Board 383: Socially Responsible Computing: Promoting Latinx Student Retention Via Community Engagement in Early Computer Science Courses

Dr. David M. Krum, California State University, Los Angeles

Dr. David Krum is an Assistant Professor of Computer Science at the California State University, Los Angeles. His research interests include human-computer interaction, virtual/augmented reality, and 3D interaction.

Dr. Zoe Wood, California Polytechnic State University

Whether it is creating computer graphics models of underwater shipwrecks or using art and creativity to help students learn computational thinking, Professor Zoe Wood's projects unite visual arts, mathematics and computer science.

Prof. Eun-young Kang, California State University, Los Angeles

Professor Computer Science California State University, Los Angeles

Dr. Ayaan M. Kazerouni, California Polytechnic State University
Dr. Jane L. Lehr, California Polytechnic State University

Jane Lehr is a Professor in Ethnic Studies and Women's and Gender Studies and Director of the Office of Student Research at California Polytechnic State University, San Luis Obispo. She is affiliated faculty in Computer Science & Software Engineering and

Dr. Sarah Hug, Colorado Evaluation and Research Consulting

Dr. Sarah Hug is director of the Colorado Evaluation & Research Consulting. Dr. Hug earned her PhD in Educational Psychology at the University of Colorado, Boulder. Her research and evaluation efforts focus on learning science, technology, engineering. She leads a social science and evaluation organization that focuses on inclusive excellence, broadening participation, and democratizing science.

Paul Salvador Bernedo Inventado, California State University, Fullerton
Fang Tang,

Dr. Fang (Daisy) Tang is the Chair and Professor in the Computer Science Department at California State Polytechnic University - Pomona (Cal Poly Pomona). Dr. Tang received her Ph.D. degree in computer science in 2006 from The University of Tennessee - Kn

Prof. Ilmi Yoon

Professor Ilmi Yoon, Professor of Computer Science at San Francisco State University (SFSU), is an expert in gamification and game development, particularly in interactive media, 3D over the Internet, and network information visualization. She has collabo

Anagha Kulkarni, San Francisco State University

Anagha Kulkarni is an Associate Professor of Computer Science at San Francisco State University. Her research investigates problems at the intersection of information retrieval (IR), natural language processing (NLP), and machine learning (ML). Her work a

Yu Sun, California State Polytechnic University

Dr. Yu Sun is an associate professor of Computer Science at California State Polytechnic University, Pomona. Dr. Sun has extensive work, research, and entrepreneurial experience in software engineering, mobile communications, cloud computing, and Internet applications. He currently serves as director of Software Engineering, Cloud and Mobile Computing Lab (SotCom Lab), and guides student research and entrepreneurship projects. At the same time, Dr. Sun is also the founder of Coding Mind, an

technology educational startup that promotes Computer Science education for K-12 students. Prior to founding Coding Minds, Dr. Sun also co-founded Ziiio, an indoor navigation startup based on mobile technology. Dr. Sun also worked as a software engineer at Amazon and participated in the development of Amazon Silk, the world's first cloud-based mobile web browser.

Mohsen Beheshti
Aakash Gautam, University of Pittsburgh

Aakash is an assistant professor at the University of Pittsburgh.

Aleata Hubbard Cheuoua
Sahar Hooshmand
Kevin A Wortman, California State University, Fullerton

Kevin Wortman is a Professor of Computer Science at California State University, Fullerton. He holds a PhD in Information and Computer Science from the University of California, Irvine. His professional interests include computer science education, algorithm design and analysis, and data structures.

Socially Responsible Computing: Promoting Latinx Student Retention Via Community Engagement in Early Computer Science Courses

Abstract

The NSF BPC Socially Responsible Computing (SRC) alliance, consisting of six universities in the California State University (CSU) system, is transforming the early college educational experience in computing. The goal is to motivate and engage historically marginalized students, particularly Latinx students, to pursue computing. The alliance is creating and deploying curriculum that demonstrates the value of computing to help society and provides students with the opportunity to see the alignment of their communal goals with computing as well as opportunities to bring their own cultural assets into the computing classroom. These assets include students' community-based knowledge or skills, general communication skills, and their skills related to teamwork and community engagement. We believe this framework will foster students' sense of belonging, motivation, and engagement in computing. Additionally, the alliance utilizes faculty learning communities as a vehicle to bring change to the climate and curriculum of computing education. The alliance's work is being evaluated by a research and evaluation team that is using multiple performance measures, including evaluation of the curricular materials, faculty surveys, faculty focus groups, student surveys, student focus groups, analysis of institutional data and synthesis of findings. Although we have completed just one year of our multi-year project, we have achieved significant results in terms of instructor skill gains and attitudes. We are poised to make a meaningful impact on students as we have begun introducing new curricular and pedagogical changes. In this paper, we will share our current progress and core activities related to each objective, which include establishing a supportive alliance structure, developing new computing curriculum that includes a socially responsible component at each site, creating the structure and content for the first faculty learning community (FLC), and implementing the collective impact model. In addition, we also share survey data, including feedback from both students and instructors, and lessons learned during the first-year implementation.

Introduction

With the support of the NSF Broadening Participation in Computing program, the Socially Responsible Computing (SRC) alliance is committed to transforming early computing experience to motivate and engage historically marginalized students to pursue computing. This alliance, of six public universities from the California State University (CSU) system, collectively serves over

two thousand computing students who identify as Hispanic/Latino (Latinx). Unfortunately, Latinx students face a higher attrition rate across these campuses compared to non-Latinx students (34.6% versus 21.5%), especially during the first two years of their computing journey. The primary goal of our alliance is to change this trend and broaden participation in computing. Specifically, we are creating and deploying curriculum in the early Computer Sciences courses that demonstrate the value of computing to help society, which will provide students with the opportunity to see the alignment of their communal goals with computing and opportunities to bring their own cultural assets into the computing classroom. This includes students' community-based knowledge or skills, general communication skills, and their skills related to teamwork and community engagement. We believe this framework will foster student's sense of belonging, motivation, and engagement in computing. To achieve our goal of improve retention of Latinx students, the alliance has set four specific objectives.

- O1: Designing and bringing curricular and pedagogical changes in the earliest computing courses that integrate considerations of social responsibility into computing assignments (i.e. CS 0, CS 1, CS 2).
- O2: Introducing a new intervention in computing courses that focuses on creating a different kind of student experience focused on community driven computing projects.
- O3: Building faculty learning communities to help train, orient and support instructors of this curriculum.
- O4: Employing a cross site collaboration structure using a collective impact model, allowing variance for each site while working towards a common goal.

Our alliance brings together six campuses, each with unique strengths and local challenges. We use a collective impact model, allowing each campus to contribute to the development, deployment, and continuous improvement of the curriculum. Our team is composed of computer science educators and social scientists with expertise in evaluating inclusive STEM education and training faculty at Hispanic-Serving Institutions (HSIs). Our evaluation plan examines both student and faculty outcomes, enabling us to reflect and refine our approach. Shared leadership and site teams are integral to sustaining the work, even amid potential academic personnel changes.

Our research is impactful in the learning sciences for several reasons. It utilizes faculty learning communities as a vehicle to bring change to the climate and curriculum of computing education. Furthermore, this project is developing a broadly applicable introductory curriculum that is designed, deployed, and evaluated across a range of public education institutions serving the diverse state of California. We aim for the success of this alliance to extend to all other sister CSU campuses, potentially reaching tens of thousands of computing students. This curriculum will also be broadly deployed nationwide to help marginalized students pursue computing.

Despite being in the initial year of the project, we have achieved significant results in terms of instructor skill gains and attitudes. We are poised to make a meaningful impact on students as we have begun introducing new curricular and pedagogical changes. In this paper, we will share our current progress and core activities related to each objective, which include establishing a supportive alliance structure, developing new computing curriculum that includes a socially

responsible component at each site, creating the structure and content for the first faculty learning community (FLC), and implementing the collective impact model. In addition, we will also share survey data, including feedback from both students and instructors, and lessons learned during the first-year implementation.

Background

The California State University (CSU) educational system is one of the largest and most diverse in the world, serving close to half a million students with a focus on undergraduate education. While the state of California includes a high school student population of $\sim$60% Latinx students, the CSU system serves 46% Latinx students. Even though there is more work to be done to increase undergraduate enrollment of Latinx students, we strive to serve the students currently at our campuses. The six CSU's universities represented in this alliance serve varying percentages of Latinx students, with populations ranging from 11.1% to 62.5%, allowing us the opportunity to learn from one another. Several members of our alliance are active in CAHSI, the NSF-funded Computing Alliance of Hispanic Serving Institutions INCLUDES national alliance, bringing extensive experience, knowledge, and a nationwide collaboration network that will help with our understanding of collective impact and *servingness* [1]. Across the six sites, 28.8% of our shared computing student population identified as Latinx. Together, we serve over two thousand Latinx computing students across the six sites.

To understand how we are currently serving our students, CSU-wide the collected institutional data categorizes student demographics as underrepresented minority (URM), and non-URM as shown in Table 1, with URM population predominantly (>84%) Latinx for all sites. All sites face the challenge of losing large percentages of Latinx students in the first two years of computing. Table 1 shows that we lose URM students at a rate much higher than non-URM students. On average across the sites, URM students leave CS at a rate of 34.4% while non-URM students leave at a rate of 21.5%.

CSU Site	**Total CS pop**	**CS % Latinx**	**Total % who leave CS**	**% URM who leave CS**	**% non-URM who leave CS**
Cal Poly, San Luis Obispo (Site 1)	1,026	11.1%	21%	17.8%	7.9%
CSU, Dominguez Hills (Site 2)	1,142	62.5%	40%	42%	35%
CSU, Fullerton (Site 3)	1,973	27.3%	19.8%	30%	16%
CSU, Los Angeles (Site 4)	1,002	54%	34%	45%	22%
Cal Poly, Pomona (Site 5)	1,203	26.9%	17%	26%	13%
San Francisco State Univ. (Site 6)	1,550	25.7%	37%	45%	34%
Total across sites	7896	28.2%	27.6%	34.4%	21.5%

Table 1: CS population information for alliance sites, including demographic percentage of Latinx student, retention in the major (from CSU institutional dashboards)

The goal of the alliance is to improve retention of Latinx students in the first years of their computing career. We have introduced two styles of curricular activities both centered in socially responsible computing and with the aim of providing students with an enhanced sense of belonging and better industry preparation yielding positive impacts on student retention. To help

ensure sustainability, we also introduced a community of practice with faculty teaching introductory programming courses across the six California State Universities. We organized our alliance using a collective impact model allowing for the flexibility of learning from our peers as faculty colleagues, while developing customized curriculum with the same goal – serving marginalized students better.

This work is influenced by research documenting that early computer science courses can be challenging for all students [2, 3]. And, while there are nationwide efforts to tackle the creation of entry ways into computing that are welcoming for all students (CS4All), specific intention and focus on the experience of historically marginalized students is essential for broadening participation in computing. A wide array of literature addresses the complex issues that students of color face in STEM courses [4, 5, 6]. While external forces cannot be ignored, such as financial challenges and family and work obligations [7], we focus on academic factors of influence: classroom climate, including defensive culture [8], over-emphasis on narrowly defined cultural skills [9, 10], entrenched cultural contexts, limited support in the classroom and lack of community support [7, 11, 12, 13, 14]. We specifically target increasing students' sense of belonging in computing by providing course material that demonstrates a strong communal goal affordance, demonstrating how students can use computing to benefit society and their communities and providing opportunities for students to succeed in course assignments which draw on diverse skills, beyond just syntax retrieval.

Women and other underrepresented students are likely to hold strong communal goals [15], i.e., a desire to work for the betterment of others. However, computing is perceived to afford fewer opportunities to meet these goals than other STEM fields such as the life sciences or physical sciences [16, 17, 18]. In a survey of over 5000 students, Lewis et al. [15] find that a student's sense of belonging in computing, the extent to which they feel valued, accepted, and part of a computing community, is negatively impacted by this misalignment between goals and perceived ability to meet those goals. Research has found that Latinx students report a lower sense of belonging than white students [19, 20]. A lowered sense of belonging can in turn negatively affect the decision to major in CS, performance in CS courses, and retention.

For students from marginalized groups in particular, their sense of belonging can highly influence persistence in the field [5, 21, 22]. Tissenbaum et al. [23] advocate nurturing a computational identity and empowerment in computing through the use of real-world authentic experiences and tools. Belanger et al. [18] present several studies of communal affordance in STEM and its positive impact on sense of belonging. Our work here focuses on socially responsible computing, i.e. coursework that is explicitly aimed at the betterment of the community, to address this incongruence between underrepresented students' communal goals and their perceived ability to meet those goals with computing. Our alliance objectives build on this body of work showing that the inclusion of clear signaling in academia of the ability for STEM to benefit communal goals could have improved recruitment and retention of underrepresented students. Broadly, influenced by culturally responsive pedagogy [24, 25], we propose curricular and pedagogical changes to create more inclusive and equitable computing classrooms. This work builds on ongoing work expanding social justice considerations in computing by other educators nationwide [24, 17, 10, 26, 27, 28].

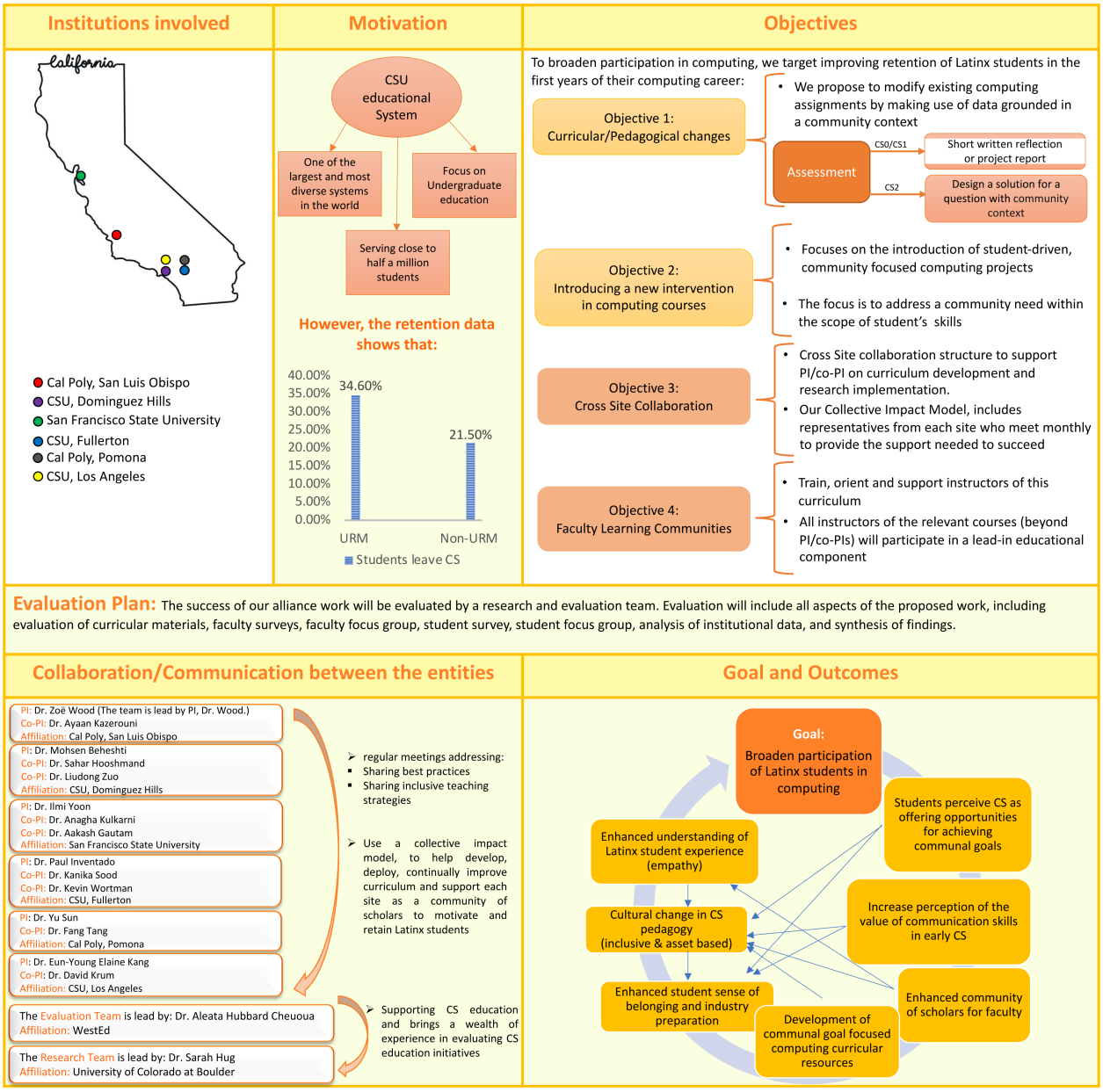

Figure 1: Overview of the motivation, objectives, goals and outcomes

Methods

To meet our goal of increasing retention of Latinx students in their early undergraduate coursework in computing, our alliance is working together, using a collective impact model, to develop curricular interventions to promote more Latinx students to opt-in to computing, using culturally responsive pedagogy (CRP) in early computing courses [24, 29, 18]. We are creating and deploying curriculum in these early courses that demonstrate the value of computing to help communities, allowing students to bring their own cultural assets into the computing classroom. This includes a student's individual community-based knowledge or skills, general

communication skills, and skills related to teamwork and community engagement. Examples of assignments include discussions, readings, and programming activities related to algorithms to allocate student housing, data about air pollution, impacts of tree planting, and matching donors and patients for blood transfusions. We believe a culturally responsive pedagogical framework provides opportunities to build students' sense of belonging, motivation, and engagement in computing. In addition, these curricular changes create the opportunity for early computing students to practice industry relevant skills related to team work and communication. Our work includes student-focused curricular activities, evaluation to understand student engagement in computing given these curricular changes, an alliance structure to help build a faculty learning community, and cross-site collaboration across our six sites in California.

As experienced computer science educators all working within the same CSU system, we work under the umbrella CSU commitment to 'inclusive excellence,' a comprehensive framework for change through leveraging diversity for student learning and institutional excellence [30]. This global shared perspective of working to educate the diverse population of California has facilitated collaboration, the sharing of data related to retention and success of students in our majors, and a partnership to enact change. Several of the site participants are active leaders in CAHSI and bring their wealth of knowledge and experience to this new synergistic alliance, which includes sites working to grow and better serve their Latinx student population. Agreeing upon our collective objectives and engaging in courageous conversations that explore the tensions between known difficulties in staffing introductory computing and the need for cultural change in computing departments in general, has brought us together as a collaborative alliance of passionate educators. We are joined by an experienced team of educational evaluators and researchers who will help us measure and understand the outcomes of our objectives. Figure 1 illustrates the alliance participants, motivation, objectives, collaboration overview and goals and outcomes.

To broaden participation in computing, we target improving retention of Latinx students in the first years of their computing career via two styles of curricular activities:

- **Activity 1:** Incorporate curricular and pedagogical changes in the two earliest computing courses that integrate considerations of social responsibility into computing assignments.
- **Activity 2:** Integrate a new intervention using socially responsible project-based learning for a community-driven computing project within the first year of coursework.

Further, to ensure that our approach is sustainable, we have created a community of practice with faculty teaching introductory programming courses across the six California State Universities:

- **Activity 3:** Develop and sustain faculty learning communities to help train, orient, and support instructors of this curriculum.
- **Activity 4:** Establish a cross-site alliance collaboration structure to support PI/co-PIs on curriculum development, research implementation, and inquiry/learning using a collective impact model.

Our curricular activity includes a two-pronged approach: (1) support students to form an identity as someone who can think and enact solutions to social problems using computational tools and skills and (2) develop course materials that demonstrate a better communal goal (illuminating

how computing can help society, particularly our students' communities) and opportunities for students to succeed in course assignments that draw on their diverse existing skills, including cultural knowledge and communication skills. We believe that these two approaches best help to boost the students' sense of belonging within the broader computing community.

Each site is implementing these changes in multiple sections, potentially impacting thousands of computing students during the grant period. In addition, our model provides support to bring new instructors into the alliance and structures to empower faculty to change the computing culture at their sites. The faculty learning community, for example, encourages connections between faculty at each site, and connections between sites through regular online meetings and annual in-person workshops. These lasting curricular and cultural changes have an impact beyond the life of the project and there is a natural path to extend this alliance to both inside and outside the CSU system. In addition, we are sharing all the curriculum and research with the wider community of CS educators.

Results

Evaluation plan Our evaluation team includes a member dedicated to evaluating the alliance and student related outcomes (Objectives 1, 2 and 4) led by Dr. Hubbard Cheuoua and a member dedicated to understanding the outcomes related to the faculty learning community (Objective 3), led by Dr. Hug.

Evaluation of Objectives 1, 2 and 4: Led by Dr. Hubbard Cheuoua, the evaluation has focused on gathering formative and summative feedback on the alliance (Objective 4) and impact on students (Objectives 1 and 2). Using [31]'s methodology, a set of indicators for early-stage collective impact initiatives, evaluation data was analyzed to rate how well the alliance is making progress on each of the five elements of collective impact (i.e., common goal, continuous communication, Backbone function, mutually reinforcing activities, and shared measurement system). Formative evaluation of student impacts will focus on (a) how students react to the new course modules and projects and (b) how these materials influence future course taking and identity and belonging in CS. Existing instruments such as Computer Science Attitude and Identity Survey by [32] and Measuring Students' Sense of Belonging in Introductory CS Courses by [33] will be used to design a student survey. A focus group protocol will also be created to probe into students' reactions to specific curricular changes. Summative evaluation in year 3 will focus on (a) measuring how successful the alliance was in achieving its student impact goals and (b) assessing the alliance's potential for scale drawing on Coburn's 2003 framework of four factors needed for scale (i.e., depth, sustainability, spread, and shift in reform ownership).

Formative feedback on the alliance will address two questions:

- **EQ1.** How well is the alliance designed to incorporate the five core conditions of collective impact?
- **EQ2**. How does the alliance evolve in response to progress or challenges in working towards it outcomes? Why does it respond and adapt in specific ways? These questions will be answered by (a) observing Backbone organization meetings each fall and spring, (b) analyzing alliance documents and records, and (c) yearly surveys of all alliance members.

Formative feedback on student impacts will address three questions:

- **EQ3.** Do students find the new course modules/projects more motivating and engaging than existing modules/projects?
- **EQ4.** Do the new course modules/projects encourage students to continue to enroll in subsequent CS courses?
- **EQ5.** Do the new course modules/projects increase student identity and belonging in CS as compared to baseline data? These questions will be answered by (a) gathering baseline student survey data in Fall 2022, (b) gathering student survey data each semester at the start of CS0/1, the end of CS0/1 and the end of CS1/2, and (c) conducting focus groups with a subset of students each Spring semester.

Summative feedback will address three questions:

- **EQ6.** To what extent has the alliance achieved its goals related to the enrollment and retention of Latinx students in CS courses and majors? How does this compare to the enrollment/retention of non-URM students?
- **EQ7.** What are key lessons learned for the CS education community about engaging in collective impact to implement socially responsible computing in introductory CS courses?
- **EQ8.** How sustainable and scalable is the alliance? These questions will be answered in Y3 by (a) analyzing institutional data on student course enrollment and retention by race and ethnicity and (b) synthesizing alliance data collected across all years.

Evaluation of Objective 3 Led by Dr. Hug, the data collection and reflective practices used to understand the outcome of the faculty learning community include:

- Participation in all sessions of the FLC, recorded;
- Participation in all planning sessions of the FLC, recorded;
- Reflection meetings with structured agenda, following each session, recorded;
- Focus groups with faculty participants, twice annually;
- Documentation of curriculum development and changes over time;
- Course observations in Year 2 across at least 3 campuses;
- Faculty departmental climate survey for participating departments in Years 1 and 3.

How the research and evaluation will improve practice for the CSU Alliance: Each summer, the Backbone organization of the alliance along with the research and evaluation teams will meet to review data gathered during the year. At the meeting, attendees will examine the impact of the alliance activities and revise the curriculum design, FLC, and alliance structure as needed. The research and evaluation teams will work closely to triangulate their data and identify any trends or results that span across their data sources prior to these meetings. Both teams will also provide the Backbone organization and each other with periodic memos outside of the annual meetings to keep each other apprised of their progress and to surface any issues that arise during the academic year.

Results from Objectives 1 and 2: Curricular Enhancements

Our work has led to a rich repository of curricular materials that provides students with opportunities to engage in computing projects that position computing and the students' computing skills as being in service of society. Further, we have facilitated instructors in creating curricula that orient with students' diverse goals to strengthen the students' sense of belonging in computing, helping them see how computing impacts others' lives, thereby promoting retention. This work and the associated faculty learning community have provided both students and faculty the space to broaden their notion of computing and its value beyond business applications.

Each of the current collaborating universities has implemented SRC focused curricular changes in multiple sections, impacting hundreds of computing students over the first year of the project. These include incorporation of socially relevant contexts into introductory computing course modules and longer-running projects in conjunction with community members who were stakeholders in the societal problem being addressed in the projects. To this end, individual sites developed a number of new curricular materials over the first two years of this alliance. However, we have come to realize that we need to further explore potential mismatches between faculty and student definitions of "socially responsible computing" (SRC) assignment. In part this understanding come from our first year evaluation which revealed that in spring 2023, Latinx students responding to our curriculum interventions "found assignments less supportive of socially responsible computing than other students, but they agreed slightly more that the assignments helped them use CS to solve problems they find interesting." Going forward, we propose to engage with local student populations to better understand student goal orientation. In addition, we plan to enhance our delivery of flexible and customizable curricula to help support instructor and student variance.

Sites have proposed coursework with varying degrees of infusion of social contexts. These have ranged from swapping in contexts like greenhouse gas emissions or blood donations into existing assignments to the design of entirely new courses centered around specific engagement with societal contexts. In tandem, instructors in our alliance have themselves been on a learning trajectory, becoming increasingly comfortable with incorporating societal contexts into CS coursework.

Results from Objectives 3 and 4: Faculty Learning Community (FLC) and Cross-site Alliance

Our faculty learning community is currently comprised of 13 computing instructors, in addition to 18 computing instructors and evaluators who participated directly in the grant. The community has been meeting together monthly to discuss socially responsible computing content, with an effort made to vary the discussion topics and materials so that returning participants are covering new ground. An in-person workshop was held at one of the alliance sites CSU LA: in June 2023. Members of the faculty learning committee have introduced completely revised courses at multiple campuses and enhanced existing courses with new assignments at other campuses.

Key evaluation results from our year one evaluation report showed the following with respect to our alliance: "EQ1. How well is the alliance designed to incorporate the five core conditions of collective impact? The Alliance is making progress on all five areas of collective impact but could benefit from additional discussion of their common agenda, shared measurement system, and organizational processes. EQ2. How does the alliance evolve in response to progress or

challenges in working towards its outcomes? Why does it respond and adapt in specific ways? The Alliance is attentive to internal and external efforts related to their goals. They (a) consider how these efforts might impact their Alliance activities and participating instructors and (b) make adjustments to their processes as needed."

In summary, our evaluator reported: "Overall, Alliance members seem satisfied with the project and the accomplishments of year 1. In particular, members commended the collaborative nature of the Alliance and the learning culture that emerged. People generally feel their voices are heard and that they benefit from interacting with the other members."

Conclusion and Future Work

Our preliminary, but impactful, progress has encouraged us to continue our alliance and deepen our understanding of the impact of computing curriculum focused on socially responsible context. We will also be encouraging deeper connections between the curriculum we create and the communities and social contexts with which SRC engaged. We are organizing curricular materials around different levels of community engagement. For example, we are developing: **Level 1 assignments** that introduce societal contexts into existing coursework; **Level 2 assignments** that add reading, writing, and discussion components to the assignments to encourage deeper engagement with the societal context; and **Level 3 assignments** that incorporate longer-term projects defined by the students in conjunction with community stakeholders, and would ideally involve evaluation by the community stakeholder. This classification can allow instructors to select the appropriate levels of engagement as students progress through the curriculum at their specific computing program at their specific site.

We are also making additional refinements to our process of on-boarding faculty. We will support a model where new faculty are introduced to the alliance and the FLC in a group or cohort. This will encourage a sense of community within each cohort that complements the larger FLC community. The members of each cohort have the opportunity to learn about SRC and grow their skills and experiences together. This will empower us to expand our work to new partner institutions. In particular we aim to add partner institutions that represent different sizes and types of learning institutions to help add new data, new experiences, and new perspectives to the process of incorporating SRC into early computing courses.

The cross-site collaboration model, as well as the detailed data collection and evaluation activities, has enabled the alliance to recognize opportunities to change, evolve, and customize our interventions based on experiences at each of the partner institutions. Many of these new refinements are based on experiences and discussions that have organically emerged from the bottom up as instructors share their experiences and challenges. We expect that as new partner institutions join our alliance and new students encounter SRC curricula, our approach will continue to evolve and grow to address new challenges and opportunities for learning.

Acknowledgements

The authors wish to thank the many instructors who have joined the faculty learning community and collaborated with us to create new SRC curricula. The authors also wish to thank the many

students that have participated in the curricula and provided feedback. This work was funded by the National Science Foundation: NSF 2216672 (Cal Poly, Pomona), NSF 2216694 (CSU, Los Angeles), NSF 2216687 (Cal Poly, San Luis Obispo), NSF 2216575 (San Francisco State University), NSF 2216520 (CSU, Dominguez Hills), and NSF 2216513 (CSU, Fullerton).

References

[1] Gina A. Garcia, Anne-Marie Núñez, and Vanessa A. Sansone. Toward a multidimensional conceptual framework for understanding "servingness" in hispanic-serving institutions: A synthesis of the research. *Review of Educational Research*, 89(5):745–784, 2019. doi: 10.3102/0034654319864591. URL https://doi.org/10.3102/0034654319864591.

[2] Yizhou Qian and James Lehman. Students' misconceptions and other difficulties in introductory programming: A literature review. *ACM Trans. Comput. Educ.*, 18(1):1:1–1:24, October 2017. ISSN 1946-6226. doi: 10.1145/3077618. URL http://doi.acm.org/10.1145/3077618.

[3] Karyn L. Lewis, Jane G. Stout, Noah D. Finkelstein, Steven J. Pollock, Akira Miyake, Geoff L. Cohen, and Tiffany A. Ito. Fitting in to move forward: Belonging, gender, and persistence in the physical sciences, technology, engineering, and mathematics (pstem). *Psychology of Women Quarterly*, 41(4):420–436, 2017. doi: 10.1177/0361684317720186. URL https://doi.org/10.1177/0361684317720186.

[4] Katherine Rainey, Melissa Dancy, Roslyn Mickelson, Elizabeth Stearns, and Stephanie Moller. Race and gender differences in how sense of belonging influences decisions to major in stem. In *International Journal of STEM Education*, 2018.

[5] 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. Improving underrepresented minority student persistence in stem. In *CBE—Life Sciences Education*, 2017.

[6] Kyle M. Whitcomb and Chandralekha Singh. 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*, pages 1054–1089, 2021.

[7] J. Peckham, L. L. Harlow, D. A. Stuart, B. Silver, H. Mederer, and P. D. Stephenson. Broadening participation in computing: issues and challenges. In *ACM SIGCSE Bulletin*, pages 9 – 13, 2007.

[8] Kathy Garvin-Doxas and Lecia J. Barker. Communication in computer science classrooms: Understanding defensive climates as a means of creating supportive behaviors. *J. Educ. Resour. Comput.*, 4(1), March 2004. ISSN 1531-4278. doi: 10.1145/1060071.1060073. URL http://doi.acm.org/10.1145/1060071.1060073.

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

[10] Ron Eglash, Audrey Bennett, Laquana Cooke, William Babbitt, and Michael Lachney. Counter-hegemonic computing: Toward computer science education for value generation and emancipation. *ACM Trans. Comput. Educ.*, 21(4), oct 2021. doi: 10.1145/3449024. URL https://doi.org/10.1145/3449024.

[11] S. A. A. Allen-Ramdial and A. G. Campbell. Reimagining the pipeline: Advancing stem diversity, persistence, and success. In *BioScience*, pages 612 – 618, 2014.

[12] A. W. Boykin and P. Noguera. Creating the opportunity to learn: Moving from research to practice to close the achievement gap. In *ASCD*, 2011.

[13] A. Finley and T. McNair. Assessing underserved students' engagement in high-impact practices. In *Association of American Colleges and Universities*, (2013). URL https://vtechworks.lib.vt.edu/bitstream/handle/10919/87004/AssessingUnderservingStudents.pdf.

[14] Susan M. Lord and Michelle Madsen Camacho. Latinos and latinas in the borderlands of education researching minority populations in engineering. In *2013 IEEE Frontiers in Education Conference (FIE)*, pages 561–566, 2013. doi: 10.1109/FIE.2013.6684886.

[15] Colleen Lewis, Paul Bruno, Jonathan Raygoza, and Julia Wang. 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*, pages 11–19, Toronto ON Canada, July 2019. ACM. ISBN 978-1-4503-6185-9. doi: 10.1145/3291279.3339426. URL https://dl.acm.org/doi/10.1145/3291279.3339426.

[16] E. Soep, C. Lee, S. Wart, and T. Parikh. Code for what. In *Popular Culture and the Civic Imagination: Case Studies of Creative Social Change*, pages (pp. 89–99), 2021. URL https://doi.org/10.18574/nyu/9781479891252-008.

[17] S. Vakil. Ethics, identity, and political vision: Toward a justice-centered approach to equity in computer science education. In *Harvard Educational Review*, pages 26–52, 2018.

[18] Aimee L. Belanger, Mansi P. Joshi, Melissa A. Fuesting, Erica S. Weisgram, Heather M. Claypool, and Amanda B. Diekman. Putting belonging in context: Communal affordances signal belonging in stem. *Personality and Social Psychology Bulletin*, 46(8):1186–1204, 2020. doi: 10.1177/0146167219897181. URL https://doi.org/10.1177/0146167219897181. PMID: 31928327.

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

[20] T. Lamont Strayhorn. Sentido de pertenencia: A hierarchical analysis predicting sense of belonging among latino college students. In *Journal of Hispanic Higher Education*, pages 301–320, 2008.

[21] K. L. Lewis, J.G. Stout, S.J. Pollock, N.D. Finkelstein, and T.A. Ito. Fitting in or opting out: A review of key social-psychological factors influencing a sense of belonging for women in physics. In *Phys. Rev. Phys. Educ. Res.*, 2016.

[22] M. Estrada, A. Eroy-Reveles, and J. Matsui. The influence of affirming kindness and community on broadening participation in stem career pathways. In *Social Issues and Policy Review*, 2018.

[23] Mike Tissenbaum, Josh Sheldon, Lissa Seop, Clifford H Lee, and Natalie Lao. Critical computational empowerment: Engaging youth as shapers of the digital future. In *2017 IEEE Global Engineering Education Conference (EDUCON)*, pages 1705–1708. IEEE, 2017.

[24] Kalisha Davis, Shana V. White, Dinah Becton-Consuegra, and Allison Scott. Culturally Responsive-Sustaining Computer Science Education: A Framework. Technical report, Kapor Center, June 2021. URL https://www.kaporcenter.org/equitablecs/.

[25] Gloria Ladson-Billings. Toward a theory of culturally relevant pedagogy. *American educational research journal*, 32(3):465–491, 1995.

[26] Rodrigo Ferreira and Moshe Y. Vardi. *Deep Tech Ethics: An Approach to Teaching Social Justice in Computer Science*, page 1041–1047. Association for Computing Machinery, New York, NY, USA, 2021. ISBN 9781450380621. URL https://doi.org/10.1145/3408877.3432449.

[27] Colin M. Gray, Shruthi Sai Chivukula, Kassandra Melkey, and Rhea Manocha. Understanding "dark" design roles in computing education. In *Proceedings of the 17th ACM Conference on International Computing Education Research*, ICER 2021, page 225–238, New York, NY, USA, 2021. Association for Computing Machinery. ISBN 9781450383264. doi: 10.1145/3446871.3469754. URL https://doi.org/10.1145/3446871.3469754.

[28] Kelly M. Mack, Kate Winter, and Melissa Soto. *Culturally Responsive Strategies for Reforming STEM Higher Education: Turning the TIDES on Inequity*. Emerald Publishing Limited, 2019. ISBN 9781787434066.

[29] Colleen M. Lewis, Ruth E. Anderson, and Ken Yasuhara. "i don't code all day": Fitting in computer science when the stereotypes don't fit. In *Proceedings of the 2016 ACM Conference on International Computing Education Research*, ICER '16, pages 23–32, New York, NY, USA, 2016. ACM. ISBN 978-1-4503-4449-4. doi: 10.1145/2960310.2960332. URL http://doi.acm.org/10.1145/2960310.2960332.

[30] Damon A. Williams, Joseph B. Berger, and Shederick A. McClendon. Toward a model of inclusive excellence and change in postsecondary institutions. Technical report, Association for American Colleges & Universities, Washington, D.C., 2005. URL https://www.aacu.org/sites/default/files/files/mei/williams{_}et{_}al.pdf.

[31] H Preskill, M Parkhurst, and J.S. Juster. Guide to Evaluating Collective Impact, 2014. URL https://www.fsg.org/publications/guide-evaluating-collective-impact.

[32] Alicia Nicki Washington, Shaefny Grays, and Sudipta Dasmohapatra. The computer science attitude and identity survey (csais): A novel tool for measuring the impact of ethnic identity in underrepresented computer science students. In *2016 ASEE Annual Conference & Exposition*, 2016.

[33] Sukanya Kannan Moudgalya, Chris Mayfield, Aman Yadav, Helen H. Hu, and Clif Kussmaul. *Measuring Students' Sense of Belonging in Introductory CS Courses*, page 445–451. Association for Computing Machinery, New York, NY, USA, 2021. ISBN 9781450380621. URL https://doi.org/10.1145/3408877.3432425.

[34] Cynthia E. Coburn. Rethinking Scale: Moving beyond Numbers to Deep and Lasting Change. *Educational Researcher*, 32(6):3–12, 2003. ISSN 0013-189X.