The Experience of Near-Peer Computing Mentors: Strengthening and Expanding Women's Computing Identities in Undergraduate Interdisciplinary Contexts

Jennifer Rosales
Barnard College
New York, NY, USA
jrosales@barnard.edu

Elizabeth Melville
Teachers College, Columbia
New York, NY, USA
egm2152@tc.columbia.edu

Melissa A. Wright
Barnard College
New York, NY, USA
mawright@barnard.edu

Saima Akhtar
Barnard College
New York, NY, USA
sakhtar@barnard.edu

Rebecca N. Wright
Barnard College
New York, NY, USA
rwright@barnard.edu

ABSTRACT

In this paper, we investigate the effect of participating as a near-peer mentor for computing activities in undergraduate courses across disciplines. Many studies on near-peer mentorship have demonstrated academic and professional growth—as well as an increase in self-efficacy—of mentees. In this paper, we focus on how participation as a mentor in an undergraduate Computing Fellows program contributes to the strengthening and expansion of the mentors' computing identity through their interactions in the program, including via investigation of the mutual benefits of the program on mentees and mentors. The Computing Fellows program "attaches" near-peer mentors to undergraduate courses across the sciences, social sciences, humanities, and the arts. The mentors support the integration of computing into courses through activities including in-class workshops and drop-in office hours. In a mixed-methods study, we conducted semi-structured interviews over two years with mentors (all of whom identify as women) after their participation and we cross-reference the results with course evaluation data. We find that fellows' experience in the program, both as near-peer mentors and through their engagement in critical discussions about computing and computing pedagogy as part of their training, expands and deepens their computing identity and the various ways they can engage with computing in their lives in and beyond college.

CCS CONCEPTS

• **Social and professional topics → Computing education**.

KEYWORDS

undergraduate, peer mentoring, interdisciplinary, computing

SIGCSE 2024, March 20–23, 2024, Portland, OR, USA

ACM ISBN 979-8-4007-0423-9/24/03…$15.00
https://doi.org/10.1145/3626252.3630946

ACM Reference Format:
Jennifer Rosales, Elizabeth Melville, Melissa A. Wright, Saima Akhtar, and Rebecca N. Wright. 2024. The Experience of Near-Peer Computing Mentors: Strengthening and Expanding Women's Computing Identities in Undergraduate Interdisciplinary Contexts. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1 (SIGCSE 2024), March 20–23, 2024, Portland, OR, USA.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3626252.3630946

1 INTRODUCTION

Peer and near-peer mentoring programs in STEM fields have been shown to support self-efficacy and a sense of belonging and inclusion for students, particularly women and students from underrepresented groups [21, 32, 40]. In our work, we focus on the mentors, or fellows, in our undergraduate near-peer program and find that participation strengthens their computing identity. In the women's college context of the program we study, all of the fellows identify as women. We find that the program supports computing identity growth through (1) teaching practices that strengthen fellows' confidence and validate their computing competencies and (2) a broadened computational and sociotechnical landscape to which the interdisciplinary program exposes them.

We study a near-peer mentoring program in which undergraduate "Computing Fellows" are trained through a cohort model. The fellows are matched with undergraduate courses across disciplines (including environmental science, chemistry, neuroscience, cognitive science, history, education, first-year seminars, and computer science (CS)) in order to integrate and support computing in the courses. The program aims for students across disciplines to understand the role that computing can have to answer important real-world questions and to feel empowered to learn more. The fellows are considered "near peers" because they all have established computing experience, while the students in their attached courses may not. As part of a larger mixed-methods study, we are studying the impact on both the fellows and the course students (the students in the courses that fellows are attached to), with two primary research questions RQ1: How do Computing Fellows contribute to course participants' engagement with computing? and RQ2: How does being a student Computing Fellow contribute to the fellow's engagement with computing? Building on our preliminary results [35], this paper focuses specifically on the program's

influence on the fellows (RQ2). We include analysis of the influence on the course students to provide supporting evidence of the value of the near-peer relationship created between the mentors and mentees in the program. We argue that fellows' understanding of their roles—internally and with students and the teaching team—strengthens and broadens their computing identity.

In the context of a women's college, our results explore the influence and value of participation as a near-peer mentor on the mentors themselves in the context of computing-related mentoring in classes across disciplines, including introductory ("CS0") computing classes in a CS department but not part of the CS major, introductory applied computing classes taught by other departments, and non-computing classes in other departments in which the fellows support the addition of computing activities or inclusion of computing in individual students' projects.

We describe the Computing Fellows program in more detail in Section 2. We discuss related work in Section 3 and describe our research methods in Section 4. We present our results in Section 5 and additional discussion in Section 6.

2 COMPUTING FELLOWS PROGRAM

The Computing Fellows program supports faculty to incorporate computational projects and activities into their courses by assisting with the development, planning, and implementation of the activities. The program hires and trains a number of undergraduates to be fellows each semester. Fellows are "attached" to courses at the college across science, humanities, and the arts. Fellows work with the faculty and directly with course students to support student learning and can be attached to courses in three ways: teaching a workshop on computing-oriented topics related to the course, offering office hours, or offering one-on-one conferences to assist students on a computing-related class project. The program also provides leadership and skills development for the fellows themselves through weekly or biweekly meetings. The Computing Fellows program promotes the inclusion of computing across the liberal arts curriculum, ensuring that students are exposed to the value of computing in the context of specific disciplines and in an accessible way.

To recruit fellows each semester, an open call for Computing Fellow applications is publicly posted. Selection of fellows focuses on the applicants' teaching experiences, application materials, interviews, and computing experience. We also focus on how fellows may help a peer troubleshoot or debug, leadership experience, and general interest in helping other students. Each semester, instructors have an opportunity to request a Computing Fellow for their course. Fellows are then matched to courses according to their interest, availability, and familiarity with the coding language or computing-related topic needed to work with students in the attached course.

3 RELATED WORK

Research has demonstrated the value of computer science pedagogy and culture that fosters community-oriented learning and strengthens students' self-efficacy especially in introductory courses, where failure rates are high both in the U.S. and elsewhere [23, 46]. Creating and sustaining such environments is key to promoting inclusivity and the retention of computer science students, reducing attrition from introductory courses [5], and changing the culture and reputation of the discipline in order to attract a greater diversity of students to continued study of computing [19, 30, 47]. Vital to creating environments of inclusivity—which in turn can promote greater gender, racial, and ethnic diversity, as well as retention of students within the field—is peer and near-peer mentoring, which is the foundation of the Computing Fellows program.

Research demonstrates that students benefit from having multiple mentors whom they can seek out for diverse personal and professional needs [29, 45] and that near-peer mentoring provides meaningful social and academic support for undergraduate students [14, 26, 39]. Women and people from underrepresented groups benefit from role models in STEM fields [4, 24]. Researchers have documented that mentoring programs increase student retention and academic success [15, 31, 33, 38]. Mentees and mentors feel more integrated with and connected to their institutions [25, 26] and develop an increased sense of belonging and science identity [43]. The peer and near-peer mentorship models equally emphasize the undergraduate's ability to share knowledge and their ability to acquire knowledge [40] and in this way is importantly distinguished from and augments a traditional mentoring relationship (with the undergraduate as the mentee and the expert scientist-professor as mentor) [18, 36]. Peer mentors can provide students with rapport and guidance [40] and directly impact students' self-efficacy through the social relationships formed, the similarities perceived between themselves and their peer mentors, and students seeing the mentor effectively and successfully perform tasks [2, 3].

For students who are peer mentors and educators, the experience can provide them with a sense of community, a resource for improving self-efficacy, and greater understanding of the concepts they engage with [48], particularly for students who identify as women [27]. Near-peer mentors have the potential to become ambassadors for their disciplines, to gain communication skills, to strengthen their own knowledge, and to deepen their commitment to computing [1, 7, 42]. Additionally, by identifying with their discipline and feeling like contributing members of the field, mentors are more likely to persist in the field [34].

Computing identity [9] has been defined in multiple ways to explain how computing interest, skills, and community are integral to one's conceptions of self [12]. Boyer et al. define it "as a sense of pride and belonging" [8] to a computer science community and Lunn et al. define it as "their [computing] interest, recognition, sense of belonging and competence/performance beliefs" [28]. Carlone and Johnson explain that computing identity is constantly negotiated and can be challenging particularly for women of color because it is not only about ability and how one sees themselves, but also how others see them and their legitimacy in the field [10]. Clarke et al. propose three themes that help define computing identity across the literature: engagement in computing, need for role models of similar identities in the field, and exposure to computing persistence [12].

Though scholarship on near-peer mentorship programs is fairly extensive, computing mentorship in non-CS disciplines and the way in which mentors negotiate their own relationship to the role,

including how the experience of co-creating a learning environment contributes to mentors' understanding of their computing identity, have been less studied. Our study explores these areas.

4 RESEARCH METHODS

Our mixed-methods design was developed based on previous studies in mixed-methods computer science education research (e.g., [6, 13, 37, 44]). We use a concurrent nested strategy to embed the quantitative data collection within the qualitative data collection [41]. The mostly qualitative design seeks to unpack how the program contributes to fellows' engagement with computing and computing identity. Some quantitative data collection is employed to corroborate our qualitative findings.

Positionality of Research Team. Our research team members all identify as women, two as women of color. We come from a broad range of disciplinary backgrounds and expertise, including computer science, education, social science, anthropology, and design.

Computing Fellow Participants and Interviews. From Spring 2022 through Spring 2023, 14 fellows participated in the program. Within this group, ten fellows were CS majors (one is a double Psychology major) and four were non-CS majors in the fields of Mathematics, Economics, Philosophy, Neuroscience, and Biochemistry. In Spring 2022, three were graduating seniors, compared to four graduating seniors and seven rising seniors as of the end of Spring 2023. All of these fellow participants identified themselves as women of color.

In Spring 2022, we conducted semi-structured interviews with the six fellows in credit-bearing classes. In Fall 2022 and Spring 2023, we conducted semi-structured interviews with all 10 of the eligible fellows, with five out of these 10 being follow-up interviews with returning fellows who were also interviewed in Spring 2022. Questions included motivations and interest in the Computing Fellows program and computing more broadly; values and identity in connection to computing; and their interactions and responsibilities in the program [20]. As presented in earlier work [35], our research questions and indicators guided the interview questions and set parameters for relevant topics in our thematic analysis coding process. We also identified emergent themes based on participant responses.

Course Evaluations. To measure course students' experiences with the fellow in their attached class and with computing more broadly, course evaluation data was collected at the end of semesters Spring 2022 (N=194), Fall 2022 (N=172), and Spring 2023 (N=120). These evaluation results can provide insight into the student view of the interactions with the fellows. Questions were aimed at understanding the nature of student interaction with fellows, their perception of the difficulty of the computing work assigned, self-reported competency and interest in computing, among other measures [11]. Retrospective pre-post questions [22] were included to measure students' (1) self-reported competency and (2) interest at the beginning and end of the course.

Thematic Analysis. Given the semi-structured nature of the fellow interviews, we combined deductive and inductive thematic analysis to understand both our main factors and to allow for emergent themes to develop. One researcher defined the deductive codes based on the research questions and literature in the field. Then, a second and third researcher read the interviews multiple times to facilitate "data immersion" and update the codebook with inductive codes. One of these two researchers then coded all interview data, meeting periodically with the other two researchers to discuss changes to the codebook. All three researchers came together in discussion to confirm themes based on the coded data.

5 OUR RESULTS

We first explore the fellows' reported experience of their computing identity through analysis of fellow interviews (Section 5.1). Three major themes emerged: (1) developing computing identity within a broadened landscape; (2) validating and strengthening confidence in computing; and (3) teaching practice that expands computing identity. Fellows repeatedly describe the unique characteristics of the fellow teaching and learning environment, particularly their relationship with course students. We further corroborate whether course students also experience similar characteristics of this relationship by exploring the course students' perceptions of their own computing competency and interest (Section 5.2).

5.1 Fellow Results

Interviews with fellows reveal that fellows' participation in the program strengthens and expands their computing identities in three ways. Fellows reported benefiting from their engagement in weekly cohort meetings, where they regularly discussed the social impact of computing. Fellows' reported a sense of increased confidence in computing as a result of their mentoring work. And, fellows developed their computing identity through their teaching, including their ability to see gains the course students were making. We describe each of these findings in more detail.

5.1.1 Developing Computing Identity within a Broadened Landscape. Through the fellows' experience in the program, the data shows the emergence of a theme of students' broadened interests for computing for social good. This broadened awareness of the social implications of computing primarily emerged from their cohort meetings, which were led by program staff and frequently centered on readings recommended by fellows within the cohort. In the interviews, some fellows described how the Computer Science major is largely focused on computing theory and computing skills, leaving little room for questions of ethics or applications, with the exception of a handful of upper-level courses. For these majors, the Computing Fellows meetings were the first time they were able to engage in sustained conversations around critical approaches to computing.

Following an otherwise traditional pathway through the CS major, a fellow Olivia[1] joined the fellows program at the start of her junior year. In program meetings, she encountered critical and technical discourses around ethics and computing for the first time. She explains that this experience has shifted the way she engages in computing more generally, recounting that she had recently watched a forum on brain monitoring technology and, rather than

[1]All participant names are pseudonyms.

exclusively engaging in the excitement around the technology, she began to engage with larger ethical questions of labor relations and the price of optimization. "*I wouldn't have been able to see the red flags*," Olivia reported, "*if I hadn't been involved with computing fellows because we have had discussions on this, or around this topic, several times last semester. So having the tools to critically think about a technology is something that I learned here and I'm glad that I did.*" The impact on a fellow Sara came from her multi-semester work as a fellow for interdisciplinary courses where she began to really develop a sense for how CS can be a tool for social change. Through a robust and collaborative relationship with the course professor, she was able to "*see where the applications are, like, 'Oh, there's a lot of actionable items I can do when I say my interests are computer science and social good, right?'... I have a better idea of the spaces online where people are using computing for good and it's a lot more actionable than when I first started in the Computing Fellows program.*" This realization redirected her interests from a traditional CS research context to spaces within non-CS departments where her computing skills could be used in a way that aligned with her larger social values.

A fellow Padma also reflected on the value of thinking critically about computing in the Fellows program. She states, "*One other thing I value about the program is how much we talk about ethics in the computer science or technology field in general.*" She further relates her experience in fellow trainings and weekly meetings back to her experience working with students, explaining how valuable it is for students to develop a critical lens in their own work with computing: "*it's good that we're not just helping students with specific projects, but also contextualizing what we do in this wider arena that's getting scary now.*" In these reflections and in the relationship Padma draws between her own learning in the program and her work mentoring students, we see how the critical orientation of the program can support fellows' interests in computing and in their work as mentors as well. The Computing Fellows program supports fellows in developing this critical orientation through facilitated discussions in the weekly fellows meeting and through their engagement with workshops they lead in their attached classes. Some workshops were created in earlier years and are led regularly by new fellows, such as a workshop around the privacy implications of data collection and analysis. Some workshops are newly developed by the fellows based on their own understanding of the courses they are attached to. For example, a fellow Priya proposed, developed, and led a workshop around data science and social justice in a data science course that would otherwise not have addressed the ethical and social context of data science.

5.1.2 Validating and Strengthening Confidence in Computing. When asked how the Computing Fellows program broadly impacted their relationship with computing, the majority of fellows reported a feeling of increased confidence. For fellows who were already CS majors, many explained that they had struggled with low confidence in their computing skills, their ability to work independently on debugging problems, and their sense of connection to their majors. Due to their work as computing fellows, however, many reported that their relationship to computing has been positively impacted through cohort meetings, prep work, and working directly with course participants.

In some cases, this manifested in increased confidence in computing itself. For example, a fellow Tiffany explained that she had previously turned to teaching assistants for help when she would get stuck, but working with students and helping them debug code made her feel more confident in tackling her own computing work without needing to seek additional support. Along the same lines, a fellow Emily said, "*I always just thought I was a really bad coder*," but noted that through work with students and successfully breaking down and teaching computing concepts, she feels validated that she does have a command of the content and that she's "*not actually as bad as [she] thought [she] was.*" Beyond an elevated sense of competence, these changing relationships with computing have impacted some fellows' trajectories within the CS field. Sara's increased feelings of confidence in computing led her to take on higher-level CS courses in artificial intelligence and natural language processing that she would normally not have felt capable of taking on. Although she finds the courses challenging, she has come to an understanding that "*[she's] more capable than [she] thought [she] was.*" In a similar reflection on her place within computing, Padma explained that her position as a kind of representative of computing within interdisciplinary courses "*made [her] more confident in pursuing the major and more aware of [her] place within the CS major.*"

The relationship to computing of the four fellows who are not CS majors was also positively impacted by their work as fellows. From general reports of feeling more confident given their position as both near-peer mentors and as collaborators with faculty to more specific discussions of how working as a fellow personalized computing and made further self-driven computing education more accessible, serving as a fellow enriched these fellows' understanding of themselves in relation to computing. A non-CS major fellow Abigail, who uses a considerable amount of computational modeling in her major, reported that she had felt timid going into the fellows program as a non-major and self-taught coder. However, over time working with an involved interdisciplinary course that also required modeling of other complex systems, she began exploring the theory behind the computing concepts she worked with, and came to "*feel more confident in [her] own abilities as a coder, as a computational person.*" In Spring 2022, Priya reported that she repeatedly rejected a close identification with computing, citing difficulty in courses and feelings of inferiority compared to CS majors. By contrast, in a follow-up interview in Spring 2023, Priya expressed that she had begun to actively associate herself with computing, and that computing has increasingly become central to her disciplinary interests. Although partly attributed to continued CS coursework, Priya also felt that her trajectory has been positively impacted by her work as a fellow and the computing community she's built within the program.

5.1.3 Teaching Practice Expands Computing Identity. Though nearly all fellows describe an increased interest in teaching computing or computing pedagogy, the way they describe their mentorship roles varies. In Spring 2022, Priya described herself as a member of the "*teaching team*" for her attached course, which included the professor and teaching assistants; similarly, nearly all of the fellows describe their work with students as a form of teaching. In contrast, Olivia shared that the program helped her realize that she "*really*

enjoy[s] teaching [computing]," but revised her wording a moment later, clarifying, "*and they are my peers, so it's not like I'm a teacher.*" In Spring 2023, Padma similarly shared that she valued the emphasis in the training workshops of the fellow's unique position, as neither teaching assistant nor professor. Rather than roles "*where it's about telling students a right and a wrong way to do things*," she notes that her role is "*figuring things out with students*," further saying that this nature of the near-peer role "*eased a lot of my anxieties about being a sophomore who just started the CS Major [...] and made me excited about the possibilities of these mutual collaborative interactions that you can have with students.*"

When asked why they joined the Computing Fellows program, several fellows expressed that they wished they had a fellow in their courses when they started their computing journey and wanted to provide that encouraging academic support for others. Other fellows mentioned the novelty of working collaboratively with faculty and the sense of recognition they feel when their ideas are valued by others on the teaching team.

In the interviews, fellows also frequently described their role as more focused on making students comfortable with engaging in computing than teaching technical computing. As Padma explained, "*you can solve the problem itself within five minutes, and then you have to more broadly make students feel comfortable.*" Rather than teaching technical computing, Emily described her work as largely focused around encouragement and "*a lot of verbal affirmation like, 'Oh, you did that,' or 'You walked through that really well. That logic makes absolute sense. Now we just need to translate.'*" These comments point to the ways in which fellows themselves have developed a supportive and empathetic approach to mentoring in the context of computing.

When asked what experiences stuck out to them in their work as fellows, both Olivia and Priya recounted multiple anecdotes where students were emotionally and academically struggling with the computing content in their courses, and how they as fellows were able to approach their pedagogy in different ways in order to support their students' re-engagement. For Olivia, her pedagogical approach involved providing availability beyond office hours to sit with the student and encourage her through the assignments. By the end of the semester, she reported that the student still asked for additional time with her, but the student was able to complete the work almost entirely independently. She says her role was more "*moral support rather than technical support but [she] appreciated that [the student] had felt comfortable enough to ask for it. Because [she] feels like getting over that hump of, 'Can I do it? Can I not?' is a really big deal.*" Priya reported sitting with a student while the student tearfully expressed her struggles with the course and taking several subsequent steps to support the student: offering to move office hours to make them more accessible, going through the different computing help resources on campus with her, and organizing to pair her up with a more experienced student in the course so that she would have a community for working through assignments. In both of these cases, the impactful experiences the fellows recounted emphasized their interest in computing pedagogy, particularly their attentiveness to the emotional barriers students face in entering computing for the first time.

5.2 Student Results

Fellow interviews combined with course evaluation data demonstrate that fellows contribute to students' increase in sense of computing competency and engagement, further validating the fellows' sense of helping students. In Section 5.2.1, we provide a case of fellow Abigail, who describes both her impact on a student in her attached course and the implicit value she places on that impact. This case is further supplemented by course students' evaluation of Abigail's impact. Section 5.2.2 provides a summary of general trends across three semesters of course evaluation data, with a focus on Spring 2023 results. Students' ratings and comments corroborate the fellows' impressions that they are making computing more accessible for the course students.

5.2.1 Fellows Support Course Student Learning. Fellows value their role in making computing more accessible to others, especially for non-majors in interdisciplinary courses. Abigail explained that she decided to join the program because it emphasized the importance of "*creating those environments for people who feel like they don't belong there, felt like they've never belonged there, or could never really access [computing].*" When asked if she felt she accomplished this goal throughout the year she served as a fellow, she responded that students would often "*come up to [her] and be like, 'This is my first coding class, I have no confidence in this and some of these assignments are really freaking me out because I look at this code, and it's like, what am I supposed to be doing with this?'*" Abigail further reported that through continued engagement in office hours, she "*could see a great improvement in at least [the student's] willingness to try these assignments and then come to [her] or the teacher to get feedback to really learn how to think about these different assignments.*" In this example, Abigail shared that her goal for the year was not necessarily increased student competence in computing but rather to instill in students a sense of motivation to persevere.

Corroborating this perception, an analysis of the end-of-semester evaluations for Abigail's Spring 2023 attached course, a coding-oriented class taught in a non-CS department, shows that 11 out of the 16 students who responded to the course evaluation reported being helped by Abigail, either in office hours or via email. There is evidence of the effective bridge Abigail created into computing. As one student explained, "*[the fellow] made this course doable and encouraged me to continue with this course instead of withdrawing due to my lack knowledge [sic] ... Before entering this course, I had no prior knowledge of any computing. Throughout the course and with the help of 'Abigail' I was able to start understanding what computing was and how to read syntaxes [sic]. Now, as the course is over, I am able to have a decent understand[ing of] what Matlab is and how to write very simple code.*"

5.2.2 Student Self-Reported Computing Competency and Interest. Building on our earlier analysis and initial findings [35], results from three semesters (Spring 2022, Fall 2022, Spring 2023) demonstrate a positive relationship between access to computing fellows and self-reported competency in computing, providing further validation of the fellows' reported sense of helping the course students. We further analyzed these results to understand potential differences between relevant subgroups, including (1) students in Computer Science courses as compared to those in non-Computer

# Interac.	Pre-Competency			Post-Competency			Pre-Interest			Post-Interest		
	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N
0	3.29	1.2	43	3.79*	1.22	43	3.89	0.99	43	3.94	1.07	43
≥ 1	2.53	1.34	32	4.38***	0.79	32	3.47	1.14	32	4.16**	0.92	32

Statistical significance:
* p < .05
** p < .01
*** p < .001

Table 1: Spring 2023 Non-CS Course Students' Self-Reported Competency and Interest in Computing

Science courses and (2) students who interacted with a fellow at least once, as compared to students who did not interact with a fellow. The mean calculations across all sub-groups for the same three semesters show a consistent increase in self-reported computing competency based on retrospective pre-post questions. These questions were asked at the end of the course, asking students to reflect on their competency to perform in the computing components required in the class at the beginning and end of the class. Using a Wilcoxon signed-rank test, this finding was statistically significant for students in non-Computer Science courses. This gain was particularly notable in Spring 2023, with a statistically significant difference of 1.85 on a five-point Likert scale. In Spring 2023, this subgroup of students in interdisciplinary courses, who interacted with a fellow at least once, also reported the largest gains in self-reported interest in developing their computing skills, with a statistically significant difference of 0.69 on the same scale. The questions on computing interest were added in Spring 2023. Table 1 shows a statistical summary of that semester's responses for course students in non-CS courses with attached fellows.

Further illustrating the particular benefits to students in non-CS courses, one course student from an Education course in Spring 2023 described her experience as follows: "*[This course] has made me aware that I am capable of what I think I am. The digital world seems intimidating but when you have someone to guide you it can be amazing. The fellow in this course made sure we always felt guided.*" These data also suggest that fellows serve a particularly important role in non-CS courses by exposing students to critical aspects of computing. In the same Education course, another student shared that her understanding of computing "*evolved significantly. I realized that computing also has the potential to be placed in a broader context, beyond just technical skills and programming languages. I now have a deeper understanding of the impact of technology on society, as well as a greater appreciation for the social and ethical responsibilities of computing professionals.*"

6 DISCUSSION AND LIMITATIONS

We find that computing fellows experience a strengthened and broadened computing identity through their experience as near-peer mentors. Their experience mentoring students in turn enriches their own understanding of how and why they want to pursue computing in the future. Through the process of defining and exploring the possibilities of their mentoring roles, fellows connect their pedagogical interests, confidence, and broadened understanding of computing to their future lives and careers.

A strength of the near-peer model is that social proximity coupled with content knowledge specialization can provide a supportive entry point into computing for the mentored students. This is particularly evident for students who are learning about computing in a course in a non-CS department. For many students, the fellows also help students understand that the cognitively and emotionally challenging aspects of computing are part of the process of learning to code or use computing tools. The fellows' attentiveness to their own recent memories of learning computing seems to support students in persevering through difficult learning moments and developing confidence in their computing abilities. In making computing learning more accessible to others, the fellow experience strengthens fellows' computing identity and expands their understanding of the various ways they too can access computing.

As an area for further study, we note that the concept of "liminal" (or "in-between") positions in higher education teaching and learning contexts [16, 17] may be useful to supplement the study of peer and near-peer mentorship, particularly in an interdisciplinary context such as ours. Liminal teaching and learning positions are those in which student consultants or partners are invited to shape the teaching and learning environment and iteratively define their role through their work with students, faculty, and others on the teaching team. While emergent literature on liminality in pedagogical partnership programs focuses on student consultants' role somewhere between faculty and student, computing fellows in non-CS courses also embrace a disciplinary liminality, as they collaborate with students on computing problems while also calling upon the students' disciplinary knowledge and skills to shape the learning experience. Fellows value this in-between position and describe the virtues of their non-hierarchical and collaborative relationship with students. We believe this is a rich area for future study.

The context within which the Computing Fellows program takes place is critical in understanding the larger culture of computing and interdisciplinary collaboration. Our program and study take place at Barnard College, a small liberal arts college for women, which is affiliated with Columbia University, a coeducational "R1" institution. Only Barnard students are eligible to be fellows; the course students include both Barnard and Columbia students due to cross-registration. The Computing Fellows program is an avenue by which fellows contribute to the building of a woman- and non-binary-focused pedagogical space. Nonetheless, this unique setting may be a limitation regarding the replicability and generalizability of our results.

As students who chose to study computing at a liberal arts women's college, our fellows may have pre-established interests and identities that inform the ways they find value and interest across disciplines. Although this is a limitation of our study in terms of direct replicability, our study does indicate that rethinking computing and STEM in a liberal arts context could enhance the development of more complex computing identities. This limitation also points to the need for further study of the role of near-peer mentors in a variety of interdisciplinary computing contexts.

ACKNOWLEDGMENTS

This research was supported by the National Science Foundation under award #2142628.

REFERENCES

[1] Thalia Anagnos, Alicia Lyman-Holt, Claudia Marin, and Ellen Momsen. Impact of engineering ambassador programs on student development. *Journal of STEM Education: Innovations and Research*, 15, 2014.

[2] Albert Bandura. Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, 84(2):191–215, 1977.

[3] Albert Bandura. Self-referent thought: A developmental analysis of self-efficacy. In J.H. Flavell and L. Ross, editors, *Social Cognitive Development: Frontiers and Possible Futures*, pages 200–239. Cambridge University Press, 1981.

[4] Anat Barnir, Warren Watson, and Holly Hutchins. Mediation and moderated mediation in the relationship among role models, self-efficacy, entrepreneurial career intention, and gender. *Journal of Applied Social Psychology*, 41:270 – 297, 02 2011.

[5] Robert A. Blanc, Larry E. DeBuhr, and Deanna C. Martin. Breaking the attrition cycle: The effects of supplemental instruction on undergraduate performance and attrition. *Journal of Higher Education*, 54(1):80–90, 1983.

[6] Jennifer M. Blaney. Looking beyond representation: How women develop their leadership perceptions during the introductory computing course. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*, pages 453–458, 2018.

[7] Bethany Bowling. Professionalizing the role of peer leaders in STEM. *Journal of STEM Education*, 16(2), 2015.

[8] Kristy Boyer, E. Thomas, A. Rorrer, Deonte Cooper, and Mladen Vouk. Increasing technical excellence, leadership and commitment of computing students through identity-based mentoring. In *SIGCSE'10 - Proceedings of the 41st ACM Technical Symposium on Computer Science Education*, pages 167–171, 03 2010.

[9] Nancy W. Brickhouse and Jennifer T. Potter. Young women's scientific identity formation in an urban context. *Journal of Research in Science Teaching*, 38(8):965–980, October 2001.

[10] Heidi B. Carlone and Angela Johnson. Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8):1187–1218, 2007.

[11] Instruments: Course evaluation questions. Personal Website at https://www.cs.columbia.edu/~rwright/Instruments/CourseEvals.html, December 2023.

[12] Nagash Clarke, J.L. Mondisa, Becky Packard, Carin Schemanske, Anu Tuladhar, and Kinnis Gosha. Examining the role of computing identity in the computing experiences of women and racially minoritized undergraduates: a literature review. *Journal of Computing in Higher Education*, pages 1–40, 05 2023.

[13] Diane Codding, Chrystalla Mouza, Rosalie Rolón-Dow, and Lori Pollock. Positionality and belonging: Analyzing an informally situated and culturally responsive computer science program. In *Proceedings of FabLearn 2019*, 2019.

[14] Peter Collier. Peer mentoring: A tool for serving the diverse needs of 21st century college students. *Metropolitan Universities*, 28(3):3–8, 2017.

[15] R. Collings, V. Swanson, and R. Watkins. The impact of peer mentoring on levels of student wellbeing, integration and retention: A controlled comparative evaluation of residential students in UK higher education. *Higher Education: The International Journal of Higher Education and Educational Planning*, 68(6):927–942, 2014.

[16] Alison Cook-Sather. *Co-Creating Equitable Teaching and Learning: Structuring Student Voice into Higher Education.* Harvard Education Press, 2022.

[17] Alison Cook-Sather and Zanny Alter. What is and what can be: How a liminal position can change learning and teaching in higher education. *Anthropology & Education Quarterly*, 42(1):37–53, 2011.

[18] Erin L. Dolan and Deborah Johnson. The undergraduate–postgraduate–faculty triad: Unique functions and tensions associated with undergraduate research experiences at research universities. *CBE Life Sciences Education*, 9(4):543–553, 2010.

[19] Lorelle Espinosa. Pipelines and pathways: Women of color in undergraduate STEM majors and the college experiences that contribute to persistence. *Harvard Educational Review*, 81(2):209–241, 2011.

[20] Instruments: Fellow interview questions. Personal Website at https://www.cs.columbia.edu/~rwright/Instruments/PostFellowInterviews.html, December 2023.

[21] Patricia Garcia, Melissa Perez, Devon Farrell, Sarah Bork, Barbara Ericson, and Joi-Lynn Mondisa. Supporting mutually beneficial near-peer mentoring relationships within computing education programs. In *2021 Conference on Research in Equitable and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, pages 1–9. IEEE, 2021.

[22] G. John Geldhof, Danielle A. Warner, Jennifer K. Finders, Asia A. Thogmartin, Adam Clark, and Kelly A. Longway. Revisiting the utility of retrospective pre-post designs: The need for mixed-method pilot data. *Evaluation and Program Planning*, 70:83–89, 2018.

[23] Rashina Hoda and Peter Andreae. It's not them, it's us! Why computer science fails to impress many first years. In *Proceedings of Sixteenth Australasian Computing Education Conference (ACE2014)*, 2014.

[24] T. Holloman, J.S. London, W.C Lee, C.M. Pee, C.D. Hawkins Ash, and B.A. Watford. Underrepresented and overlooked: Insights from a systematic literature review about black graduate students in engineering and computer science. *International Journal of Engineering Education*, 37(2), 2021.

[25] Alan Hughes and Rebecca Fahy. Implementing an undergraduate psychology mentoring program. *North American Journal of Psychology*, 11:463–470, 2009.

[26] M. Jacobi. Mentoring and undergraduate academic success: A literature review. *Review of Educational Research*, 1991.

[27] J. Liebenberg, E. Mentz, and B. Breed. Pair programming and secondary school girls' enjoyment of programming and the subject information technology (IT). *Computer Science Education*, 2012.

[28] Stephanie Lunn, Monique Ross, Zahara Hazari, Mark Weiss, Michael Georgiopoulos, and Ken Christensen. How do educational experiences predict computing identity? *ACM transactions on computing education*, 22(2), 2021.

[29] Amaury Nora and Gloria Crisp. Mentoring students: Conceptualizing and validating the multi-dimensions of a support system. *Journal of College Student Retention: Research, Theory and Practice*, 9:337–356, 2007.

[30] Maria Ong, Carol Wright, Lorelle L. Espinosa, and Gary Orfield. Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. *Harvard Educational Review*, 81(2):172–209, 2011.

[31] Ralph Pagan and Runae Edwards-Wilson. A mentoring program for remedial students. *Journal of College Student Retention: Research, Theory & Practice*, 4(3), 2002.

[32] Heather Pon-Barry, Becky Wai-Ling Packard, and Audrey St John. Expanding capacity and promoting inclusion in introductory computer science: a focus on near-peer mentor preparation and code review. *Computer Science Education*, 27(1):54–77, 2017.

[33] Maria Elena Reyes. A sophomore-to-junior mentoring program that works: The SAM program at the University of Texas Pan American. *Journal of College Student Retention: Research, Theory and Practice*, 13(3):373–382, 2011.

[34] Sarah Rodriguez and Kathleen Lehman. Developing the next generation of diverse computer scientists: the need for enhanced, intersectional computing identity theory. *Computer Science Education*, 27(3):229–247, 2018.

[35] Jennifer Rosales, Elizabeth Melville, Melissa A. Wright, Saima Akhtar, Zoë Webb-Mack, and Rebecca N. Wright. Computing fellows across disciplines: Preliminary results. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education (SIGCSE)*, 2023.

[36] Susan H. Russell, Mary P. Hancock, and James McCullough. Benefits of undergraduate research experiences. *Science*, 316(5824):548–549, 2007.

[37] Jean J. Ryoo, Tiera Tanksley, Cynthia Estrada, and Jane Margolis. Take space, make space: how students use computer science to disrupt and resist marginalization in schools. *Computer Science Education*, 30(3):337–361, 2020.

[38] Geri Salinitri. The effects of formal mentoring on the retention rates for first-year, low achieving students. *Canadian Journal of Education / Revue canadienne de l'éducation*, 28:853–873, 2005.

[39] Alan M. Schwitzer and Celeste Thomas. Implementation, utilization, and outcomes of a minority freshman peer mentor program at a predominantly white university. *Journal of the Freshman Year Experience & Students in Transition*, 10(1):31–50, 1998.

[40] Laura S. Tenenbaum, Margery K. Anderson, Marti Jett, and Debra L. Yourick. An innovative near-peer mentoring model for undergraduate and secondary students: STEM focus. *Innovative Higher Education*, 39(5):375–385, 2014.

[41] Steven Terrell. Mixed-methods research methodologies. *The Qualitative Report*, 17(1):254–280, 2011.

[42] Lydia T. Tien, Vicki Roth, and J. A. Kampmeier. A course to prepare peer leaders to implement a student-assisted learning method. *Journal of Chemical Education*, 81(9):1313, 2004.

[43] Gloriana Trujillo, Pauline G Aguinaldo, Chelsie Anderson, Julian Bustamante, Diego R. Gelsinger, Maria J Pastor, Jeanette Wright, Leticia Márquez-Magaña, and Blake Riggs. Near-peer stem mentoring offers unexpected benefits for mentors from traditionally underrepresented backgrounds. *Perspectives on undergraduate research and mentoring : PURM*, 4 1, 2015.

[44] Nanette Veilleux, Rebecca Bates, Cheryl Allendoerfer, Diane Jones, Joyous Crawford, and Tamara Floyd Smith. The relationship between belonging and ability in computer science. In *Proceeding of the 44th ACM Technical Symposium on Computer Science Education*, SIGCSE '13, pages 65–70, 2013.

[45] Dawn Wallace, Ron Abel, and Becky Ropers-Huilman. Clearing a path for success: Deconstructing borders through undergraduate mentoring. *The Review of Higher Education*, 24:87–102, 2000.

[46] Christopher Watson and Frederick W.B. Li. Failure rates in introductory programming revisited. In *Proceedings of the 2014 Conference on Innovation & Technology in Computer Science Education*, 2014.

[47] T. Whitney, D. Gammal, B. Gee, J. Mahoney, and C. Simard. Priming the pipeline: Addressing gender-based barriers in computing. *IEEE Computer*, 46(3):30–36, 2013.

[48] Mark Zarb and Janet Hughes. Breaking the communication barrier: guidelines to aid communication within pair programming. *Computer Science Education*, 25(2):120–151, 2015.