AC 2009-338: AN INTERACTIVE, STUDENT-DRIVEN PROGRAM TO FACILITATE SCHOLASTIC ACHIEVEMENT IN COMPUTER SCIENCE, ENGINEERING, AND MATHEMATICS

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An Interactive, Student-Driven Program to Facilitate Scholastic Achievement in Computer Science, Engineering, and Mathematics

Abstract

This paper describes experiences and lessons learned from a National Science Foundation-funded Science, Technology, Engineering, and Mathematics (STEM) scholarship program at Missouri University of Science and Technology. The principal conclusion is that it is imperative to the success of this type of program to provide a mechanism for frequently collecting feedback in order to prioritize and schedule activities to best meet the needs of participants.

Introduction

The National Science Foundation (NSF)-funded project "A Program to Facilitate Scholastic Achievement in Computer Science, Engineering, and Mathematics" at Missouri University of Science and Technology (Missouri S&T) ran from August 15, 2004 through July 31, 2009. The goals of this program were to address: (1) the decline in the number of students pursuing degrees in mathematics, computer science, and engineering, and (2) the minimal rate of low-income students attending college and completing degrees. The approach taken was to offer scholarships to low-income, academically talented students pursuing an undergraduate or graduate degree in computer science, mathematics, or engineering, with the stipulation that the students would be required to participate in a specially designed scholastic achievement program called CSEM Scholars. It was hoped that this program would provide them with a mixture of motivational activities that were aimed at promoting personal, academic, and professional development, and would create a support community of students with shared experiences which was actively cultivated by holding interactive meetings in a relaxed environment.

Although we initially had planned to cover particular topics over a very specific timeline, our CSEM scholarship program ended up being student-driven to ensure maximal relevance of the topics. Buy-in of the students was achieved by having them propose and select the topics that they felt were important to their personal, academic, and professional success, and about which they had minimal previous knowledge. We also found that the students strongly preferred workshops wherein they interacted with each other, the presenters, and members of the local community through role-playing skits, small group discussions, and external service activities such as mentoring. In this paper we describe how our plans for this program evolved, the degree to which the desired outcomes were achieved, and the lessons that we learned.

Background

According to recent U.S. Department of Labor Statistics [1], the demand for certain computer specialists is expected to grow for the 2006-2016 decade at a much faster rate than the average growth rate for all other occupations. Similarly, overall engineering employment is expected to grow over the same time period, with civil engineers seeing the largest employment increase [1]. Accordingly, the demand for science and mathematics teachers (particularly at the pre-college

level) also is expected to increase over the same period of time [2]. Although these are recent projections, similar predictions have been made for years. For example, a report in 2004 estimated that by 2008, jobs in information technology requiring science and mathematics skills would increase by 5.6 million [3]. To satisfy that demand, the Department of Labor estimated that postsecondary institutions would have to produce nearly four times as many graduates in computer science [3]. The situation was found to be similar in the field of engineering, in which the number of students pursuing engineering degrees had dropped in each of the past five years, while the need for engineers steadily increased [3].

Despite the availability of such jobs over the past several years, there continues to be a decline in the number of students pursuing degrees in mathematics, computer science, and engineering. That low enrollment trend, combined with the minimal rate of low-income students attending college and completing degrees in those areas, has sustained a critical need for programs that facilitate scholastic achievement by providing scholarships, mentoring, and encouragement for low-income, academically talented students who are pursuing majors in mathematics, engineering, and/or computer science at the undergraduate and graduate levels.

Over the last 15 years, Missouri S&T –formerly the University of Missouri-Rolla (UMR) – has taken major roles in planning and implementing NSF-sponsored Human Resource Development (HRD) initiatives in efforts to address the needs of pre-college students and teachers, bridge pre-college to undergraduate student transition, and strengthen the recruitment of minority undergraduate students in science, technology, engineering, and mathematics (STEM) education. These program efforts have included the St. Louis Comprehensive Regional Center for Minorities, the Jackling Institute, the Missouri Alliance for Minority Participation, and two NSF-funded Computer Science, Engineering, and Mathematics (CSEM) scholarship programs. Specifically, these programs have been committed to achieving the following objectives:

1. Increase student enrollment and retention in computer science, engineering, and mathematics.
2. Increase the percentage of students enrolled in CSEM degree programs that originate from low-income households.
3. Increase the retention and graduate rate of CSEM low income students.
4. Increase the post-graduation success of CSEM graduates originating from low-income households by providing them with an environment to achieve their best academic performance, and enable them to succeed in the workforce by guiding them in leadership, professional development, and personal growth.

Herein we focus the discussion on our most recently NSF-funded CSEM scholarship program which ran for the past four years. The demographics of the participants (which were fairly consistent over the course of the program) are shown in Table 1.

Gender:	
Male	13
Female	15
Ethnicity:	
Black	2
Hispanic	3
Other	23
Major:	
Mathematics	1
Computer Science	11
Mechanical Engineering	2
Chemical Engineering	4
Nuclear Engineering	1
Mining Engineering	2
Environmental Engineering	1
Aerospace Engineering	1
Architectural Engineering	2
Petroleum Engineering	1
Electrical Engineering	2

Table 1. Demographics of the CSEM scholarship program participants

Evolution of the Program Activities

A. Topics Covered

CSEM and STEM scholarship programs typically include a well-planned series of workshops and seminars designed to provide students with regular exposure to academic achievement strategies, personal, professional, and leadership development activities, and approaches for success in their professional and personal life. That course of action apparently had worked well for Missouri S&T's previous CSEM scholarship program which had been organized by a different set of principal investigators. Therefore, at the beginning of our most recently NSF-funded CSEM scholarship program, we made the following plans. The first year of the program would focus on academic success, with workshops on academic skill development (including time management, goal setting, reading for content, where to find tutoring help, etc.), and writing skills for academics (e.g., researching a topic, using the library, developing an outline, proper citation format, etc.). The second year would focus on personal and social development, with workshops on leadership skill development (e.g., commitment, responsibility, ethics, peer mentoring, etc.) and balancing one's professional, academic, and personal life (including priority setting, multi-tasking, relaxation techniques, participation in extracurricular activities, etc.). The

third year would focus on professional development and would include a workshop on oral communication skills (including mock interviews, etiquette, professionalism, and networking) and professional writing skills (e.g., resume writing, cover letters, other forms of written communication in the workplace, etc.). The last year would focus on post-graduation success and social responsibility with workshops on life after university studies (including graduate and professional school opportunities, scientific and professional societies, and teamwork in the workplace), and being a member of a community (e.g., giving back to society, civic responsibility, mentoring others, etc.).

A survey given to the 28 participants at our first workshop showed that the students' interests and knowledge deficiencies were less than a perfect match for what we had expected and for which we had planned activities. The survey results (shown in Table 2) indicated that an overwhelming majority of the students wanted to learn more about the following as soon as possible: additional scholarship and fellowship opportunities, overall planning for successful future careers, how to find co-ops and internships, and how to plan ahead which courses to take and when in order to achieve desired objectives such as double majors, minors, etc. Additional topics of lesser interest to the majority of the participants were: how to get the most out of academic advising, how to deal with stress, technical writing, preparing for and taking tests, and resume writing. Therefore, we prioritized (and rescheduled) the coverage of topics for the remainder of the program based on the student responses.

B. Workshop Format

The first year and a half of our CSEM scholarship program, we held four workshops per academic year, each workshop scheduled on a Saturday and lasting approximately four hours including a complementary lunch. Although attendance at each of those workshops was good (approximately 98% or above), when informally asked after those first workshops what they would like to change about the format, the majority of the students requested that the workshops be much shorter and not held on weekends, even if the frequency of the workshops would need to be increased. As with the timeline of the topics presented, we once again obliged and modified our scheduling of the workshops for the remainder of the program.

Another aspect of the workshop format that evolved over the course of the program was the degree of interactivity that we required of the participants. The format of our initial workshops was a presentation by one or more external speakers, followed by a related (paper) exercise performed by the students (individually or in pairs). The students were then called upon to answer questions about their work on the exercise. Again, when asked in a later workshop what, if anything, the students would like to change about the workshop format, they requested more interactivity. Therefore, we changed the format of subsequent workshops to include situational role-playing skits, small group discussions, and external activities that they would be responsible for performing outside of school and then discussing in future workshops. Although not formally evaluated, the students appeared to be much more engaged in the workshops once these changes were made.

	Current knowledge						Desired additional knowledge					
	1	2	3	4	5	Avg.	1	2	3	4	5	Avg.
Topic												
How to get the most out of advising	3	7	13	3	2	2.79	1	3	4	12	7	3.78
How to plan ahead which courses to take and when, in order to achieve your desired objectives (e.g., majors, minors, dream job)	1	7	12	6	2	3.04	3	1	1	9	14	4.07
Overall planning for successful future careers	1	7	11	8	1	3.04	1	1	2	6	18	4.39
Time scheduling	0	1	7	14	5	3.85	2	7	4	6	6	3.28
Preparing for and taking tests	1	2	6	12	7	3.79	4	4	2	7	11	3.61
Finding co-ops and internships	3	11	7	4	3	2.75	2	0	3	4	19	4.36
Studying abroad	14	7	5	1	1	1.86	7	2	7	7	5	3.04
Obtaining scholarships / fellowships	1	6	14	6	1	3.00	0	0	4	8	16	4.43
Enrollment in MS&T's Honors Academy	13	5	4	3	3	2.21	4	4	8	6	6	3.21
Use of the university library	3	4	8	6	7	3.36	6	2	7	8	5	3.14
Resume writing	1	2	10	7	8	3.68	4	5	5	2	12	3.46
Technical writing	5	3	8	7	4	3.07	4	1	5	8	9	3.63
How to get special consideration for test taking such as extra time and/or distraction free test area	10	10	6	1	1	2.04	10	3	4	6	5	2.75
How to get medical assistance (for sickness and alcohol, drug & other wellness issues)	1	4	7	10	6	3.57	8	7	5	2	6	2.68
How to get counseling assistance	2	10	9	3	4	2.89	5	4	7	9	3	3.04
How to get tutoring assistance	1	7	10	5	5	3.21	4	6	7	8	3	3.00
How to make friends in college	0	2	4	8	14	4.21	7	7	4	3	7	2.86
How to find a significant other in college	1	3	7	7	9	3.74	12	1	7	3	5	2.57
How to deal with depression	1	8	6	8	5	3.29	3	9	3	8	5	3.11
How to deal with stress	1	7	11	5	4	3.14	2	4	6	5	11	3.68

Table 2. Survey results comparing current knowledge about a topic and desired additional knowledge about the topic (1 = low, 5 = high)

Results

Overall, our CSEM scholarship program was successful in the following respects. Over the course of the program, only two of the participants became ineligible to continue in the program due to their grade point average falling below the required 3.0 (on a 4.0 scale). All other participants have graduated or are scheduled to graduate at the end of this academic year.

In terms of the benefits of the workshops, survey results (shown in Table 3 for 21 of the original 28 participants who had not yet graduated by the time the survey was issued) show that the majority of the students felt that the workshops had helped them to learn more about the following: dealing with difficult academic situations, external service in the form of mentoring, writing a resume and interviewing for a job, post-undergraduate opportunities, co-ops and internships, and undergraduate research opportunities. These topics addressed the key areas that the students had indicated an interest in early in the program. In addition, many participants indicated that the CSEM scholarship program was to some degree responsible for their success at Missouri S&T.

Question/Response	5	4	3	2	1	avg.
I learned more about how to deal with **difficult academic situations** (e.g., sexual harassment, bad advising, etc.) than I knew before.	2	8	6	4	1	3.29
I learned more about **mentoring** than I knew before.	10	6	3	2	0	4.14
I learned more about **writing a resume and interviewing for a job** than I knew before.	1	8	5	6	1	3.10
I became more informed about **making decisions to pursue post-undergraduate opportunities** like grad school and jobs in industry.	11	8	1	1	0	4.38
I learned more about **co-op and internship opportunities** than I knew before.	1	8	8	3	1	3.24
I learned more about **undergraduate research** than I knew before.	11	5	3	1	1	4.14
I was better able to **succeed academically** at Missouri S&T.	0	8	11	2	0	3.29

Table 3. Survey responses at the end of the CSEM scholarship program (1 = strongly disagree, 5 = strongly agree)

The survey also asked the students to list what they liked most and least about the program, as well as comments about how the program could have been improved. The most commonly

mentioned aspects of the program that they liked were: (1) tailoring of the program to their particular interests, (2) the informal and highly interactive format of the workshops, and (3) the opportunity to perform external service through mentoring. In terms of their dislikes, several students mentioned that they had not liked the longer duration of the workshops that were held in the beginning of the program, and were pleased that we had responded in kind. The only part of the program that they said that they thought could be improved was the low amount of the scholarships (relative to tuition and other academically related expenses), an issue that has since been addressed by NSF in their current STEM scholarship programs.

Additional Impact

In addition to the benefits that the participating students said that they had received, our CSEM scholarship program has had broader impact at our institution. The model of student-driven, interactive lunch meetings and mentoring activities that we developed for this program have since been adopted for several pending extramural grant proposals originating from various Missouri S&T departments, including an NSF IGERT proposal, a Department of Education GAANN proposal, and an NSF Scholarship for Service proposal. The CSEM scholarship program also has increased our institution's awareness of the availability and potential benefits of related STEM scholarship programs at NSF, the U.S. Department of Defense, and the Computing Research Association (CRA).

Summary

We learned several lessons from conducting this CSEM scholarship program and analyzing its results. First of all, instead of trying to fully anticipate participant needs and planning a high-quality, but rigid, program of activities to meet those needs, it is imperative to the success of this type of program to provide a mechanism for frequently collecting feedback. The organizers must then be responsive to reprioritizing and rescheduling activities to meet the needs of the participants. Secondly, while students generally value the motivational activities that typically accompany this type of scholarship program, they greatly favor many short activities that are of a highly interactive nature.

Acknowledgements

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References

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