Peer Mentoring in an Interdisciplinary Computer Science Training Program: Mentor & Student Perspectives and Lessons Learned

1. Introduction and Background

Peer mentoring has been identified as an effective practice to support students' academic, social, and professional success in higher education (Colvin & Ashman, 2010; Crisp & Cruz, 2009; Terrion & Leonard, 2007). A typical peer mentoring program pairs a junior student (mentee) with a senior student (mentor) who has more experience and training in their shared academic discipline. The benefits and limitations of this model have been studied extensively; however, our understanding of this model when implemented in an interdisciplinary setting is limited. If the mentor, mentee, and the faculty supervisor are all from different academic disciplines, how should the implementation of the peer mentor program be adapted? Do the benefits and limitations of the traditional model still hold? These are the central questions we seek to explore in the context of a novel, NSF-funded Computer Science (CS) training program at San Francisco State University (SFSU). The PINC: Promoting INclusivity in Computing program (https://cose.sfsu.edu/pinc) is designed for life sciences majors, and the program's goals are to increase computing literacy among life science students and to improve diversity in the computing workforce (Kulkarni et al., 2018; Yoon et al., 2018).

The PINC program is a collaboration between the Biology, Chemistry, and CS departments at SFSU. Undergraduate students majoring in Biology, Biochemistry, or Chemistry take five introductory and application-oriented CS courses through the PINC program to earn a minor in Computing Applications. Many of these courses are taught by non-CS faculty and the course contents are adapted for life sciences students. Every course is assigned a dedicated group of peer mentors who assist instructors and students during lectures and hold separate mentoring sessions every week.

The curriculum for the Computing Applications minor (aka PINC minor) consists of the following five courses, and the recommended course sequence is as follows:

Fall (Year 1, Semester 1)
- CSc 306: An Interdisciplinary Approach to Computer Programming

Spring (Year 1, Semester 2)
- CSc 219: Data Structures and Algorithms

Fall (Year 2, Semester 3)
- CSc 308: An Interdisciplinary Approach to Web Programming
- CSc 698a: Topics in Computing I (Project-based Learning)

Spring (Year 2, Semester 4)
- CSc 698b: Topics in Computing II (Project-based Learning)

Since its launch in Fall 2016, three cohorts have graduated. The cohort size has been 15 students, on average. In the 2020 graduating cohort, the graduating cohort of students was 85% women, 37% Latinx, and 11% Black/ African-American - starkly different from the typical demographics of a traditional CS major program, and also those of Biology/Chemistry major

programs. We have made efforts to have these demographics reflected in the mentors selected for the program: 77% of the mentors recruited to date have been female or URM.

2. PINC Peer Mentoring Program

Program Description

For each of the five PINC courses, a group of peer mentors is selected before the start of the semester. The typical mentor-mentee ratio is maintained at 1:8 for early courses, and 1:4 for the later, project-based courses in the program. The selection criteria for mentors is: 1) academic competence (typically demonstrated through PINC program GPA or major GPA), and 2) interpersonal skills. For the early courses, PINC program graduates (junior and seniors in life sciences majors) are selected as peer mentors, and CS seniors or Master students are selected for the last two courses in the program. The expected time commitment and the corresponding pay for peer mentors is for 5 hours per week. The typical breakdown of the 5-hours is as follows:

- Mentor-mentee meeting: 120 minutes
- Asynchronous assistance over email and Slack channels: 60 minutes
- Assistance during course lectures: 60 minutes
- Meeting with course instructor: 30 minutes
- Peer Mentor training: 30 minutes (details below)

All peer mentors are expected to provide technical guidance and assistance to their assigned mentees. However, in the early courses this support is focused around homework assignments while in the last two courses it is driven by group projects.

Overview of Peer Mentor Training

Colvin and Ashman (2010) have shown that the roles and responsibilities of peer mentors are not self-evident even in traditional settings. In an interdisciplinary program like PINC, there is potential for even more ambiguity because mentor, mentee, and instructor may not have the shared context of an academic discipline.

Most PINC peer mentors have no prior mentoring experience. Until Fall 2018, the mentors were provided training through a series of monthly workshops facilitated by a CS faculty member involved in the PINC program. The goals of these workshops were to (i) to create an environment where the mentors would assume ownership over the mentoring component of the program, (ii) to develop strategies to identify and resolve learning challenges that their mentees were facing, and (iii) to co-discover effective tutoring methodologies to resolve specific student issues. To provide psychosocial support to program students, mentors were also encouraged to share with mentees their personal stories about how their CS studies began, as well as their own struggles with the material.

To help bridge the disciplinary gap, a facilitator from the Biology department was brought onboard starting Spring 2019. The new facilitator was formally trained by the National Research Mentoring Network (NRMN) in strategies to effectively provide the necessary skills and support for peer mentors to excel. These skills include: establishing mentor/mentee trust; building a strong mentoring relationship; problem-solving strategies; mentoring diverse populations in STEM; strategies for mentoring online; and several other components of effective

mentoring techniques, such as evidence-based practices to support mentors. Each meeting consisted of mentor training, an opportunity to reflect on their mentoring relationships, and an opportunity to strategize with fellow mentors about effective strategies and discuss challenges. These monthly sessions consisted of 2-hour meetings where mentors are engaged in interactive activities, allowing them to personalize their approach to mentoring.

Motivations for Peer Mentoring

The motivation for incorporating peer mentoring in PINC courses is three-fold. Below we describe these reasons along with the unique challenges that we tackle in the PINC program.

1. Approachable technical support: The first motivation for implementing peer mentoring is to leverage the shorter intellectual and psychosocial distance between junior and senior students (as opposed to junior students and faculty) to establish an easily approachable technical assistance channel for the mentees (Terrion & Leonard, 2007). The novel aspect here for the PINC program comes from its interdisciplinary nature -- a life sciences student with no computing background is not going to find a senior CS student easily approachable for basic programming questions. Thus the argument based on *shorter intellectual distance* between mentees and mentors breaks down for introductory PINC courses. These observations have led to the following adaptation of the traditional peer mentoring model: PINC program graduates, that is, senior life sciences students are selected as mentors for the early PINC courses. For the last two courses of the program that need mentors to have substantial computational training and experience, CS students with diverse professional and socioeconomic backgrounds are selected as mentors.

2. Relatable, supportive role models: The second reason for incorporating peer mentoring is to expose mentees to relatable role models, as doing so is known to increase student achievement and persistence in STEM (Herrmann et al., 2016; Shin et al., 2016). In the PINC program, the notion of 'relatable role models' takes on two facets: other students who have successfully taken the interdisciplinary path, and other students who are socio-ethnically relatable. The adaptation described above, recruiting PINC program graduates as mentors in early courses, helps with the first facet of relatable role models. To address the second facet, we try to maintain similar socio-ethnic demographics of mentors and mentees. As students (mentees) progress through the PINC courses, their disciplinary identity gradually widens to include computational skills, thus increasing the relatability of CS students as role models in later courses of the program.

3. Sense of belonging in a community of professionals: Third rationale for peer mentoring is to help students become part of a professional computing community and thus develop a sense of belonging and computational identity, both of which are known to improve motivation, self-efficacy, engagement, and retention (Blaney & Stout, 2017; Good et al., 2012; Master et al., 2016; Narayanan et al., 2018). However, developing this sense of belonging can be tricky in a heterogeneous community like that of the PINC program, where the mentee, mentor, and instructor are potentially all from different disciplines. Having cohort-based structure and the example of peer mentors who are successfully navigating the integration of these disciplines can help mentees embrace their computational biologist or computational chemist identity and develop a sense of belonging in both fields.

3. The Study

In Fall 2018, the PINC program received NSF support and began conducting formal evaluation of the various program components, including mentoring. For the past year, COVID-19 has both led to unexpected program changes (e.g. a sudden move to fully online instruction) and created new difficulties in collecting data. However, we see value in using this small, somewhat anomalous data set as part of our ongoing formative assessment of the program, and believe it has utility in helping us shape the next, post-COVID phase of our work.

Four students who served as mentors for the PINC program were interviewed in small groups in May of 2020 and four more were interviewed in January 2021. The interviews followed a semi-structured format. Topics included, but were not limited to, mentors' perceptions of student needs, the mentor training experience, the roles that mentors play, and the benefits of mentoring. We also interviewed seven student mentees (5 male, 2 female) in May of 2020. Topics for these interviews included prior experience in computing, reasons for joining PINC, career plans, and program supports. The interviews were conducted via videoconference and lasted approximately 45 minutes. They were transcribed in their entirety and coded by the project's external evaluator using a combination of deductive and inductive methods (Graebner et al., 2012).

4. Results and Discussion

Due to the small sample size associated with this qualitative data and the atypical nature of the educational climate during COVID-19, results should be interpreted with caution. It should also be noted that recruitment for participation in interviews was made more difficult by the COVID-19 pandemic. Although we sent invitations to all mentors, it appears likely that our sample is biased toward those who had a positive experience with mentoring. This further limits the conclusions we can draw about the efficacy of the program, but does not in any way detract from the insights of the mentors and mentees with whom we spoke. With these limitations in mind, initial data analysis does point to several interesting themes that may be emerging from the data. These emerging themes are outlined below:

4.1 Mentorship Functions

When asked about the roles they play, mentors discussed three major functions they serve in this capacity: technical support, psychosocial support, and professional role model. This is in line with the observations made by Terrion and Leonard (2007) on this topic; they note that peer mentors fulfill distinct types of functions depending upon the context in which they operate -- they provide 1) vocational (task-related or career-related) support, and 2) psychosocial support (Terrion & Leonard, 2007). Although Terrion and Leonard collapse task- and career- related functions into one category that varies based on context, PINC mentors function in multiple contexts simultaneously and thus serve both career-related (professional role model) and task-related (academic support) functions in their role.

Technical Support. Both mentees and mentors spoke to the ways in which the mentors provide technical support for classwork and homework assignments. Mentees focused on the

helpfulness of their mentors, saying, *"The mentor actually helped a lot. . . to explain the material."* and "*Mentors. . . come up with sample problems for us to solve."* When explaining their role as technical support, however, mentors tended to focus more on the ways they tried to foster a productive approach to learning. One mentor outlined their methods for using questioning to help students find the errors in their work, saying *"I try to motivate, ask leading questions. I want them to figure out the syntax is not good …I like to use a lot of analogy."* Another mentor explained how they encouraged students to prepare in advance in order to use the time in mentoring more effectively: *"I used to email them to 'look at this part of the homework and think about how you would approach it'. Some would come prepared, some would not. After a while they would notice they were the odd one out if they didn't look at it ahead of time."* In addition, some mentors expressed concerns about their mentees' approach to academics, with one noting, *"There's a thing that concerns me about their attitude toward the class: they think of the class not as a regular class but as an elective…They come to the mentor meeting saying 'this (meeting time) is the time I have to put into understanding the concepts I had trouble with in class'."* In light of the relatively minor emphasis placed on pedagogy in the mentor training, the frequency of these types of comments could indicate that this is an area for future development in mentor training.

Mentors also spoke about the unique considerations they had to make when providing technical support within an interdisciplinary context. A PINC program alum who had returned to mentor explained this by noting, *"When you code you need to know the story behind it...when we have those coding assignments, we have [a] certain biology - there is some story to it. Being a PINC minor myself was helpful because I understood how a biologist would approach a coding problem. I started PINC with no coding background. We had mentors that had CS but not coding. They helped us with coding but Bio lagged."* Mentors who were PINC program alumni - who had comparatively less experience with CS - also spoke about how the process of teaching others helped improve their own coding skills, *"When mentees would come up to me and ask me questions in the meetings, sometimes I wouldn't know the answers and it helped me to improve my troubleshooting skills. I learned a lot about Unity."* In contrast, mentors who were CS majors had strong foundational coding skills, but needed to consider the context in which the CS technical support was happening, with one mentor saying, *"I am always trying to have a mental note of how I am explaining things to the students, presenting it because these are people who don't have a background in CS."* Mentees appeared to have a global sense that the technical support they received was unique because it incorporated multiple disciplines. One mentee noted, *"The mentor actually . . . helps us to learn how to use the coding in a different perspective."* The interdisciplinary nature of the mentoring also arose in the context of the professional role model role that mentors play (see below).

Psychosocial Support. Mentors and mentees both indicated that a central component of their mentoring experience was the provision of psychosocial support, with particular emphasis on the role of empathy and understanding. Mentors spoke about the efforts they put forth to make their mentees feel that they cared about them as individuals, saying, *"I always try to ask them questions about their life, how are classes, what's going on with your life, do you have anything that's stressing you?"* Mentors also wanted to ensure that their mentees didn't feel alone: *"[I] talk to them about their lives, make them feel like they are not alone in their struggle, I will share stuff I'm doing in my classes, things that are hard, and how I struggled. That's how I*

support them in a way." Mentees also noted the impact of these efforts on their own sense of connection, noting, *"It was just a lot closer connection to everyone . . . more comfortable than usual."*

Professional Community Support. In addition to offering social support, mentors also spoke about serving as role models for how to be an interdisciplinary computer scientist. One way mentors do this is by sharing goals and passions, *"They ask me how I got into computer science, what drives me, so I get to share that info with them and hopefully elucidate what they want to do."* Another is by demonstrating perseverance: *"Sometimes they will not want to do their task or be frustrated, so I kind of model how to deal with that."* Being only slightly further along in their studies, the mentors are able to provide insight into the next steps the mentees will need to take to reach their professional goals : *"I will share stuff I'm doing in my classes, things that are hard, and how I struggled. That's how I support them in a way."* Mentees also noted the value of having exposure to people who can model what it might be like to be an interdisciplinary computer scientist: *"I think it's really helpful to help us to have a view of. . . how to use computer science to work as a biologist . . . so you understand both languages [and] you can sit between these two groups of people and analyze data together."* Mentees further noted some of the struggles that came up in this regard, particularly around wanting more advising to help them meet their professional goals, "*In terms of career planning, I wish there was more support there. . . so I'm also getting biology advice and computer science advice."*

4.2 Essential Relationship Attributes

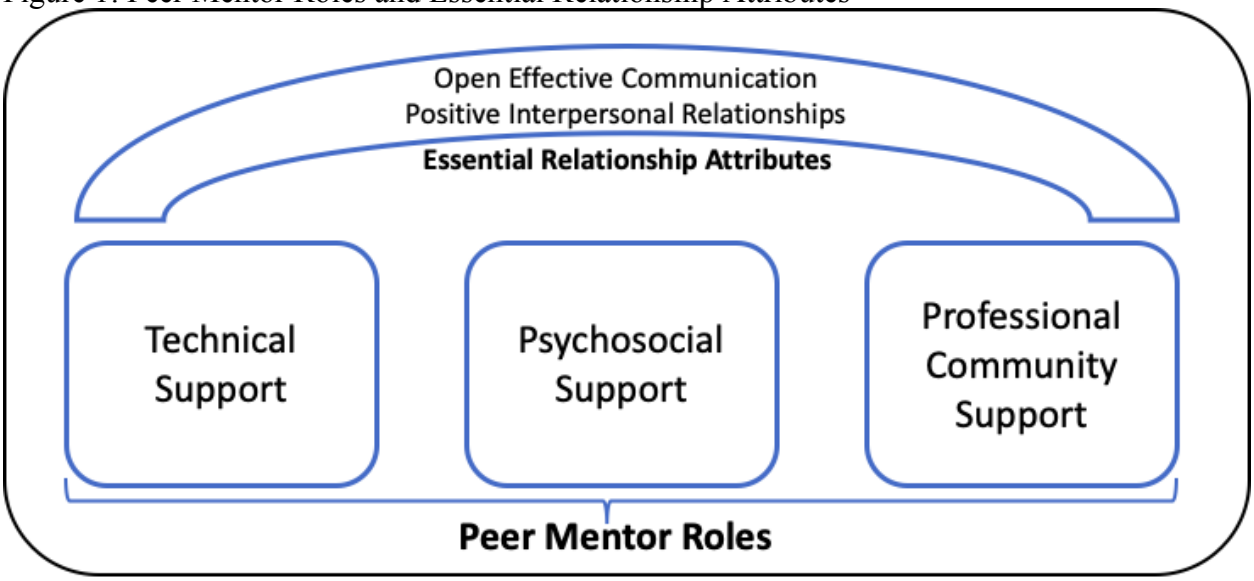
The ability of mentors to be successful in these three functions is largely dependent on their facility with the essential relationship attributes that emerged: open and effective communication, and positive interpersonal relationships. Mentors who experience positive interpersonal relationships and open, effective communication modeled by their mentor trainer will be better prepared to demonstrate these relationship attributes with their mentees. In turn, mentors who are able to form positive interpersonal relationships and engage in open, effective communication with their mentees will be better able to provide technical, psychosocial, and professional support to their mentees. Thus, the aspects of communication and interpersonal relationships outlined below are threaded throughout their conceptualization of their various roles in their work as mentors. Figure 1 demonstrates the ways that these essential relationship attributes interface with the peer mentor roles outlined above.

Open and Effective Communication. Mentors highlighted the centrality of communication to their experience, noting several ways in which the importance of communication arose in their work as a mentor and in the mentor training they received. Mentors spoke about how they appreciated the environment of open communication that was created in the mentor training meetings. This openness allowed mentors to feel comfortable receiving feedback, sharing their experiences, and asking questions. Mentors said, *"[The professor who leads the mentor training meetings] is very open, chill and we are all talking, very open and asking questions"* and *"I always appreciate that we have those talks with [the professor leading the mentor training]. It helps me to understand where I'm at as a mentor, not only with the PINC program but leadership in general. It helps me a lot."* Mentors, in turn, tried to cultivate a similar environment of open communication in their work with their mentees; one mentee commented on these efforts, *"[My mentor] is really open and available. If I ever have questions she is willing to Zoom in and help me out."* Mentors further spoke about how the effort they put into establishing open, effective communication with their mentees will help them in their future careers. One mentor said, *"I am always trying to have a mental note of how I am explaining things to the students…It will be the same thing when*

I get into the job field, there will be times when I have to explain my ideas to people who don't have my background and I will have to find ways to make it relatable." Another noted, *"After I complete my PhD, I'll go into a biotech company. I know their work ethic is working in groups, so I hope to bring to the table the communication skills I developed through mentoring into those groups."*

While mentors and mentees agreed that the PINC mentoring program successfully created an environment of open communication, they noted times when communication within the program was less effective - in particular, mentors noted times when more communication was necessary. One mentor stated, *"Being a mentor virtually was difficult. The problem that we faced was that we didn't attend the lectures, we were clueless about what is happening [in the class]. I had to put time into understanding what the professor wants [my mentees] to do. After mid-semester we started doing more communication, so we overcame that problem."*

Figure 1: Peer Mentor Roles and Essential Relationship Attributes



Positive Interpersonal Relationships. Mentors also spoke to the importance of building positive interpersonal relationships through their mentoring experience, both in the mentor training they received, and in their own work with their mentees.

In the mentor training, mentors were able to build relationships with their fellow mentors and with the professor who designed and ran their mentor training series; these relationships offer valuable support and guidance to mentors and contribute to a positive experience as a mentor for the PINC program. A mentor said, *"One of the things that helped me most was to learn that other mentors had problems with their mentees coming unprepared…I saw I'm not the only one who is struggling sometimes."* Further, the mentor training provided instruction and support to help the mentors build positive relationships with and between their mentees, as well. One mentor noted, *"The most resonating meeting I've had with [the professor leading the mentor training] was ice breakers and getting to learn more about my mentees and initiating that friendship between them."* Another mentor spoke about the relationship-building efforts they put forth when they think their mentees are struggling:, *"I have these students that are like,*

maybe right now I can't join the [mentor] meetings because there are a lot of distractions at my house. . . I try to send follow up emails to see what happened if they don't join the meetings."

Mentees in the PINC program also spoke about the importance of interpersonal relationships to their experience. One mentee said, *"We are a little PINC family, we know each other, see each other in the hall. In this stuff you see the same faces."* Another mentee noted: *"For PINC, I knew everyone. . . who I was going to interact with. It was just a lot closer connection to everyone. . . more comfortable than usual."* Like their mentors, the mentees also spoke about how their mentoring experience helped them to build positive relationships with their classmates. One mentee said, *"Gathering in the group is helpful. It's not just the mentor, but also the other classmates in the group.*" Another mentee noted, *"My peers in the PINC program, I do enjoy collaborating with them a lot more. . . . Being in that kind of environment really helped me enjoy coding because it was really tough at first and boring, but being around people who actively enjoyed [it]. . . and were enjoying learning it made me want to learn it, too. . . Keeping that type of environment - especially with the mentors - was really helpful."*

5. Next Steps

The current implementation of the peer mentoring component for the PINC program and its general evaluation described in this paper will inform the next steps in terms of 1) the modifications made to peer mentoring implementation, and 2) the focused evaluations conducted moving forward.

The following four areas will be prioritized for the peer mentoring program implementation moving forward:

1. Peer mentor training: Adapt existing peer mentoring practices to promote, support, and sustain the interdisciplinary aspect of PINC program. For instance,
    a. Training topics and material need to be revised to reflect that some of the peer mentors are from life sciences while others from CS.
    b. During training, multiple modes of communications -- verbal, visual, and written -- need to be used to ensure that all types of learners from different disciplines can absorb the information. This also helps with #3 and #4 below.
2. Communication square: Establishing regular and multi-directional communication between the four key actors in the mentoring process: peer mentor, mentee, course instructor, and mentor trainer.
3. Scalability/Sustainability: Identify specific best practices for interdisciplinary peer mentoring that can be scaled up with realistic resource allocation as the program grows.
4. Reusability: Create, maintain, and share program material on the PINC website to enable other institutions and educators to recreate similar interdisciplinary peer mentoring programs.

The following five areas will be prioritized for the peer mentoring program evaluation:

1. Conducting studies with larger sample size will be one of the first tasks for strengthening the evaluation.

2. The peer mentor roles and essential relationship attributes that have emerged from the qualitative study will be investigated further via continued qualitative interviews and focus groups with peer mentors, mentees, and course instructors. Instrumentation will also be developed to allow quantitative assessment; this will both enhance the current research and facilitate continued assessment as the program grows.

3. As described in Section 2, peer mentors in the early PINC courses are selected from the program's pool of graduates (life sciences majors) while for the last two courses CS students are selected as peer mentors. This adaptation of the traditional peer mentoring model needs to be carefully studied from mentee, mentor, and instructor perspectives to understand its strengths and limitations.

4. It is known that peer mentors themselves derive benefits from the mentoring experience, and the PINC program mentors have confirmed this as well. However, we believe that the interdisciplinary nature of the PINC program affords more benefits and opportunities to the mentors. For instance,
    a. they learn to communicate with people from different disciplines, either by developing the skills to abstract away from disciplinary framework and jargon or by developing the skills to understand the other person's disciplinary frame of reference;
    b. their ability to envision applications of the theory that they learn and teach is more developed than that of traditional mentors;
    c. their professional network is more diverse than their counterparts', which opens up non-traditional career opportunities.

    These hypotheses about the additional benefits to peer mentors due to the interdisciplinary nature of the program will be studied.

5. The reusable peer mentoring materials generated by the program and all evaluation instruments developed as part of the above studies will be shared on the PINC website for adoption by other researchers. Information can be found at https://pinc.sfsu.edu/pinc/pinc-mentorship

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