs and universities that you were interested in, but ultimately did not apply to? If so, please list them.	Open-ended
SQ18	Were there programs and universities that you were interested in, but ultimately did not apply to? If so, would you please let us know the reason?	Open-ended
SQ19	Do you remember any detail that made your current university stand out in the application process? If yes, please include.	Open-ended
	Application Experience	
SQ20	Where did you go to get information about admissions? Please select all that apply.	Multiple Answers
SQ21	I attended different universities' open houses before deciding about the pool of universities I wanted to apply to.	5-Point Likert Scale
SQ22	When looking for universities to apply to, I preferred those that explicitly mentioned their commitment towards diversity.	5-Point Likert Scale
SQ23	While reading the admission requirements in the pre-application process, I found myself a competent applicant having all of the requirements.	5-Point Likert Scale
SQ24	I found the the computing science application and admission processes welcoming and encouraging.	5-Point Likert
SQ25	What did you consider when deciding which programs and universities to apply to?	Open-ended
	Additional Comments	
SQ26	What is the one thing that if done could improve diversity, equity, and inclusion in admissions procedures?	Open-ended
SQ27	Do you have any other comments, questions, or concerns?	Open-ended
	About You	
SQ28	Do you have any accessibility needs ?	Multiple Choice
SQ29	Do you identify as a racialized person/person of colour?	Multiple-Choice
SQ30	Please indicate which of the following terms best describe your racial and/or ethnic identity.	Open-ended
SQ31	Please indicate which of the following terms best describes your gender identity.	Open-ended
SQ32	To assist us in our review of this survey, please share any comments about the questions or process of this survey with us. We appreciate your feedback as we work to collect accurate information.	Open-ended
SQ33	If you are interested in providing further feedback through an in-person interview, please provide your preferred contact information here.	Open-ended

Table 16: Interview Questions: Chairs and Decision Making Roles

No.	Question
	Observations
I1Q1	What deliberate admission programs for diversity and inclusion of historically marginalized groups in your institution you are aware of?
I1Q2	To what extend do you think your institution's computer science admission is competitive?
I1Q3	Would you describe your institution's computer science admission as inclusive?
I1Q4	How diverse is the pool of applications to your program?
I1Q5	Does your institution employ affirmative action for education equity in the application process?
I1Q6	What work, if any, is your institution currently doing to move towards more inclusive admission processes?
I1Q7	How much control does the faculty have over the admissions process?
I1Q8	What impact does your role have in the design of the admissions process?
I1Q9	How would you improve your program's admission process in terms of racial and ethnic diversity?
I1Q10	How would you improve your program's admission process in terms of gender diversity?
I1Q11	How do you think your university should improve admission process in terms of racial and ethnic diversity?
I1Q12	How do you think your university should improve admission process in terms of gender diversity?
I1Q13	How do you think CS Programs should improve admission process in terms of racial and ethnic diversity?
I1Q14	How do you think CS Programs should improve their admission process in terms of gender diversity?
	Participant Self-identification
I1Q15	University name
I1Q16	Department Name
I1Q17	If you are comfortable answering, with which gender would you most identify?
I1Q18	If you are comfortable answering, do you identify as a racially minoritized person?
I1Q19	If you are comfortable answering, how would you best describe yourself in terms of race and/or ethnicity?

Table 17: Interview Questions: Registrar Offices and Affiliate Programs

No.	Question
	Observations
I2Q1	How many institutions have you worked with to implement diversity and inclusions programs?
I2Q2	To what extend have you found that those institutions are open to implementing EDI programs in their admissions processes?
I2Q3	To what extend do you believe institutions in <REGION X> are generally open to implementing EDI programs in their admissions processes?
I2Q4	To what extend do you believe admission processes are influential in the diversity of the student population?
I2Q5	How do your affiliated programs are compared to other institutions in attracting applicants and admitting gender-diverse student population?
I2Q6	What deliberate admission programs for diversity and inclusion of historically marginalized groups are you aware of?
I2Q7	Do you work with institutions that employ affirmative action for education equity in the application process?
I2Q8	What impact does your role (and your institution) have in the design of the admissions process for your affliated programs?
I2Q9	How would you improve your organization's process in terms of racial and ethnic diversity?
I2Q10	How would you improve your organization's process in terms of gender diversity?
I2Q11	How do you think CS Programs should improve admission process in terms of racial and ethnic diversity?
I2Q12	How do you think CS Programs should improve their admission process in terms of gender diversity?
	Participant Self-identification
I2Q13	Organization name
I2Q14	Department Name
I2Q15	If you are comfortable answering, with which gender would you most identify?
I2Q16	If you are comfortable answering, do you identify as a racially minoritized person?
I2Q17	If you are comfortable answering, how would you best describe yourself in terms of race and/or ethnicity?

Table 18: Interview Questions: Follow up from Survey

No.	Question
I3Q1	In Question X of the survey "Admissions", you identified Y. Can you please provide more details? For example: How did you realize Y? Why did you find Y? Why do you feel Y? Can you provide more details about Y?
I3Q2	Do you want to share any additional information about admissions procedures with us?