Human-Centered Computing Scholars: Fostering a New Generation of Underrepresented and Financially Disadvantaged Researchers

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Abstract

Human-Centered Computing (HCC) is an emerging discipline focused on understanding how to design, build, and evaluate computational technologies as they relate to the human condition and how these technologies affect society. The HCC Scholars program is a NSF S-STEM funded project constructed to prepare doctoral students to successfully navigate their doctoral program and enter the computing workforce as a professor or research scientist. Accordingly, the S-STEM program consists of academic mentoring, advising, research opportunities, social experiences, and internships that are designed to provide doctoral students with a comprehensive scholarly experience that engenders a dedication and commitment to pursuing socially-responsible, HCC. A program evaluation was conducted to examine the effects of the S-STEM program on participants' educational experiences and occupational outcomes versus a peer control group. The S-STEM program positively impacted S-STEM students' development. Specifically, it was shown that providing research experiences, providing leadership opportunities, and encouraging mentoring relationships among S-STEM participants seems to be promoting the development of a scholarly community.

Keywords

Learning Communities, Human-Centered Computing, Scholarships, Doctoral Students, Computer Science

Introduction

"The NSF Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM) program provides institutions with funds for student scholarships to encourage and enable academically talented students demonstrating financial need to enter the STEM workforce or STEM graduate school following completion of an associate, baccalaureate, or graduate degree in fields of science, technology, engineering, or mathematics. The program was established by the National Science Foundation (NSF) in accordance with the American Competitiveness and Workforce Improvement Act of 1998 (P.L. 105-277) as modified by P.L. 106-313 and P.L.108-447 in 2004. The Act reflects the national need to increase substantially the number of American scientists and engineers." [10]

The scholarly activities that constitute the programmatic elements of the HCC S-STEM program include interactions with computing faculty and interactions with other students that lead to the production of research in the human-centered computing field. The S-STEM program also includes organized events, conferences, and professional development meetings as well as site visits at computing businesses. The students also get career counseling with respect to internships and permanent employment opportunities after the PhD. Although these activities may appear to be obvious to some faculty, the data presented here suggests not all PhD students, specifically, those from underrepresented groups, get the same treatment. In this regard, S-STEM students work in a laboratory setting with faculty, and other doctoral students on innovative research projects that enable S-STEM students to lead computing projects as well as mentor undergraduate, master's, and doctoral students. Each S-STEM student receives a $10,000 scholarship per year, advanced mentoring opportunities designed to encourage the highest scholarly accomplishments in computer science. For example, in the 3rd year the PIs hosted a National Science Foundation Graduate Research Fellowship workshop for the S-STEM students. As a result of this workshop, one of the S-STEM participants was awarded a Graduate Research Fellowship. Additionally, the S-STEM program works with each student based on the student's classification, previous work experiences, and level of research experience.

Background

For first-year doctoral students, academic advising and research engagement experiences are designed to help S-STEM participants understand how to achieve success in graduate school and understand the scholarly expectations. In year 2, S-STEM doctoral students are expected and encouraged to work on a research paper, work on a conference presentation, work on a research project, as well as achieve academically in their courses. In year 3, S-STEM doctoral students are mentored by senior faculty and have the opportunity to lead a research project. Doctoral students in year 3 of the S-STEM program are also expected to work on research projects with other doctoral students as well as help undergraduate students to develop research skills, while successfully pursuing coursework and doctoral degree requirements. In year 4, S-STEM participants are expected to lead several research and writing projects, lead several conference presentation proposals, work with other graduate students, help undergraduate students to complete projects, excel academically, complete their dissertation research, and apply for employment in academic or research settings. In year 5, S-STEM students are expected to graduate and obtain a job in academia, research workforce or as an entrepreneur.

In the 3rd year of the project, an extensive evaluation was conducted to examine the effects of the S-STEM program on participants' educational experiences and occupational outcomes versus a peer control group. The program components, instructional modules, and S-STEM research projects (as shown in Table 1), which constitute the HCC S-STEM Program, were developed in conjunction with the scholarly literature and theoretical perspectives.

Table 1. S-STEM Participants' Research Projects Overview

Project Category	Project Description
Naturally Interactive Systems	We research the design, implementation, and evaluation of Naturally Interactive Systems. These systems allow users to interact with computers using speech, touch, and/or other modalities. In general, we are conducting research on natural interactions that use spoken language and multiple modalities to perform human-computer interaction.
Advanced Learning Technologies	We are building adaptive learning environments that allow educators to create instruction and provide learners with personalized instruction. These systems interact with people using multimodal interfaces, some use Animated Pedagogical Agents. We are building game-like interfaces that provide naturally interactive instruction using animation, artificial intelligence, and speech.
Usability	We are investigating holistic evaluation methods for computing systems. Currently, we are working on a holistic evaluation method called the holistic usability measure for voice user interfaces.
Databases and	We use data mining to investigate business, education, and societal issues. We also have projects that

Data Analytics	investigate data warehousing and information management.
Note. The project information was obtained and adapted from the research team's lab website.	

Theoretical Foundation and Methodology

Bandura's social cognitive theory [1] suggests that behaviors and attitudes are mediated through a complex dynamism of socially-based stimuli. Lent, Brown, and Hackett [6], advanced the social cognitive career theory to formally consider the role of social interactions on an individual's career and academic development. The social cognitive career theory, which was utilized to develop the S-STEM program, is diagrammed in Figure 1.

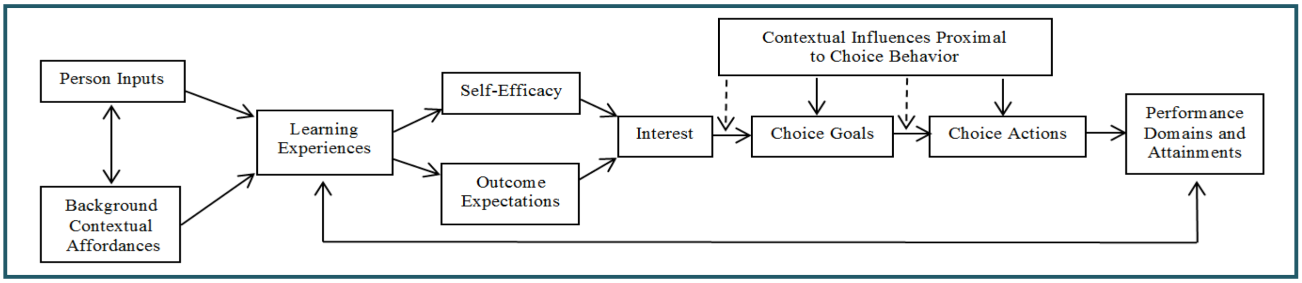

Figure 1: Social Cognitive Career Theory [6]

The theoretical framework informed the analytical procedures of each of the major dimensions of the program evaluation. It should be noted that information derived from the theoretical framework was also used to interpret the research findings. Employing statistical analysis [12] and qualitative research methods [7], the evaluation project was designed to examine S-STEM program participants' intellectual dispositions and career orientations. Thus, in addition to examining the effects of the S-STEM program using quantitative techniques, qualitative research components were integrated into the research design to assess students' experiences in their doctoral program. Moreover, to examine the relationships among S-STEM program participants' academic orientations and student engagement experiences, mixed methods research approaches were utilized [13].

The data for the quantitative research component were collected using a survey instrument. Several items and scales were used to collect data for the S-STEM program evaluation. Data collected online enabled students to complete the survey instrument and submit their responses to a secure server. A description of each survey is shown below.

Demographic Questionnaire. The Demographic Questionnaire was designed to ascertain information about participants' demographic characteristics and academic experiences.

Doctoral Student Development and Outcomes Survey. This assessment category was based on the work of Nettles and Millet [11] and Lovitts [8]. It contained several scales that measure the extent to which students were satisfied with their doctoral experience as well as engaged in productive scholarly activities in their doctoral program. The Doctoral Student Experiences section was based on a Likert-type scale and utilized an agreement/disagreement response scale (i.e., Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree). The Doctoral Student Involvement section was based on a Likert-type scale and utilized a satisfaction-based response scale (i.e., Very Dissatisfied, Dissatisfied, Neither Satisfied nor Dissatisfied, Satisfied, Very Satisfied). The Doctoral Student Perceptions section was based on a Likert-type scale and utilized frequency items (i.e., Never, Seldom, Sometimes, Often, Very Often).

Career Decision Self-Efficacy Scale. The Career Decision Self-Efficacy Scale employed a Likert-type scale. This scale, which included five sub-scales (i.e., Self-Appraisal, Occupational Information, Goal Selection, Planning, and Problem Solving), was designed to assess the extent to which respondents had confidence in their ability to pursue and achieve occupational goals [2]. Each sub-scale was based on a five-point scale (i.e., 1 = no confidence at all to 5 = complete confidence). Higher scores were associated with higher levels of career self-efficacy.

A quasi-experimental research design [4] was utilized to conduct the program evaluation for doctoral students who participated in the S-STEM program and doctoral students who did not participate in the S-STEM program ($N = 12$). Thus, doctoral students in the S-STEM program ($n = 7$, treatment group) and students who did not participate in the S-STEM program ($n = 5$, control group) completed a battery of assessments. Utilizing descriptive statistical analyses [3,9], the project team expected that there would be discernible differences in the perceptions and productivity of doctoral students based on the extent to which they participated in the S-STEM program. Group comparisons were based on scores from the Doctoral Student Development and Outcomes Survey and the Career Decision Self-Efficacy Scale. The use of this quasi-experimental design enabled the project team to assess the extent to which participation in the S-STEM program helped its participants to navigate their doctoral program, develop career orientations, and pursue employment outcomes. It should be noted that the control group students, while not participants in the S-STEM program, may have been mentored by the principal or co-principal investigators. In the next evaluation cycle, the PIs will seek to ensure that the control group has not been mentored by the principal or co-principal investigators.

The HCC S-STEM scholars program consisted of 7 computing sciences PhD students. With respect to gender, there were 4 males and 3 females. There were 5 African-Americans, 1 American Indian/Alaska Native, and 1 Hispanic/Latino. The control group consisted of 5 African-American computing sciences PhD students, 1 male and 4 females. A limitation of this study is the small sample size; however, the study is the first group of findings in a 5 year study. The authors expect to increase the sample size in future years.

Results

Descriptive statistical results highlight the impact of the S-STEM program on doctoral students. The data collected from this research study indicates that S-STEM participants fare as well or better than students from other universities (i.e., control group). When interpreting the data, it should be noted that control group students were more likely to be in their doctoral program for an extended period of time as compared to the S-STEM participants. Additionally, the qualitative data collected from the S-STEM students converged on the idea that the programmatic elements of the S-STEM program positively impacted S-STEM students' development. More specifically, it was shown that providing research experiences, providing leadership opportunities, and encouraging mentoring relationships among S-STEM participants seems to promote the development of a scholarly community.

The data suggest that control group students and S-STEM participants were somewhat equally likely to note that faculty members were instrumental in their development. However, control group students were more likely to disagree with some of faculty member involvement question items, while S-STEM participants were more likely to report that they agreed with the statements on these questionnaires regarding faculty involvement. S-STEM participants also noted a greater sense of community with faculty and students than did the control group students, see figures 2, 3 and 4. Furthermore, the doctoral students in the S-STEM program were likely to report spending time with other graduate students, discussing issues with faculty, and receiving feedback from faculty. These data indicate that S-STEM participants had the opportunity to engage in developmental experiences that have been shown to support retention and graduation outcomes [11].

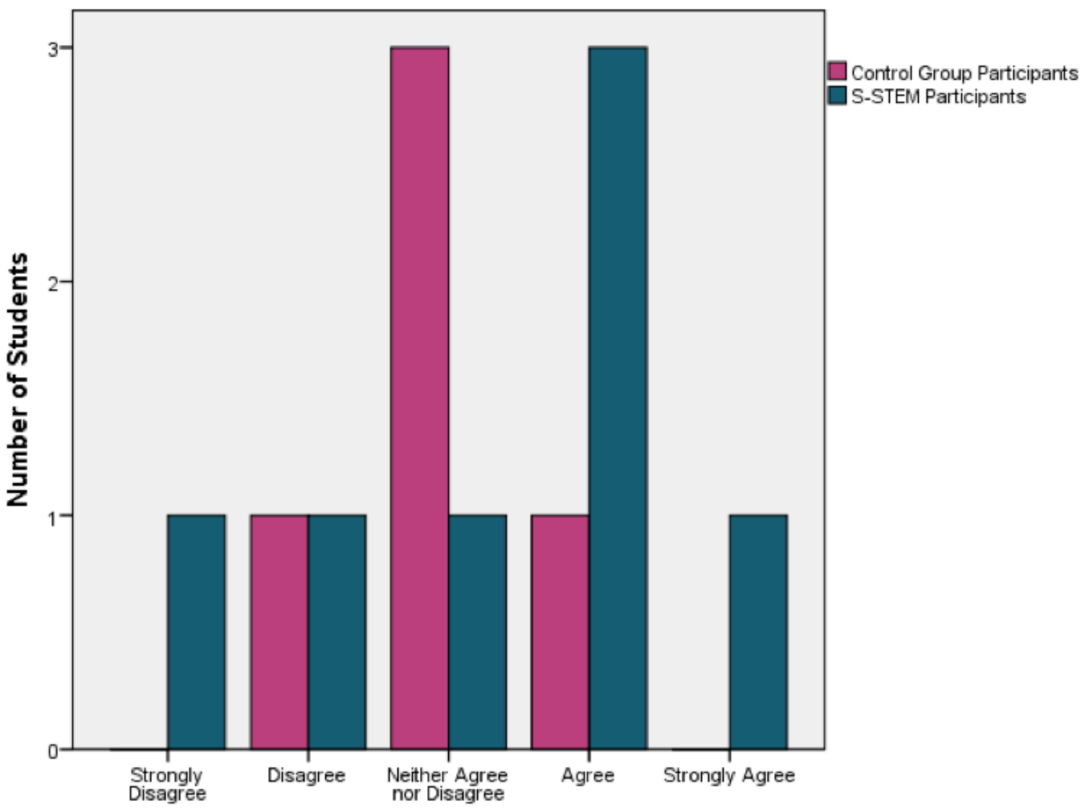

Figure 2: There is a great deal of contact between professors and students in my program outside the classroom.

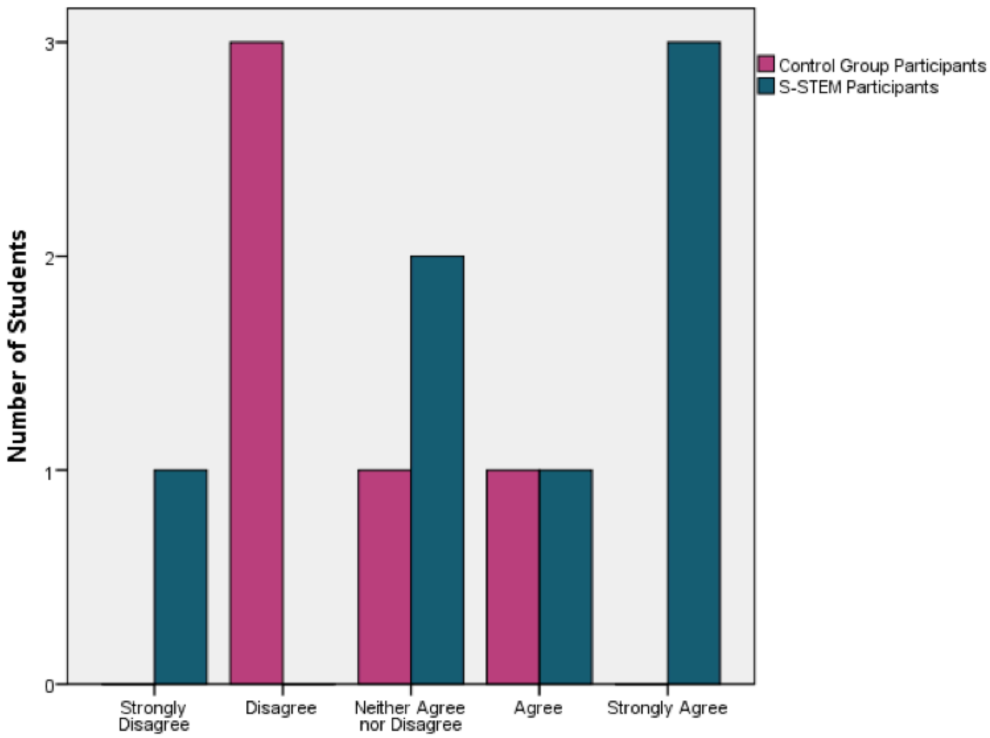

Figure 3: There is a strong sense of community, a feeling of shared interest and purpose in this program.

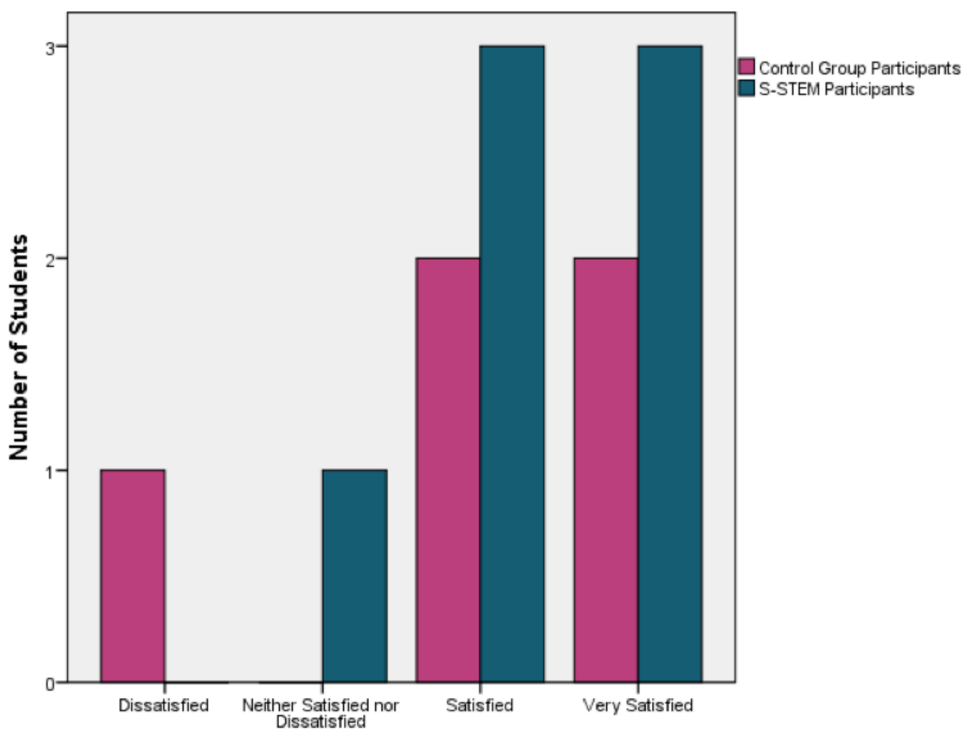

Figure 4: Collegial atmosphere between the faculty and the students.

In terms of the number of scholarly products that students pursued during the academic year, there were some differences noted between control group participants and S-STEM participants with regard to the number of manuscripts in progress, number of conference presentation proposals submitted, number of grant proposals submitted, number of internship offers received, and number of internships completed. For each of these aforementioned items, the control group participants reported a higher number of scholarly deliverables. However, S-STEM participants were more likely to report having a greater number of manuscripts submitted for publication, number of conference presentation proposals in progress, number of conference presentations completed, number of awards or honors applied for, number of awards or honors received, number of patent projects in progress, number of patent projects submitted, number of internships applied for, number of internship interviews completed, and number of ongoing research projects.

With respect to self-efficacy, the S-STEM participants were more likely to report higher scores on the Self-Appraisal, Occupational Information, Goal Selection, Planning, and Problem Solving sub-scales on the Career Decision Self-Efficacy Scale which suggests that they reported higher levels of career self-efficacy when compared to the control group, see table 2.

Table 2: Self-Efficacy Measures

		Self-Appraisal	Occupational Information	Goal Selection	Planning	Problem Solving
Control Group Participants	Mean	3.88	4.00	4.12	4.20	4.04
	Std. Deviation	.923	.735	.944	.860	.910
S-STEM Participants	Mean	4.20	4.46	4.26	4.26	4.07
	Std. Deviation	.577	.395	.526	.597	.734

Overview of the Findings

The data suggests that the HCC S-STEM program enhances doctoral students' development as they transition through the various phases of their doctoral program. With regard to doctoral student development, the HCC S-STEM Program was informed by Gardner's research [5], which suggests that doctoral students proceed through three phases. The first phase, entry, occurs before the student is enrolled and through the early stages of coursework completion. The second phase, candidacy, occurs while the student is taking courses and continues to the completion of their comprehensive or qualifying examinations. The third phase, integration, occurs while the student is writing their dissertation and concludes once they have begun their professional position. This 3-phase model is useful because it acknowledges that two sources of information (i.e., support and challenge) are present during each phase and interact to positively or negatively influence doctoral student outcomes. Accordingly, the HCC S-STEM program includes critical learning experiences and opportunities for doctoral students to enhance their course experiences, student-faculty interactions, student-student interactions, research experiences, and leadership experiences at each phase of the doctoral program.

The data reported in this paper are descriptive. The researchers also collected quantitative data, i.e. number of papers published, number of papers submitted, and other quantitative measures, but that data is not reported here due to page limitations.

Enhancing the S-STEM Program

Viewed collectively, the quantitative and qualitative data highlighted strategies that the project team can implement to improve the quality of the HCC S-STEM program. For example, while many HCC S-STEM students noted that there were significant opportunities for interaction with HCC faculty, they also noted that additional experiences may be needed to help them explore their individual research interests as well as to help them manage their time wisely. Moreover, the data implies that the project should incorporate additional workshops for the HCC S-STEM students related to applying for internships, preparing career-related documents, negotiating internship and job offers, and negotiating the collaborative process with other researchers and students. As a result of the information analyzed in the context of this program evaluation, the project team will create a series of specialized workshops and experiences for the S-STEM participants that will consist of faculty-led learning experiences for students to address a host of academic, research, and career development issues.

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