Tips, Traps, and Troubleshooting: A Multi-Disciplinary Approach to Multiple Modes of Mentoring for Success in the Fields of Computer Science, Engineering, Math, and Technology

A. Phillips-Lambert, D. J. Russomanno, R. Hairston

The University of Memphis

Abstract

If educators are going to be successful in guiding, advising, and mentoring students majoring in the fields of computer science, math, technology, and engineering, it is essential to develop a complementary approach to the leadership team. While we often tell our students that teamwork skills are essential for success at school and at work, we do not always practice what we preach.

This research presents our attempts at using a multi-disciplinary leadership team comprised of faculty and staff members from six different disciplines as applied to the administration of a National Science Foundation CSEMS grant (DUE-0122950). The NSF/CSEMS program supports financially disadvantaged students in computer science, math, technology, and engineering with goals including increasing retention rates and decreasing the amount of time required to complete an undergraduate degree. At The University of Memphis, we have also included the goal of increasing female and minority graduates. Through a process of trial and error based on the findings of similar programs, we present the lessons learned in our study as each faculty and staff member has responded to changes based on feedback from the student participants.

Originally, our grant was scheduled from 2002-2004, but our program has received an additional four years of support from the NSF (DUE-0410290), and this extension allows for several unique opportunities to (1) increase multi-disciplinary partnerships and specificity for each faculty member and staff member leading the project; (2) increase time to gather, analyze and report student feedback based on previous metrics employed in the 2002-2004 cycle; (3) and to provide an opportunity to examine an interactive, dynamic process of multi-disciplinary team over a period of six years.

In this paper, we share some of the lessons we have learned about multi-disciplinary projects and provide examples of the strategies we have used in attempting to solve the situations that have been encountered, and we detail new processes planned for the 2004-2008 project cycle.

Introduction

This paper presents the efforts of a multi-disciplinary leadership team comprised of faculty and staff members from six different disciplines as applied to the administration of a National Science Foundation grant (DUE-0122950). The program is titled "A Scholarship Program for Computer Science, Engineering, and Mathematics Students: An Industry-Academia Partnership Approach (CSEMS)," at The University of Memphis, Herff College of Engineering. We will refer to our specific project as the CSEMS program throughout the remainder of this paper. The primary purpose of the CSEMS program seeks to support financially disadvantaged, under-represented students majoring in computer science, math, technology, and engineering with goals of increasing retention rates and decreasing the amount of time required to complete an undergraduate degree.

This paper's approach begins with a brief description of the CSEMS program, the rationale for the program, and its objective and goals. Next, we present the complementary approaches of our multi-disciplinary faculty and staff members working collaboratively to help CSEMS students succeed by supporting them from multiple perspectives with the goals of maintaining/increasing enrollment status in engineering, computer science, or math programs and decreasing the stresses that affect academic performance due to financial considerations. Following this description, we present a summary of some of the difficulties we have encountered in administering this program as a team, and we include subsequent modifications based on assessment and evaluation data. We conclude the paper with practical tips, traps, and advice that can be generalized for other engineering educators interested in implementing similar programs.

Description/Background of CSEMS

As the objective of this paper is to describe the innovative and multidisciplinary approach at the staff/faculty level, a brief description of the program itself puts the information in its original context. The project is sponsored by The National Science Foundation (NSF), (Grants 0122950 and 0410290), and is titled: "A Scholarship Program for Computer Science, Engineering, and Mathematics Students: An Industry-Academia Partnership Approach (CSEMS)". At the participant level, the program targets 25 students per year who are majoring in the fields of computer science, engineering, technology, or math, and who meet specific financial eligibility criteria defined by the U.S. Department of Education (DOE). Based on focus reports provided by the Office of Financial Aid, approximately 285 enrolled computer science, engineering, engineering technology, and mathematics majors completed the Free Application for Federal Student Aid (FAFSA) application by the initial May, 2002 CSEMS application deadline. Of the 285 students, approximately 215 satisfied the DOE financial eligibility criteria, and approximately 50 applied for 25 slots in the CSEMS program. It is suspected that several additional candidates may have been eligible but did not complete the FAFSA on time to be in the focus report or did not have their program of study distinction updated in the University's database.

More specifically, the program gives priority to students from under-represented groups, and in most cases, potential students must have accrued between 60-75 credit-hours toward their undergraduate degree to be considered for the program.

Students selected as CSEMS students receive up to $1563 per semester stipends, meet regularly in small groups for special-topic discussions, and work closely with project administrators from six different disciplines. In addition to the Principal Investigator, who communicates with each student via e-mail and in person throughout the semester, CSEMS students have access to a dedicated counselor, a Financial Aid Officer, an educational psychologist, and supplementary faculty and industry leaders from the local and regional area.

The CSEMS project represents a multidisciplinary approach to addressing the problem of attrition of students majoring in Math, Science, Engineering, and Technology programs and includes the following detailed objectives:

1) To increase the graduation rate of CSEMS students, with an emphasis on recruiting underrepresented populations including minority and female students;
2) To decrease the average time to degree completion for CSEMS students;
3) To decrease the number of CSEMS students working in non-intellectually engaging jobs by increasing opportunities for students to work on a faculty member's funded research or through approved co-op or summer internships with industry partners of the program;
4) To improve employment placement in highly sought-after positions.

Specifically, the CSEMS program provides a focused, integrative academic experience for scholarship students through the processes of emphasizing career and personal counseling, tutoring, mentoring, career development, research or application-oriented opportunities, student collaboration, and countless other academic and personal advantages gained by being fully engaged in the University community.

Program Rationale

Statistical data relating to attrition and retention of students majoring in science, technology, engineering, or math (STEM) fields continues to be alarming, with high-ranking administrators and researchers describing these trends as a "leak in the engineering pipeline."[1,2,3,4] In a time of great technological growth, these losses have serious implications on multiple levels. Data collected in conjunction with a study commissioned by Department of Education Secretary Richard Riley notes that in 1950, 80% of jobs were categorized as "unskilled positions", meaning the potential applicants were not expected to possess a specific skill set in order to obtain the job; the 2004 data shows a significant reversal with 85% of current jobs categorized as "skilled positions". An example cited was that of a machinist. Because machine tooling equipment now uses computer-numerically-controlled (CNC) technology, an operator must have some knowledge of the principles of calculus and some experience working with computer programming in order to work independently.[5]

Additional conclusions reached by this committee estimate that in order to keep pace with the current annual increase in national productivity (2.6%), and to meet the needs of an anticipated twenty million additional jobs by 2008, universities and colleges will need to teach and train nearly four times the number of students currently enrolled in the field of computer science alone.[5]

Clearly, industrial and technological employers have relevant concerns because the STEM students of today will be their employees of tomorrow, and the response of the academic community has been expressed in a typical scientific manner through collection, analysis, and triangulation of data. The most influential of these academic commissions investigating these trends include "The Neal Report," sponsored by The National Science Foundation (NSF) in 1986, "The Report of Disciplinary Workshops on Undergraduate Education," also sponsored by NSF in 1988, and the Sigma Xi National Advisory Group's "Wingspread Conference" (1989). [1,6,7,8] While each study examined different populations and used differing methodological approaches, one conclusion was consistent: solutions to these needs can be provided best by a coordinated, integrated system of educators, students, and employers working together to maximize results.

The 15-year period between 1985-2000 was characterized by examination of the factors contributing to attrition of STEM students, and current programs are more focused on implementing solutions, yet implementation also comes with its share of difficulties. Ohland and Zhang (2002) noted that political support at both the university and state level is critical for implementing and sustaining intervention programs.[8,9] Other research results affirm success through multi-disciplinary intervention programs as a type of "bridge program" between attrition and retention of students, and virtually all engineering educators and researchers agree that sustainability of any program requires top-down support.[1,8,9,11]

Another persistent factor in attrition of STEM students relates to insufficient financial resources, and for students in under-represented groups, there is a disproportionate connection between "persistence in STEM fields" and economic stability.[12,13,14]
In one of the few longitudinal studies to compare the attrition rate of STEM majors to those of students in other majors, Seymour and Hewitt demonstrated that while STEM students exhibit a higher rate of attrition than other majors, in some cases, the differences are not as great as many engineering educators have assumed.[1,2] Hewitt and Seymour obtained data from the 1990-1994 period from the Higher Education Research Institute's (HERI) unpublished data from UCLA's Cooperative Institutional Research Program (CIRP) survey data, and analysis of the compiled data representing 810,794 undergraduates from a national sample of four-year institutions revealed the following information:

- Students majoring in English have the lowest rate of attrition at 15%;
- Students majoring in social sciences, fine arts, education, history, and political science exhibited an attrition rate between 28-35%;
- Students majoring in engineering or business had an attrition rate of 38-40.5%;

- Students majoring in the sciences, computer sciences, and mathematics exhibited attrition rates of 47-63%;
- The highest rates of attrition were found in students majoring in non-technical fields and health professions with a rate of 73%.[1,2]

Seymour and Hewitt describe students who leave fields as "switchers", and while their data suggests that STEM students are not an isolated group of "switchers," the separation in categorization of engineering students from students in math and science majors likely underestimates the combined rate of attrition. In a three-year longitudinal ethnographic study probing of differences between STEM "switchers" and "non-switchers", Hewitt and Seymour identified several key trends directly from students' perceptions that are influential in continuing in STEM: academic assistance, advising and counseling assistance, and social networking assistance. For students in under-represented groups, these issues were disproportionately realized, and each of these issues was considered and addressed pedagogically in the design and implementation of the CSEMS program.[1,2]

CSEMS Program Activities

Based on the existing literature and statistics espousing the call for intervention programs aimed at retaining STEM students, the CSEMS program seeks to meet the needs of under-represented students through program activities and resources suited to their particular needs. Accordingly, we aimed for diversity in the CSEMS faculty group as well: for the initial grant, one female professor and an additional female counselor participated in the leadership team along with three male professors; the subsequent CSEMS faculty was comprised of one female faculty member with primary responsibilities of designing assessment and evaluation data and working individually with CSEMS participants, one female counselor, and two male faculty members. In addition, a female member representing the Financial Aid Office was added to our CSEMS team in order to address financial constraints and scholarship opportunities available to our students.

Each member of the CSEMS leadership team is focused and dedicated on a specific area of Engineering, and in addition, each represents a wide variety of disciplines:

- The Principal Investigator leads the team and his areas of expertise are in Electrical and Computer Engineering as well as Computer Science, and he is also active in engineering education research;
- The Counselor is a licensed counselor trained to work specifically with the psychological and psychosocial issues common to college students, and she works with each CSEMS student on an as-needed basis throughout the duration of the CSEMS program.
- The Financial Aid Administrator is an integral component of our leadership team and brings her extensive experience in working with college students to obtain financial aid through scholarships, grants, and loans, and she also meets with each CSEMS student throughout each semester. The Financial Aid Office compiles focus reports listing students by major, GPA, sex, race, etc. who qualify for federal financial aid.

- The Educational Psychologist/Researcher is a member of the faculty of the College of Engineering and Director of the Writing Lab Center, and she is trained in both data collection and analysis procedures and in teaching STEM undergraduate students in the field of technical communications.

Due to varied content-area expertise, differences in individual approaches to working with students, and differences as defined by specific employment responsibilities, each researcher brings a different skill set and experience or background to the CSEMS program, yet a commitment to undergraduate student success is the common denominator of the group. In addition, a larger number of potential CSEMS applicants can be targeted because each researcher works in separate sections of the university. Also, the four-person group is also able to share the load of targeting students from under-represented groups as part of the CSEMS objective.

Findings for the initial 2002-2003 CSEMS project exceeded the original CSEMS proposal goals. As a result of the active recruiting approach, the first year CSEMS awards ultimately consisted of fifty-two percent (52%) minority and forty percent (40%) female students while the general enrollment within The U of M consisted of thirty-eight percent (38%) minority students in engineering and computer science and nineteen percent (19%) female students in engineering and thirty-four percent (34%) female students in computer science, respectively.

Traps: Consistent Areas of Discord/Difficulty

Lessons learned through administration and participation in this program follow.

Trap 1: Don't assume the students are aware of scholarship opportunities.
Our research and experiences have documented that students majoring in the fields of math, science, and engineering are not always aware of supplemental and existing opportunities that may be available to them to improve their chances of reaching their goals. Evidence of this issue surfaced during the initial enrollment period for the program. Too often, minority students contacted informally through class interaction with program administrators have indicated that they were unaware of the CSEM scholarship opportunity. Research findings in retention studies specific to the fields of science and math suggest that this disconnect between program availability and student awareness could be due in part both to the full-time/part-time student classification of the student and/or the amount of time students are able to spend on campus unrelated to specific classroom experiences.[1,9,10] If these findings are accurate and minority students do not spend a significant amount of time on campus other than to attend class, it could be difficult to notice various posters and flyers distributed throughout the university. Moreover, Seymour and Hewitt suggest that both minority and female students may not be as networked to learn about opportunities compared with their peers, and this would

appear to confound the difficulties associated with learning about supplemental educational opportunities.[1]

As noted previously in this paper, our CSEMS leaders have made extra efforts to seek out and encourage both female and minority students to apply for the CSEMS program. These extra efforts include close coordination between the Financial Aid Officer and the PI to identify eligible students who did not apply and contact them to make them aware of the opportunity as well as efforts to involve other college faculty in targeted departments to actively seek out students during each semester and encourage them to apply for the following semester.

Trap 2: Don't assume that the traditionally-structured research project with one investigator is always best.

Results from the increased role of the Co-PI in counseling were also encouraging. Ms. Hairston has extensive experience in working with minority students to provide counseling on issues stemming from family obligations, financial instability, interpersonal conflicts, and other issues that impede students' academic progress, and her participation in the 2003-2004 cycle of the project resulted in tangible benefits for the program participants. For example, one minority student discussed the problem of often arriving late for a given class because she had to take her mother to the doctor. Ms. Hairston worked with the student to suggest other remedies to the problem including sharing the responsibility with other family members and friends from the student's local church. This approach resulted in the student arriving to class on time and she was able to complete the class successfully. Another female student discussed issues related to her husband's resentment that she was not available to provide home prepared meals and childcare. Ms. Hairston counseled the student to help her approach and seek solutions to partially resolve the problem. This student also remained in the CSEMS program and was able to design an approach to divide her study/home time more equitably.

Trap 3: Don't assume that students who don't ask for additional help do not want and need additional assistance.

Information provided by Regina Hairston, the CSEMS counselor, notes that her many years of individual interaction focused on African American students indicates that minority students, particularly African Americans, are timid because they are often first generation college students and they are not accustomed to interpersonal conversations and relationships with non-African American professors who dominate science, technology, engineering and math (STEM) areas.

At the same time, it is important that assistance programs are available to minority students who are free to participate on a voluntary basis as opposed to controlled, mandated assistance that students perceive negatively. An example of such an environment comes from Ohland and Zhang's (2002) description of a Minority Engineering Program between engineering students at Florida State and Florida A&M

University. [9,10] This program was initially supported by NSF (Grant # 0118073) and the NSF's Southeastern University and College for Engineering Education (SUCCEED), and the program was moderately successful, yet there was a fundamental disjunct between the program leaders and the student participants. This disjunct centered around a required tutoring program that was required of all participating students. Because the program included only minority students, and included no differentiation between individual skills or backgrounds, nearly all students reported negative perceptions of the required attendance. Clearly, there is a fine line between intent and actualization, and we suggest a short form of "pilot-testing" suggested activities with current students in order to obtain different perspectives.

2002-2004 CSEMS Results

In the 2002-2004 period, 59% of the CSEMS participants received bachelors degrees from The University of Memphis, and 34% were still actively engaged in the CSEMS program at the program's completion. Of the 7% who were not retained as CSEMS participants, one (1) minority student became ineligible due to academic performance and one (1) female student resigned from the CSEMS program due to family commitments, yet she was retained in the University as a part-time student. Interestingly, her circumstances have changed and she is currently a CSEMS recipient for the 2004-2005 academic year, meaning she has been able to return to her studies on a full-time basis.

Goal 2's objective to decrease the average time to degree completion for CSEM students also compares favorably within the Herff College of Engineering, and The University of Memphis total student body as well. Seven (7) of the initial twenty-five (25) recipients graduated within the first year of the program, and nine (9) graduated within the second year of the program.

Program data revealed that Goal 3 was met as the 2002-2004 CSEMS graduates reflect a higher percentage of underrepresented students than the general population for The University of Memphis. Program participants are represented in all categories of the NSF's demographic categories with the exception of Native Hawiian students.

In addition, a majority of CSEMS students have indicated that they have become more aware of the University community and feel more engaged with their peers than before receiving the scholarship. Moreover, almost all CSEMS students have indicated that the financial award has enabled them to spend more time on academics and less time on addressing financial concerns. Several graduate students have served as tutors exclusively for the CSEMS program. This experience has resulted in some of the tutors indicating that they felt their interpersonal and teaching skills had improved by having the opportunity to work with students in this capacity, yet the tutors also introduced an area of difficulty for the program. Initially, one tutor was available for four (4) hours Monday, Tuesday, Wednesday, and Thursday afternoons from 1:00 pm-4:00 pm, yet the tutors were under-utilized. By their own accounts, most were busy less than 25% of their allotted time. However, our CSEMS program also had funds for specialized tutors on a

first come first serve basis. Essentially, students were encouraged to notify any of the CSEMS faculty of a need for tutoring in some very specialized course like topology or electromagnetic field theory. If appropriate tutors for these specialized topics could be located, the CSEMS program funded individual tutoring on a case by case basis while funds were available.

A short post-program survey was distributed via email to program participants to obtain first-hand student feedback from the program participants, and as might be expected based on the average number of respondents in all educational research, approximately 26% of the students replied to the emails. Their responses, however, were overwhelmingly positive, and excerpts are included below:

I will be returning to the University of Memphis next semester to pursue my Master's Degree in Mechanical Engineering. (from a 2004 CSEMS graduate currently employed in a mechanical engineering position at Federal Express)

Thank you very much for all that you have contributed to my success in my effort to secure a solid job. From your software engineering class and testimony of your personal experiences in industry to the CSEMS scholarship program and all of the impromptu advice, I greatly appreciate your help. (from a 2004 CSEMS graduate currently employed in his major field)

The CSEMS scholarship helped me a lot by having the peace of mind and less worry…..that eliminates the need to work part-time. (from a current CSEMS program participant who is raising four children and attending school full-time)

I am very grateful that the university is offering this scholarship. It has greatly decreased my personal stress level in regards to financial and time constraints. I feel like my grades, personal life, and future job opportunities are greatly improved due to this scholarship. (from a 2004 CSEMS program graduate)

I truly believe that this scholarship will enable me to achieve a greater understanding of course material due to the fact that my financial necessities have been minimized (from a 2003 CSEMS program participant)

I can honestly say that without this scholarship, I would not be a Computer Science major today. Throughout the semester, she (Mrs. Hairston), would often stop me and ask how the tutoring was going or ask about my progress. Her guidance and intervention gave me the push I needed to keep going. The CSEMS scholarship for me has offered that missing link to advising, career opportunities, tutoring services, and finances that I definitely needed to keep me in this major. Thanks, Dr. Russomanno, for having the foresight to offer these much-needed services to students. (from a 2004 CSEMS graduate)

Tips or Traps? Generalization to Other Outreach Programs

As noted in the introduction to this paper, if long-term change is to be expected in retaining STEM students, there must be continued support from external organizations and sponsors. An example is taken from Ohland and Zhang's (2002) description of a Minority Engineering Program between engineering students at Florida State and Florida A&M University. [9,10] This program was initially supported by NSF (Grant # 0118073) and the NSF's Southeastern University and College for Engineering Education (SUCCEED), and evolved through constant and consistent attention to the academic, advisory, and networking needs of their STEM students and showed a significant rate of retention for students in the program, yet the program was discontinued after an eight year period due to "personnel changes". [9,10] While our CSEMS program is also supported by a grant from NSF, and it has been extended to 2008, we must seek out additional sponsors in order to continue the program indefinitely.

Conclusions

We believe that the diversity of the CSEMS program, both at the student level and at the faculty/leadership level, is a critical component of a successful program, and we seek to share what we have learned in this program in hopes of encouraging other engineering educators to implement similar programs of their own. Templates and examples of assessment instruments are available by contacting Anna Phillips Lambert (apphllps@memphis.edu), and any interested engineering educators are encouraged to modify these instruments to fit specific needs at their respective institutions.

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Bibliographic Information

ANNA PHILLIPS LAMBERT is the Director of Technical Communications for the Herff College of Engineering at The University of Memphis, and she is a faculty member in the Department of Civil Engineering. In addition, she is a doctoral candidate in Educational Psychology and Research with research interests in learning and cognition styles as applied to undergraduate engineering students.

DAVID J. RUSSOMANNO is the Interim Chair and Associate Professor of Electrical and Computer Engineering at The University of Memphis. He received the B.E.E. degree in Electrical Engineering from Auburn University in 1986, the M.E. in Electrical and Computer Engineering and the Ph.D. in Computer Engineering from the University of South Carolina in 1989 and 1993, respectively.

REGINA HAIRRSTON is the Program Manager for several grants directed by the Department of Physics at The University of Memphis. She received her BA degree in Political Science from Cleveland State University, the MS in psychological counseling & MBA from The University of Memphis. Prior to joining U of M, Ms.Hairston was employed by Youth Villages as a psychological counselor.