Connecting Computer Science Education to Students' Passions: A Critical Step Toward Supporting Equity in CS Education

Working Paper

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With computer science, I'd want to help strengthen the progress of healthcare—
a few examples of the benefits computer science can bring to the world
(regarding healthcare) are: more knowledge regarding genomics,
and higher supply levels of personalized medicine.
--High School Computer Science Student

Introduction

Important Opportunities Supported by the CS for All Movement

As the Computer Science for All (CS for All) Movement gains momentum across the US, our communities are provided with a unique opportunity: to breathe new life into our students' experiences with learning and school through computer science.

Rapidly changing technologies necessitate shifts in the ways educators and students alike experience schooling—impacting how people interact with one another and novel technologies in the classroom. Simultaneously, the growth of CS education as an important subject that *all* students need to learn regardless of their educational or career trajectories also creates space to challenge how populations historically underrepresented in the field of CS (i.e., students of color, women, students from rural and low-income communities) have been systematically denied access to quality CS learning opportunities.

As we commit to the idea that CS should truly be for *all*, we have an opportunity to bring *all* people to the table to envision what equitable CS education in our public schools can and should look like. Indeed, the current movement has taken root through the shared efforts of educators, administrators, researchers, and policymakers. While these are exciting times in which many different stakeholders are coming together to make positive change in our schools through CS education, there is a voice still largely missing from the movement: the voice of students. During this pivotal moment when programs focused on democratizing access to quality CS education are implemented across the nation--like Advanced Placement Computer Science Principles (APCSP), Exploring Computer Science (ECS), and others--we need to know: What are students' experiences in CS education? What are they doing? Do they feel like they can excel in this field? How are they learning?

Listening to Students' Voices

In the current CS educational research landscape, various programs have been conducting surveys of CS students in order to surface their perspectives about the importance of CS or general interest levels in CS (Margolis, Goode, Binning, 2015; Outlier Research & Evaluation, 2017a), or about advice they would give to first-time CS teachers (Outlier Research & Evaluation, 2017b). This work provides an important first look at how students recognize the relevance of CS to accessing college or career goals, as well as why positive teacher-student relations matter.

Yet what remains unknown is the nature of students' classroom learning and how CS educational experiences are impacting students' sense of:

1) **Identity** (e.g., Do students see themselves as "computer science people," even if they don't necessarily look like today's prominent computer scientists?), and
2) **Agency** (e.g., Do students feel like they can actively use CS to improve their lives, the lives of their families and community members, and/or pursue their personal goals/interests?)

Identity and agency in relation to CS learning are important to understand, because if students' understandings of themselves conflict with their image of what it means to be a computer scientist, then why would they choose to learn CS? Why would they feel motivated to learn CS if they do not feel welcomed or see a connection between CS and their personal goals, interests, and concerns?

Therefore, our research team wants to know: For the majority of our students who are newer to CS and from groups historically underrepresented in the field, what are their feelings about what CS has to offer? What do they envision as the possibilities of CS to achieve personal interests, goals, and dreams? If we hope to engage *all* students in CS learning, then educators, curriculum-developers, and policymakers need a better grasp of who our students are and what they care about. With that information, we can better illuminate for students how the creative potential of computer science connects to their concerns and interests.

Purpose of this Working Paper

In order to answer these questions and address this gap in current CS educational research, this paper is the first in a series of working papers in which we seek to share our REAL-CS[1] research focused on the voices, perspectives, and visions of students learning CS and what matters the most to them for their CS educations and

[1] REAL-CS, the name of our current research project, stands for "Research Equity, Access, and Learning in Computer Science Education."

futures. This paper is focused on our early findings from a pre-survey administered to over 3,000 high school students taking ECS, APCSP, and CSP courses in the Los Angeles Unified School District (LAUSD). More specifically, we examine students' responses to the open-ended question: **"Think about something you really care about or are passionate about. If you could change/improve/do that thing or anything else in this world, using computer science, what would it be?"** Future papers will build on this first piece, to share students' perspectives learning in different CS classrooms, students' processes developing CS projects and artifacts, and students' personal narratives along their unique CS pathways. In this way, we hope to surface how students understand their sense of engagement, identity, and agency in relation to CS learning experiences.

In what follows, we will share the theoretical framework guiding our inquiry into students' perspectives, followed by our research methods, survey findings, and final reflections on the implications of this work.

Theoretical Framework

Sociocultural theories of learning guide our work. We understand learning as a complex process that does not happen in a vacuum within the boundaries of a student's brain, but rather through the social interactions learners have with peers and teachers; such learning is impacted by various cultural, historical, and political factors influencing our ideas, words, gestures, sense of self, and interaction with objects mediating our physical and psychological experiences (Vygotsky, 1978; Wertsch, del Rio, & Alvarez, 1995). In other words, learning does not happen simply when a student sits alone at a desk. Learning happens through the words and gestures that pass between a student and a teacher, as well as between a student and her peers. Learning happens through interactions with tools, such as books or computers or language, that are infused with cultural meaning and historical influences. The cultural and political world—impacting people's views of right and wrong and directly influencing our daily lives from struggles to eat, to struggles to find work, to struggles to keep our families together in the same country—changes our classrooms and what happens within them on a regular basis and does not exist separate from schools (Freire, 1972; hooks, 1994).

As such, we believe it is imperative to find out how youth understand the value of CS education within the context of their sense of self and the world they experience. Their cultural, social, historical, and political worlds directly influence the depth of their engagement with learning and experiences of their lived realities. If we want all youth to learn CS and build on that learning in whatever they pursue, then we need to pay attention to what youth care about most and how to connect to those concerns.

Methods

<u>Larger Study Context</u>

The results shared in this paper are part of a larger study that begins in the Los Angeles Unified School District (LAUSD), and will continue in the upcoming school years in the Deep South and Northeast. In an effort to amplify student voice, the current year's study involves not only a range of both close- and open-ended survey questions (which are the focus of this paper), but also detailed observations of student participation and learning in four CS classrooms (ECS and APCSP) in conjunction with in-depth interviews of twenty focal students about CS artifacts created in these classrooms. Weaving these data sources together, we wish to gain a clearer understanding of how CS learning experiences inform students' sense of CS identity, agency, and engagement.

Further, challenging historical research methods that reinforce dominant power hierarchies in which researchers are perceived to be the primary keepers of knowledge who exercise greater authority than educators, our study involves a Research-Practice Partnership (RPP) that places value in the experiential knowledge of our partner teachers and administrators. Throughout the duration of this study, educators, administrators, and students have been invited to shape data collection protocols, data collection processes, and data analysis efforts. We believe that by creating new knowledge together, this research can more accurately inform policy and practice in ways that can most positively impact youth.

Data Source: Student Beginning-of-the-Year Survey Responses

Findings described in this paper focus on a small but telling portion of a pre-survey of all ECS, APCSP, and CSP students from LAUSD, the second largest school district in the US. This survey was administered to students approximately a month and a half into the school year when teachers were certain that their student rosters had stabilized. This paper closely analyzes 3106[2] total surveys.

Specifically, the question we analyze most closely in this paper prompted participants to think about something they really cared for or were passionate about. Then, participants were asked to consider what (if anything) they would change, improve, or do in that area of passion using CS.

Data Analysis Process

The first three authors of this paper used the Dedoose coding software online. During the initial coding cycle, researchers individually coded approximately 200 responses each in order to create an initial scheme of codes. Following discussion

[2] Of the 3466 participants who completed the survey, 3168 answered the survey question that we are analyzing in this paper. A total of 62 responses were discarded because they were either indecipherable (for example, "priverty" or "shih"), or because they required interpretation that may potentially change the student's intended meaning (for example, when trying to understand what students meant by responses such as "pit" or "being able to"). Thus, this paper closely analyzes 3106 of the surveys total.

surrounding the coding scheme in this first read-through of responses, researchers solidified key themes or codes based on mutual understanding. The team repeated this process of refining the codes in discussion together through another three rounds of coding over the following month. Each discussion also involved identifying which responses needed to be discarded from further analyses as a result of lack of clarity, as well as re-coding previously coded survey responses to ensure they were consistent with refined definitions. In total, each researcher read and coded an equal number of survey responses (over 1000 each). Pooled Kappa scores on the team's inter-rater reliability test were between 0.93-0.95 for the three researchers, which fall into the "excellent" range for inter-rater reliability scores recommended by Miles and Huberman (1994) for qualitative data analysis.

Through the above described process, codes were first organized into main codes or "parent codes" such as "Personal Passions" or "I Don't Know/Not Sure." Within these parent codes, "child codes" were created that described in greater detail the various subcategories fitting within the parent codes, such as "health" or "academics" or "art/film." Examples from our coding scheme of parent codes describing overarching themes, child codes describing sub-categories within those themes, as well as definitions and examples of each are described in the figure below.

Figure 1. Code Definitions and Examples

Parent Code	Personal Passions	**Definition:** Student describes what they are interested in or passionate about	
Child Code	Sports	**Definition:** Student describes loving sports	**Example:** "I love soccer"
	Video games	**Definition:** Student describes enjoying gaming	**Example:** "Playing video games"
Parent Code	Impacting the World	**Definition:** Student describes using CS to impact change in their area of interest/passion	
Child Code	Environmental Impact	**Definition:** Student describes using CS to impact positive change in the environment or helping animals	**Example:** "Create a device to absorb carbon dioxide"
	Communal or Familial Impact	**Definition:** Student described using CS to impact their local community or address family issues	**Example:** "a web app that's helps parents deal with kids aggressive issues by giving them advice that was provided by physiology websites and by getting them in contact with advisors"

Findings

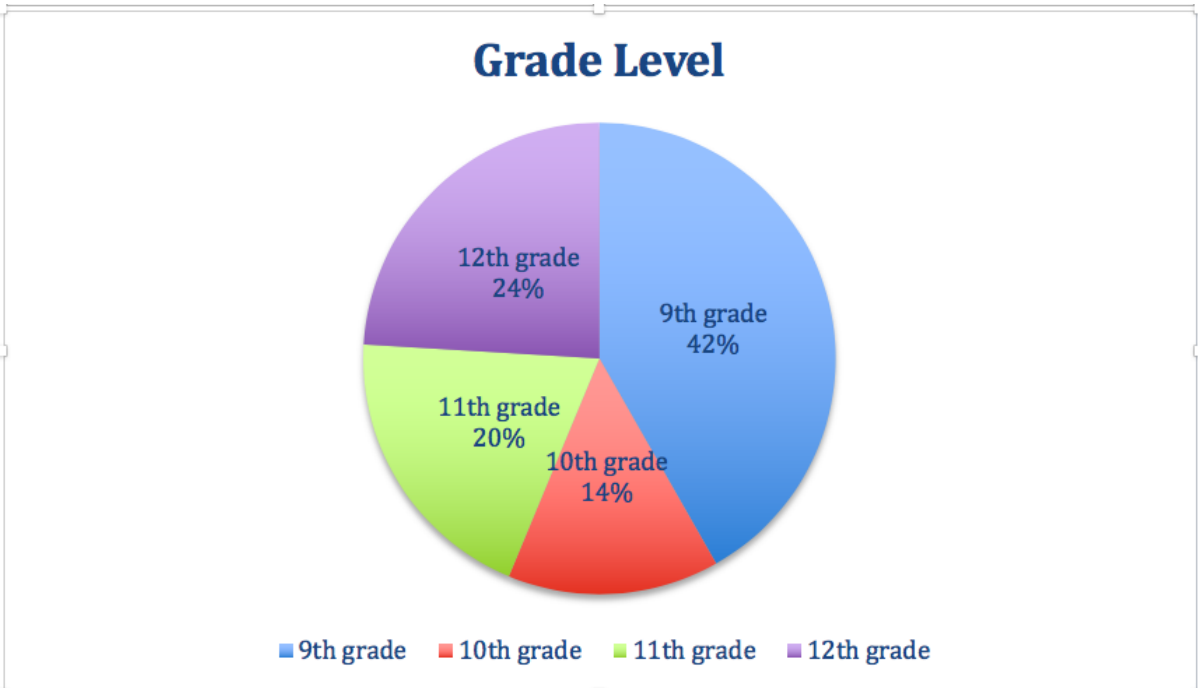
Who Took This Survey?

The survey was taken by LAUSD students, from the second largest school district in the country. LAUSD covers 710 square miles, 26 cities, and includes 863 schools. The district has close to 500,000 students of which 73.4% are Latinx, 10.5% White, 8.2% African American, 4.2% Asian, 4.1% other. 81% of the students are low-income, qualify for free and reduced lunch, over 7000 students are part of the foster care system, and 23% are English Learners. LAUSD's overall 2018 proficiency in English was 42.31% and in Math was 31.62%[3]. The district is impacted by the low per-pupil spending by the state (approximately $9K per student), which is almost 1/3 of the amount spent in NY, making California one of the states with the lowest per-pupil spending.

[3] Please see: https://achieve.lausd.net/site/default.aspx?PageType=3&DomainID=4&ModuleInstanceID=4466&ViewID=6446EE88-D30C-497E-9316-3F8874B3E108&RenderLoc=0&FlexDataID=70093&PageID=1

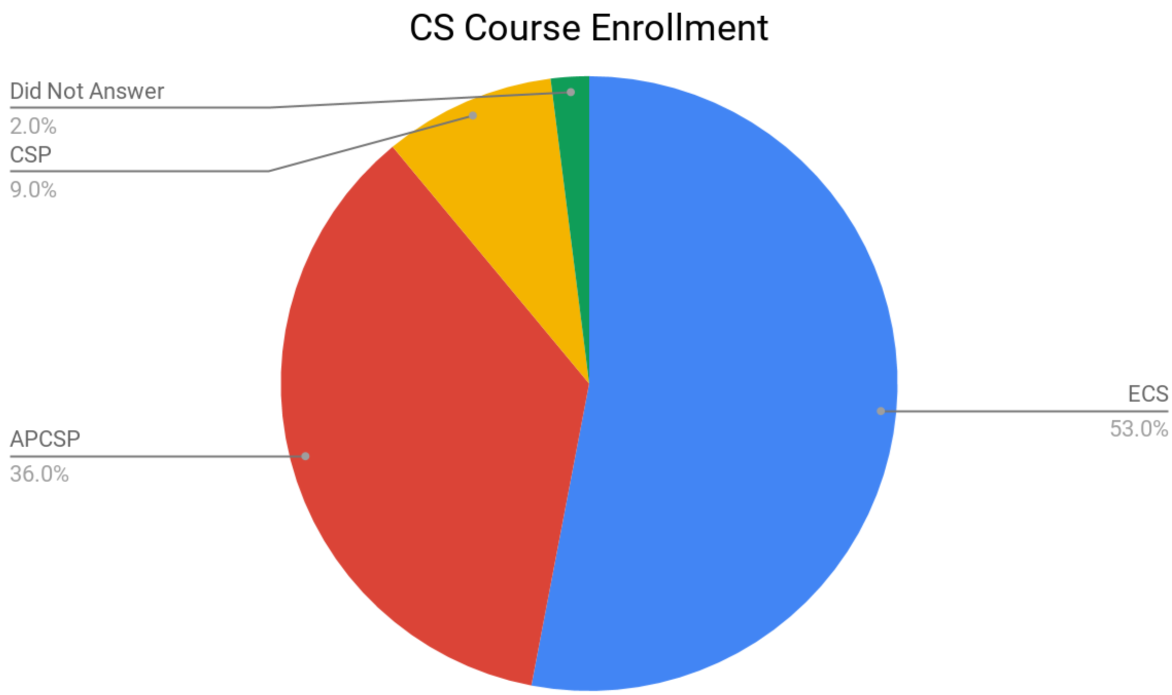
This section provides an overview about the students who took this survey, including demographics, course-taking history, etc. As shown in the pie chart below, 42% of survey-takers were 9th graders, 14% were 10th graders, 20% were 11th graders, and 24% were 12th graders.

Figure 2. Student Survey-Takers' Grade Levels



When examining what courses students were enrolled in and their CS course-taking history, 53% of students were enrolled in ECS, 36% in APCSP, and 9% in CSP[4]. The remainder did not name the course they were enrolled in (see chart below).

Figure 3: Student CS Course Enrollment

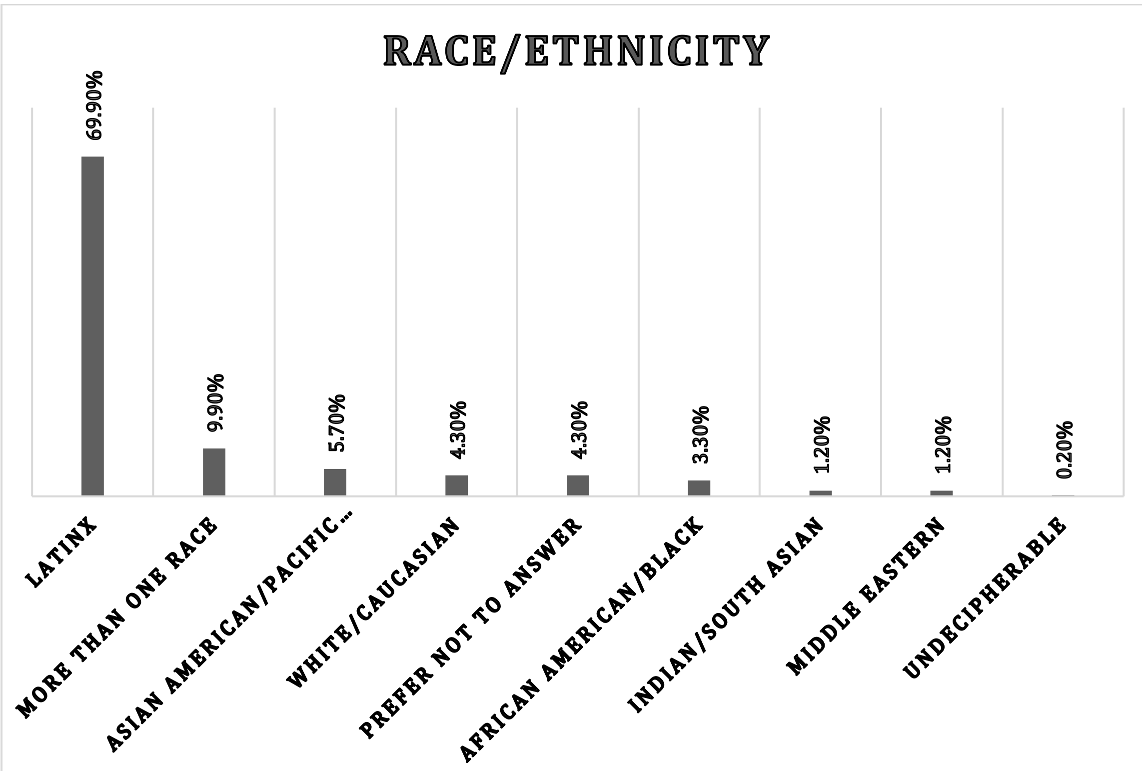


Over half of the students (54%) noted that this was the first CS class they had ever taken. Additionally, 18% noted that they had taken ECS before.

[4] In LAUSD, students are able to enroll in a Computer Science Principles class that follows similar curricula as APCSP, but students do not take the AP Exam or have the course counted as an AP course.

Of these students, almost 70% identified as Latinx, almost 10% identified as mixed race, 5.7% as Asian American/Pacific Islander, 4.3% White/Caucasian, 3.3% African American/Black[5], 1.2% Indian/South Asian, 1.2% Middle Eastern, and 4.3% preferred not to answer. A small percentage of responses were indecipherable (for example, responses in the "other" category that stated things like "human" or "asdf"). These are shown in the table below.

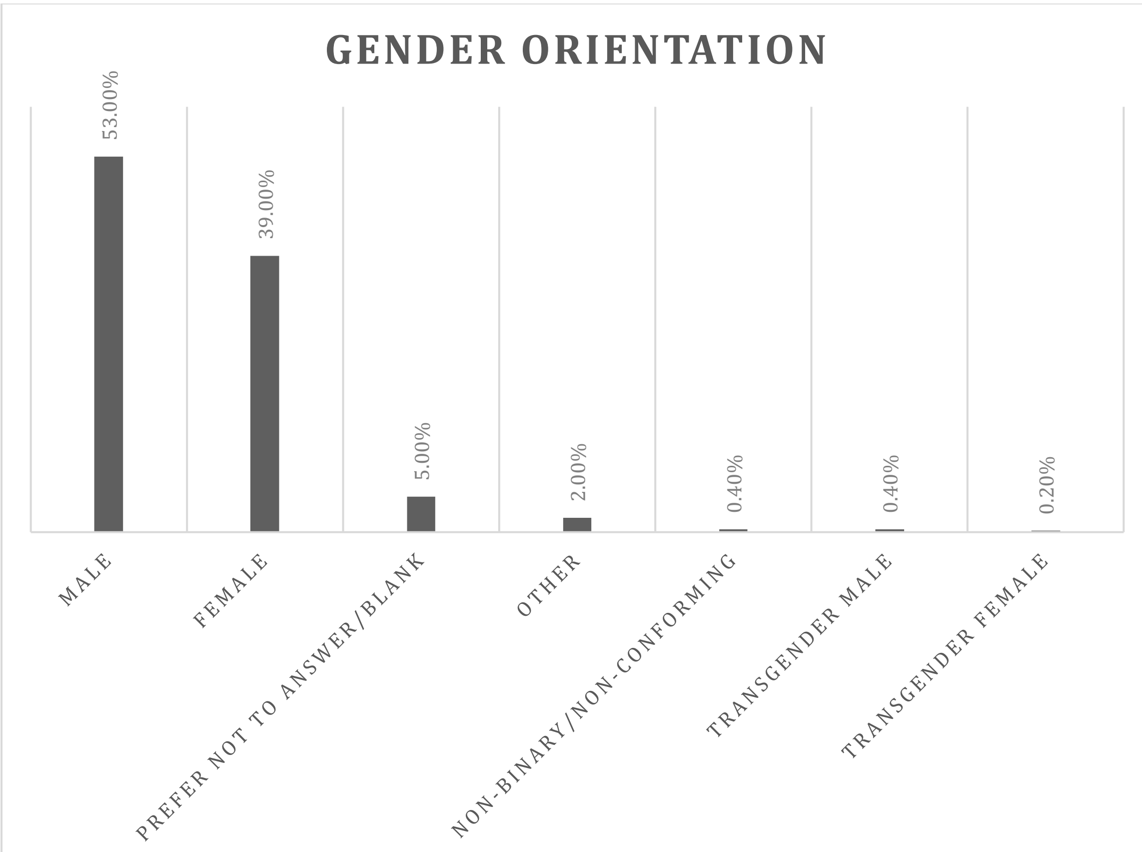
Figure 4: Student Race/Ethnicity



[5] Both Whites/Caucasians and African Americans/Blacks were underrepresented in our survey data in comparison to LAUSD district demographics. We are exploring whether or not, by providing the option for students to identify as more than one race (of which nearly 10% of students did identify), if this resulted in a decrease in their numerical representation in our survey. We are in conversation with LAUSD to make sense of these differences.

Regarding gender orientation, 53% of students identified as male, 39% as female, 2% as “other,” 0.4% as non-binary/non-conforming, 0.4% as transgender male, 0.2% as transgender female, and 5% preferred not to answer.

Figure 4: Student Gender Orientation



Students' General Interest and Belief about the Value of CS

Before diving into students' descriptions of their passions and views about how CS teachers can support those passions, we think it is important to understand students' general engagement with CS and sense of value of CS. This provides an important backdrop for understanding how CS relates to their articulated interests and passions.

On the pre-survey, students were asked a series of likert questions to gauge their interest in CS, their desire to learn more CS in the future, and whether or not they believed CS was beneficial to their educational or career goals. An overview of their responses are shown below:

The **majority of students like computer science** and find it interesting:	
56%	of students **agreed** or **strongly agreed** with the statement **"I like computer science"** (only 18% of students disagreed or strongly disagreed; the remainder replied "neither agree/disagree").
63%	of students **agreed** or **strongly agreed** with the statement, **"I think computer science is interesting"** (only 15% disagreed or strongly disagreed with this statement; the remainder replied "neither agree/disagree").
50%	of all survey-takers either agreed or strongly agreed that they **want to learn more computer science**, either in or out of school (only 26% of students disagreed or strongly disagreed; the remainder replied "neither agree/disagree").

In a future working paper, we will break down the demographics of students answering the above questions, and compare these pre-survey responses at the start of the school year to students' responses to these same questions at the end of the school year. However, we share these initial pre-survey responses about interest and engagement with CS because they show that more than half of all students began the school year interested in CS, with half of all survey-takers showing an interest in learning more. This suggests that students are coming into the school year with some initial excitement and interest.

Students' Stated Passions and Visions for Using CS to Pursue Their Interests

Going beyond these initial analyses of student likert-scale ratings regarding interest in CS and beliefs about personal ability to pursue CS, students' written answers to the open-ended question: **"Think about something you really care about or are passionate about. If you could change/improve/do that thing or anything else in this world, using computer science, what would it be?"** revealed a much richer vision of the world and students' roles in it.

This open-ended question had two parts to it: 1) describe your interest/passion; and 2) describe how you could use CS to impact that interest/passion. Of the 3,106 students who answered part 1 of this question, all answered except a small percentage who stated "I don't know" (6%) or "Nothing" (5%). If we remove these students' answers from the total responses and examine more closely only those responses that described specific interests/passions, then a total of 2,760 students described having a specific interest or passion. Of those answers, the various categories emerged below:

- Academic activities (i.e., interest in specific subject areas such as biology or math)
- Art/music/film
- Career focus (i.e., interest in specific careers such as becoming a doctor or lawyer)
- Education/schooling (i.e., interest in improving the public education system)
- Environment/animals (i.e., interest in fighting against global climate change)
- Fashion/beauty
- Finances (i.e., interest in making money)
- Friends/family (i.e., interest in supporting the health and wellbeing of friends or family)
- Gaming
- Health
- Sports
- Technology (i.e., interest in using technology, creating with technology, etc.)

Of these various interest categories listed above, the largest percentage of students mentioned an interest in technology or using **technology (32%)** in relation to their passions. The next most popular areas of interest were **gaming (12%)**, **art/music/film (9%)**, **sports (6%)**, **health (4%),** and **environment/animals (4%)**. Other categories (fashion/beauty, finances, etc.) were less popular among students.

Looking more closely at part 2 of the above question (what would you change, improve, or do in your area of interest with CS?), 1,968 students clearly articulated how they could use CS in their area of interest or passion. Of those students who described how they could use CS, the **largest percentage of students (41%) described wanting to use CS toward scholarly or inventive pursuits**. In other words, students described being *creative users and not just consumers* of technology. For example, they described using CS to develop programs, websites, etc. that could impact the world in statements (emphasis added) such as:

- "I am really passionate about Mental Health. Using computer science, **I would create a free program/website** in which when people are feeling sad, depressed, anxious, or anything negative, they can sit down and have a chat online with a professional psychologist."
- "**Make free amazing video games** so anyone on the planet could play"
- "I would change the way people are getting hacked, by **creating an app** that is efficient when clearing your device from any viruses."
- "Using computer science I'd try to **create online programs** that spread better knowledge to help people live a healthier and better lifestyle."

As noticeable in the statements above, students' creative pursuits with technology also overlapped significantly with a desire to use CS toward impacting social or political change in the world. In fact, **nearly a third of all students (27%) described a desire to use CS toward impacting social or political change**. Students shared powerful statements [emphasis added] such as:

- "I think it would be really beneficial to use computer science to **enforce international laws concerning sex trafficking and forced labor** - although our government already tries to shut down such institutions, there has been little anyone can do to effectively eradicate them. Perhaps utilizing computer science through an agency such as the FBI or INTERPOL to track and combat these organizations would be more effective than current methods. Of course, I'd be more than happy to take part in that if I was capable."
- "Something I would like to improve using computer science would probably be **school systems** and the way students are analyzed, evaluated and helped out."
- "I will design a computer algorithm that would **evenly distribute any and all resources** to everyone based on their needs in order to better operate society."
- "Something that I'm really passionate about is **helping others especially the disabled**. I would like to change the world by designing better prosthetics."
- "Something that I really care about is the **environment** that surrounds me. I strongly think that people should pay more attention to the environment that surrounds them. If I had the ability to try to improve the environment using computer science, I would program 3 different robots that would go around the city to pick up recycle bottles, Garbage and green waste, like dead grass and leaves."
- "I would use computer science to create video games to **help the mentally impaired or people suffering from depression**."

- “I would use computer science to **empower younger girls and women alike to use computer science**. If they are showed and exposed to this concept then we empower them to be in these kinds of fields.”
- “I would improve machines in **transportation and medical fields**.”
- “I would want to work on a drone and make it used to **help people in a crises**”
- “Using computer science I'd try to create online programs that spread better knowledge to **help people live a healthier and better lifestyle**.”
- “I could help improve the medical field with computers by prescribing antibiotics or medicine for **patients in much pain as fast as possible for the exact pain they are facing**.”
- “It would be to develop new and modern techniques to **prevent against identity theft, hacking, and privacy invasion**.”

A smaller percentage **(20%) described wanting to use CS for personal growth/impact**. For example, students in this category described creating apps that could help them improve their baseball or football skills, work on improving their grades at school, etc. And **4% of students specifically described wanting to positively impact the environment with CS**, describing ways to counter global climate change, deforestation, or the use of plastic in our communities.

Discussion & Conclusion

The findings above reveal that students who are newer to CS and historically underrepresented in the field of CS are coming into the classroom with interest in technology, curiosity about CS, and ideas about how to apply CS creatively toward their personal interests and passions. While students may not necessarily say that they are “passionate” about CS specifically—instead describing their interests in areas such as music or sports or gaming—students were able to articulate the ways that they could see CS as instrumental to achieving an impact in their personal areas of interest. Whether students described CS as a means to create new types of video games or develop better prosthetics for soldiers coming back from war or design robots to help the elderly, they saw the possibilities of actively using CS to change the world around them. And, importantly, nearly one-third of students answering the second part of this question were focused on improving the lives of people around them around issues of poverty, violence, health, the environment, etc.

We believe that these findings are incredibly important for the following reasons. Just as educational theory rests on the importance of pedagogy in showing students how content is linked to issues they are familiar with and/or engaged with (e.g., Calabrese Barton & Tan, 2010; Freire, 1972; Gay, 2000), we believe that CS teachers have a valuable opportunity to motivate youth to learn and want to excel in CS classrooms by showing connections between students’ passions/visions and real uses of CS in the world. If educators can make connections between students' passions/visions and CS learning in the classroom, then students may be motivated to deepen their understandings of why CS matters and how it can be used as yet another tool toward improving our world. We believe that these connections are also critical as they allow for a broader range of students to develop a CS practice-linked identity (Nasir and Hand, 2008, p. 176).

Secondly, this means that CS curricula and professional development need to provide educators with appropriate tools and methods for helping educators get to know what their students really care about, as well as showing students how CS connects to their own interests and goals. What are the ways that CS lesson plans can show the sociopolitical contexts of CS in ways that connect to the many statements students made in this survey regarding the desire to use CS to address homelessness, immigration issues, or hacking? How can professional development experiences frame CS teaching methods around surfacing students' passions/visions and supporting meaningful connections between youth and CS learning? How can CS learning experiences embrace the social and political realities of our students' daily lives and concerns?

Thirdly, these findings highlight that many high school students' desires to impact our social and political worlds are rooted in a strong sense of ethics and making the world a better place for those who are less fortunate. This suggests an important opening for teachers to help students understand that technology is not neutral because it is created by non-neutral human beings and for human-centered purposes. As such, these findings suggest there is a pressing need for what some universities like Harvard, MIT, UT Austin, and Stanford have recently been trying to build into their own CS courses: examinations of ethics in the field of CS (Singer, 2018). Similarly, high school CS classrooms need to make space for discussions about how the ways we create with CS tools can have a range of unintended impacts on communities around us. Curricula and professional development opportunities need to support educators in being able to facilitate challenging conversations not only about CS concepts or practices, but the actual greater ethical, social, and political aftershocks that the CS world can make with each new innovation and programming decision.

Finally, we found the students' voices incredibly inspirational for reminding us about why educational research needs to focus more on the perspectives and experiences of youth themselves. Youth often know best about what works or doesn't work for them, and as the ways human interact and engage with the world begin to evolve with the world's ever-changing technology, materials, tools, language, etc. (i.e., consider how differently teenagers today interact with one another via texting and social media platforms compared to teenagers before the Internet), we will need to embrace the fact that the ways humans learn will also shift. With that shift, teaching and curricula will also need to change. It is time to listen directly from our students to understand what changes will be most valuable for their learning.

Because of the impact that computing is making on our world, we see the introduction of CS as a subject area in public education as an opportunity to strengthen new methods for engaging youth in learning, especially those who have been underrepresented in the field. Connecting schooling to students' interests, passions, and lives beyond classroom walls is not a new idea. From critical pedagogy to culturally relevant pedagogy to inquiry-based learning, educators and researchers have been trying to ensure that learning is rooted in students' visions of the world while providing youth with opportunities to engage in their sociopolitical and cultural worlds (Gutiérrez, 2008). And because computing has transformed how we all experience culture, play, do business, communicate, meet people, create, and because computing has introduced very serious ethical questions (such as privacy, who gets knowledge and who doesn't, hate sites etc), we need to be designing curricula and supporting pedagogical practices that address these issues and ensure that the things students care about in their communities and lives are interwoven with new learning – students need to be able to see how what they learn can empower them in what they want to do and change. This has been a design principle of programs such as Exploring Computer Science, specifically to help broaden participation in computing.

Our findings also closely parallel those of the "Rethinking Mathematics" community that has found how critically important it is that "students can recognize the power of mathematics as an essential analytical tool to understand and potentially change the world, rather than merely regarding math as a collection of disconnected rules to be rotely memorized and regurgitated" (Gutstein and Peterson, p. 2, 2013) and that contextualizing math within students' own cultural and community histories, students' motivation to learn mathematics is positively influenced.

Ultimately, as we attempt to address how CS is segregated across race/ethnicity, gender, and class lines, the need to take on the charge of ensuring CS learning opportunities relate to students' personal interests and visions for change are more important than ever. As we ask questions such as: Which schools offer CS learning opportunities? Who gains access to quality CS education? Which students, through all their schooling experiences, ultimately feel confident that they can excel in CS, even if they do not fit the current CS demographic? We must also ask: How are our curricula and teaching practices honoring diverse students' cultures and knowledge that they bring into the classroom? How do they tap into and build upon students' exciting visions for changing the world with CS? How are students being prepared with the right tools and resources throughout their education, so that their aspirations can be realized? How can we listen to the needs and interests of our youth, so that we can better facilitate their process of democratizing CS through their own passions and actions?

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