Networking and Computing: Creating opportunities for low income students to succeed in computing careers

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***Abstract*— With the national need for computer science, computer engineering, and robotics professionals soaring, computer science depts. are struggling to attract, and graduate students from low-income groups. In particular, women, Native Americans, and other ethnic minorities who are highly represented among low-income students, are not entering computer science. Thus, they are not available to provide the variety of perspectives needed for effective problem solving in computer science domains. To respond to this need, we designed a Track 1 project, Networking and Computing (NAC), with the overall objective of enabling low-income academically talented Univ. of Minnesota Duluth computer science students to attain a 4-year baccalaureate degree and enter into a computer science job or graduate program within 1 year of graduation. Mechanisms to attain this goal are to increase students' sense of belonging, professional identity, and networking capabilities. Our Longer-Term Outcomes are to establish a model of student support that is effective and transferrable to other STEM programs, and substantially increase the number of low-income students who enter the computer science field.**

Keywords-Networking; computing; low-income students, career opportunities, mentoring

I. Introduction

A robust workforce of computer scientists is critical to ensuring national security and competitiveness. Yet, there is an enormous gap between the available jobs in the computer science industry, and the number of computer scientists available to fill those jobs. For example, in September 2021, the National Foundation for American Policy reported over 1 million unfilled jobs in software development, computer programming, and other computer science jobs representing billions of dollars in unrealized output. Among cyber-security specialists, only 2/3 of available jobs are currently filled, leaving a 600,000-employee shortage in this critical profession (CyberSeek, 2022). This gap leaves government and industry, as well as individuals, vulnerable to computer hacks, ransomware attacks, and other types of computer and network infiltrations.

In addition to the current gap, the Bureau of Labor Statistics (BLS; 2021) estimates that the need for computer scientists will be even greater in the future. According to the BLS, the growth rate for computer and mathematical occupations will be 12.2% from 2020 to 2030, with the growth rate for information security analysts at 33%, computer and information analysts at 27.8%, and computer developers and programmers at 23.2%. In Minnesota, the latest estimates for projected job growth (2020-2030) is 89,295 jobs (MN Employment & Economic Development, 2022). Moreover, "the median annual wage for computer and information technology occupations was $91,250 in 2020, which is higher than the median annual wage for all other occupations of $41,950" (BLS, 2021). Employment in a computer science occupation means that low-income, academically talented individuals who prepare for computer science careers can increase their salaries, build personal wealth, fulfill a rewarding career, and secure greater social mobility.

II. BackgroundType Style and Fonts

In order to have a comparative advantage in obtaining computer science jobs upon graduation, students need to demonstrate real-world, hands-on skills and experience, proficiencies in new technologies (e.g., direct programming, advanced software development), as well as interpersonal skills, such as the ability to lead and work on teams, communicate effectively, problem-solve, and co-create solutions to emerging societal challenges. These skills can be learned through networking, mentoring, internships, and working on research and project development teams, as well as by striving toward common educational and career development goals with a cohort of other students who are at the same developmental level (Opaci ch, 2019). Additionally, both Vocational and other psychologists have

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agreed that students need to develop at least an initial sense of identity with their chosen STEM field in order to pursue a career in that field post-graduation (e.g., Cheryan et al., 2017). Moreover, in the world of computer science, students need to network with other professionals in their quest to obtain a job that is right for them. Experts agree that exploring careers and forming relationships through networking and participating in internships that are aligned with students' interests and goals are primary mechanisms for obtaining employment that is satisfying and meaningful.

In regards to networking, there is a robust literature supporting the value of networking among STEM professionals and STEM professionals in training. Networking is one of the most important skills that young people can develop in terms of their abilities to explore careers, make career decisions, embark on the careers they love, and transition to other career opportunities in the future (U.S. Department of Labor, 2019; Van Hoye et al., 2009; Wanberg et al., 2020b). Through networking, individuals can obtain occupational and job information, increase employment options (Wanberg et al., 2020a), and increase job offers (Obukhova & Lan, 2013). Networking can help students find the answers to "What is in it for me?" Why should I bother?" and "How did you get through school?" Networking can provide students with insights into how to get the job that matches their interests, can help them reformulate problems and think about things in a different way, and can provide validation for their decisions (Cross & Sproull, 2004). Networking can increase students' sense of belonging, and can increase a sense of shared identity with the profession (Cyr et al., 2021). Networking can make a job-search process less stressful, can decrease disparities in job placement between individuals from minoritized and low-SES backgrounds and those from more privileged backgrounds, and can increase career planning behaviors, optimism, subjective perceptions of success, job satisfaction, and career fulfillment (Forret & Sullivan, 2002; Franzen & Hangartner, 2006; Spurk et al., 2015). In particular, among low-income students, networking has been shown to improve awareness of their own career trajectories (Videla, 2021).

To take full advantage of networking, students need to develop networking skills, which are often taught in learning by doing or in mentoring relationships (Gerard, 2012). Mentors not only teach students how to network, but take them places where they can meet influential people in their profession. Networking in particular helps women computer science students who do not always have access to the same professional networks as men do (Woehler et al., 2020). Career coaching/counseling have been shown to be particularly effective in helping people learn how to engage in networking effectively, especially for women who are often excluded from professional and social networks and activities, and from low-income students whose networks are not as consistently reliable as higher income students in giving information, advice, or providing references (Nzau et al., 2021). Learning to network in college can assist students not only when they are beginning their career, but also when they are seeking to advance their careers.

III. Methods

A. *Determination of Needs*

We conducted a mixed-methods study using an explanatory design where qualitative data helps to explain quantitative results (Creswell & Plano Clark, 2017). Low-income undergraduate UMD computer science students (N = 63) were surveyed using the McWhirter's Perceptions of Educational Barriers Scale (1997), with additional UMD-specific questions added by computer science faculty. Data were analyzed using frequency counts. Then, we conducted 3, 1-hour focus groups with (6 to 7 students in each group) using a semi-structured format. We constructed the focus group questions in consultation with 4 faculty who are directly involved in training undergraduate STEM and computer science students in their major subject areas. Five variables were endorsed by 25% of the students. These variables also had substantial qualitative support.

In sum, greater than 50% of the students in this survey expressed significant challenges with a low sense of belonging and a lack of professional identity, with not enough money, challenges with coursework, and a lack of career information also being issues of concern for a quarter to a third of them.

B. *Hypothesis*

Our working hypothesis is that networking will abrogate these substantive concerns by helping students form connections with faculty, peers, mentors, computer science professionals in the field, and student service professionals within the university.

C. *Design of the NAC program:*

Thus, based on these identified needs, we have constructed the Networking and Computing (NAC) program. The University of Minnesota system has a singular focus on assisting low-income students to successfully graduate via a firm commitment to fully funding their undergraduate tuition for 4 years. This offsets some of the financial need that arises at other institutions, which means that the NAC program can support more students to graduation due to the average unmet financial need of $6013 per year.

D. *Program Eligibility*

Eligibility into the NAC program is determined by students who are recognized as low-income students as determined by the UMD's definition of being Pell Eligible, and who are maintaining a GPA of at least C- as the academic eligibility requirement imposed by the project team.

E. *Activities and Infrastructure on which the Current Project Builds*

The Networking and Computing (NAC) program is based on enabling students to succeed academically, to develop networking, career development, research/project development, and academic skills, and to develop professional networks while still in college, in order to graduate in 4 years and place in a job aligned with their interests and abilities. To do this, we have adapted and enhanced three existing programs. These are the Undergraduate Research Workshop developed by Pl Dr. Khan under the Google eCSR grant, the Mentoring Training Program developed by Pl Dr. Khan under NSF Award #0965948, and the PeerUp Mentoring and Training Program, developed by Co-Pl Dr. Hinderliter under NSF Award #0845676. The NAC program is a tiered, developmentally keyed program that is designed and led by the Pl Team, and implemented by the Pl Team, and UMD's academic and student service professionals, UMD administration, peer mentors, faculty, and computer science industry professionals.

The Undergraduate Research Workshop has been offered 4 times in the Computer Science Department with great success as evaluated by survey. The focus of this workshop has been for students to work with faculty and industry professionals to conduct research or engage in project development. Through this workshop, students have received hands-on training and guidance, and have been able to present the results of their work at on-campus research forums.

IV. Conclusion

The NAC program (described next) is designed so that students participate in development and support activities that are appropriate for their academic level in college (1st year Freshmen through 4th Year Seniors). Each year's programming is structured so that there is a workshop at the beginning of the fall semester, with follow-up activities the rest of the year designed to support students' goals and meet institutional goals and student-identified needs.

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