

CS@Mines: PATH Ambassadors to High Success, A Successful S-STEM Scholarship Program

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Tracy Camp is a Full Professor and Head of the Department of Computer Science at the Colorado School of Mines. She is the Founder and Director of the Toilers (<http://toilers.mines.edu>), an active ad hoc networks research group.

Her current research interests include the credibility of ad hoc network simulation studies and the use of wireless sensor networks in geosystems. Dr. Camp has received over 20 grants from the National Science Foundation, including a prestigious NSF CAREER award. In total, her projects have received over \$20 million dollars in external funding. This funding has produced 12 software packages that have been requested from (and shared with) more than 3000 researchers in 86 countries (as of October 2012). Dr. Camp has published over 80 refereed articles and 12 invited articles, and these articles have been cited almost 4,000 times (per Microsoft Academic Search) and over 7,000 times (per Google Scholar) as of December 2012.

Dr. Camp is an ACM Fellow, an ACM Distinguished Lecturer, and an IEEE Fellow. She has enjoyed being a Fulbright Scholar in New Zealand (in 2006), a Distinguished Visitor at the University of Bonn in Germany (in 2010), and a keynote presenter at several venues, e.g., at the 7th International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP 2011) in Adelaide, Australia, and the 3rd International Conference on Simulation Tools and Techniques (SIMUTools 2010) in Malaga, Spain. In December 2007, Dr. Camp received the Board of Trustees Outstanding Faculty Award at the Colorado School of Mines; this award was only given five times between 1998-2007.

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PATHS S-STEM Scholarship: Successful Recruitment and Retention for Computer Science Majors/Minors

1 Recruitment and Retention Success

The Path Ambassadors to High Success (PATHS) S-STEM scholarship program, which is funded by the National Science Foundation (NSF), is a successful model of a research-based undergraduate STEM scholarship program that provides academic and community supports for low-income undergraduates majoring or minoring in computer science (CS). PATHS scholars receive up to \$10,000 per year for four years with an average award of \$4,700. Since the program's inception in Fall 2017, PATHS has received over 450 applications from low-income students and enrolled 48 at Colorado School of Mines (Mines). PATHS students are diverse (29.2% female, 41.7% students from groups underrepresented in computing, and 35.4% first generation) as well as academically successful (mean GPA is 3.4 and 38% have GPAs of 3.5 or higher). We define students from underrepresented groups (URGs) in computing in alignment with NSF-defined student populations, e.g., women, African Americans, Hispanics, American Indians, Alaska Natives, Native Hawaiians, Native Pacific Islanders, and persons with disabilities^{1,2,3}. PATHS scholars receive on average \$4,600 per year for four years.

PATHS retention rate is high (91.7%). Only four PATHS scholars have left Mines and the PATHS program since its inception. Two of the four students transferred to another university due to research interests that do not exist at Mines. We include these students as "not retained" in the retention rate of our program, though both are not "failures" in terms of educating low-income students (e.g., one of the two transferred to a top 30 university). The other two students left Fall 2020 due to health and personal reasons. The departure of these students is a new occurrence for the PATHS program that we attribute to the COVID-19 health crisis. Recruitment of PATHS scholar applicants has increased each year since 2018. There were 53 PATHS scholarship applicants in 2019, 169 in 2020, and 227 in 2021. PATHS provides financial support for academically talented students who face financial and socialization struggles common to low-income and first generation college students^{4,5}. PATHS results verify the importance of creating a pathway of personal connection and community from high school to career for low-income students (See Figure 1). Analyses of our program successes underscore the importance of social capital, community, and a sense of belonging as successful recruitment and retention strategies.

2 Recruitment Pathways

PATHS successful recruitment efforts can be attributed to making the application process streamlined with the general admission process and K-14 outreach that PATHS scholars conduct as CS@Mines ambassadors. Forty percent of PATHS scholars participated in K-12 outreach four or more times over the academic year as opposed to just 8% of the Computing Research Association's (CRA) Center for Evaluating the Research Pipeline (CERP) national comparison group⁶.

The flexible CS degree program, now with seven tracks (General, Data Science, Business, Robotics and Intelligent Systems, Computer Engineering, Space, and Research Honors), is another aspect that accommodates a broad range of interested PATHS applicants. The seven tracks within the CS degree program are referred to as CS+X tracks, where X is another STEM discipline. The structure recognizes the wide application of CS and invites students to combine their CS education with another discipline of their choice.

Admitted students are automatically notified when they designate CS as a major or express interest in CS as a minor. For example, students who list Mechanical Engineering with "robotics" or "robot" mentioned in their application and meet the remaining PATHS eligibility criteria (e.g., Colorado resident and FAFSA filed) receive an email alerting them of the opportunity to apply to PATHS. Staff in Mines Admissions and Financial Aid also steer high-potential prospects to the PATHS website and encourage them to apply. The PATHS scholarship opportunity was also promoted by surrounding community college staff and faculty, as well as Colorado high school CS teachers.

PATHS scholars provide K-14 outreach based on their interests (e.g., visiting their previous high school or providing K-12 CS presentations). K-14 outreach provide the PATHS scholars with valuable experience and provide the high school students role models with whom they can identify (especially female and URG CS@Mines ambassadors). K-14 outreach has proven to aid the development of self-efficacy, retention, and recruitment for first-generation, low-income, STEM students^{7,8}. K-14 outreach provides scholars with an opportunity to improve professional communication and presentation skills. Service learning and CS presentations to K-12 students also aide scholars in building confidence and developing their identity as knowledgeable and successful CS students. In this regard, K-14 outreach serves dual purposes, i.e., helping scholars develop their CS identity and sense of belonging in the profession AND recruiting K-12 students to PATHS (which is successful due to the interactions between the K-12 students and the diverse college students in PATHS).

We note that PATHS scholars are helping to broaden the participation of historically underrepresented groups in computing at Mines. Specifically, before PATHS began, CS@Mines had 15.2% (43 of 282) students from underrepresented groups and, as of Fall 2020, had 18.2% (143 of 786) from underrepresented groups (approximately 20% increase). Also, in Fall 2020, 21.6% (170 of 787) of all CS majors were women (up from 15.6% in 2016). PATHS scholars will, ultimately, help diversify our computing workforce as well. Unfortunately, the percentage of URG students in CS@Mines declined from Fall 2019 (21.5%) to Fall 2020 (18.2%) which we hypothesize resulted from COVID-19-related personal and financial challenges. The decline of URG students at CS@Mines underscores the need for supportive programs like PATHS.



Figure 1: PATHS Progression of Activities

3 Retention: Community and Belonging

The strong retention rate of PATHS scholars is supported by activities that foster community and belonging. Low-income PATHS scholars are specifically chosen for their high school academic talent and passion for CS/STEM activities predisposing them to college academic success. Overall, PATHS students excel academically: six have graduated, three have continued with graduate studies, and only five have dropped below the required 2.75 GPA (and, thus, are on probation with additional supports). As mentioned previously, the average student GPA is 3.4 and 38% of PATHS scholars have a GPA of 3.5 or higher. Thanks to support structures in the PATHS program, two students who struggled academically during their first year improved significantly (e.g., one student's GPA improved from 1.2 (F18) to 2.7 (S19) to 3.0 (F19) to 4.0 (S20)). In addition, the majority of students (90%) are on track to graduate in four years. The pandemic affected scholars' academically in varying ways. PATHS remote support during the 2020-21 academic year may have contributed to a program first: six first year PATHS students earned 3.9/4.0 GPA's. Unfortunately, two other PATHS scholars dropped courses, withdrew from a semester, and one student left the program and the university. Additional PATHS supports include a first-year academic success seminar and scholar-to-scholar peer mentoring. PATHS scholars have secured internships at the FBI, Lockheed Martin, Home Advisor, GoGo Air, and more. PATHS graduates work at Tyler Technologies, Woodridge Software, Apple, and Workday.

The primary benefit scholars reported they received from the program was a sense of *belonging*. Belonging begins for new scholars at the annual summer retreat, which is attended by new and returning scholars. Ninety-three percent of PATHS scholars found the annual two-day retreat held in-person in August 2019 as "valuable" or "very valuable" in fostering connections among fellow scholarship recipients. In August 2020, a two-day eight hour virtual retreat was offered. The majority of 2020 retreat attendees (70.9%) reported that speakers, meeting with peer mentors, and fun activities were very helpful or helpful. In sum, scholars reported that PATHS supports, such as peer mentoring and regular academic advising, helped them lower stress and perform better academically. Scholars (82%) shared they benefited from learning how to navigate through college in their cohort first year seminar, prepare resumes, obtain internships, and eventually gain employment.

4 Comparisons with National Cohorts

Comparisons with national cohorts confirm that belonging and community supports significantly benefit the PATHS program. PATHS scholars complete a national survey for computing students, i.e., the Data Buddies Survey, facilitated by CERP⁹. Responses from PATHS scholars (n = 26) were compared to a similar group of undergraduates in the United States and Canada (n = 1,906). Compared to a national cohort, PATHS scholars in Spring 2020 reported statistically significant greater: 1) Positive attitudes towards computing; 2) Growth mindset (e.g., computing can be learned); 3) Positive attitudes about the computing department; 4) Sense of feeling welcomed in computing; 5) Skills in identifying career options; 6) Support from mentors and peers; 7) Engagement in K-12 outreach and mentoring others; and 8) Sense that CS administrators and faculty care about diversity.

PATHS scholars reported that they saw computing as a path of service and planned to pursue graduate degrees in computing-related fields. That is, PATHS scholars reported greater agreement (mean 4.08, SD (0.84)) than the national cohort (mean 3.65, SD (1.06)) with the statement that a career in computing would allow them to serve humanity. More PATHS scholars (23%) also reported they planned to pursue a doctoral degree, which was more than the national comparison group (13%); 42% of PATHS scholars reported wanting to obtain a Masters's degree.

5 Discussion

PATHS provides a successful model for recruiting, retaining, and supporting academic and career pathways for low-income diverse undergraduates majoring or minoring in CS. Sax et al.^{3,10,11} and Strayhorn¹² determined that having a sense of belonging is important for underrepresented students and a predictor of both general and CS academic success. Strayhorn and Longden et al.⁵ attribute the importance of belonging in college success to Bourdieu's social capital theory and Tinto's interactionist theory. PATHS scholars receive a sense of belonging and support from fellow PATHS scholars, CS@Mines staff, and faculty. PATHS scholars, many of whom are female and from underrepresented groups, share this sense belonging and identity as a CS student and future professional with K-12 students. Thus, recruitment and retention activities in the PATHS program are reciprocal processes, mutually benefiting current scholars and prospective students.

6 Conclusion

PATHS (Path Ambassadors to High Success) is a successful NSF-funded S-STEM scholarship program for academically talented, low-income Colorado high school and community college students to study CS at Mines. Success factors of the program include: high retention rate (91.7%), strong academic success (e.g., average GPA is 3.4), graduation rates, and successful employment in CS careers. PATHS recruitment and retention activities are replicable and could benefit low-income students at other universities and colleges.

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