Board 283: Expanding and Sustaining Education Programs beyond the Nsf Support Period

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Expanding and sustaining education programs beyond the initial NSF support period

Sustainability and scaling of grant-funded education initiatives is a persistent challenge for investigators.[3] The ability of any NSF-funded program to have a significant, long-term impact, however, is contingent upon its capacity to maintain and institutionalize its benefits; to do so, it is often necessary to seek further funding to continue work towards the full integration of program components and ensure that they are sufficiently embedded in the university culture. This case study will outline how the most successful components of an NSF-funded interdisciplinary computing program at San Francisco State University (SFSU) - the Promoting INclusivity in Computing (PINC) program - have been expanded and strengthened through further grant-funded efforts to create widespread improvements in Computer Science (CS) education at the university and discuss lessons learned from this process over the last five years. Though our experience may be unique to our university in some ways, we believe that this case study can be of use to others who wish to effect large-scale educational change at their own institutions.

The PINC Program

The PINC program is funded through the NSF Division of Undergraduate Education's IUSE program (2018-2023). It is an interdisciplinary effort that offers a minor in Computing Applications aimed at Biology and Chemistry students with an interest in computational biology. The main goals of the minor program are to improve diversity in computing and increase computing literacy in data intensive fields.[4] In recruiting historically marginalized students, the minor program hopes to shift the prevalent stereotypes about CS in regard to its difficulty, its abstraction from the real world, and its lack of diversity.[4] The program consists of five classes, unique to the minor, that span across two academic years (4 semesters) and relies on the use of cohort-based program structure, near-peer mentoring, and project-driven learning. The cohort structure allows for close relationships to form, combatting the social isolation that historically marginalized students may feel in CS classes. Peer mentoring benefits students by offering further academic, social, and professional development support within the program. Project-based learning provides strong ties to students' major area(s) of study (primarily biology and biochemistry) and supports students' future success in fields that are becoming increasingly data-driven.[1] Finally, the minor program courses focus on real-world computing applications, and instructors make significant efforts to demonstrate ties between CS and the students' major fields of study.

The PINC program has been quite successful at recruiting and retaining a diverse group of students, including those who have historically been marginalized in computing fields. In 2018, the minor program had a total of 27 students, with 85% women and 48% students from underrepresented racial/ethnic groups. By 2022, the minor program has served over 400 students, with 53% women and 42% students from underrepresented racial/ethnic groups. Out of those students, about 30 students are currently in Ph.D programs or medical schools. For more information about the structure and implementation of the PINC program, specifically, we recommend checking out the 2022 paper by Reyes and colleagues.[1]

Early successes from the PINC program have contributed to the development of seven additional large-scale, NSF- and foundation-funded projects that focus on increasing equity and diversity in computing through the use of peer mentoring, career-building and professional development, and evidence-based teaching practices, including real-world applications of course material. We outline these grants and their goals below and explain their conceptual ties to components of the PINC program.

Expansion and Sustainability Efforts

GOLD: The Graduate Opportunities to Learn Data Science **(**GOLD) program (2019-2022) was funded by NSF Innovations in Graduate Education to support the development and delivery of a 9-unit Graduate Certificate in Data Science for Biology and Chemistry. The GOLD program is also an interdisciplinary computing program aimed at students in the Biology and Chemistry departments - in this case, master's students - and it builds on the structure and institutional support implemented in the PINC program, including requiring one of the courses designed for the PINC minor. In early interviews with PINC students, they indicated that the cohort structure and peer mentor support helped them stay motivated, build relationships with their peers, and develop an identity as scientists and programmers; using this feedback as a guide, these aspects were also incorporated into the GOLD program structure. GOLD PI Rohlfs (Biology) was a co-PI on the PINC grant and PINC co-PIs Pennings (Biology) and Adelstein (Chemistry) both served as co-PIs for this project.

gSTAR: The gSTAR Program (2020-2023) is funded by Genentech Inc. (a biotechnology corporation headquartered in the San Francisco Bay Area) and has led to the development of a 1-year Certificate Program in Data Science and Machine Learning for Biotechnology. This award brought together the practitioner's experience of the Genentech researchers and academic experience of SFSU faculty to develop an academic program that is aligned with the computational needs of the biotech industry. Coursework in the certificate program builds on the foundational computation skills that students develop in the PINC program courses, with a strong emphasis on the specific, high-level computing skills valued by industry partners; thus, the gSTAR program helps develop clear professional pathways for students to find jobs at pharmaceutical companies like Genentech or other biotech companies. Genentech researchers work closely with SFSU faculty to design the course curriculum, including a 1-unit seminar series that features scientists currently working in the biotechnology industry and a 2-unit course that focuses on the skills necessary to successfully interview for biotech positions. The first cohort of students to earn this certificate graduated in Spring 2022, and more than 60% of the students received a summer internship position in a biotech company or at a university. In addition, a fully online version of this certificate program targeted toward working professionals is being developed for current Genentech employees who wish to further their education at SFSU. This program will begin in Summer 2023. PINC co-PI Kulkarni (CS) serves as the PI for the gSTAR program, and PINC PI Yoon (CS) and co-PIs Pennings (Biology), Adelstein (Chemistry), and Ihorn (Psychology) all serve as co-PIs for this project.

Gen-PINC: A second Genentech partnership via the Genentech Foundation provides funding for the Gen-PINC Scholars Program (2020-2023) which offers scholarships and further mentoring support to PINC students, and funds personnel support to strengthen and expand the PINC

program. Roughly forty percent of students enrolled at SFSU each year are considered low-income (based on Pell grant eligibility), and financial constraints or the need to work while attending school can negatively impact students' ability to graduate on time, or at all. The Gen-PINC scholarship program was created with these students in mind, with the goal of improving retention and graduation rates for PINC program students. Scholarship recipients receive funding; enhanced academic and professional development; and psychoeducational support and community building activities during regular faculty-led group check-ins. PINC co-PI Kulkarni (CS) serves as the PI for the Gen-PINC program, and PINC PI Yoon (CS) and co-PIs Pennings (Biology), Adelstein (Chemistry), and Ihorn (Psychology) all serve as co-PIs for this project.

Peer Mentoring: The HSI Implementation and Evaluation Project: Self-sustaining Peer Mentor Support System for Computer Science Students (2022-2025) is funded by the NSF Division of Equity for Excellence in STEM and provides support to implement an expanded peer mentoring program in all early CS courses at SFSU. This peer mentoring program is modeled after the mentoring program developed as part of the PINC grant, and it focuses on the development of community and belonging within early CS courses through the use of peer mentors. As part of their role, the CS peer mentors receive weekly training in evidence-based teaching practices and the psychoeducational processes that help create a supportive classroom environment. PINC PI Yoon serves as a Co-PI on this grant and PINC Co-PI Ihorn (Psychology) serves as the external evaluator.

CIC: SFSU's Computer Science department received funding from the Center for Inclusive Computing (2022-2025) to redesign the introductory Computer Science curriculum. With this funding, the introductory CS course sequence is being reworked to better support the recruitment and retention of historically marginalized students in the field of computing, including female and BIPOC students. Through this grant, the PINC program's efforts to improve recruitment and retention by eliminating barriers to success in early courses (e.g. by carefully selecting and limiting the CS content presented in early courses) and to improve student engagement by focusing on real-world computing applications that are geared toward student interests are being expanded to the CS department as a whole. Efforts include strengthening the CS department's focus on evidence-based teaching practices, lowering the barriers to entry in early CS courses by creating a new introductory course that allows for a slower-paced introduction to programming, and focusing the content of this new course on applied problems within the context of contemporary societal and ethical issues (i.e. Socially Responsible Computing, see below). PI Yoon (CS) serves as the PI for this project, and co-PI Ihorn (Psychology) is a co-PI on this project, as well.

BPC-A: The Broadening Participation in Computing-A grant (2022-2025) is an NSF-funded multi-institutional project including six campuses from the California State University (CSU) system who come together with the goal of increasing recruitment and retention of historically marginalized students in introductory computing courses. This grant funds the creation of faculty learning communities to shift CS culture and curriculum at each university, as well as the development of curricular and pedagogical changes in the first two computing courses in the CS major sequence at each of these campuses. The redesigned courses will use project-based learning to demonstrate the use of computing in addressing community needs (Socially Responsible Computing) and are intended to provide an opportunity for students to see the

alignment of communal goals with computing, provide opportunities to apply communication and other community cultural assets, and to ultimately increase students' sense of belonging in computing. This project further expands on prior success in the PINC program with its strong focus on community and belonging, project-based learning, and applied problems. PINC PI Yoon (CS) and co-PI Kulkarni (CS) are on the leadership team for this grant project.

CS4All: The NSF-funded CS4All program (2022-2026) is a high school-strand research-practitioner partnership (RPP) project. In this project, four universities (including San Francisco State), 20+ school districts, and WestEd (a non-profit research and service agency) will collaborate to support equity and excellence in high school CS courses. This program will provide preparation, professional development, and ongoing pedagogical support for high school CS teachers, particularly in schools and districts where secondary students currently lack access to CS courses. Over the course of this project, the program will serve 200 teachers and support 25,000+ high school students. The current iteration of this project came out of the "NSF INCLUDES Design and Development Launch Pilot, San Francisco: Computing for All Levels & Learners (SF CALL) (2016-2019)" and the "Collaborative Research: CS4SF: A Scalable Model for Preparing High School Teachers to Provide Rigorous, Inclusive Computer Science Instruction" (2018-2021) grants. The PINC grant works synergistically with the CS4All grant, as they share the same vision of inclusive computing (though expanded to the high school level) and focus on many of the same ideas about the role of community and belonging. PINC students are also regularly hired to serve as teaching assistants in this program. PI Yoon has been one of the primary contributors for all of these grants.

Lessons Learned: What Works

We've learned several lessons throughout our efforts to sustain and support lasting change and institutionalization of the most successful components of the PINC program, while also expanding the scope of the program's goals. We outline the most salient of these below, including: the value of a shared mission, the advantages of collaboration with an expanded range of stakeholders, the centrality of strong interpersonal relationships, and the importance of leveraging existing resources.

The value of a shared mission

SFSU is a diverse, public, urban university that espouses a strong commitment to the ideals of equitable and socially just education practices and has a long history of working (albeit imperfectly) toward this vision. While campus mission statements are rarely fully and universally supported, these aspirations are broadly shared by faculty at our university and there is a general willingness of leadership to meaningfully support efforts to promote equity and diversity in educational programs at SFSU. The alignment of the University's mission with the overall goals of the PINC program has helped with efforts to recruit faculty from a broad range of departments and has contributed to the ease with which CS department faculty are willing to make curricular and pedagogical shifts to better support these ideals in their classrooms. Over the years, the PINC program and subsequent related efforts have also benefited from strong and continued support from leadership. Our Dean was closely involved in the early development of the PINC program before she moved into her current role, and several Department Chairs have

helped facilitate the implementation of PINC program goals. Further, the university recently applied for and was awarded an Hispanic Serving Institution (HSI) designation, a move that has greatly expanded our access to funding opportunities to support our Latinx students.

Collaboration is key

A strong collaborative spirit is an essential component to our success in sustaining change and obtaining continued funding. The efforts required to sustain these projects is too much for any one person to manage; indeed, any undertaking of this scope requires a dedicated team of individuals who can share the responsibilities and benefits of the work. The PINC project PI and co-PIs work together in various subgroups across all of these efforts, switching roles and duties as expertise and available time allow. Further, program faculty embrace collaboration in many forms: interdisciplinary collaboration, collaboration-as-mentoring for early career faculty, and industry partnerships.

The interdisciplinary nature of these projects is a key component of our success. Faculty from the CS, Biology, Chemistry, and Psychology departments at SFSU are all involved in these efforts, and each brings their distinct disciplinary perspective to the team. We believe that the diversity of our perspectives fuels creativity and has allowed us to overcome our disciplinary blind spots and conceptualize new ways of thinking about curriculum, pedagogy, student success, and the learning community as a whole. For example, PINC PI Yoon notes that she quickly recognized that the climate and expectations in the Biology department were very different from those in the CS department, and Biology students seemed to struggle under the CS norms in their computing courses. Discussion and problem solving with co-PIs in the Biology Department led PI Yoon to a new understanding of certain aspects of typical CS department culture, as well as ideas for potential new ways to support student success, both for Biology students taking CS courses and for CS students, more generally.

Collaboration across faculty levels and the use of collaboration as a form of mentoring of junior faculty by more senior members is an important aspect of our work, as well. Junior faculty often have the time and a strong desire to participate in grant-funded work, but may lack the skills and knowledge necessary to successfully secure grant funding on their own. In an environment where most faculty broadly share a common mission (in this case, a commitment to equity and diversity in STEM), it becomes easier for faculty to find shared projects that fit their interests and career goals. Senior faculty involved in the PINC program have taken significant efforts to support newer faculty in grant-funded work, both by involving them as co-PIs and by generously supporting the grant-writing efforts of junior faculty, even when the senior faculty take a smaller role in the eventual implementation of the grant-funded program in question. When the original PINC grant was written, only the PI had tenure - she was a full professor at the time. Several of the PINC co-PIs have taken the lead on the projects outlined above, with the full support of more senior PINC program faculty. As PINC co-PIs move into leadership roles and earn tenure, they, in turn, have continued to include newer junior faculty in these ongoing efforts, as well. Thus, collaboration on these projects provides a form of mentorship to the early career faculty involved in this work, and this mentorship directly supports junior faculty's efforts to develop grant-writing and -management skills, as well as enhancing their own tenure case. Perhaps most importantly, however, this form of mentorship also helps pass down a clear understanding of the

value of these efforts to junior faculty, which helps to institutionalize and sustain meaningful change in the long term.

Finally, close collaboration with industry partners has also allowed us to expand and strengthen our efforts to increase equity and diversity in computing. Our work with Genentech is a mutually beneficial partnership for SFSU, our students, and the Genentech corporation. SFSU faculty and Genentech scientists worked together to co-create the certificate program and the accompanying course content, and Genentech scientists are also heavily involved in the execution of these courses, as well; they act as co-teachers, guest speakers, and assist with the interview prep course by conducting mock interviews with students. The courses in the certificate program provide students with an opportunity to interact with industry scientists and gain cutting-edge skills that make them more competitive for biotechnology jobs, and Genentech scientists have access to a diverse and better-prepared pool of job candidates who require less on-the-job training in key areas.

Work to build and maintain relationships and community

The benefits of successful collaboration are manifest, but less commonplace forms of collaboration like interdisciplinary work and industry partnerships can prove particularly challenging at times. Organizations, departments, and disciplines often have idiosyncratic ways of thinking about the world and engaging in problem solving efforts. Further, individuals are experts in their own area, but may have difficulty understanding cultural differences between, say, industry and academia, or lack the background necessary to grasp key concepts from other academic disciplines. For these reasons, communication and goal-setting on interdisciplinary teams and within industry-academic partnerships teams can be difficult. Positive interpersonal relationships between collaborators can help buoy teams during trying times. In addition to the work that we do to create community and build relationships among our undergraduate computing students, we also take steps to support *all* of the relationships necessary to make the program function well. We work to enrich the relationships between the faculty who work directly on our projects, as well as the relationships we share with all of our stakeholders (and potential future stakeholders), including University faculty who are loosely affiliated with or impacted by the program, University leadership, and current and potential future industry partners. Practically, this involves the regular planning and execution of events meant to celebrate successes and bring individuals together. The PINC program regularly holds more formal events such as graduation ceremonies, student work showcases, industry panels, and dinners where faculty, university leadership, industry partners, and students are invited to share work, share ideas, talk, ask questions, learn from each other, and generally strengthen individual relationships. We also hold less formal get togethers, including group lunches and family picnics, to help bolster the bonds between program faculty. We believe that the efforts we invest in building a strong sense of community and positive interpersonal relationships have a significant impact on our ability to effectively work together to address our mission.

Leverage existing resources and support mechanisms to lighten the load

To help reduce the amount of effort required to enact positive changes in computing education at SFSU, the PINC program and subsequent grants have also sought out and used several widely

available educational resources to develop curriculum and pedagogy that better supports historically marginalized students. Most of these excellent resources were not well-known or familiar to the majority of CS faculty. Many universities have pre-existing (and often underutilized) resources available to support faculty in the development of high-quality curriculum and the use of evidence-based teaching practices. When designing these programs, we sought the support of SFSU's College of Science and Engineering (COSE), Center for Equity and Excellence in Teaching and Learning (CEETL), Center of Science and Math Education (CSME) as well as the Science Education Partnership and Assessment Laboratory (SEPAL), a community of scientists that conducts research on effective science education and provides resources to science teachers.

Conclusion

Any funded education initiative that wishes to have a long term, positive impact on a university campus must put forth significant effort to ensure that its core tenets are sufficiently embedded in the university and academic department culture. To accomplish this, it is often necessary to seek further funding to continue work towards institutionalization of program components beyond the initial support period. This case study demonstrates how an interdisciplinary group of faculty at SFSU is working to put in place structures and an overall culture that will better support equity and diversity in computing. Although these efforts are still a work in progress, we are excited about our successes and hope that sharing our insights about our own programs will help others who have similar aims.

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