

MemphiSTEP: A STEM Talent Expansion Program at the University of Memphis

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I. Introduction

The Mid-South corporate community has reported an extremely inadequate supply of local STEM graduates for its major biomedical research and development sector; international distribution center; and electronics, chemical, energy, and other technical industries. A study commissioned by the Memphis Regional Economic Development Council (Wadley-Donovan, 2006) found that only 12.8% of the Mid-South companies surveyed have significant recruitment activities at the area's postsecondary institutions. One recommendation was to set a goal for the region to be a national leader in science, engineering, and mathematics graduates. The University of Memphis (U of M) must become well-positioned to meet the needs of major local employers, such as the Memphis Bioworks Biomedical Research Center, St. Jude Research Hospital, Medtronic, Smith and Nephew, Wright Medical, Federal Express, AutoZone, International Paper, ThyssenKrupp, Cargill, Brother, and Memphis Light, Gas, and Water, as well as many other corporations. Further, as a national distribution center, Memphis would be well positioned to become a high-tech manufacturing center, were an appropriately educated workforce available.

The percentage of students in a given fall semester over the past few years who have declared a STEM discipline as a major at the U of M has been approximately 12%. However, the percentage of U of M graduates with majors in the STEM fields has been approximately 10%, indicating significant levels of attrition. Given this trend, the U of M prepared a comprehensive proposal and was awarded a STEM Talent Expansion Program (STEP) grant (NSF-DUE 0756738) by the National Science Foundation starting on June 1, 2008. The project is a five-year program with the overall goal of increasing the number of STEM graduates at the U of M. The remainder of this paper highlights the first year activities of the project and some initial assessment results where available. Although MemphiSTEP is still in progress, with the lon-

gitudinal efficacy of several of the project's components undetermined, the project's organizational structure, objectives, and findings to date should be of value to others conducting or proposing projects with similar goals.

II. Foundational Research and Best Practices

MemphiSTEP employs a series of strategies and activities that are informed and guided by the current research of numerous investigators; well-established best practices; and results from funded projects, including U of M projects (Ivey and Lambert, 2005; Phillips-Lambert et al., 2005). For example, Tinto (Tinto, 1993; Tinto, 2002; Tinto, 2003), whose initial academic preparation was in physics, explains that the depth of a student's integration into the academic and social systems of an institution can have a tremendous effect on a student's persistence to obtaining a degree. He identified several factors that stand out as supportive of degree completion including: advising and counseling, mentoring, bridge programs, network groups, and active engagement in learning. Research also indicates that peer-student and faculty-student interactions represent a powerful influence on undergraduate students (Astin, 2005; Pascarella and Terenzini, 2005).

Given that many minorities and women are underrepresented in STEM fields (Maton, Hrabowski, and Schmidt, 2000), special efforts related to these groups also form an important component of the MemphiSTEP project. A Building Engineering and Science Talent (BEST) study (Best, 2004) identifies higher education practices that successfully improve retention of underrepresented students in STEM fields. The work was based on a comprehensive nationwide review of targeted STEM efforts. The most effective strategies identified include: engaged faculty, mentoring and tutoring opportunities for students, peer support networks, and enriched research experiences for undergraduates. That peer tutoring can be effective, both for the student tutors and the students being tutored, is

Abstract

MemphiSTEP is a five-year STEM Talent Expansion Program at the U. of Memphis sponsored by the National Science Foundation. The project focuses on retention and persistence to graduation to increase the number of STEM majors and graduates. The project includes a summer Mathematics Bridge Bootcamp, research experiences for undergraduates, peer-student and faculty-student mentoring, grants for student professional organizations, STEM learning communities, and a faculty seminar on pedagogical approaches to STEM education. Although the project concentrates on all STEM areas across the campus and each year of a student's undergraduate career, mathematics as used in science and engineering is a focal point in many of the project's strategies and activities. The assessment results for the first summer Mathematics Bootcamp are presented in detail and lessons learned during year one for other components of the project are discussed. Results show that the Bootcamp was effective in fostering mathematics skills, increasing students' awareness of/interest in STEM courses and careers, and facilitating networking opportunities, such that STEM students may work collaboratively with peers and faculty members. Overall, the paper intends to highlight program activities designed to foster retention and graduation, as well as the successes and lessons learned from year one program activities employed by MemphiSTEP.

a finding supported in recent research (Chi et al., 2003; Cohen et al., 1992). Similarly, college-level interventions have shown that strategies like bridge programs, mentoring, and research experiences play an important role in enhancing graduation rates among minority students in STEM areas (Yelamarthi and Mawasha, 2008; Koenig, 2009). Mentoring programs, for example, create effective learning communities and support systems which facilitate persistence to graduation.

Several investigators have emphasized that receiving clear and consistent information about institutional requirements and other forms of effective advising and counseling (e.g., discussions of career opportunities) can play a tremendous role in students' persistence to a degree. See, for example, Besterfield-Sacre et al., (1997) where NSF Directorate for Education and Human Resources (EHR) and Division of Research Evaluation and Communication (REC) funded projects suggest that targeted advising and mentoring sessions are successful in reducing attrition for at-risk engineering students. Research has also shown that advising programs designed to educate students about the rewarding opportunities in STEM fields, such as Information Technology, play a role in recruiting students, in particular female undergraduates (Harriger, 2008). Coordinating advising and mentoring throughout the campus and working with several different advisors across college units play a fundamental role in the MemphiSTEP project.

Early intervention can be very important to a student's potential for success, especially among minority students and females (Gilmer, 2007). Brainard and Carlin's 1998 study of early intervention concluded that intervention for women must occur in freshman and sophomore years due to the significant decrease in self-confidence women experience during these critical years. Bridge programs are also helpful for building mathematics skills and increasing GPAs among lower-level majors (Gilmer, 2007; Yelamarthi and Mawasha, 2008). In addition to offering early intervention, studies have shown that a balance of activities through the four years in college must be in place to sustain positive momentum and progress toward graduation (Gilmer, 2007). Beyond the specialized learning and mentoring programs often designed for freshmen and sophomores, comes a junior/senior stage focusing on preparing students to graduate and to embark on STEM careers or graduate school. Research experiences, in which students contribute to active research

projects, provide students additional opportunities to develop research skills, network with professors or potential advisors/employers, and generate interest in STEM careers. Even though students working extensive hours do not persist as well as students who do not have such a heavy work schedule, job opportunities for students on campus can have positive effects and generally are better than working off campus (Pascarella and Terenzini, 2005; Chubin, 2005; Patterson, 2004). MemphiSTEP provides students with several possibilities for on-campus STEM work opportunities, including working with faculty members on research projects.

The strategies and activities discussed in this paper include strong faculty, staff, and student interactions, both inside and outside the classroom. Many of these activities target the vital first year for students, but the focus is on student participation and success at all levels and often includes special related work opportunities. In the remainder of this paper, we discuss how these ideas and research are integrated in the MemphiSTEP project resulting in a large-scale effort, and one that can potentially be adapted and implemented at other institutions, particularly metropolitan research universities. Preliminary data regarding the efficacy of the activities are reported using data from the first-year evaluation study conducted by the Center for Research in Educational Policy (CREP) at the U of M. CREP is a national center recognized for its experience in evaluating PreK through 12 and post-secondary educational programs and initiatives.

III. Year One Activities and Findings

A summary of year one activities, findings, and lessons learned for the mathematics bootcamp, undergraduate research and travel awards, mentoring, STEM clubs, learning communities, and the faculty seminar are provided in the subsequent sections. These activities are not orthogonal but are supportive of improving retention and graduation rates. For example, incoming freshmen participating in the mathematics bootcamp are mentored by upper-division students, made aware of and encouraged to participate in STEM clubs, and to take advantage of tutoring services. As students progress to the upper division, they are engaged through various modalities to increase their participation in research experiences and to take leadership roles in STEM clubs and professional organizations.

A. Mathematics Bridge Bootcamp

The Mathematics Bridge Bootcamp is an annual, two-week event conducted as part of the MemphiSTEP project. It was piloted as a local initiative over the two summers preceding the grant, and it was expanded in scope once funding was secured. Although the Bootcamp focuses on incoming first-year students, continuing students who express an interest in transitioning to STEM programs of study are encouraged to participate. The Bootcamp has three major goals as listed below:

- Providing information regarding STEM courses and careers
- Providing opportunities for networking with fellow STEM students, faculty, and practicing professionals
- Providing context and instruction on the mathematics skills and study techniques required to succeed in STEM disciplines

The 2008 Bootcamp was conducted two weeks prior to the fall semester and comprised 45 students. The Bootcamp was structured with a range of speaker and group working sessions related to applications of mathematics in science and engineering to provide context and motivation (week one) and mathematics instruction (week two). Several U of M faculty members, speakers from local businesses, and upper-division STEM students also participated in the Bootcamp as instructors and peer-mentors/teaching assistants.

Results from CREP's evaluation of the first Bootcamp (CREP, 2008) were deemed of key importance because the Bootcamp provides a natural means to form student cohorts for mentoring and other project activities. Furthermore, recommendations from the first Bootcamp are being used to improve subsequent activities to be conducted during the remaining four years of the project. CREP's evaluation, which consisted of observations of speaker and group-work sessions, attitude surveys, focus groups, and analysis of scores on a pre- and post-Bootcamp math test, indicated that the Bootcamp met program goals with respect to enhancing math skills and offering opportunities for social networking and learning about STEM careers.

A pre- and post-Bootcamp mathematics achievement test developed by MemphiSTEP was administered to the Bootcamp students to assess their knowledge of algebra and trigonometry. The students' performance on algebra and trigonometry problems increased by approximately 15% and 14%, respectively, after the Bootcamp activities.

In addition to enhancing math skills, Bootcamp attendees taking part in focus groups reported that some sessions highlighted limitations in their mathematics skills and areas of mathematics that presented difficulty (e.g., calculus). Some students claimed to reconsider the mathematics course they were scheduled to take in the fall semester, for example, changing from calculus I to pre-calculus because of the Bootcamp. Some students felt the sessions increased their confidence in learning mathematics, helped them realize that it is not impossible to succeed in STEM careers, and offered important insights into real-world applications and motivation to learn the underlying mathematics regardless of their current state of knowledge of mathematics.

Table 1 summarizes the students' responses to statements about the Bootcamp activities included in a post-Bootcamp survey. In addition to enhancing mathematics skills, students reported that the Bootcamp was successful in terms of preparing them for STEM courses, as well as offering opportunities for student networking and information about STEM careers. Research findings from all data collection methods (observations, surveys, and focus groups) suggested that Bootcamp attendees were given a wide range of information about STEM courses and careers. Speakers discussed mathematics classes required as part of STEM majors, postgraduate opportunities, and career oppor-

Statement (Bootcamp abbreviated as BC)	% Strongly Agree	% Agree	% Neutral	% Disagree	% Strongly Disagree
The BC has made math more enjoyable.	14.7	50.0	26.5	5.9	0.0
The BC has improved my math skills.	11.8	64.7	20.6	0.0	0.0
The BC did a good job of showing me how math can be used in real life.	38.2	47.1	11.8	0.0	0.0
The BC has made me more confident about math.	23.5	55.9	17.6	0.0	0.0
I will do better in math at school because of the BC.	26.5	61.8	8.8	0.0	0.0
The BC showed me important connections between math and science/engineering.	29.4	58.8	8.8	0.0	0.0
I am more interested in majoring in a STEM field after the BC.	14.7	61.8	17.6	2.9	0.0
The BC has helped me prepare for college.	17.6	67.6	8.8	0.0	0.0
The BC has made me aware of STEM career opportunities.	32.4	61.8	2.9	0.0	0.0
I felt comfortable asking questions during the BC.	17.6	67.6	11.8	0.0	0.0
The information that the speakers discussed was helpful.	20.6	67.6	8.8	0.0	0.0
I enjoyed the practice and question sessions.	20.6	44.1	26.5	5.9	0.0
I was able to network with other incoming freshmen.	44.1	38.2	8.8	0.0	2.9
I was able to network with representatives from local businesses.	23.5	29.4	38.2	5.9	0.0
Overall, I am glad that I attended the BC.	55.9	41.2	0.0	0.0	0.0

Note: Item percentages may not total 100% because of missing input from some respondents.

Table 1. Student attitudes regarding the Bootcamp

tunities for people with STEM qualifications. Furthermore, a number of guests from local businesses discussed their backgrounds with respect to degrees completed and the types of tasks they carry out in their role as engineers, mathematicians, and scientists. Survey and focus group data from the Bootcamp attendees suggested that information about STEM degrees and careers was very helpful and widened views about the opportunities for STEM majors. However, students in the focus groups indicated that the Bootcamp had little impact on the particular STEM fields they wished to pursue if they had already decided on a specific STEM career before the start of the Bootcamp.

While the Bootcamp was successful in terms of meeting program goals, CREP's evaluation pointed to two key lessons regarding the organization of Bootcamp activities. First, Bootcamp attendees and student assistants reported that it would be optimal to reorganize speaker and group sessions such that science/engineering sessions are paired with mathematics sessions rather than separate science/engineering sessions and mathematics sessions in week 1 and week 2, respectively. Thus, morning activities would focus on an area of mathematics (e.g., trigonometry) whereas afternoon sessions would focus on an application area within science/engineering (e.g., electrical engineering) utilizing the morning mathematics topics. Secondly, students were more likely to participate in group tasks that were conducted in small classrooms. Attempts to conduct collaborative, problem-solving activities in lecture halls were generally unsuccessful in that students were more likely to work individually or socialize.

B. Undergraduate Research and Travel Awards

The MemphiSTEP research experience for undergraduates was patterned in part after NSF's Interdisciplinary Training for Under-

graduates in Biological and Mathematical Sciences (UBM), Computational Science Training for Undergraduates in the Mathematical Sciences (CSUMS), and Research Experiences for Undergraduates (REU) programs. The goal is to engage declared STEM majors in active research projects run by STEM faculty. Students are exposed to the fundamentals of research (e.g., laboratory work), encouraged to participate as co-authors of research papers, and engage in scholarly activities associated with their major. The research positions are available to all STEM majors and at all levels, although the majority of awards during the first year of the MemphiSTEP grant were allocated to upper-division majors. Applications are invited from academically strong students (e.g., students with high GPAs), as well as at-risk students (e.g., students with low GPAs) who may be in danger of withdrawing from STEM majors. At-risk candidates, deemed by faculty advisors to benefit from working in a research setting, are partnered with other undergraduate students who may have a stronger academic record and the ability and willingness to serve as peer mentors. All successful applicants are expected to work 5 hours per week for \$10 per hour (\$500 per semester) and document their research experience in a final report. To reward their contribution to the project, faculty advisors overseeing the undergraduate research receive a small stipend to purchase supplies for their research.

To become an undergraduate research fellow, students apply to work with a professor on projects in their area of study. Projects are summarized in research abstracts produced by faculty. Examples of abstracts submitted by faculty for undergraduate research experiences during the first year of the project are shown in Table 2. Current abstracts of undergraduate research projects available through the MemphiSTEP program are documented at the following proj-

Discipline	Abstract
Biology	Oocyte Physiology of the Zebrafish
Biomedical Engineering	Open Source Biomechanical Simulation Tools for Orthopaedics
Chemistry	Polymer Absorption
Civil Engineering	Transportation Improvement Plan for the Rozelle-Annesdale Neighborhood in Memphis, TN
Computer Engineering	Clustering for Improved Learning in Maze Traversal Problem
Electrical Engineering	Method of Continuous Intensive Care Monitoring of Cerebral Blood Flow for Brain Injury
Geology	Field Study in the Gauja National Park Latvia
Mathematics	New Algorithms for Fractal Forgeries of Images
Mechanical Engineering	Cryogenic Propellant Management in Low-Gravity

Table 2. Sample abstracts submitted by STEM faculty for undergraduate research experiences

ect website: www.memphis.edu/memphistem/abstracts.php. The selection committee uses a variety of criteria when selecting undergraduate research fellows, including, but not limited to, the recommendation of the faculty member who would be supervising the student's work, as well as the student's prior academic performance and potential for success in a STEM field. Faculty members are encouraged to include undergraduate research fellows on research teams that include other undergraduate students, as well as graduate students.

During Year 1, the undergraduate research fellowships commenced in the spring 2009 semester. There were high levels of interest in the spring undergraduate research fellow positions. Forty-nine students applied, and 24 fellowships were awarded (out of a possible 25 allotted for the spring 2009 semester). However, an additional two applicants, although recruited via the MemphiSTEP project, were funded by other STEM projects at the U of M. Thus, in total, there were 26 undergraduate students selected as MemphiSTEP research fellows in the spring 2009 research cohort.

Table 3 summarizes the demographics for the research applicants and the 26 research fellows recruited by MemphiSTEP. As shown in Table 3, applications were generated from a wide range of students. One disappointing aspect of this initial cohort of research fellows was that only 10 (20.8%) applications were received from females. Thus, the proportion of female applicants was lower than the percentage of

female Baccalaureate students enrolled at the U of M during the spring 2009 semester (see Table 3). A further analysis demonstrated that 7 of the 10 female applicants applied for research fellowships in science, compared to 3 in engineering, and none in engineering technology. As reported in the introductory section, engaging females in various STEM areas, such as engineering technology, may require special intervention. Harriger (2008), for example, pointed to the importance of engaging female interest in information technology by offering advice about rewarding work opportunities. Thus, it is important that rewards associated with engineering and engineering technology domains are made known to potential research applicants. Information could be advertised via the research abstracts posted on the project website, as well as via STEM advisors and mentors working in the engineering and technology fields.

A second disappointing outcome concerned the low percentage of African-American students who were offered research fellowships. While 51% of the applicant pool was African-American, only 20.8% of African-American students were selected as research fellows. Furthermore, although the proportion of African-American students that applied for research funding was higher than the proportion of African-American Baccalaureate students enrolled at the University in the spring 2009 semester (see Table 3), the proportion of African-American students granted MemphiSTEP research funding was lower.

Demographics	All Applicants N* (% based on 49 applications)	Funded Students N* (% based on 26 awards)	Baccalaureate students at the U of M (S09) N (% based on total undergraduates)
Gender			
<i>Male</i>	38 (79.2)	19 (73.1)	5839 (39.9)
<i>Female</i>	10 (20.8)	7 (26.9)	9160 (61.1)
Ethnicity			
<i>African American</i>	23 (51.1)	5 (20.8)	5787 (38.6)
<i>Caucasian</i>	20 (44.4)	17 (70.8)	8036 (53.6)
<i>Asian</i>	2 (4.4)	2 (8.3)	357 (2.4)
Major			
<i>Engineering</i>	22 (46.8)	17 (65.4)	522 (3.5)
<i>Engineering Technology</i>	7 (14.9)	0	165 (1.1)
<i>Sciences</i>	18 (38.3)	9 (34.6)	1196 (7.9)

*Note that various data were missing regarding gender, ethnicity and major. Valid percentages reported.

Table 3. Demographics for Undergraduate Research Applicants

GPA	All Applicants	Funded Students
Mean GPA (SD)	3.02 (0.51)	3.23 (0.45)
Minimum GPA	2.02	2.11
Maximum GPA	3.96	3.96

Table 4. Average GPA for Undergraduate Research Applicants

One common trend among African-American applicants was that many of the students did not specify a particular research project area they were interested in and/or they did not specify a faculty member who they would be interested in supervising their work. In these cases, the MemphiSTEP team attempted to network with faculty members across campus to match students with an appropriate research project; however, in some cases, particularly with engineering technology students, matches were not always found. This can be attributed in part to the fact that engineering technology faculty members at the U of M have higher teaching loads and do not have the same research expectations as faculty in the engineering disciplines and other STEM fields. An alternative explanation concerns limitations in students' knowledge regarding the application process. Even though details regarding application formalities were available to students, various applicants, such as the African-American subset in our sample may have been unaware of the recommendation to network with faculty and identify a potential research advisor in advance of applying to the program.

Overall, while the MemphiSTEP project was effective in advertising the undergraduate research fellowship opportunity to minority students, as evidenced by the high percentage of African-American applicants, it was less successful in matching minority applicants with appropriate opportunities. Thus, an important lesson learned from the spring 2009 research program concerned the need to inform potential applicants about MemphiSTEP procedures and recommendations for applying for fellowships. Information can be made available via the project website, faculty, STEM advisors, and mentoring group sessions. Encouragingly, our attempts to disseminate information about the fall 2009 research program, via the project website and contact with STEM faculty, resulted in applications from a diverse range of students (males and females of varying ethnicities). All applicants networked with and identified a research advisor. The first round of fall 2009 awards included 6 African-American, 2 Asian, and 4 Caucasian students. Of these 12 students, 5 are female and 7 male.

Table 4 shows the GPAs for the 49 applicants and 26 research fellows. There was a wide range of GPAs (2.02 through 3.96). Awards were granted to marginally performing ("at risk") students with lower GPAs (e.g., 2.11) as well as the high achieving students with strong GPAs (e.g., 3.96). As indicated above, the goal of funding at risk applicants is to retain students who may otherwise move out of a STEM field. One of the long-term goals is to track improvements in retention as well as class grades and graduation of students considered to be at risk (as well as all MemphiSTEP students).

In addition to research funding, MemphiSTEP has a \$4,000 annual budget to fund student travel to STEM activities. Each student may apply for up to \$400 to present research findings, or attend STEM club functions/conferences to network with experts and peers. Thus, travel awards extend to non-research fellows wishing to attend STEM-related functions. As with the research fellows, all students who receive a travel award are required to submit a written report of the STEM activity in which they participated. While there is not currently a MemphiSTEP conference requiring students to present their work verbally or using a poster, a selection of research fellows and travel award recipients are invited to talk to faculty, U of M visitors, and fellow students about their awards. Student presentations serve to develop presentation skills and inform interested parties about opportunities for undergraduate research. Another option for presentation of research conducted by MemphiSTEP research fellows is through an annual Student Research Forum held each spring at the U of M. This event has been held for several years, and offers an opportunity for both undergraduate and graduate students to showcase their research activity in a competitive environment. Resources are available online to guide students in preparation for the event through the Student Research Forum website (<http://www.memphis.edu/srf/>). Students receiving MemphiSTEP fellowships will be made aware of this opportunity prior to the application deadline for Spring 2010. Requiring MemphiSTEP research fellows to submit an abstract to the forum may be considered in future years of the program.

There were high levels of interest in the travel awards for attending research conferences and meetings of student professional organizations during the first year of the grant. Twenty applications were approved for conference and STEM club travel. There was more interest in student travel to present technical papers and for other MemphiSTEP-related opportunities than anticipated. This was very satisfying and, at the same time, frustrating since we were not able to support several worthy travel requests. As is the case with the various student initiatives MemphiSTEP is supporting, we have developed and refined the application and reporting process for undergraduate research fellows. Likewise, we are working on ways to provide additional guidelines and expectations to both students and faculty.

Over and above high levels of interest in the research and travel award opportunities, CREP's evaluation (CREP, 2009) indicated that both the research and travel funding activities were highly successful with respect to offering valuable STEM experience. Focus group discussions with STEM faculty and funded students together with reviews of student reports indicated that the research and travel awards fostered interest in STEM areas in addition to facilitating learning and social networking opportunities. The research program was arguably the most successful component of the MemphiSTEP program during year one. Numerous students commented that the research experience had been invaluable to developing STEM research skills. At least one undergraduate research fellow co-authored a peer-reviewed conference paper (Anderson et al., 2009). Furthermore, the research opportunities fostered interest in STEM careers. Numerous students claimed an increased interest in graduate school in STEM as a result of their research experiences. Many students expressed interest in reapplying for MemphiSTEP research funds or applying for other research opportunities.

C. Mentoring

The MemphiSTEP project facilitates the mentoring of freshmen and sophomore students in STEM disciplines. The mentoring program aims to extend the mentoring infrastructure already in place at the U of M (which is currently set up for first-year scholarship students). Mentees are assigned to mentoring groups based on their field of study. The group structure is designed to involve STEM faculty and upper-division STEM students, such that there is at least one faculty and peer mentor assigned

to each group. Peer mentors drive the mentoring process by arranging meetings and activities (e.g., excursions to local exhibitions, or meeting over coffee to discuss experiences pursuing a STEM field of study) to network with lower-division students in their mentoring group. However, STEM faculty help oversee the mentoring program and also arrange mentoring activities for mentees. Most faculty mentoring activities are set up for students in specific mentoring groups, although there are also general mentoring outings (e.g., museum visits), open to all mentees regardless of their field of study. Both faculty and peer mentors receive a stipend for their involvement in the program.

The MemphiSTEP goal is to have mentoring available to 500-1000 STEM students by the end of the project. However, the first year served as a pilot program, mainly targeting the 2008 Mathematics Bridge Bootcamp attendees. Peer mentors (many of whom were student assistants at the 2008 Bootcamp) were upper-level STEM students, considered to be knowledgeable in their subject area and able to network with freshmen and sophomores. Faculty mentors comprised MemphiSTEP personnel as well as STEM professors recruited to help with the mentoring program.

During the first year of the MemphiSTEP grant, six mentoring groups were formed in fall 2008 to pilot the MemphiSTEP mentoring program with the 2008 Bootcamp students. The mentoring groups included: Computer Science, Electrical/Computer Engineering, Engineering Technology, Biomedical Engineering, Civil Engineering, and a single mentoring group for Math/Physics/Chemistry. In Spring 2009, the mentoring program grew to include students that were not part of the Bootcamp. A "Women in STEM" mentor was added in the spring semester to mentor female students from all disciplines, which extended the services offered by the local Society of Women Engineers (SWE) student professional group.

While the pilot program involved a small number of mentees (59 in the spring 2009 semester) relative to the projected 500 to 1000 mentees expected to take part in the mentoring program by the end of the project, there was an increase in the scope of the mentoring program between the fall and spring semesters. Valuable insight was obtained from the pilot mentoring group that will be useful as the program is expanded in future years. Lessons learned through the pilot program included effective communication and involvement strategies. We found that multiple mechanisms of communica-

tion must be used to reach student participants, including email, targeted announcements on student webpages, Facebook, hallway postings, in-class announcements, and personal invitations from faculty and student mentors. Activities targeting the entire mentoring program (rather than only through discipline-specific mentoring groups) are essential to foster a sense of community among STEM majors. Additionally, the mentoring groups that were most successful in recruiting mentees and facilitating participation in activities during the pilot program were those that had two mentors. Two mentors were able to reach out to more students as well as work collaboratively to facilitate a group environment which was attractive to mentees. Indeed, group mentoring is thought to facilitate important mentoring relationships between mentors as well as mentors and mentees. The abandonment of the single-mentor model in favor of a group mentoring approach is advocated by multiple researchers, due to the fact that group mentoring allows for the highly varied needs of mentees to be met through a diverse group of mentors (Ragins and Cotton, 1999; Phillips-Jones, 2009). Thus, a paired mentoring approach will be used in future years of the MemphiSTEP mentoring program. Because this approach will be resource intensive, we will also combine similar majors within a single mentoring group. It is expected that this change will result in more students participating in each group, and will lead to greater networking and communication among disciplines.

The CREP (2009) evaluation, based on focus group feedback from faculty and peer mentors and reports produced by peer mentors, indicated that it had been difficult to facilitate mentee buy-in and participation in mentoring activities. Low attendance at mentoring functions was linked to various factors, including inadequate advertising and expenses incurred by participating in mentoring activities (e.g., museum entrance fees or food costs). However, key explanations suggested by both faculty and peer mentors concerned the lack of familiarity between mentees and (faculty and peer) mentors and taking part in mentoring group activities that did not include friends. Respondents reported that mentees are more likely to take part in activities if they know the mentors and mentoring activities include friends. Thus, with respect to increasing participation in mentoring programs, it is important that mentors network with prospective mentees prior to the mentoring activities and efforts are made to organize "inclusive" mentoring activities whereby friends

from different mentoring groups participate in the same activities. It is also imperative that mentoring activities are sufficiently advertised. Another explanation for low levels of mentee participation relates to limited mentoring experience on the part of peer mentors. Focus group feedback suggested that peer mentors were unclear about how to recruit mentees, establish relationships with mentees, and develop mentoring activities. Therefore, a further lesson learned concerned the need to provide peer mentors with more comprehensive training. Indeed, previous research has shown that comprehensive mentor training leads to more effective mentoring programs (e.g., Brainard and Ailes-Sengers, 1994). Thus, for the second year of the project, a greater focus will be placed on training and continued support for peer mentors.

D. STEM Clubs Mini-Grant Program

MemphiSTEP awards up to ten mini-grants per year to assist with STEM club activities arranged by student members. STEM club student chapter leaders are encouraged to apply for awards of up to \$400 to (a) increase participation in STEM organizations (particularly at the freshman level), (b) enhance professional development/career exploration in STEM majors, and (c) increase opportunities for service learning and outreach activities within STEM fields. During the 2008-09 academic year, eight mini-grant applications were funded. Proposed activities included sponsoring meetings (food, speaker incentives) and other typical student organization activities, travel support for freshman and sophomore students to national student organization conferences, and funding to support pre-college outreach activities. Two particularly innovative proposals were submitted by the student chapters of the Society of Women Engineers (SWE) and the Institute of Transportation Engineers (ITE). The SWE organization held a monthly kiosk in the U of M engineering buildings offering free food and information about upcoming SWE and MemphiSTEP events. The ITE students used part of their funds to prepare and deliver an outreach activity to middle-school students, and the other portion to develop materials and handouts for an ITE membership drive targeting freshman and sophomore students. The ITE student chapter received recognition for their activities, particularly those partially sponsored by MemphiSTEP, and were selected for the Outstanding Student Chapter Award of the Tennessee Section ITE. All of the funded student organiza-

tions reported an increase in student participation and awareness of both the STEM student organizations and the MemphiSTEP program.

CREP's (2009) evaluation of the student organization mini-grants, including feedback from faculty and upper-level majors during focus groups and a review of reports produced by mini-grant recipients indicated that the STEM club activities had been successful in terms of fostering participation in STEM club activities and facilitating STEM learning and networking opportunities. Membership rates in STEM clubs increased by at least 10%. Grant recipients thought that successful STEM club activities must offer appealing reasons for students to attend, such as opportunities for networking and high quality presentations. Respondents also emphasized the importance of food for drawing student chapter members. In addition to offering appealing reasons to attend STEM club activities, recipients suggested that participation rates depend on effective advertising. Various STEM club award recipients thought earlier, more widespread advertising is needed to get students on board by encouraging participation.

STEM faculty reported that they played an important role in promoting the mini-grant funding opportunities and facilitating the submission of applications (e.g., offered numerous reminders to student chapter leaders to apply for MemphiSTEP funding and helped students fill out applications/submit applications to the grant holders). Even when aware of the MemphiSTEP funding opportunities, student leaders were described as slow in submitting their mini-grant applications. Focus group participants thought that delays with mini-grant submissions may be due to an initial lack of awareness about funding opportunities and the prospect of writing a "grant proposal." In terms of writing the proposal, respondents thought that prospective mini-grant applicants would benefit from a MemphiSTEP meeting that offered advice about completing the application forms.

The faculty respondents thought that the amount of funding available through the mini-grants (up to \$400), while insufficient to cover most planned student chapter activities (e.g., hosting a conference), was appropriate. Partial funding was said to help students become more active in terms of seeking funding. If one grant covered all costs, students may be less driven to seek out funding available through other sources including the Student Government Association (SGA) and other STEM initiatives at the U of M. The focus group respondents

thought that the mini-grants they had overseen (e.g., proposals to host conferences and luncheon meetings with chapter members) were important for facilitating STEM learning and networking opportunities.

E. Learning Communities

The U of M offers freshmen an opportunity to participate in learning communities referred to as "Fresh Connections Learning Communities." The Fresh Connections Learning Communities use clusters of courses to connect different disciplines to a common theme. Students in these learning communities take courses together to develop a deeper understanding of the material and correlation of various disciplines. Support groups for studying and collaboration in learning usually result from making these connections. Fresh Connections also provides a social and academic experience that will lead to student success by providing a collaborative learning experience in which groups of students become responsible for their own learning, and enhance the educational experience of their peers as well.

The U of M began its Fresh Connections learning Community program in Fall 2006, allowing some entering freshmen to enroll as a cohort in 3-5 courses. While the program has been an overall success, with higher retention and fewer students going on academic probation, implementing learning communities in the STEM areas has presented special problems owing to diverse student educational backgrounds. For example, some students have placed out of freshman composition and arrive with credit for one or two semesters of calculus, while others might need augmented instruction in English and algebra or trigonometry courses instead of calculus. In Fall 2008, we offered two STEM communities, one for honors students, and one for future engineers, and in Fall 2009 we are increasing to three communities: one for engineers, which allows for the study of mathematics at several different levels, one combining Honors Calculus and Chemistry, and one on Evolution. In addition, there are two health professions learning communities and a seminar course for future biologists, which provide some of the learning community benefits to a wider range of students. General information on Fresh Connections can be found at www.memphis.edu/freshconnections/.

CREP's (2009) evaluation of the learning communities offered in fall 2008 (Honors STEM and Entry to Engineering), based on feedback from students and an instructor associated with

the Entry to Engineering community, suggested that the learning communities played an important role in facilitating social networking opportunities among students. Students reported engaging in collaborative study as well as building friendships with other learning community students. Learning community classes were also said to offer opportunities for undergraduates to learn about STEM content and careers.

Learning communities have been a part of higher education since the 1930s and the U of M program was designed with advice from Vince Tinto of Syracuse University and Nannette Commander of Georgia State University, as well as several other leaders in the Learning Community Movement. One consistent piece of advice is that in initiating a program of learning communities one must go slowly, crafting the program to the character of the school, its students and faculty. Learning communities can be an important part of a university's STEM recruitment and retention plan, but must be adapted to local circumstances.

F. Faculty Seminar

One targeted strategy undertaken by the MemphiSTEP project to engage STEM faculty is to provide a series of seminars for STEM faculty regarding student active pedagogies. During each project year, STEM faculty and first-year course instructors are encouraged to attend one-hour seminars. The overall objective of the seminars is to examine and implement teaching and learning approaches to help improve STEM retention, while especially targeting common problems among incoming students. The seminars are organized by the MemphiSTEP team and the presentations are conducted by STEM faculty (including MemphiSTEP personnel) and external speakers. Honoraria are provided to presenters.

During year 1, there were seven faculty seminars. Seminars were conducted by U of M and external faculty members. In accordance with the MemphiSTEP project goals, the seminars covered teaching and learning approaches to help improve performance in STEM areas. The presentations also covered themes pertinent to STEM undergraduate education, such as STEM pedagogies for undergraduates. There were moderate levels of attendance, with seminars comprising between ten and twenty faculty participants.

CREP's (2009) evaluation of the faculty seminar series, which involved focus groups with STEM faculty and results from a survey completed by STEM faculty regarding the

seminar contents, indicated that the seminar series had been useful for generating ideas for methods of teaching, research, and grant proposals focusing on STEM education. However, a review of the seminar topics and feedback from faculty indicated that the collection of talks was possibly too broad. In future years, STEM faculty may benefit from a more focused set of talks.

IV. Conclusions

The first year of the MemphiSTEP project served as a pilot year, whereby student and faculty strategies designed to enhance retention and graduation rates were developed and implemented. The project's comprehensive strategies focus on almost every aspect of an undergraduate STEM student's academic life, from the summer before entering the freshman year to graduation. Data have been provided for each major component of the project. While the impact of these strategies on graduation rates cannot yet be determined, lessons learned from the first year of the project may be useful to other institutions, particularly large metropolitan research universities, who are actively engaged in attempting to recruit and retain STEM students. Although determining the efficacy of the strategies in terms of enhancing student performance and graduation is crucial for determining overall program success, the following recommendations are designed to offer a guide as to ways in which strategies used in the MemphiSTEP program may be improved and more successfully implemented.

- To increase the connection between mathematics and the engineering and science fields, arrange Bootcamp/Bridge course activities such that the science and engineering sessions are closely matched to the mathematics sessions (e.g., session on trigonometry followed by earth science incorporating trigonometry problems).
- To increase student collaboration in group sessions, conduct collaborative activities in small classrooms whereby students can work effectively on multi-disciplinary teams.
- To increase participation of minority students and females in research experiences, make students aware of the project's procedure for applying for research positions, and reinforce the impact that STEM research has on improving living conditions for humanity.
- To increase student participation in men-

toring programs, expand opportunities for freshmen and sophomores to meet program personnel, mentors, and tutors in a social or informational setting.

- To increase student participation in mentoring programs, offer more inclusive mentoring activities, which may include groups of friends. Students are more likely to participate if they join in activities with friends or acquaintances. Ensure that costs associated with mentoring activities (e.g. museum entrance fees) are covered by external funds and not incurred by mentees.
- To enhance the mentor-mentee relationships, where possible, have student mentors work in pairs, such that mentors work collaboratively to facilitate activities. Mentoring pairs may be more successful in recruiting mentees and developing a group environment, which is appealing to mentees.
- To increase applications for funding opportunities for student professional clubs and travel support, arrange workshops to offer guidance to students about how to apply for funding.
- To increase participation in the faculty seminar series, focus on STEM pedagogies at the college level.
- To increase participation in project activities, augment traditional advertising techniques (e.g., email, class announcements, flyers, and webpages) with alternative techniques, including Facebook. Techniques involving direct contact with students and increasing familiarity between faculty/mentors and students are most likely to be effective.

Finally, the next focus of the MemphiSTEP project is evaluating the impact of the project strategies on student outcomes. In addition to monitoring graduation trends for STEM majors, performance (GPAs) and retention rates of students involved in the MemphiSTEP activities will be compared to other, non-participating STEM majors at the U of M.

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