Reflections of a Diversity, Equity, and Inclusion Working Group based on Data from a National CS Education Program

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ABSTRACT

In the US, many groups of students are underrepresented in computer science (CS) classes at the K-12 level [23, 25]. Many of the activities of TEALS (Technology Education and Literacy in Schools), a national computer science education program, have the potential to impact the diversity of students enrolled in computer science classes, student performance on AP exams, and student attitudes towards CS careers. TEALS works with high schools to build and grow sustainable computer science programs through teaching partnerships between classroom teachers and volunteers who work in the tech industry. In 2016, TEALS initiated a Diversity, Equity, and Inclusion Working Group (DEIWG) to holistically address the overall impact of the program on increasing diversity in CS, including TEALS' approach to: selection of schools, student recruitment efforts into CS courses, recruitment and training of TEALS volunteers, curriculum design and resources, and instructional support of volunteers and teachers. The working group compared national, regional, and state-wide outcomes and demographics to those of TEALS partner schools, students, volunteers, and teachers to identify best practices and areas in need of investment. This paper describes these findings and presents strategies for future work.

CCS CONCEPTS

• **Social and professional topics** → **Computing education**;

KEYWORDS

Gender and diversity; CSforAll; K12 CS Education

1 INTRODUCTION

In the US, participation in Computer Science (CS) classes often under-represents many groups of students, including female students, African American/Black students, and Hispanic/Latinx students [23, 25]. Recently, colleges and universities have been celebrating improved diversity numbers for incoming freshman classes [18, 20], and K-12 education is celebrating the increased diversity of students participating in Advanced Placement (AP) computer science courses in high school [17].

Many efforts have launched to increase diversity in K-12 CS education, including curricular implementations [15], policy initiatives [10], and informal education programs [24]. Organizations like the National Center for Women in Information Technology (NCWIT) and others also provide teacher resources to help with classroom diversity [3, 14].

As a large, multi-state organization, TEALS (Technology Education and Literacy in Schools) recognizes the importance of addressing the national lack of representation in computer science. In this experience report, we share both national statistics and statistics of participation in TEALS program classrooms as collected by a TEALS working group. The data is presented to foster discussion as well as to share recommendations from the working group in order to engage the community in a dialog for the improvement of TEALS as well as other CS programs across the nation.

2 DIVERSITY AND STUDENT PARTICIPATION IN AP CS

There has been significant media reporting about the underrepresentation of women and people of color in the professional technology ("tech") industry. Many have argued that expanding the pipeline and engaging more diverse K-12 students needs to precede changes in industry [11, 14]. Current data supports inequity in access and courses taken by K-12 students. According to a Gallup and Google report on the state of CS education, African American/Black students are less likely than White and Hispanic/Latinx students to have computer science classes at school; Hispanic/Latinx students are less likely than White and African American/Black students to use computers at home; and female students are less likely than

male students to be encouraged and supported in their computer science learning [3].

Although imperfect, the AP Computer Science (AP CS) exam numbers offer a national view of student participation in rigorous computer science classes. We acknowledge that many schools offer rigorous CS classes in the form of Career and Technical Education or dual enrollment programs, where students attend local colleges while still in high school, however there are no easy data sources for those enrollment numbers at a national scale. We therefore present the AP CS A numbers as a sample, acknowledging their limitation.
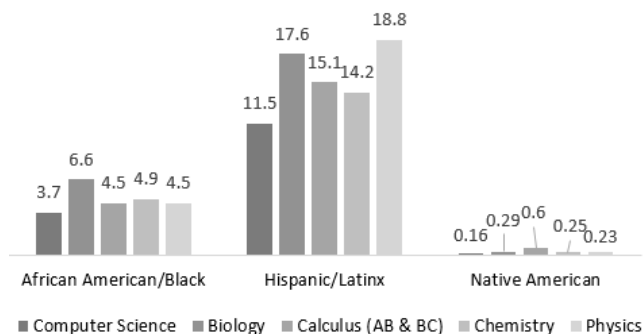
Figure 1: Underrepresented minority students as a percentage of AP exam-takers in STEM subjects

In many regions, underrepresented minorities may have less access to advanced coursework (See Figure 1). With STEM courses, we also see discrepancies in the number of girls taking AP exams. Female students made up 23.3, 60.9, 47.1, 49.5, and 38.5 percent of the students taking the CS, Biology, Calculus (AB/BC), Chemistry, and Physics AP exams, respectively. Overall, these data present a picture where young women and students of color either lack access, or are discouraged by environment or other factors from taking some AP CS courses and exams.

3 TEALS AND DIVERSITY

3.1 TEALS program

TEALS provides a high-touch in-classroom professional development model for high school teachers to learn or strengthen their knowledge of computer science by working closely with trained technology industry professionals who volunteer their time throughout a school year [16]. TEALS partnerships help classroom teachers learning to teach a computer science class with one of several TEALS-supported curricula. TEALS engagements range from co-teaching with volunteers, to volunteers as lab TAs, and volunteers as teacher consultants. Since 2009, TEALS has partnered with 467 high schools in 33 U.S. states plus the District of Columbia.

3.2 Diversity in TEALS program

During the 2016-17 school year, the TEALS program formed a Diversity, Equity and Inclusion Working Group (DEIWG) with the mission to look holistically across all facets of the program for leverage points, and in each area to define goals and metrics, assess current progress against the goals, and recommend changes to the

program to better meet these goals. Section 4 of this paper details the working group's analysis of five key program areas: school recruitment and selection, student recruitment and engagement, volunteer recruitment and placement, instructional support, and curriculum. Section 5 conveys DEIWG's recommendations to the TEALS program.

4 DIVERSITY, EQUITY AND INCLUSION WORKING GROUP FINDINGS

4.1 School recruitment

By definition, students in TEALS-supported CS classes are a subset of students enrolled in TEALS partner schools. With the aim to represent US student diversity, TEALS can create a portfolio of schools roughly matching national demographics for gender, race and ethnicity, students' English language proficiency, school's location, and self-identified Title I designation [6]. During the 2016-17 school year, TEALS partnered with 225 schools in urban, suburban, and rural areas. Sixteen percent of TEALS schools were in rural areas of the US. While individual students do not report their socio-economic status, 41.7% of TEALS schools noted their eligibility for Title I funding; nationally, about 56.6% of public schools are designated as Title I schools [5, 6].

According to the most recent data from the National Center for Education Statistics (NCES) High School Longitudinal Study, the gender and ethnic makeup of students in TEALS partner schools relatively aligns with the national average (See Figure 2) [9]. In TEALS partner schools, Hispanic/Latinx, and African American/Black students make up 29.7% and 8.2% of the overall student body; these groups comprise 20.3% and 13.6% of the US high school population. Similarly, male and female students in TEALS partner schools have near equal representation (50.8% male and 49.2% female in TEALS schools, compared to 50.4% male and 49.6% female in US).
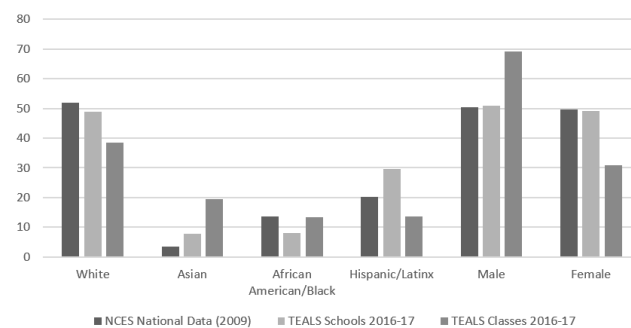
Figure 2: Student Demographics: TEALS Partner Schools vs TEALS classes vs National Data

TEALS finds new school partners each year using proactive and reactive strategies. These successful strategies include speaking with current school partners and regional school leaders, connecting with curriculum providers, responding to contact form inquiries on the TEALS website, working together with partnerships within the parent organizations and area Computer Science Teachers Associations, and exhibiting, presenting, and attending educator's conferences.

4.2 Student recruitment and engagement

Effort is needed to generate interest and awareness of CS classes. In 33 states plus DC, students can earn math or science credit for CS classes, but CS is currently not required for graduation in any state [2]. TEALS is not directly involved in student recruitment, however it provides partner schools with resources and guidance on best practices for attracting a diverse set of students into their CS classes, encouraging schools to reach demographic parity between the CS classroom and the student body. TEALS measures diversity efforts from student gender data provided by classroom teachers, and race/ethnicity data provided directly from students on pre- and post-course surveys. Since 2009, over 25,000 students have taken TEALS CS classes. Over the past three years, TEALS partner schools have narrowed the gap between the number of male and female students in CS classes (See Figure 3).
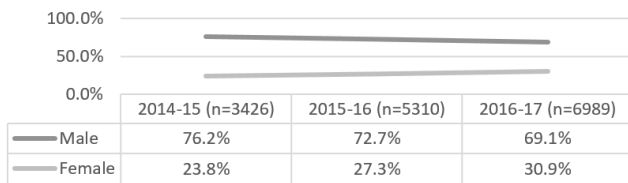
	2014-15 (n=3426)	2015-16 (n=5310)	2016-17 (n=6989)
Male	76.2%	72.7%	69.1%
Female	23.8%	27.3%	30.9%

Figure 3: TEALS Student Gender by Year

Some regions are making greater strides than others; schools in New York (NY) are nearing gender balance in their CS classes (See Figure 4). TEALS has yet to investigate specific factors contributing to these advancements, however preliminary analysis of student survey data shows the primary response by female students in NY partner schools to the question "Tell us the reasons you are taking this course", across all three school years analyzed (2014-2017), was "No clue, it was just on my schedule". In comparison, male students in NY partner schools as well as male and female students in WA, CA, and VA for all three school years, primarily selected "Interested in Computer Science". This suggests NY schools actively assign CS classes to female students as a means of increasing their representation.

Comparing race/ethnicity of students in TEALS classes versus those of the student population in TEALS partner schools, shows an overall over-representation of Asian students, with an under-representation of Hispanic/Latinx students. However, the percentage of White and African American/Black students in schools and classes is generally in alignment (See Figure 2). Students from all races/ethnicities investigated primarily selected "Interested in CS" on the pre-survey question "Tell us the reasons you are taking this course". However, while the second most common response by Asian and White students was "Encouraged by family or friend" (43.4%, 34.7%), African American/Black and Hispanic/Latinx students chose "Recommended by teacher or counselor" (24.9%, 22.6%) and "No clue, it was just on my schedule" (30.3%, 22.9%) in near equal proportions. This data suggests additional effort is needed to help stimulate awareness of computer science within minority communities.

n =	WA	CA	VA	NY
2014-2015	1246	1041	553	159
2015-2016	1492	1234	985	493
2016-2017	2159	1996	620	625

Figure 4: TEALS Student Gender by State

4.3 Volunteer recruitment and placement

Industry volunteers are a critical component of the TEALS program – providing content knowledge and industry perspective in the classroom and helping fill the CS education gap for teachers and students. TEALS builds volunteer teams for each classroom according to geographic location and teaching style fit, followed by demographic considerations, striving to create inclusive environments in each classroom by diversifying the volunteer teams as much as possible. Students, particularly those from underrepresented groups, benefit from same-sex or same-race role models, preserving their sense of belonging and self-worth [13, 22].

For the 2017-18 volunteer recruitment cycle, TEALS increased outreach and developed more targeted approaches to diversify the volunteer pool. Marketing materials (e.g. flyers, postcards, social media) used representative images to appeal to female and racial/ethnic minority individuals. Conscious efforts were made to reach out to national organizations and local affinity groups for specific minority groups; TEALS sent volunteer recruitment information to share with their members, and spoke at member events on the importance of broad representation in TEALS classrooms and the opportunity to give back to the communities members care about. Data from the 2017-18 applications show overall TEALS volunteer to student gender balance is near parity (Table 1), but TEALS still has more work to do to match students in terms of ethnicity (Table 1).

	Female	White	Asian	Af-Am/ Black	Hisp/ Latinx
Est. Industry*	19%	51%	37%	5%	3%
TEALS Volunteers	22%	61%	26%	5%	4%
TEALS Students	31%	39%	20%	6%	14%
US H.S. Students [9]	50%	52%	4%	14%	22%

Table 1: Volunteer vs Student Demographics (2017)

*Averages technical staff self-reported by Apple [1], Facebook [4], Google [7], and Microsoft [8]

4.4 Instructional support

TEALS provides instructional support to its volunteers and classroom teachers through in-person and online summer volunteer training; in-person classroom teacher orientation and CS bootcamp; summer check-in meetings with teaching teams; 1-4 classroom observations during the school year; monthly training meetups; a national online discussion forum; and on-demand staff advice and troubleshooting.

In general, volunteers report that the TEALS program prepares them well for their teaching experience. Of the 89 volunteers who responded to the 2016-17 post-year survey, 97.6% reported that TEALS prepared them very or moderately well. In particular, volunteers report that their level of perceived readiness to enter the classroom is significantly increased by the TEALS summer training program [21]. Lesson pacing and differentiated instruction emerge from qualitative survey feedback as common areas where volunteers seek more help from TEALS.

In designing the content and focus of instructional support activities, TEALS can influence strategies, techniques, and tools volunteers and teachers use with students. For instance, TEALS can emphasize or de-emphasize topics in training sessions and add or remove criteria from its classroom observation form. TEALS aims to provide instructional support enabling volunteers and teachers to engage and include students of all backgrounds in learning computer science.

Of the 2168 TEALS students who completed the post-class anonymous survey, 87.8% report that their TEALS volunteers were effective or very effective in helping them learn CS. However, African American/Black (17.2%) and Hispanic/Latinx (15.9%) students were more likely than average (12.3%) to report that their volunteers were "ineffective" or "very ineffective." Additionally, male students were more likely than female students to agree that "I felt comfortable asking questions in my CS class" and that "I was comfortable talking to my CS teachers" (see Figure 5).
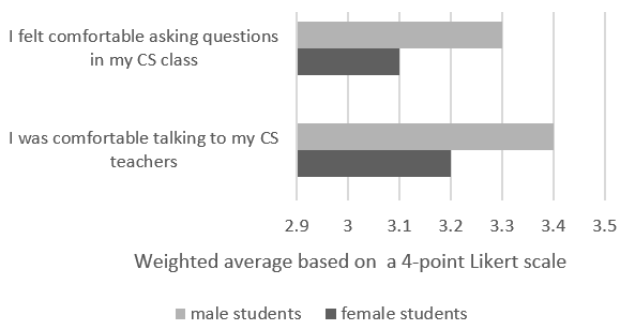

■ male students ■ female students

Figure 5: Self-reported student comfort level

4.5 Curriculum

Curriculum influences attracting a diverse student body into computer science pathways. TEALS curricula offerings include an introductory course, both College Board AP computer science courses, and additional advanced CS classes (Post AP) offered as schools expand beyond the initial introductory and AP classes. TEALS has worked with partners to develop introductory CS and AP CS A curriculum, relies on outside organizations to provide AP CS Principles (AP CS P) curricula, and supports schools and volunteers as they develop their own Post AP curriculum.

For the two curricula TEALS developed, TEALS and partners made deliberate choices to broaden the appeal of the coursework. The introductory course is based on University of California Berkeley's CS 10 course, "Beauty and Joy of Computing" (BJC). TEALS worked closely with the Berkeley CS department to adapt BJC to be flexible and approachable for a wide range of high school students from diverse backgrounds. Many of the labs in this course are based around games. Labs for the AP CS A course use a Pokémon theme specifically because Pokémon seems to appeal across genders [12]. To date, student gender in these classes is still skewed towards males, with enrollment around 70% male and 30% female students (Figure 6).
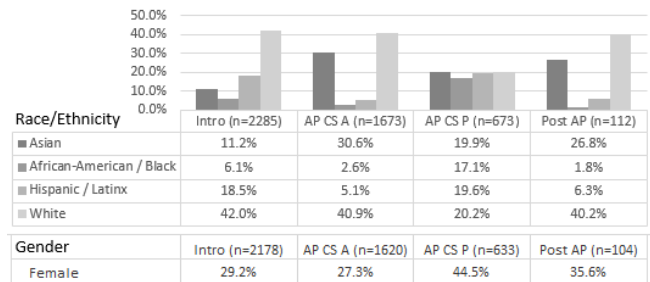

Race/Ethnicity	Intro (n=2285)	AP CS A (n=1673)	AP CS P (n=673)	Post AP (n=112)
■ Asian	11.2%	30.6%	19.9%	26.8%
■ African-American / Black	6.1%	2.6%	17.1%	1.8%
■ Hispanic / Latinx	18.5%	5.1%	19.6%	6.3%
■ White	42.0%	40.9%	20.2%	40.2%

Gender	Intro (n=2178)	AP CS A (n=1620)	AP CS P (n=633)	Post AP (n=104)
Female	29.2%	27.3%	44.5%	35.6%

Figure 6: Self-reported student demographics by course (2016-17)

As Figure 6 shows, TEALS student demographics for the AP CS P class show more gender and ethnic diversity. National enrollment and test statistics for this course show this diversity is widespread [17], so TEALS AP CS P diversity may be due to the course itself rather than targeted recruitment efforts of TEALS or partner schools and teachers. Additionally, TEALS student numbers for AP CS P are relatively small compared to the overall program data, thus the trending increase in gender parity shown in Figure 3 cannot be attributed to the AP CS P class alone.

5 FUTURE WORK

The TEALS DEIWG is making the following recommendations based on its research and analysis. As TEALS implements changes based on the recommendations, it will study their impact and look to share results with the community.

5.1 School Recruitment

Create comparative data reports. TEALS should examine the demographics of partner schools compared to the overall student demographics of regions, states, and the nation to monitor the impact of its outreach efforts, and to identify regions and demographic groups for targeted recruitment.

Strategies and training for TEALS staff. TEALS should train its staff with well-structured, team-wide school outreach strategies that help bring CS education to even more diverse student populations.

Work together with CS organizations. There are well- established CS school and outreach organizations that specialize in working with diverse populations of students. TEALS should collaborate with these groups to learn strategies and connect with schools with more diverse populations.

Continue to invest in remote instruction. A program manager has been hired to oversee TEALS' remote/rural learning program. This manager also advises TEALS staff in how to identify and partner with rural/remote schools. TEALS should continue to invest in this area to serve more rural/remote schools and their teaching teams.

5.2 Student recruitment and engagement

Identify and leverage best practices for recruiting diverse students into CS. TEALS has identified regions and states where gaps in student gender and/or racial/ethnic representation in TEALS classrooms are narrowing. TEALS should identify tactics used by these schools and share them program-wide to aid schools struggling to reach parity. In addition, TEALS can proactively reach out to teachers and administrators from partner schools showing the widest gaps in student classroom demographics, and help them brainstorm ideas for increasing diversity in their CS classes.

Develop a marketing campaign to increase awareness of CS in diverse communities. To maintain student engagement in CS beyond the classroom, TEALS has showcased different careers and career paths in CS during classroom field trips, discussions with volunteers, and at regional CS fairs. To expand this messaging beyond the classroom and diversify student enrollment in CS classes, TEALS has begun to promote the importance of CS for all and the application of CS principles in a range of traditional and non-traditional CS fields to the wider school community. As a first step, TEALS created student–facing posters with creative messaging and distributed them to partner schools for their student recruitment efforts. Online, "Student Stories" highlight TEALS student journeys in CS.

Identify and promote diverse CS opportunities for students in all regions of the country to expand their knowledge and gain experience in CS. Hosting a definitive and timely list of CS opportunities (internships, competitions, workshops, and trainings) would establish TEALS as an essential resource for students, and for companies who are interested in piloting, building, and expanding their student outreach. TEALS volunteers can help to identify existing student opportunities and encourage the development of new ones. In 2016 TEALS hired a dedicated Student Engagement Manager to oversee these efforts.

5.3 Volunteer recruitment and placement

Improve recruitment efforts by analyzing volunteer demographic data. During the 2017-18 recruitment cycle, TEALS began asking applicants about their race and ethnicity. This data will allow TEALS to assess the demographic makeup of the volunteers, and create targeted recruitment strategies within each region to meet the volunteer demographic needs in that region. These strategies should leverage relationships between TEALS and national and local affinity groups.

Analyze teaching team demographics for each class. Though TEALS regional managers strive to create diverse teaching teams, there

has not yet been systematic analysis of the composition of the teams. This analysis will allow TEALS to understand not just overall diversity in the program, but diversity seen by students in each classroom.

Showcase diversity of TEALS volunteers. TEALS has begun compiling background stories from current volunteers as a way to highlight them. These stories, pictures, and quotes, showcased on the TEALS website, can provide greater visibility of the diversity already within TEALS, hopefully encouraging additional candidates to apply.

5.4 Instructional support

Increased emphasis on active learning, differentiated instruction, and practicing formative assessment. TEALS training emphasizes the topics of active learning, formative assessment [21], and differentiated instruction (as of 2017). Data from TEALS staff classroom observations suggest that these areas remain challenging for TEALS volunteers. For instance, students from underrepresented groups were on average less comfortable talking to their instructors and asking questions. Therefore, TEALS believes it is especially important to ensure that TEALS volunteers and teachers use formative assessment strategies to evaluate the learning of each student and differentiate instruction based on the needs of each student.

Increase awareness of diversity challenges. TEALS findings show a significant demographic gap between TEALS volunteers and their students. Volunteers (or teachers) may not recognize challenges associated with membership in a minority or underrepresented group, or be ready to teach in a culturally relevant manner [19]. TEALS should work to incorporate training content showcasing voices of members of underrepresented groups to explain the challenges they face in CS. TEALS staff members may need additional support in this area.

Reinforce training topics over time. The TEALS summer training program is intensive but relatively short in duration, and removed from the time when teaching teams work with students in the classroom. Additionally, volunteers returning to TEALS after their first year are not required to attend training. TEALS should find additional opportunities to reinforce topics for new volunteers and to refresh the training of returning volunteers.

Teach student recruitment strategies as part of training and support. TEALS volunteers can help schools recruit diverse students to CS classes. TEALS should prepare volunteers, as well as classroom teachers, with recruitment strategies (like those discussed above) and facilitate the discussion of student recruitment during summer check-in meetings and classroom observations.

5.5 Curriculum

Review TEALS curriculum through the lens of diversity, equity, and inclusion. TEALS should examine the curricula and make changes to ensure the content includes examples relevant to different groups, including females, and underrepresented minorities. Gathering input directly from students to help in this process would ensure the content is engaging and relevant. For example, TEALS student post-survey data shows a difference in answers to the prompt "I have an interest in computer games". White, Asian, Hispanic/Latinx, and African American/Black students selected "A lot" 51.83, 48.41, 27.20,

and 38.80%, respectively. This difference leads to a recommendation that TEALS change one or more Intro CS projects from video games to other domains.

Assess the school's current CS program infrastructure. TEALS may be able to work with schools to identify potential learning gaps and help them select a curricular structure that is better aligned to their students' starting background. A curricular pathway in schools may provide students access to more CS courses throughout high school.

6 SUMMARY

In this experience report we presented strategies that may impact diversity in TEALS' partner schools. We have seen and continue to see increases in the diversity of students in TEALS-supported classes. There is still much work to be done, and we plan to share subsequent research in future publications. The TEALS program welcomes additional collaboration to discover more methods that may impact student and volunteer diversity, and create more inclusive curricula. TEALS encourages other organizations to dive deep into their strategies and practices so CS education in K-12 continues to grow in its inclusiveness for all students.

7 ACKNOWLEDGMENTS

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