The Benefits of Socially Responsible Computing in Early Computing Courses: A Multi-Institutional Study at Primarily Undergraduate Hispanic-Serving Institutions

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Background and Context. Computing is considered a fundamental skill for civic engagement, self-expression, and employment opportunity. Despite this, in our state in the USA, there are significant equity gaps in post-secondary computing enrollment and retention. Specifically, in the California State University system (CSU), which serves close to half a million undergraduate students, students identifying as Hispanic/Latino make up a smaller percentage of CS majors than expected from the state's overall population; and, once enrolled, tend to leave the CS major at higher rates than other students.
Purpose. We report on the impacts of a curricular intervention aimed at strengthening the sense of belonging of Hispanic/Latino students in computing, with the eventual goal of improving retention in computing majors for those students.
Methods. Working in an alliance of six universities within the CSU (five of which are designated as Hispanic-Serving Institutions), we have incorporated socially responsible computing across early CS courses. We aim for alignment between our curriculum and students' communal goal orientations, and for coursework that

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attends to students' interests, values, and cultural assets. Over a two-year-long study, we collected survey data to learn about the impact of our curricular intervention on students' sense of belonging and perceived learning and agency.
Findings. We found that students generally reported high communal goal orientations and, at the campuses *without* competitive enrollment policies, our intervention had a significant positive impact on students' senses of belonging. This effect was observed between control and treatment terms as well as within treatment terms. We also note that Hispanic/Latino students were more likely than other students to report that non-curricular factors like work and family obligations interfered with their learning, and appeared to experience slightly stronger benefits from the intervention.
Implications. Our data suggest positive outcomes for integrating socially responsible computing into early CS courses, especially for Hispanic/Latino students at certain primarily-undergraduate institutions (PUIs). Unlike much prior research, we found that conducting studies outside of primarily white institutions (PWIs) can provide new insights into the impact of curricular interventions on student experience and retention. Our varying results by campus suggest that factors such as campus population, acceptance rate, and departmental enrollment policies ought to also be taken into account in studies that aim to broaden participation in computing. Would results from prior research on recruitment and retention of Hispanic/Latino students or other underrepresented students look different if such studies were replicated at institutions with different demographics and enrollment policies?

CCS Concepts: • **Social and professional topics → Computing education**; *User characteristics.*

Additional Key Words and Phrases: Socially Responsible Computing, Broadening Participation in Computing, Hispanic/Latino students, Primarily Undergraduate Institution, communal goal endorsement, sense of belonging

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1 Introduction

Computing has long been considered a fundamental skill for civic engagement, offering opportunities for self-expression, education, civic and critical consciousness, and financial and social mobility [30, 41]. Yet, White and Asian male-identifying students are disproportionately over-represented in computing. Efforts to challenge these gaps are underway. For example, NSF's Broadening Participation in Computing calls on us as CS educators to address the "missing millions—those who are yet to be engaged in the STEM workforce so that it reflects the racial, ethnic and gender representation of the general population". The problem is systemic and requires institutional-level changes.

Attending to this call, our project brings together faculty from six primarily-undergraduate institutions in California in the USA, all part of the California State University system (CSU). The six participating institutions are CSU Dominguez Hills (DH), CSU Los Angeles (LA), CSU Fullerton (FULLERTON), San Francisco State University (SF), Cal Poly Pomona (*POMONA*), and Cal Poly San Luis Obispo (*SLO*). Though the six institutions are part of the same public University system, they vary significantly in several aspects of the student experience (§3). The CSU system serves close to half a million students. In Fall 2023, 48.3% of these students identified as Hispanic/Latino,[1] but only 25% of the 3704 computer science degrees awarded at the CSU in 2023 went to students identifying as Hispanic/Latino.[2] While there is work to be done statewide to continue to boost undergraduate

[1]https://tableau.calstate.edu/views/SelfEnrollmentDashboard/EnrollmentSummary (Accessed March 20, 2025)
[2]https://tableau.calstate.edu/views/CSUDegreesIssued/CSUDegreesIssued (Accessed March 20, 2025)

enrollment for Hispanic/Latino students, in computing we have an additional burden to attend to the disproportionate under-enrollment in computing for Hispanic/Latino students.

Within this context, our work is centered on developing socially responsible computing (SRC) curriculum and integrating it into the first two years of post-secondary CS courses, with the goal of supporting students who are historically underrepresented in computing. Despite being part of the same University system, we find that our six sites have significant variance demographically and with respect to departmental and institutional policy. Our work engages with this difference, encouraging curriculum development tailored to each context but with a common thread that emphasizes strengthening students' sense of belonging in computing by (1) developing early computing course materials with clear signaling that computing can be used to benefit society, thereby appealing to students' communal goal orientations [40], and (2) incorporating tenets of culturally relevant pedagogy [38], specifically providing opportunities for students to succeed in course assignments that draw on diverse backgrounds and interests. Engaging with multi-site variations as we work towards a shared goal enables us to identify differences in effects arising from institutional factors such as inclusiveness in terms of admission and major selection criteria.

We address the following research questions (described in more detail in §5):

RQ1 What was the level of communal goal endorsement from our CS students?
RQ2 How did sense of belonging in computing change with the inclusion of SRC coursework?
RQ3 How did SRC curricula affect students' self-reported learning of technical and "social technical"content?
RQ4 What other factors impacted students' experiences in early CS courses?

We used surveys given during a Control term (with no curricular additions) and three Treatment terms to measure the impact of curricular intervention on students' sense of belonging in computing. Additionally, we studied students' communal goal endorsements, their perceptions of the SRC curricular additions, and other factors that might have interfered with their coursework. We received 435 responses from students in the first year of the study and 2670 responses in the second across all six sites, and learned that the student experience and the impact of our intervention varied between campuses that were had more competitive enrollments, and those that did not.

Our results also let us explore conceptual replications of existing research in the field, much of which has been historically executed at primarily White institutions (PWIs), where results may not necessarily transfer to minority-serving institutions (MSIs). Of the six sites participating in the present alliance, five are designated as Hispanic-Serving Institutions (HSIs) by the US Department of Education.

Our curricular intervention has had a positive impact on students' self-reported learning, including technical skills and SRC skills. Additionally, communal goal orientation was found to be important for *all* CS students, including for Hispanic/Latino students and students from underrepresented gender identities. We also found a significant positive change in the sense of belonging for Hispanic/Latino students at our most inclusive institutions, in terms of competitive enrollment, from Control to Treatment terms as well as within Treatment terms. This data indicates the value of integrating SRC assignments into computing courses when working towards broadening participation in computing.

2 Background

Our work is focused on improving the retention and experiences of historically underrepresented students in early post-secondary computing courses. We are working within an alliance of six post-secondary institutions that are all part of the CSU in California in the USA. Given the population demographics in our state, our long-term focus with this work is specifically to **broaden participation of Hispanic/Latino students in computing**. All authors of this paper are faculty dedicated to broadening participation in computing who work at primarily undergraduate institutions that are HSIs or, in the case of one institution, an emerging HSI. There is also substantial cross-over and collaboration between our team and CAHSI (Computing Alliance for Hispanic Serving Institutions).

A wide array of literature addresses the complex issues that students face in STEM courses [22, 50, 62]. While external forces such as socio-economic realities surrounding families and communities or broader campus climate cannot be ignored [47, 49], our work focuses on academic factors of influence. Specifically, we focus on strengthening students' sense of belonging in computing, which we believe is necessary to broaden participation in computing. Further, echoing Nuñez [47], we move away from a universal approach to promoting a sense of belonging and instead examine the impact of our intervention on a specific group: Hispanic/Latino students.

A student's sense of belonging in an academic discipline has been described as their sense that they fit in and are valued as part of that community [29]. This sense can significantly influence a student's academic persistence and performance in the discipline [22, 23, 40]. Hispanic/Latino students have tended to report a lower sense of belonging than White students in college environments and in STEM fields like CS [32, 39, 46] and, at the institutions involved in this study, face higher attrition rates in CS programs (§3).

One factor that may affect a student's sense of belonging in computing is their perception that computing would enable them to meet communal goals [40], i.e., the sense that they can use computing for the betterment of society or their communities. Clear signaling in early courses that computing could further communal goals could positively impact students' sense of belonging in computing, particularly for those students with stronger communal goal endorsements.

Our work arises from a shared theme in the literature that both women and/or students of color are likely to strongly endorse communal goals [5, 9, 19, 22, 23, 31, 40], i.e., they tend to be drawn to goals that further the betterment of society. For example, there have been calls to "creatively find ways to better connect [under-represented] STEM students to community-based learning opportunities or to find ways to emphasize how classroom content relates to prosocial communal outcomes" [22], leading Estrada et al. [23] to argue that "Among [historically under-represented] students there is growing evidence that communal goals are important to the retention and departure of students in science and engineering fields." In computing in particular, there have been calls to integrate justice and ethics into coursework to improve the experience of students of color [54, 59], and Lewis et al. [40] report, based on large-scale survey data, that students' senses of belonging in computing were negatively impacted when they perceived computing to offer *low* opportunity to meet communal goals. This effect was heightened when the student reported high levels of communal goal endorsement—significantly more likely for women and students of color. We note that not all prior literature has carefully attended to intersectionality [15, 51] or sometimes mixes findings, applying results from studies focused on women to students of color and vice-versa, implying that the same approach to broadening participation applies to different identity groups. We have found in our data that distinguishing along varied axes of identity is important.

We are also driven by certain tenets of culturally relevant and culturally responsive pedagogies, which are concerned primarily with the academic success and thriving of students of color. Culturally relevant pedagogy emphasizes the recognition of the varied cultures, perspectives, and experiences that students bring to the classroom [27, 38]. Ladson-Billings [38] recommends that culturally relevant classrooms "provide a way for students to maintain their cultural integrity while succeeding academically" by incorporating students' interests and existing strengths into lessons and assignments, and teaching "to and through" those strengths [28]. We integrate this emphasis with our focus on socially responsible computing by utilizing Yosso's community cultural wealth model as an assets-based framework grounded in and responsive to students' lived experiences [67].

One major way in which teachers can teach "to and through" students' strengths is by enabling them to make choices about their learning [57]. In an introductory programming classroom, this could take the form of students choosing a domain in which to exercise their developing programming abilities. For example, though not originally described as culturally relevant pedagogy, Bart et al. [4] empowered students in their data-centric introductory computing course to work with datasets of their own choosing, and students experienced improved outcomes in terms of learning and confidence. As another example, Johnson et al. [34] report that students formed strong connections between their designs, home lives, and computing when they were asked to use found materials from their own homes to design and create computing artifacts.

Also in accord with our emphasis on communal goal affordance, Ladson-Billings [38] emphasizes that culturally relevant classrooms should help students to "recognize, understand, and critique current social inequities", and Gay [28] and Tanase [57] describe culturally relevant classrooms as empowering students to focus on social justice and communal welfare.

Finally, our students do not experience our computing courses in a vacuum, and related work addresses the complex social, emotional, and historical contexts and injustices that impact marginalized students' experiences [22, 49, 50]. While our work is primarily focused on strengthening student sense of belonging through curricular interventions, we are also cognizant of the student experience holistically within an institution, for example through the lens of servingness [25]. This broader context seeks to acknowledge that students can face external pressures that can interfere with their academic performance. These obligations may include family duties, work responsibilities, and cultural expectations, which can vary significantly across different demographic groups.

There is evidence that students of color are more often managing external obligations that can impact their learning and computing experience. Salguero et al. [52] sought to learn about the various sources of struggle that students might face in early CS courses, and found that Black, Hispanic/Latino, Native American, and Pacific Islander students were more likely than other students to report that personal obligations (like family obligations, work obligations, or illness) interfered with their learning. Duran and Núñez [21] reported that Hispanic/Latino students were more likely to experience basic needs insecurities. Similarly, plenty of evidence suggests that factors outside of the classroom can impact learning for the student body in general [42, 55, 56, 65]. Therefore, we also investigate at our institutions how and for whom personal obligations might affect learning.

In the following sections, we describe the varied contexts of our six participating institutions and provide examples of our curricular interventions aimed at enhancing the sense of belonging of Hispanic/Latino students in our classrooms.

3 Institutional contexts

The CSU is a large and diverse university system in a large and diverse state in the USA. Access to CS courses in high school is highly inequitably distributed in California, with lower-income counties and counties with larger populations of Hispanic/Latino, Black, Indigenous, and Pacific Islander students tending to have fewer schools that offer CS courses [36].

Similar variability is present among the six CSU campuses participating in this work, summarized in Table 1. While all sites are a part of the same university system, social, economic, geographic, and historical contexts have shaped the various individual institutions to create a fertile ground to examine student experience. For example, some of our sites that are located in urban centers provide more ready access for students who commute to campus (which allows some students to prioritize family connections) while others are residential campuses with higher perceived prestige.

While a complete exploration of the political and economic variance in our sites is beyond the scope of this current work, we acknowledge the impact of variance and share key measures of economic, social, and demographic composition in Table 1. We also recognize that historical funding inequities across our six campuses are exacerbated as some participating campuses are experiencing sharp enrollment declines while others are growing their student bodies, leading to changes in funding allocations to our campuses. This work focuses on understanding computing students' sense of belonging when considering a specific curricular lens (communal goal alignment) with attention paid to demographic variance.

Our CS departments serve varying percentages of Hispanic/Latino students, ranging from 11% to 63%. Across the six sites, 29% of our shared computing student population identified as Hispanic/Latino. Our varying contexts allow us to learn from one another and to see that the impacts of interventions to broaden participation in computing differ based on these contexts.

When considering what may influence a student to opt into and thrive in computing, we considered several factors that may influence the student experience: prior experiences with computing, program attrition rates, and institutional admission policies. We ultimately narrowed our focus to campuses grouped in terms of their institutional selectivity, but we discuss a number of factors for the sake of context.

Prior experience with computing. In Spring 2024, the percentage of students who reported having any high school experience with CS ranged from 21% to 65%. When considering the task of helping students opt-in to computing, we aim to influence students most newly exposed to computer science. We note that CSU Los Angeles (LA) is somewhat unique as it draws from a large urban center that has been well served by efforts related to exposing high school students to AP Principals in Computing [24].

Student retention. As shown in Table 1, different sites have different retention rates. CSU institutional data about race and ethnicity categorizes students as belonging to "under-represented minority" groups (URM) if they identify as Hispanic/Latino, Black/African American, Native American, Hawaiian/Pacific Islander, or multiple races including least one of those races. We acknowledge that the term "URM" risks hiding students' different circumstances by collapsing distinct groups into a single umbrella term [63]. In our context, over 84% of "URM" students identify as Hispanic/Latino across all sites. Table 1 includes composite departmental attrition rates for those students because that is the institutional data that is publicly available. We note that Hispanic/Latino identity is complex with recent work indicating important stratification within this ethnic identity [3]. While we do not ask students to refine their ethnic identity within Hispanic/Latino, we do see variance in student experience across our sites. For example, we see that retention rates also correlate with admission with the largest potential impact for retention focused on certain sites. On average across the sites, students identifying as Hispanic/Latino, Black, Native American, or Hawaiian/Pacific Islander leave CS at a rate of 34.4% while others leave at a lower rate of 21.5%.

Institutional selectivity. In terms of enrollment policies, University acceptance rates range from 33% to 93%. Additionally, two out of the six CS departments—those at the two Cal Poly campuses, *Pomona* and *SLO*—have "competitive enrollment policies". That is, students must declare a CS major at the time of admission to the university, or must meet grade thresholds to become a CS major after admission as seats are limited [46]. While Campbell et al. [12] did not find a relationship between competitive pathways to computing admissions and student sense of belonging within their single institution, a multi-institutional study by Nguyen and Lewis [46] found that competitive admissions can reduce first-year students' sense of belonging in computing and weaken their perception of their department as being "welcoming". We saw similar cross-institutional variance among our sites. Bleemer and Mehta [7] report that competitive policies can

Table 1. Our campuses vary in their student demographics, experience, and enrollment policies. All sites have between 1000-2000 CS majors in total. Campuses are identified as having a competitive enrollment policy if their identifiers are *italicised* (i.e., *Pomona* and *SLO*). Prior experience in CS was measured through survey questions (§5) and may suffer from selection bias. Other attributes are based on institutional data.

	Campus					
Attribute	DH	LA	Fullerton	SF	*Pomona*	*SLO*
Had pre-college CS education	21%	38%	43%	23%	65%	47%
% Hispanic/Latino (University)	69%	75%	52%	37%	53%	23%
% Hispanic/Latino (CS Majors)	63%	54%	27%	26%	27%	11%
% of students who leave CS who have a "URM" identity	42%	45%	30%	45%	26%	18%
% Receiving Pell grant	61%	66%	47%	43%	46%	18%
% First-generation students	46%	57%	32%	32%	55%	17%
University acceptance rate	86%	91%	59%	93%	44%	33%
Has competitive CS enrollment?	No	No	No	No	Yes	Yes

also impact access to majors with high economic value, disproportionately affecting historically underrepresented groups.

Any number of personal factors can influence an individual student's experience. Similarly, institutional variance can also be considered from various lenses, e.g., student population demographics, the institution's and students' financial situations, and the proportion of students who are first-generation college-goers. We have shared some of these key measures in Table 1, though we find that the most salient contextual differences for our students relate to institutional acceptance rates and competitive CS enrollment policies.

To reflect these differences, we group our sites into two categories, which we call *most inclusive* and *restricted*. Broadly speaking, DH, LA, Fullerton, and SF have high acceptance rates and do not have competitive CS enrollment policies, while *Pomona* and *SLO* have lower acceptance rates and competitive CS enrollment policies (students are admitted directly into the CS major or must meet pre-requisite requirements in order to take CS 1).

4 Curricular Interventions: Socially-Responsible Computing

This section provides two illustrative examples of what we mean by socially-responsible computing (SRC) assignments. Our alliance's goal is to strengthen the sense of belonging of Hispanic/Latino students in early computing courses by developing curricular materials that demonstrate to students their potential to use computing to help their communities and to think critically about the impacts of computing on communities and communities on computing. Borrowing from culturally relevant pedagogy [17, 38], we have developed curricular materials that strive to allow students to bring their own cultural assets into the computing classroom. Because of our focus on student retention, our current work focuses on early CS courses at the six campuses. Future extensions could include more curriculum- and program-wide models of integration, such as the one described by Cohen et al. [13].

In particular, our curricular intervention focuses on integrating socially responsible computing and, in doing so, situates computing firmly in the students' social surroundings. SRC goes beyond only teaching ethics in computing [13]. It encourages students to actively consider the social and ethical implications of their work, acknowledges the significant power computing systems have in society, and aims to prepare students to exercise that power responsibly as they develop technical skills. Additionally, by integrating societal considerations as students learn programming skills, we encouraged them to bring their cultural norms, mores, and lived experiences into the learning process.

While integrations of SRC in the six sites varied, we share a set of core components that guided us. In general, we sought to integrate SRC considerations in the context of technological knowledge introduced in the class, rather than introducing separate modules for ethical and social considerations. Assignments included structures to foster reflection and discussion on the ethical dilemmas that students encountered when working on the SRC assignments.

As illustrative examples, we describe a set of assignments that were developed for introductory CS courses at Fullerton and *SLO*. Assignments like the ones described below were incorporated into CS 0, CS 1, and CS 2 courses at our participating institutions. Levels of incorporation varied, ranging from the inclusion of a few new assignments to the creation of entirely new courses (e.g., [26, 35]). Participating faculty also attended monthly meetings of a faculty learning community led by social scientists dedicated to best practices for integrating SRC. This learning community is discussed in more detail in [66].

4.1 Example 1: Restaurant tip allocation assignment

Used at CSU Fullerton, this assignment was adapted from a similar assignment related to allocation of on-campus housing [48].

Target CS topic. The target topic was conditional control flow, i.e., syntax and semantics of `if/else` branching.

Real-world context. The assignments were based on the American practice of tipping, wherein a diner at a restaurant gives a tip, calculated as a percentage of their bill, and employees pool tips and allocate the pool by job title (e.g., cashier, chef, server).

Pre-reading and in-class discussion. Students completed a pre-reading that presented the *power-to, power-over* analysis framework [1], and that described the basics of the tipping practice so as to not exclude those who may not be familiar with it. Next, students completed an in-class active learning group worksheet designed with a POGIL-like structure [33]. The worksheet presented variations of a tip allocation algorithm involving a conditional: if the store was exceptionally busy, the manager worked the floor and gets a tip allocation; otherwise, they do not.

Integration with technical CS content. The activity is scheduled immediately after conditional syntax is presented, and the worksheet prompts students to reinforce conditional semantics and link these semantics to social impacts. Students conducted a power-to/power-over analysis on the presented algorithms, then designed their own algorithm intended to be more fair.

Reflection. After class, an asynchronous discussion board assignment prompted students to reflect on what they learned and justify that their group's algorithm is fair according to the power-to/power-over framework. Responses were divergent and suggest that students made connections to personal priorities, values, and experiences, consistent with culturally responsive pedagogy. The content of posts ranged from the technicalities of conditionals to principled rationalizations for adjusting the allocation weightage, arguments for reforming this tipping practice, arguments for deprecating the practice entirely in favor of a living wage, reflections on personal or family experience in the food service industry, and the racialized history of tipping in America.

4.2 Example 2: A data-centric CS course focused on social responsibility

At Cal Poly *SLO*, a new data-centric CS 0 course was developed, focused on socially-responsible computing. This section provides a high-level description of the course, which is described in detail in prior work [35].

Target CS topic. The course focused on introductory programming using TypeScript, covering topics such as data types and variables, functions and control flow, and loops and higher-order functions. It also included a significant data visualization component.

Real-world context. All programming assignments involved exploration of a chosen dataset, provided by the instructor or sourced from local non-profit organizations. For example, a series of lab assignments engaged students in critically examining the state of CS education access in California, using a data-set provided by a non-profit organization that tracks that information [36]. Other topics included those chosen by students, such as food and housing access, fatal police shootings, SAT attempts, scores and household incomes, and UFO sightings, sourced from dataset repositories like the CORGIS project [4].[3]

Pre-reading and in-class discussion. Reading materials were based on the assignment's real-world context. For example, to help students contextualize what they learned from the dataset about K-12 CS education access, we discussed access barriers discussed by Wang and Hejazi Moghadam [60].

Integration with technical CS content. Data-centricity lends itself to integration with core programming topics [37]. Even simple data analysis tasks allow students to exercise programming skills associated with data types, conditional logic, and list operations.

Reflection. Assignments often included written reflection components, asking students to reflect on *why* they see what they see in the provided data, based on the provided reading. Additionally, the final project required students to choose their own topics and datasets, ask their own questions, and present their findings to the rest of the class.

5 Methodology

This section describes our research questions and the methods employed to answer them.

- **RQ1 What was the level of communal goal endorsement from our CS students?** Given our motivation for incorporating SRC into introductory coursework, we investigate whether students are interested in coursework that might appeal to communal goal orientations.
- **RQ2 How did sense of belonging in computing change with the inclusion of SRC coursework?** We explore this change quantitatively in two ways. First, we investigate the change in belonging between a "control" group (an academic term without SRC curricular additions) and a "treatment" group (academic terms with SRC curricular additions). Next, we investigate the change *within* treatment groups, measuring the difference between sense of belonging measured early vs. late in the academic term.
- **RQ3 How did SRC coursework affect students' self-reported learning of technical and "social technical" content?** To answer this question, we look at survey responses at the conclusion of treatment terms.
- **RQ4 What other factors impacted students' experiences in early CS courses?** Beyond academic factors, we would like to learn about other potential sources of difficulty in early CS courses. We asked students about the extent to which factors like in-class confusion, lack of confidence, and personal obligations interfered with their ability to learn or complete coursework.

[3]https://corgis-edu.github.io/corgis/ (Accessed March 20, 2025)

To answer the questions above, data was collected through surveys administered in participating courses over the 2022–2023 and 2023–2024 academic years. Over the course of the two-year study, surveys were modified as we learned lessons, considered new hypotheses, or sought more feedback. In the second year of our study (2023–2024 academic year), surveys were administered twice in each term—once Early in the term and once Late in the term. Table 2 summarizes the time points at which specific items appeared in administered surveys.

Table 2. Summary of survey questions and time points at which they appeared.

Questions	**Ref.**	**Appeared in**
Campus and course	–	All surveys
Race and gender	–	All surveys
Sense of belonging	Moudgalya et al. [44]	All surveys
Sources of student struggle	Salguero et al. [52]	Fall 2023 & Spring 2024 (late)
Prior computing experiences	Alvarado et al. [2]	Spring 2024 (early and late)
Communal goal endorsement	Henderson et al. [31]	Spring 2024 (late)
Attainment of learning objectives	Table 6	Spring 2024 (early and late)

The survey included questions mapped to each research question as well as general questions meant to help us put our results into context in terms of our student sample.

RQ1: Communal goal endorsement. We measured the strength of students' communal goal orientations using the item "How important to you are goals such as working with people, helping others, and serving the community?", used by Henderson et al. [31] in their study on goal congruity of STEM students. Responses ranged from 1 (*Extremely unimportant*) to 7 (*Extremely unimportant*). Since we only used the one question (discussed further as a limitation in §10.2), we cannot compute a reliability measure like Cronbach's alpha [16] for this construct. The question was included in the final survey we conducted, i.e., the Late survey in Spring 2024. As a result, we cannot say how communal goal endorsement *changed* during our study. Nevertheless, for the purposes of understanding our student sample, we report their communal goal endorsements as measured toward the end of the Spring 2024 term. Results are presented in §6.

RQ2: Change in sense of belonging. We used the 26-item scale validated by Moudgalya et al. [44] to measure students' sense of belonging in computing. The scale had high internal reliability, measured using Cronbach's alpha ($\alpha = 0.95$).[4] The scale contains subscales for the following constructs: *membership* (4 items, $\alpha = 0.95$), positive and negative feelings of *acceptance* (8 items, $\alpha = 0.89$), *affect* (4 items, $\alpha = 0.9$), *trust* in instructors or instructional materials (4 items, $\alpha = 0.77$), and *desire to fade*, i.e., to be inconspicuous (4 items, $\alpha = 0.83$).

As suggested by Moudgalya et al., we first conducted an exploratory factor analysis (EFA) to validate the items belonging to each construct. Results of the EFA suggested that an item for *affect*—*In this computer science class, I feel calm*—was cross-loading on both the *affect* and *acceptance positive* factors. We decided to remove this item and conducted a Confirmatory Factor Analysis (CFA) with the remaining 25 items according to the factor structure reported by Moudgalya et al. [44]. Our model indicators for the CFA were slightly lower than what they found: TLI = 0.850 (compared to

[4]Based on responses in our first offering of the survey in Fall 2022.

0.885); RMSEA = 0.098 (compared to 0.082). A new composite belonging score was computed using the factors scores resulting from the CFA. Scores for the new belonging measurement ranged from -3.49 to 1.83 and are used throughout the rest of this paper.

For this research question, we administered surveys such that we can report on differences between *control and treatment groups* as well as changes *within treatment groups*, measured by surveys at multiple time points. For our control and treatment analyses, Fall 2022 was treated as our Control group, i.e., no SRC-focused material was included in the studied courses. Spring 2023, Fall 2023, and Spring 2024 made up our Treatment group. All surveyed courses in the Treatment groups included some SRC-focused content.

We also analyzed change in belonging *within* an academic term that included SRC content. For this analysis, the Fall 2023 and Spring 2024 academic terms included multiple survey administrations per term: once Early in the term, and once Late in the term.

Results are presented separately for the between-terms analysis (§7.1) and the within-terms analysis (§7.2).

RQ3: Students' perceptions of their learning and agency. We used survey questions designed by our research team (see Table 6). In the Late surveys in the second year of our study (i.e., Fall 2023 and Spring 2024), students were asked to rate the degree to which their SRC and non-SRC assignments and projects supported their (a) technical computing knowledge, (b) ability to use CS to solve real-world problems, (c) ability to engage with and design a CS solution for a real community, and (d) individual agency and interests. Responses ranged from -2 (*Not at all*) to 2 (*A lot*) for all questions. Based on responses from the first occurrence of these questions (Fall 2023), this scale displayed good internal consistency, achieving a Cronbach's alpha of 0.89, as did the individual subscales pertaining to SRC assignments ($\alpha = 0.82$) and non-SRC assignments ($\alpha = 0.86$). We used paired hypothesis tests to check for differences in students' perceptions of the affordances of SRC vs non-SRC assignments. Details and results are presented in §8.

RQ4: Other sources of student struggle. We borrowed survey questions from Salguero et al. [52], who found that Black, Hispanic/Latino, Native American, and Pacific Islander students at UC San Diego were more likely than other students to report that *personal obligations* interfered with their learning in early CS courses.

In the second year of our study, we used sub-scales from Salguero et al.'s survey to learn about potential sources of struggle faced by our students. The survey asked the question *To what degree did each of the following interfere with your ability to learn or complete the work for this course?* and presented a number of items. Possible responses ranged from 1 (*Not at all*) to 5 (*Significantly*). Based on responses from the first occurrence of these questions, the scale achieved a Cronbach's alpha of 0.85. The items in the scale corresponded to the following factors: *lack of confidence* (3 items, $\alpha = 0.76$), *in-class confusion* (3 items, $\alpha = 0.82$), and *personal obligations* (5 items, $\alpha = 0.76$). The questions were included in the Late surveys in Fall 2023 and Spring 2024. They were not included in the Early surveys since they asked the students to reflect on how the past academic term had gone. We used hypothesis tests to check for differences in levels of interference with learning reported by Hispanic/Latino students and other students. Details and results are presented in §9.

Context-setting items. In addition to the survey items that directly mapped to our research questions, our survey included questions to help us gain context about the students' experiences. These questions asked about the student's campus, the course they were enrolled in, and their race/ethnicity, gender, and prior experiences with computing (the latter using questions from Alvarado et al. [2]).

With regards to race/ethnicity, as a research project focused on broadening participation in computing for Hispanic/Latino students our survey included the choices: *Hispanic/Latino*; *Black, African American, American Indian, Alaskan Native, Pacific Islander*; *Another race/ethnicity not listed* *above*; and *Prefer not to state*. Our project sought to strengthen the participation and improve retention of Hispanic/Latino students who have been historically under-represented in our institutions. Considering this, we code responses as being *Hispanic/Latino* or *not Hispanic/Latino*, where the *not* category includes all responses that did not select "Hispanic/Latino" in response to the question.

With regards to gender, our survey included the choices *Man*, *Woman*, *Nonbinary*, *Transgender*, *Agender*, and an open-ended option if the participant's gender was not listed. However, a very small percentage of responses (roughly 2% in each survey) selected anything other than *Man* or *Woman*. Despite efforts in broadening participation in computing, CS education has the second-lowest involvement of women of all engineering and science programs in the US [45]. Our vision of a broader and inclusive computing education involves supporting non-male individuals to participate and feel that they belong in computing. To this end, we use *Man* as the control group and code responses as identifying as *men* or an *underrepresented gender* (URG), where the *URG* category includes all responses that did not select "Man" in response to the question.

The following sections report results for each of our research questions.

6 RQ1: Communal goal endorsement

As mentioned in §2, one motivation for our work is to appeal to the expected stronger communal goal orientation among students from marginalized communities. Students' sense of belonging is positively related with the alignment between their communal goal endorsements and their perception of their academic disciplines as allowing them to meet those goals [9, 20, 31, 40]. Therefore, we begin by exploring the strength of our students' communal goal endorsements.

Recall that a question about communal goal endorsement appeared in the Late survey in Spring 2024. Respondent demographics for that survey can be seen in Table 3. A total of 341 participants completed this survey with an answer to the question about communal goal endorsement.

Table 3. Survey demographics in the Spring 2024 late-term survey, which included a question about communal goal endorsement. Percentages in the **Total** column are based on **Race/Ethnicity** totals, e.g., 38% of all respondents identified as Hispanic/Latino.

Race/Ethnicity	**Gender**		**Total**
(Check all that apply)	**Men**	**URG**	
Hispanic/Latino	101 (78%)	28 (22%)	129 (38%)
Black, African American, American Indian, or Alaskan Native	19 (82%)	4 (18%)	23 (7%)
Another race not listed here	113 (67%)	56 (33%)	169 (49%)
Prefer not to state	10 (50%)	10 (50%)	20 (6%)
Total	**243**	**98**	**341**

Students in general reported a strong communal goal endorsement (mean ($\bar{x}$)=5.16, standard dev. (s)=1.44, median (M)=5 out of 7).

We did not observe a significant difference in communal goal endorsement between students who identified as Hispanic/Latino ($\bar{x} = 5.23, s = 1.31, M = 5$) and those who did not ($\bar{x} = 5.11, s = 1.52, M = 5$). Given the non-normal distribution of responses (Shapiro-Wilk test [53], $W = 0.91, p < 0.001$) and unequal variances between the two groups (Levene's test [11]; $W = 4.26, p = 0.04$), we used Welch's unequal variances t-test [61] to check for a difference in communal goal endorsements between the two groups. The test did not reveal a statistically significant difference ($t = 0.75, p = 0.45$). This is a deviation from previous findings [40].

We did observe that men were likely to report a significantly lower communal goal endorsement ($\bar{x} = 5.06, s = 1.42, M = 5$) than URG students ($\bar{x} = 5.42, s = 1.48, M = 5$). After confirming that responses from the two groups were homoscedastic (Levene's test; $W = 0.26, p = 0.61$), a Mann-Whitney U test [43] showed that the difference was statistically significant ($U = 9142.5, p = 0.01$). This is in keeping with previously reported results [9, 20, 31, 40].

A two-way analysis of variance did not suggest any significant interaction between the race and gender variables regarding their association with communal goal endorsement. We did, however, observe that non-male students who identified as Hispanic/Latino reported the highest median communal goal endorsements out of all groups at the intersection of race and gender.

Overall, our unexpected takeaway here is that targeting students' communal goal endorsements may not specifically impact Hispanic/Latino students in particular. However, it may have positive impacts in general, since the students overall appeared to find communal goals to be important.

7 RQ2: Sense of belonging

We now turn to investigating how our students' sense of belonging changed with the introduction of SRC curricular elements. We used surveys to measure differences students' sense of belonging *between* and *within* academic terms (see §5). Results from both analyses—between courses in the Control and Treatment groups, and within courses in the Treatment group—are presented below. As expected from our varied contexts (§3), results varied for different campuses.

7.1 Control vs. Treatment Academic Terms

To reiterate, Fall 2022 was a Control group, since it had no SRC content added. Spring 2023, Fall 2023, and Spring 2024 made up our Treatment group, all including some SRC content.

All courses in this analysis were first-year courses (either CS 0 or CS 1 at each campus). A given course was included only if it produced 20 or more responses in the Control group *and* Treatment group. (For those Treatment courses that included surveys at multiple time points, only the Late surveys were considered, to facilitate comparison with the survey that was taken at a similar time point in the Control group.) Fullerton was excluded from this analysis as a result of this filtering step—due to teaching assignments of the participating faculty, no course at that campus was given the survey in both the Control group and Treatment group. However, the resulting analysis still includes 277 students in the Control group and 418 students in the Treatment group, across the 5 remaining campuses.

Changes (or lack thereof) in sense of belonging for each of the remaining campuses are depicted in Figure 1. Increases in median sense of belonging are visually apparent for the DH, LA, and SF campuses (Figure 1 left). Recall that these are the campuses with *higher acceptance rates* and *no competitive CS enrollment policy*, and, with the exception of SF, *a larger percentage of CS majors who are Hispanic/Latino* (Table 1). Students at these campuses appeared to experience an increase in their sense of belonging with the introduction of SRC coursework in the Treatment terms.

We used hypothesis testing to confirm this visual inspection statistically (Table 4). We used four non-parametric Mann-Whitney U [43] tests for differences in sense of belonging between Control and Treatment groups: one test for the campuses *without* competitive enrollment policies, one test for the campuses *with* competitive enrollment policies, and an additional test each looking only at students identifying as Hispanic/Latino in each group. A Bonferroni correction [6] was applied to account for the four comparisons, and significance of the adjusted p-values was decided at $\alpha = 0.05$.

For the campuses with *higher acceptance rates* and *no competitive CS enrollment policy* (DH, LA, and SF), we observed a **statistically significant increase in students' sense of belonging**

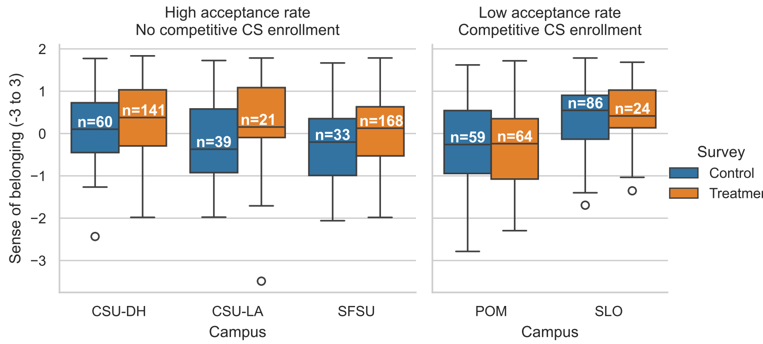

Fig. 1. Changes in sense of belonging from control to treatment terms varied by campus. Numbers printed within each box indicate the number of responses to that survey from that campus.

Table 4. Results from a series of Mann-Whitney *U* tests for differences in sense of belonging between Control and Treatment terms (§7.1). Reported p-values reflect adjustments using a Bonferroni correction.

Competitive CS Enrollment?	**Students**	***U***	***p***	**N (Control, Treatment)**
No	All	17921	0.0117	132, 330
	Hispanic/Latino	4417	0.0162	74, 156
Yes	All	7395	0.1679	145, 88
	Hispanic/Latino	582	0.9048	49, 20

between the Control and Treatment groups, with a median increase from -0.13 in the Control term to 0.22 in the Treatment groups. This increase was slightly more pronounced for Hispanic/Latino students at these campuses (median increase from -0.13 in the Control term to 0.29 in the Treatment terms).

For the campuses with *lower acceptance rates* and *competitive CS enrollment policies* (*Pomona* and *SLO*), the test revealed no significant difference in students' sense of belonging between Control and Treatment groups. There was also no significant difference when we considered only the students identifying as Hispanic/Latino.

7.2 Within Treatment Academic Terms

In Fall 2023 and Spring 2024, surveys were administered twice in each academic term—once Early in the term and once Late in the term. We omitted course sections from this analysis that included fewer than 20 responses in either Early or Late term survey responses. Following this, we were left with responses from multiple course types, i.e., introductory CS (CS 0 or CS 1), and slightly more advanced second-year courses (CS 2). Therefore, this section presents results for each course type separately. Again, we grouped campuses by whether or not they have a competitive CS enrollment policy.

Since our surveys were anonymous, responses were not attributed to specific individuals. As a result, although some students took both the Early and Late surveys, we are unable to treat the Early and Late survey responses as paired samples, since we cannot say which response belongs to

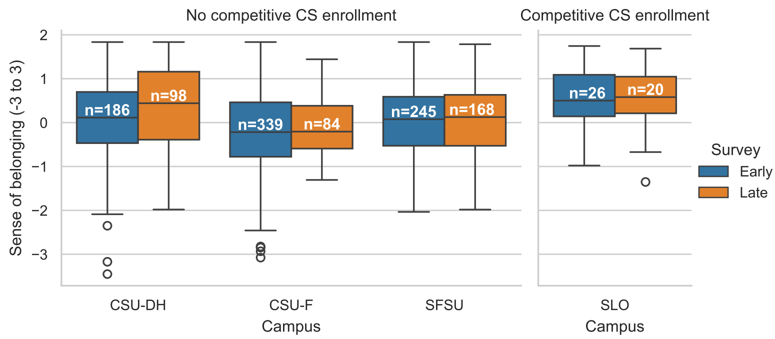

Fig. 2. Sense of belonging in CS 0 or CS 1 courses, in Early-term surveys (taken around week 3) and Late-term surveys (taken around 2 weeks before the end of the term).

which students. We therefore use the unpaired Mann-Whitney U test to check for differences in reported sense of belonging Early in the term versus Late in the term.

For CS 0 and CS 1 courses, results largely mirrored what we saw in the Control/Treatment analysis presented in §7.1. We ran three Mann-Whitney U tests to test for differences in sense of belonging between Early and Late surveys for the following groups:

- All students at the campuses *without* competitive CS enrollment policies.
- Hispanic/Latino students at the campuses *without* competitive CS enrollment policies.
- All students at the campuses *with* competitive CS enrollment policies.

We did not conduct a hypothesis test for students identifying as Hispanic/Latino at campuses *with* competitive CS enrollment since only 8 such students took the Early survey, and 7 took the Late survey. LA and *Pomona* are not present in this analysis because no CS 0 or CS 1 section at those campuses produced 20 or more responses in both the Early and Late survey, thus precluding comparisons. Bonferroni corrections were applied to account for the three comparisons, and adjusted p-value significance was decided at $\alpha = 0.05$.

Table 5. Results from a series of Mann-Whitney U tests for differences in sense of belonging between Early and Late surveys in CS 0 and CS 1 courses (§7.2). Reported p-values reflect adjustments using a Bonferroni correction.

Competitive CS Enrollment?	**Students**	***U***	***p***	**N (Early, Late)**
No	All	122399.5	0.0415	805, 370
	Hispanic/Latino	21826.5	0.0346	342, 149
Yes	All	247	1.000	26, 21
	Hispanic/Latino	*Not enough data*		7, 8

Hypothesis testing results are summarized in Table 5 and distributions of belonging scores for each campus can be seen in Figure 2. For the campuses *without a competitive CS enrollment policy* (DH, Fullerton, SF), hypothesis testing revealed a **statistically significant increase in sense of belonging** between Early and Late term surveys, for all students as well as for Hispanic/Latino students in particular. Inspecting the distributions in Figure 2 suggests that students at DH experienced much of this increase. For the campus *with* a competitive enrollment policy (*SLO*), there was no significant change in sense of belonging.

For CS 2 courses, we did not see a change in sense of belonging between Early and Late surveys for any group of campuses.

8 RQ3: Impact on student perceptions of their learning

We considered the impact of our intervention on students' self-perceived academic skills in terms of traditionally valued technical content as well as social-technical skills related to communication with community members and contextualizing computing in a larger social context. Survey items about these constructs appeared in the second year of our study, i.e., Fall 2023 and Spring 2024. Results are summarised in Table 6.

Table 6. Student perceptions of their learning and agency for treatment terms Fall 2023 and Spring 2024.

	CS 0 or CS 1 (n=304)			**CS 2 (n=267)**		
To what degree do your assignments or projects help you do the following?	**Non-SRC**	**SRC**	**Diff.**	**Non-SRC**	**SRC**	**Diff.**
Develop technical vocabulary (e.g., knowing words like "conditional statements" or "loop")	1.24	1.54	$t = 506$ $p < 0.0118$	1.23	1.26	$t = 393$ $p = 1.000$
Develop programming skills (e.g., writing and reading code)	1.27	1.54	$t = 395$ $p = 0.0375$	1.19	1.37	$t = 368.5$ $p = 0.2669$
Understand how CS can help solve concerns in society	0.87	1.43	$t = 215.5$ $p < 0.0001$	0.62	1.22	$t = 173.5$ $p < 0.0001$
Use real-world data to solve CS problems	0.80	1.34	$t = 579.0$ $p = 0.0001$	0.41	1.13	$t = 141$ $p < 0.0001$
Communicate with people (outside of your class) in a real community about their concerns and explain how CS can help solve them	0.37	0.68	$t = 1069.5$ $p = 1.000$	0.12	0.54	$t = 189.5$ $p = 0.0127$
Design a CS solution for a real community	0.46	0.88	$t = 602$ $p = 0.0142$	0.17	0.78	$t = 148.5$ $p < 0.0001$
Use CS to solve problems you find interesting	0.94	1.14	$t = 677$ $p = 1.000$	0.71	0.86	$t = 334$ $p = 0.1609$
Give you choice in what to focus on or how to approach the assignments	0.86	1.08	$t = 607$ $p = 0.3626$	0.67	0.93	$t = 410$ $p = 1.000$

Diff. columns report p-values and test statistics for paired t-tests for differences between SRC and Non-SRC assignments. All p-values reflect adjustments with a Bonferroni correction, and cells highlighted in gray indicate that a significant difference was observed.

For each question in Table 6, we ran a hypothesis test to check for differences in student perceptions of the support offered by each type of assignment—similar to the analysis in §7, we did this separately for first-year courses (CS 0 and CS 1 courses) and CS 2 courses. A Bonferroni correction was applied within each course's family of tests to control the familywise error rate, and significance of the adjusted p-values was decided at $\alpha = 0.05$. We employed the Wilcoxon Signed Rank test [14], a non-parametric paired t-test, since the samples were not normally distributed and SRC and non-SRC responses came from the same individuals.

In both groups of courses, students felt that SRC assignments, to a greater degree than non-SRC assignments, helped them understand how they could use CS to address societal concerns, work with real communities to design computational solutions, and design a CS solution for a real community. In the earlier courses (CS 0 and CS 1), students also felt that SRC assignments better supported their learning of technical CS content, and in later courses (CS 2), students felt that SRC assignments better prepared them to communicate with people outside of their classes about concerns and how CS might address them.

For the most part, results were similar when looking at the perceptions of only those students who identified as Hispanic/Latino, i.e., **they felt that SRC assignments better supported their learning and agency than non-SRC assignments**. In the earlier courses, Hispanic/Latino students ($n = 132$) felt that SRC coursework helped them develop technical vocabulary ($t = 506, p_{adj.} = 0.0118$) and programming skills ($t = 395, p_{adj.} = 0.0376$), and to understand how CS can help address concerns in society ($t = 215.5, p_{adj.} < 0.0001$), use real-world data to solve CS problems ($t = 579, p_{adj.} = 0.0003$), and design CS solutions for real communities ($t = 602, p_{adj.} = 0.0142$). In the CS 2 course, Hispanic/Latino students ($n = 97$) felt that SRC coursework helped them understand how to use CS to solve concerns in society ($t = 173.5, p_{adj.} < 0.0001$), use real-world data to solve CS problems ($t = 141, p_{adj.} < 0.0001$), communicate with communities about CS solutions ($t = 189.5, p_{adj.} = 0.0127$), and design CS solutions for real communities ($t = 148.5, p_{adj.} < 0.0001$). Similar to overall results, in neither course did students identifying as Hispanic/Latino express the increased freedom of choice that was felt by the overall student sample with SRC assignments.

While these results are based on student responses about their perception of their learning, prior evaluations of courses developed as part of this work have shown that external measurements of learning outcomes (grades; success in follow-on courses) were also not sacrificed when incorporating socially responsible computing into early computing courses, and indeed showed some improvements [35].

9 RQ4: Other sources of student struggle

We sought to learn about sources of struggle for our students in early CS courses, building on past work from Salguero et al. [52]. Our overall results are summarized in Figure 3. We conducted three Mann-Whitney U tests to test for differences in reported levels of interference from *lack of confidence*, *in-class confusion*, and *personal obligations* for students who identified as Hispanic/Latino and those who did not. A Bonferroni correction was applied to account for the three comparisons. A Mann-Whitney U test suggested that reported levels of interference from *Personal obligations* were not any different for our Hispanic/Latino students than other students ($U = 70798.5, p_{adj.} = 0.05$). Hispanic/Latino students did *not* report different levels of interference from in-class confusion or a lack of confidence than other students.

As described by Salguero et al. [52], the composite factor *Personal obligations* includes the items *requirements for other classes*; *illness*; *family obligations*; *work obligations*; and *social/personal obligations*. In addition to averaging the items into a single factor like Salguero et al. [52], we unpacked the factor further to learn *which* personal obligations appeared to affect our students most.

For each of the five items within the *Personal obligations* factor, we conducted a hypothesis test to check for differences between students who identified as Hispanic/Latino and those who

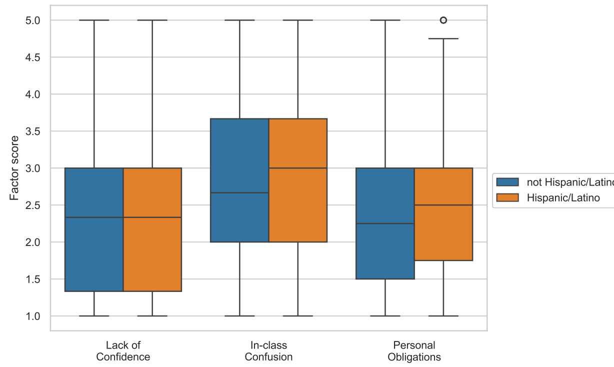

Fig. 3. Responses to questions about sources of struggle in CS courses, for students who identified as Hispanic/Latino and those who did not. Responses for each factor—*Lack of confidence*, *In-class confusion*, and *Personal obligations*—were obtained by averaging the items associated with that factor. $n = 729$, 37% Hispanic/Latino.

did not. Bonferroni corrections were applied to account for the five comparisons. We found that Hispanic/Latino students reported significantly higher levels of *family obligations* (Mann-Whitney U-test; $U = 71083.5, p_{adj.} = 0.0192$) and *work obligations* (Welch's unequal variances t-test; $t = 3.4885, p_{adj.} = 0.0026$).

We did not observe this effect when the analysis was limited to the more restrictive campuses with competitive enrollment policies—for all factors, there were no differences in levels of reported interference from Hispanic/Latino students and other students.

10 Final remarks

In this section, we discuss the implications of our findings and threats to the validity of our results. We close by considering some lessons learned and directions for future work.

10.1 Discussion of results

In general, we saw positive results at the campuses *without* competitive CS enrollment policies. All of these campuses are designated as Hispanic-Serving Institutions, have relatively high attrition rates for "URM"-designated students (including Hispanic/Latino students), and two of them (DH and LA) have high percentages of CS majors who identify as Hispanic/Latino. All of this suggests that our curricular interventions are having positive impacts. The following sections discuss implications or explanations for each of our research questions' results.

10.1.1 RQ1. Communal goal endorsements. Communal goal endorsements were relatively high for all our students, and URG students reported significantly higher communal goal endorsements than men. Prior research has reported that students of color (including Hispanic/Latino students) and women tend to report higher communal goal endorsements than White students and men (e.g., [10, 19, 40]). When considering factors that impact historically marginalized students' sense of belonging in computing (such as strength of communal goal endorsement [40]), students of color and women are sometimes considered together with shared characteristics as a minoritized group. These types of simplifications can be problematic, glossing over important specific challenges faced by subgroups with intersectional identities [51]. Our findings further the argument that a one-size-fits-all approach to promoting a sense of belonging among all groups who have been historically marginalized in computing is an over-simplified solution.

Illustrating the importance of considering intersectional identities, we observed that URG Hispanic/Latino students reported the highest median communal goal endorsement compared to other groups at the intersection of race and gender. Given the broad appeal to all students, we propose that attending to this orientation is likely to be a fruitful strategy for strengthening students' senses that they belong in computing.

10.1.2 RQ2. Sense of belonging. We saw improvements in students' sense of belonging in computing when our institutions embraced an intervention to include intentionally-designed socially responsible computing assignments in early computing courses (§7). In particular, these improvements were present and statistically significant for students in the CS programs with inclusive selection criteria and large Hispanic/Latino populations. This increase in sense of belonging at our most inclusive institutions was also statistically significant for Hispanic/Latino students in particular.

We were at first surprised by the relative stability of student sense of belonging at the two institutions with competitive enrollment policies (*Pomona* and *SLO*). However, considering that students at those two institutions have been through significant filtering criteria like AP courses and scores and university GPA requirements,[5] it is perhaps unsurprising sense that they have a relatively stable sense of self in the computing discipline. This phenomenon of populations forming subgroups with starkly different self-identity profiles has been observed in other STEM contexts [64]. Nguyen and Lewis [46] found that first-year students in CS departments with competitive enrollment policies tend to report a lower sense of belonging in computing. We observed both this and the opposite (see Figure 1)—at one institution with competitive CS enrollment (*Pomona*), we observed an average *lower* sense of belonging than other institutions, while at the other institution with competitive CS enrollment (*SLO*), we observed a *higher* sense of belonging than other institutions. However, for students at both institutions, sense of belonging appeared to be relatively stable.

This interaction between institutional contexts and malleability of sense of belonging in a discipline ought be studied further. Would results from prior research on recruitment and retention of Hispanic/Latino students or underrepresented students look different if such studies were replicated at institutions with different demographics and enrollment policies? Future work may want to run such replication studies to confirm prior findings or add context to these findings. Results from these studies will better guide us in developing appropriate interventions to ensure Hispanic/Latino and underrepresented students' success.

Overall, we view it as a success that students at our least restrictive institutions (in most cases, with large Hispanic/Latino populations) appeared to have experienced positive outcomes from our curricular interventions.

Our findings also replicated prior results that show that men tend to report a higher sense of belonging in computing than other students. In our study, when considering the Late surveys in Fall 2023 and Spring 2024, a Mann-Whitney U test indicated that sense of belonging was significantly higher for men than it was for students not identifying as men ($U = 62478.5, p = 0.021$). Similarly, we observed that a higher sense of belonging correlated with the intention to enroll in a follow-on computing course. Kruskal-Wallis H tests showed that there was a statistically significant difference in sense of belonging by level of interest in taking future CS courses ($H = 97.23, p < 0.0001$) and, for those who were so declared, intention to remain in the CS major or minor ($H = 129.10, p < 0.0001$). Interest in future CS coursework was, as expected, higher as belonging scores increased.

[5]Which parallel, in many cases, filters based on household incomes and race.

10.1.3 RQ3. Student perceptions of their learning. We found that in general, students felt that SRC assignments helped them develop skills to use computing to address societal concerns, work with real communities, and exercise more choice in how they approached coursework (§8). Students' views on benefits to their learning of technical content were mixed—they reported higher perceived benefits in earlier courses (CS 0 and CS 1), but no difference CS 2. It is likely that CS 2 students' self-assessed command of "technical vocabulary" and "programming skills" were sufficiently advanced already.

With regards to the learning of technical CS content, while we report students' self-assessments of their learning, our previous work suggests that learning of programming was not hindered by the introduction of SRC material [35].

10.1.4 RQ4. Other sources of student struggle. Finally, we observed that students identifying as Hispanic/Latino were more likely than other students to report that work and family obligations interfered with their learning in early CS courses (§7). This effect was primarily observed at the less restrictive campuses with high acceptance rates and no competitive enrollment policies. This result underscores the need for future work to examine the role that pedagogical choices (beyond curriculum) play in the student experience and particularly its impact on broadening participation and improving retention and student success. Examples of such choices include flexible due dates, dropped lowest scores, and other measures that allow students the flexibility needed to achieve a course's learning objectives while managing work or family obligations.

It is worth noting that our restrictive campuses also serve students who transfer to our institutions in their third years after completing introductory coursework at a community college. This transfer student population tends to have a higher percentage of Hispanic/Latino students, many of whom have not had prior computing experiences in secondary school. It is possible that the interventions described in this paper would have the same positive impacts reported here for their early computing courses at a four year institution; however, our current focus has been in CS courses in the first two years of a four year degree.

10.2 Threats to validity

In this section we acknowledge limitations and threats to validity, and describe mitigations where appropriate.

10.2.1 Instrument validity. For the most part, our surveys used scales that have been validated and used in previous computing education research studies with students similar to ours (post-secondary first-year students at public universities). The one exception to this is the scale used to measure students' self-perceptions of their experiences (Table 6). As reported in our methodology (§5), the scale had good internal consistency. Therefore, we have reason to believe that our study has generally high instrument validity.

We reported on measurements of students' communal goal endorsements using a single question from Henderson et al. [31] (see §5). Given that the question was added to an already-large survey, and that participants were being surveyed at multiple time points, we were wary of inducing survey fatigue. Henderson et al. reported similar concerns, so following their example we opted to use a single communal-coded question. We acknowledge that this measure would be made stronger with an accompanying agentic-coded question—this has now been added for future iterations of the survey.

10.2.2 Internal validity. We used statistical tests to study students' experiences, perceptions, and priorities. Each such test carries with it some risk of Type I error, i.e., the risk of a false positive conclusion. To mitigate this, we used Bonferroni corrections throughout to control the error rate when conducting families of statistical tests.

It is possible that the changes we have observed were a result of factors beyond our curricular interventions. Students' perceptions of computing and themselves are naturally influenced by forces within and without the classroom. Our experimental design (control and treatment groups and, in the case of RQ2, surveys at multiple time points) helps to mitigate this threat.

In RQ1, we saw that communal goal endorsements trended relatively high for our student sample. The measurement took place at the end of the Spring 2024 term, which included SRC-focused content. It is possible that communal goal endorsements were not originally high for our students on average, but rather *increased* as a result of our intervention. We cannot say for sure since we did not think to measure communal goal endorsements in earlier surveys.

10.2.3 External validity. Our work was conducted at six campuses in California that varied in a number of dimensions (Table 1). As such, our study constitutes a conceptual replication of results that were observed at multiple participating campuses, as well as results that have been observed and reported from other institutions. Of key importance are the results that were *not* observed at all campuses, allowing us to gird our findings with contextual information pertinent to each research question.

10.2.4 Ecological validity. Our study protocol required informed consent from students before they could provide survey responses. As a result, students were made aware of the high-level goals of our work and the fact that they were learning from an "experimental" curriculum. This could have affected their responses to survey questions related to the SRC assignments in particular.

Another potential threat to ecological validity is that in January 2024, faculty at all six campuses (as well as all other campuses in the CSU) withheld labor and went on organized strike. This involved cancelling classes and not doing related tasks like grading or responding to email and online class forums. Though the strike lasted one day, students and faculty were aware of the planned action from the beginning of the term. We are unsure how this would affect results, except to say that it was certainly a departure from the "normal" learning environment.

10.3 Future work

Addressing the diverse needs of students calls for structural changes within educational institutions. We plan to extend this work to more deeply understand our individual sites' student needs. Specifically, we aim to develop a more robust model of student profiles to understand the journeys experienced by our students in their early computing courses. For example, we saw that Hispanic/Latino students were more likely to report that work or family obligations interfered with their learning (§9). We will focus on how students' obligations interact with faculties' perspectives and pedagogical choices to create more or less inclusive environments. We will build on existing scholarly work on inclusive climates that suggests that policies like equitable grading using flexible deadlines [58], using more low-stakes assessments as opposed to fewer high-stakes ones, and allowing re-submissions to demonstrate mastery [8, 18] lead to more equitable course outcomes for students. We intend to lean into these strategies and, as we have done in this paper, understand the impacts for students in varying institutional contexts. One immediate question is how the effect of our curricular intervention would be mediated by pedagogical policies related to deadlines, grading, and classroom practices.

Our work also included a faculty learning community that ran monthly for the duration of our two-year study. Participants (that is, faculty whose courses are represented in this research) learned about assets-based pedagogical frameworks and culturally relevant pedagogy, and had access to like-minded faculty who were trying to make similar improvements to their computing courses.

We aim to study the extent to which faculty participation in this learning community translated into impacts on sense of belonging, learning, and agency for students.

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References

[1] Amy Allen. 2005. Feminist perspectives on power. https://plato.stanford.edu/entries/feminist-power/.
[2] Christine Alvarado, Gustavo Umbelino, and Mia Minnes. 2018. The persistent effect of pre-college computing experience on college CS course grades. *ACM Inroads* 9, 2 (April 2018), 58–64. https://doi.org/10.1145/3210551
[3] AJ Alvero, Sonia Giebel, and II Pearman, Francis A. 2024. Income and campus application disparities among European and non-European heritage Hispanic undergraduate applicants. *PNAS Nexus* 3, 9 (08 2024), pgae337. https://doi.org/10.1093/pnasnexus/pgae337 arXiv:https://academic.oup.com/pnasnexus/article-pdf/3/9/pgae337/59196281/pgae337.pdf
[4] Austin Cory Bart, Ryan Whitcomb, Dennis Kafura, Clifford A. Shaffer, and Eli Tilevich. 2017. Computing with CORGIS: Diverse, Real-world Datasets for Introductory Computing. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*. ACM, Seattle Washington USA, 57–62. https://doi.org/10.1145/3017680.3017708
[5] Aimee L. Belanger, Mansi P. Joshi, Melissa A. Fuesting, Erica S. Weisgram, Heather M. Claypool, and Amanda B. Diekman. 2020. Putting Belonging in Context: Communal Affordances Signal Belonging in STEM. *Personality and Social Psychology Bulletin* 46, 8 (2020), 1186–1204. https://doi.org/10.1177/0146167219897181 arXiv:https://doi.org/10.1177/0146167219897181 PMID: 31928327.
[6] Yoav Benjamini and Yosef Hochberg. 1995. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal statistical society: series B (Methodological)* 57, 1 (1995), 289–300.
[7] Zachary Bleemer and Aashish Mehta. 2024. *College Major Restrictions and Student Stratification*. Working Paper 33269. National Bureau of Economic Research. https://doi.org/10.3386/w33269
[8] BENJAMIN S. BLOOM. 1984. The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring. *Educational Researcher* 13, 6 (1984), 4–16. https://doi.org/10.3102/0013189X013006004 arXiv:https://doi.org/10.3102/0013189X013006004
[9] Bo Brinkman and Amanda Diekman. 2016. Applying the Communal Goal Congruity Perspective to Enhance Diversity and Inclusion in Undergraduate Computing Degrees. In *Proceedings of the 47th ACM Technical Symposium on Computing Science Education (SIGCSE '16)*. ACM. https://doi.org/10.1145/2839509.2844562
[10] Bo Brinkman and Amanda Diekman. 2016. Applying the communal goal congruity perspective to enhance diversity and inclusion in undergraduate computing degrees. In *Proceedings of the 47th ACM technical symposium on computing science education*. 102–107.
[11] Morton B. Brown and Alan B. Forsythe. 1974. Robust Tests for the Equality of Variances. *J. Amer. Statist. Assoc.* 69, 346 (June 1974), 364–367. https://doi.org/10.1080/01621459.1974.10482955
[12] Jennifer Campbell, Jacqueline Smith, and Emily Greenleaf. 2025. Exploring Sense of Belonging for CS Majors with Direct vs Competitive Admission Pathways. In *Proceedings of the 56th ACM Technical Symposium on Computer Science Education V. 1* (Pittsburgh, PA, USA) *(SIGCSETS 2025)*. Association for Computing Machinery, New York, NY, USA, 199–205. https://doi.org/10.1145/3641554.3701822
[13] Lena Cohen, Heila Precel, Harold Triedman, and Kathi Fisler. 2021. A new model for weaving responsible computing into courses across the CS curriculum. In *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*.
[14] WJ Conover. 1999. *Practical nonparametric statistics*. John Wiley & Sons, Inc.
[15] KW Crenshaw. 1989. Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine (pp. 139–168). In *University of Chicago legal forum*.
[16] Lee J. Cronbach. 1951. Coefficient Alpha and the Internal Structure of Tests. *Psychometrika* 16, 3 (Sept. 1951), 297–334. https://doi.org/10.1007/bf02310555
[17] Kalisha Davis, Shana V. White, Dinah Becton-Consuegra, and Allison Scott. 2021. *Culturally Responsive-Sustaining Computer Science Education: A Framework*. Technical Report. Kapor Center. https://www.kaporcenter.org/equitablecs/
[18] Adrienne Decker, Stephen H. Edwards, Brian M. McSkimming, Bob Edmison, Audrey Rorrer, and Manuel A. Pérez Quiñones. 2024. Transforming Grading Practices in the Computing Education Community. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1* (Portland, OR, USA) *(SIGCSE 2024)*. Association for

Computing Machinery, New York, NY, USA, 276–282. https://doi.org/10.1145/3626252.3630953

[19] A. B. Diekman, E. K. Clark, A. M. Johnston, E. R. Brown, and M. Steinberg. 2011. Malleability in communal goals and beliefs influences attraction to stem careers: Evidence for a goal congruity perspective. *Journal of Personality and Social Psychology, 101(5), 902–918. https://doi.org/10.1037/a0025199* (2011).

[20] Amanda B. Diekman, Mia Steinberg, Elizabeth R. Brown, Aimee L. Belanger, and Emily K. Clark. 2016. A Goal Congruity Model of Role Entry, Engagement, and Exit: Understanding Communal Goal Processes in STEM Gender Gaps. *Personality and Social Psychology Review* 21, 2 (April 2016), 142–175. https://doi.org/10.1177/1088868316642141

[21] Antonio Duran and Anne-Marie Núñez. 2021. Food and Housing Insecurity for Latinx/a/o College Students: Advancing an Intersectional Research Agenda. *Journal of Hispanic higher education* 20, 2 (2021), 134–148.

[22] Mica Estrada, Myra Burnett, Andrew G. Campbell, Patricia B. Campbell, Wilfred F. Denetclaw, Carlos G. Gutiérrez, Sylvia Hurtado, Gilbert H. John, John Matsui, Richard McGee, Camellia Moses Okpodu, T. Joan Robinson, Michael F. Summers, Maggie Werner-Washburne, and MariaElena Zavala. 2017. Improving Underrepresented Minority Student Persistence in STEM. In *CBE—Life Sciences Education*.

[23] M. Estrada, A. Eroy-Reveles, and J. Matsui. 2018. The Influence of Affirming Kindness and Community on Broadening Participation in STEM Career Pathways. In *Social Issues and Policy Review*.

[24] J. Flapan and J Margolis. 2019. *Plugging Into Power: What Communities Can Do to Democratize Computer Science Education: "Mobilizing Communities for Leadership in the High Tech Sector in the Los Angeles Region: Transforming Schools and Neighborhoods Through Digital Inclusion."*. Technical Report. UCLA Center for Transformation of School Conference.

[25] Gina A. Garcia, Anne-Marie Núñez, and Vanessa A. Sansone. 2019. Toward a Multidimensional Conceptual Framework for Understanding "Servingness" in Hispanic-Serving Institutions: A Synthesis of the Research. *Review of Educational Research* 89, 5 (2019), 745–784. https://doi.org/10.3102/0034654319864591 arXiv:https://doi.org/10.3102/0034654319864591

[26] Aakash Gautam, Anagha Kulkarni, Sarah Hug, Jane Lehr, and Ilmi Yoon. 2024. Socially Responsible Computing in an Introductory Course. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1* (Portland, OR, USA) *(SIGCSE 2024)*. Association for Computing Machinery, New York, NY, USA, 373–379. https://doi.org/10.1145/3626252.3630926

[27] Geneva Gay. 2002. Preparing for Culturally Responsive Teaching. *Journal of Teacher Education* 53, 2 (March 2002), 106–116. https://doi.org/10.1177/0022487102053002003

[28] Geneva Gay. 2018. *Culturally responsive teaching: Theory, research, and practice.* teachers college press.

[29] Carol Goodenow. 1993. The psychological sense of school membership among adolescents: Scale development and educational correlates. *Psychology in the Schools* 30, 1 (1993), 79–90. https://doi.org/10.1002/1520-6807(199301)30:1<79::AID-PITS2310300113>3.0.CO;2-X arXiv:https://onlinelibrary.wiley.com/doi/pdf/10.1002/1520-6807%28199301%2930%3A1%3C79%3A%3AAID-PITS2310300113%3E3.0.CO%3B2-X

[30] Mark Guzdial. 2016. *Learner-Centered Design of Computing Education: Research on Computing for Everyone.* Springer International Publishing. https://doi.org/10.1007/978-3-031-02216-6

[31] Heather L. Henderson, Brittany Bloodhart, Amanda S. Adams, Rebecca T. Barnes, Melissa Burt, Sandra Clinton, Elaine Godfrey, Ilana Pollack, Emily V. Fischer, and Paul R. Hernandez. 2022. Seeking congruity for communal and agentic goals: a longitudinal examination of U.S. college women's persistence in STEM. *Social Psychology of Education* 25, 2–3 (May 2022), 649–674. https://doi.org/10.1007/s11218-021-09679-y

[32] S. Hurtado and D. F. Carter. 1997. Effects of college transition and perceptions of the campus racial climate on Latino college students' sense of belonging. In *Sociology of education*.

[33] Paul Salvador Inventado and Joshua Caleb Dy. 2024. Exploring the Effects of a Collaborative Guided Inquiry Learning Approach on Performance and Retention of Underrepresented Minority Students across Multiple Sections in an Introductory Programming Course. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1*. 554–561.

[34] Michael J Johnson, Francisco Enrique Vicente Castro, Betsy DiSalvo, and Kayla DesPortes. 2023. Chronicles of Exploration: Examining the Materiality of Computational Artifacts. In *Proceedings of the 2023 ACM Conference on International Computing Education Research - Volume 1* (Chicago, IL, USA) *(ICER '23)*. Association for Computing Machinery, New York, NY, USA, 29–47. https://doi.org/10.1145/3568813.3600132

[35] Ayaan M. Kazerouni, Jane Lehr, and Zoë Wood. 2024. Community Action Computing: A Data-centric CS0 Course. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1* (Portland, OR, USA) *(SIGCSE 2024)*. Association for Computing Machinery, New York, NY, USA, 646–652. https://doi.org/10.1145/3626252.3630807

[36] Sonia Koshi, Laura Hinton, Lisa Cruz, Allison Scott, and Julie Flapan. 2021. The California Computer Science Access Report. (2021). https://csforca.org/wp-content/uploads/2021/09/KC21007_CS-for-CA_9-28-21-1.pdf

[37] Shriram Krishnamurthi and Kathi Fisler. 2020. Data-centricity: a challenge and opportunity for computing education. *Commun. ACM* 63, 8 (July 2020), 24–26. https://doi.org/10.1145/3408056

[38] Gloria Ladson-Billings. 1995. Toward a theory of culturally relevant pedagogy. *American educational research journal* 32, 3 (1995), 465–491.
[39] T. Lamont Strayhorn. 2008. Sentido de pertenencia: A hierarchical analysis predicting sense of belonging among Latino college students. In *Journal of Hispanic Higher Education*. 301–320.
[40] Colleen Lewis, Paul Bruno, Jonathan Raygoza, and Julia Wang. 2019. Alignment of Goals and Perceptions of Computing Predicts Students' Sense of Belonging in Computing. In *Proceedings of the 2019 ACM Conference on International Computing Education Research*. ACM, Toronto ON Canada, 11–19. https://doi.org/10.1145/3291279.3339426
[41] Colleen M. Lewis. 2017. *Good (and Bad) Reasons to Teach All Students Computer Science*. Springer International Publishing, 15–34. https://doi.org/10.1007/978-3-319-54226-3_2
[42] Janet Lowe and Vernon Gayle. 2007. Exploring the work/life/study balance: the experience of higher education students in a Scottish further education college. *Journal of further and Higher Education* 31, 3 (2007), 225–238.
[43] Henry B Mann and Donald R Whitney. 1947. On a test of whether one of two random variables is stochastically larger than the other. *The annals of mathematical statistics* (1947), 50–60.
[44] Sukanya Kannan Moudgalya, Chris Mayfield, Aman Yadav, Helen H. Hu, and Clif Kussmaul. 2021. *Measuring Students' Sense of Belonging in Introductory CS Courses*. Association for Computing Machinery, New York, NY, USA, 445–451. https://doi.org/10.1145/3408877.3432425
[45] National Science Foundation. 2023. Demographic Attributes of S&E Degree Recipients: S&E Degrees by Sex. https://ncses.nsf.gov/pubs/nsb20223/demographic-attributes-of-s-e-degree-recipients#s-e-degrees-by-sex Accessed: 2024-09-19.
[46] An Nguyen and Colleen M. Lewis. 2020. Competitive Enrollment Policies in Computing Departments Negatively Predict First-Year Students' Sense of Belonging, Self-Efficacy, and Perception of Department. In *Proceedings of the 51st ACM Technical Symposium on Computer Science Education*. ACM, Portland OR USA, 685–691. https://doi.org/10.1145/3328778.3366805
[47] Anne-Marie Nuñez. 2009. A critical paradox? Predictors of latino students' sense of belonging in college. *Journal of diversity in higher education* 2, 1 (2009), 46.
[48] Evan Peck. 2017. The Ethical Engine: Integrating Ethical Design into Intro Computer Science. https://medium.com/bucknell-hci/the-ethical-engine-integrating-ethical-design-into-intro-to-computer-science-4f9874e756af Accessed: 2025-02-19.
[49] J. Peckham, L. L. Harlow, D. A. Stuart, B. Silver, H. Mederer, and P. D. Stephenson. 2007. Broadening participation in computing: issues and challenges.. In *ACM SIGCSE Bulletin*. 9 – 13.
[50] Katherine Rainey, Melissa Dancy, Roslyn Mickelson, Elizabeth Stearns, and Stephanie Moller. 2018. Race and gender differences in how sense of belonging influences decisions to major in STEM.. In *International Journal of STEM Education*.
[51] Yolanda A Rankin, Sheena Erete, Jakita O Thomas, and Nichole Pinkard. 2024. The Choice is Yours: Intersectional Studies versus Studies of Intersectional Populations in Computing Education Research. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1*. 1098–1104.
[52] Adrian Salguero, William G. Griswold, Christine Alvarado, and Leo Porter. 2021. Understanding Sources of Student Struggle in Early Computer Science Courses. In *Proceedings of the 17th ACM Conference on International Computing Education Research* (Virtual Event, USA) *(ICER 2021)*. Association for Computing Machinery, New York, NY, USA, 319–333. https://doi.org/10.1145/3446871.3469755
[53] S. S. Shapiro and M. B. Wilk. 1965. An Analysis of Variance Test for Normality (Complete Samples). *Biometrika* 52, 3/4 (Dec. 1965), 591. https://doi.org/10.2307/2333709
[54] E. Soep, C. Lee, S. Wart, and T. Parikh. 2021. Code for What.. In *Popular Culture and the Civic Imagination: Case Studies of Creative Social Change*. (pp. 89–99). https://doi.org/10.18574/nyu/9781479891252-008
[55] Justin M. Sprung and Anna Rogers. 2021. Work-life balance as a predictor of college student anxiety and depression. *Journal of American college health* 69, 7 (2021), 775–782.
[56] Leslie S. Stratton, Dennis M. O'Toole, and James N. Wetzel. 2008. A multinomial logit model of college stopout and dropout behavior. *Economics of education review* 27, 3 (2008), 319–331.
[57] Madalina Tanase. 2020. Is good teaching culturally responsive? *Journal of Pedagogical Research* 4, 3 (Sept. 2020), 187–202. https://doi.org/10.33902/jpr.2020063333
[58] Frank Vahid, Ashley Pang, and Kelly Downey. 2023. Towards Grading for Equity in a Large CS1 Class: An Experience with Flexible Deadlines and Resubmissions. In *Proceedings of the 2023 Conference on Innovation and Technology in Computer Science Education V. 2* (Turku, Finland) *(ITiCSE 2023)*. Association for Computing Machinery, New York, NY, USA, 646. https://doi.org/10.1145/3587103.3594200
[59] S. Vakil. 2018. Ethics, identity, and political vision: Toward a justice-centered approach to equity in computer science education. In *Harvard Educational Review*. 26–52.

[60] Jennifer Wang and Sepehr Hejazi Moghadam. 2017. Diversity Barriers in K-12 Computer Science Education: Structural and Social. In *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*. ACM, Seattle Washington USA, 615–620. https://doi.org/10.1145/3017680.3017734

[61] B. L. WELCH. 1947. The generalization of 'student's' problem when several different population varlances are involved. *Biometrika* 34, 1–2 (1947), 28–35. https://doi.org/10.1093/biomet/34.1-2.28

[62] Kyle M. Whitcomb and Chandralekha Singh. 2021. Underrepresented minority students receive lower grades and have higher rates of attrition across STEM disciplines: A sign of inequity?. In *International Journal of Science Education*. 1054–1089.

[63] Tiffani L. Williams. 2020. 'Underrepresented Minority' Considered Harmful, Racist Language. *Commun. ACM* (June 2020). https://cacm.acm.org/blogs/blog-cacm/245710-underrepresented-minority-considered-harmful-racist-language

[64] Melody Wilson and Jamaal Sharif Matthews. 2024. Black adolescents' motivation to resist the false dichotomy between mathematics achievement and racial identity. *npj Science of Learning* 9, 1 (2024), 15.

[65] Melissa R. Witkow, Virginia Huynh, and Andrew J. Fuligni. 2015. Understanding Differences in College Persistence: A Longitudinal Examination of Financial Circumstances, Family Obligations, and Discrimination in an Ethnically Diverse Sample. *Applied developmental science* 19, 1 (2015), 4–18.

[66] Kevin A. Wortman, Aakash Gautam, Sarah Hug, Paul Salvador Inventado, Ayaan M. Kazerouni, Jane Lehr, Kanika Sood, and Zoë Wood. 2025. Reflecting on Practices to Integrate Socially Responsible Computing in Introductory Computer Science Courses. In *Proceedings of the 56th ACM Technical Symposium on Computer Science Education V. 1 (SIGCSE TS 2025)*. ACM, 1253–1259. https://doi.org/10.1145/3641554.3701962

[67] Tara J. Yosso. 2005. Whose culture has capital? A critical race theory discussion of community cultural wealth. *Race Ethnicity and Education* 8, 1 (2005), 69–91. https://doi.org/10.1080/1361332052000341006 arXiv:https://doi.org/10.1080/1361332052000341006

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