Abstract - Lamar University’s Increasing Student Participation in Research Development Program (‘INSPIRED’) is an NSF-sponsored Broadening Participation in Computing project that seeks to increase participation of females and underrepresented minorities in computing. This comprehensive multi-dimensional program includes a broad spectrum of supporting activities that are designed to attract, retain and transition students to the computing workforce. This paper briefly describes the motivation for the program, the research that underpins its strategies, and a comparison of the INSPIRED approach with other existing efforts. Well-developed approaches for assessing the impact of the strategies on student participants are also discussed. The paper focuses on practical methods for the implementation of the most effective program components and includes suggestions for those who would like to adopt them. Lessons learned from experience are used to address components receiving variable ratings or having the least positive impact.

Index Terms - Broadening participation in computing, diversity, retention, undergraduate research.

INTRODUCTION

Careers in computing are among the fastest growing in the United States [1]. If we are to meet the growing demand for high tech professionals we must increase the participation of women, who receive fewer than 12%, and underrepresented minorities (African Americans, Hispanics, Native Americans, and Pacific Islanders), who receive about 13% of computing degrees in this country [2]. To remedy this situation we must (1) attract more of these students to computing, (2) improve our retention rates, and (3) help graduating students make the transition to the computing workforce. The INSPIRED Program has been working to achieve these three goals since its inception in Fall of 2007. This paper describes the activities that have contributed most to the success of the program and suggestions for how others can adopt them. It also includes lessons learned from experience to address those activities having the least positive impact.

THE LAMAR UNIVERSITY INSPIRED PROGRAM

Lamar University is a comprehensive university in Southeast Texas. The university has about 14,000 students and is primarily an undergraduate institution, although it does offer about 30 masters degrees and a few doctoral degrees. The Lamar Computer Science Department has the largest graduate population in the College of Arts and Sciences, with about 75 students pursuing master of science degrees in computer science. About 100 undergraduates are pursuing degrees in Computer Science (‘CS’) or Computer Information Science (‘CIS’).

INSPIRED is Lamar University’s three-year demonstration project funded by the NSF Broadening Participation in Computing (‘BPC’) Program. INSPIRED’s mission is to increase participation of females and underrepresented minorities in computing. The overriding strategy is to engage teams of students in an enriched undergraduate experience that includes research, mentoring and other developmental activities. The students are transformed into a force for helping retain and attract other underrepresented students in the future. Details on the design of the INSPIRED Program can be found in [3, 4].

INSPIRED uses recognized strategies for engaging students in computing [5, 6]. These include: (1) engage undergrads in research; (2) provide faculty mentoring, peer mentoring and tutoring, role models; (3) expose students to careers and beneficial applications of computing; and (4) reach out to K-12.

INSPIRED differs from other programs in the way in which it puts these strategies into practice. Space limitations permit a comparison with only a sample of related work.

Participants are selected based on their grades, interest, and potential to contribute to our mission. Participating students are paid a competitive rate of $10 per hour and engage in INSPIRED activities for up to 15 hours a week. Hours are flexible to fit students’ schedules. They must maintain a B average in computing courses and a 2.5 overall GPA. Students range from excellent in terms of grades and abilities to needing help to maintain these standards, with the latter being the mode.

The students perform research and outreach in teams that include students from all levels, freshman through graduate student, and students can participate for multiple years. Those with more experience help lead, mentor and tutor the less experienced. The less experienced grow to be the leaders, mentors and tutors of others as they progress in the program. While other programs use student teams, the progressive levels of mentoring within the teams that occurs as a result of including participants at different stages in education and development is a unique aspect of the INSPIRED program. Other retention efforts typically target
students in their freshman and sophomore years; see for example [7]. Undergraduate research programs typically target more experienced students; see for example [8].

INSPIRED also differs from other existing programs in its scope, which includes activities supporting retention, research, outreach, and transition to either advanced study or careers in computing. Carnegie Mellon was a pioneer in using undergraduates in road shows to attract K-12 students [9]. INSPIRED outreach includes not only road shows but also participation in a wide range of on-campus recruiting events and computing workshops targeting middle school, high school, and entering freshmen and transfer students. In addition to research and outreach, students participate in Research Seminars, Graduate Study Seminars and computing conferences that expose them to current research and beneficial applications of computing and help prepare those who want to pursue advanced study in computing. Participation in Career Forums and Career Counseling activities help prepare those who want to pursue careers in computing. Our program is similar to that of the STARS Alliance [10], which offers a wide range of supporting activities and engages students in selected research, outreach or service activities. INSPIRED is different from STARS in that INSPIRED students typically engage in both research and a wide range of outreach activities.

RESULTS OF THE FIRST TWO YEARS

Our 2008 INSPIRED team included seven undergraduate female and male U. S. citizens of African-American, Caucasian, Hispanic, and Philippine descent, and graduate students from India. The 2009 team of ten grew in size and diversity with the loss of one team member who changed major and the addition of four new team members. Among the 2009 undergraduate team members are a Native American male and two mothers, each with two children.

The students perform research in teams of four or five under the direction of two faculty mentors. The faculty mentors receive one course release time each spring and fall and one month summer salary for their participation. Research areas include robotics, AI, computer science education, and computer architecture, areas of expertise of the faculty mentors. A full professor of computer science acts as one of the faculty mentors and is also a mentor for a junior colleague who is the second faculty mentor for the program. A psychology faculty member directs the assessment of the program. All three faculty members are female.

I. Student Retention

The program’s goal is to retain 70 percent of INSPIRED students as computing majors. This is an ambitious goal because statistics on cohorts of computing majors at our university in Fall semesters of 1999 through 2005 show that only 26% of minorities and 21% of females continued as computing majors through their first year. Throughout the first two years of the program, 9 out of 10 students were retained, and one student changed major.

We work with the Lamar student chapter of the Association for Computing Machinery (‘ACM’) to provide tutoring in computing subjects to all CS/CIS students. This year some of our INSPIRED students attended the programming lab associated with the introductory freshman computer science course for majors so that they could give hands-on help to other students. Since then students have been more comfortable asking for tutoring and other assistance from the INSPIRED team. This has not only helped our freshman students but also helped promote awareness of and support for the program. For INSPIRED students we also make peer tutoring available in other courses like math and physics. Overall, INSPIRED students gave and received about 442 hours of tutoring, and some students formed successful study groups.

We compare participating students’ grade point averages and drop rates in computing courses with that of their cohorts. Data for cohorts includes grade point averages and drop rates in 422 CS/CIS courses taken by female students and 454 CS/CIS courses taken by minority students in Fall 1999-2005. INSPIRED students’ grades have been significantly higher and drop rates significantly lower than those of the comparison cohorts, as seen in Figures 1 and 2.
The INSPIRED Self Assessment Questionnaire was developed to document INSPIRED students’ progression in professional knowledge, skills, interest, and abilities. The questionnaire requires students to rate their own abilities in seven different areas ranging from leadership abilities to technical writing skills. For both Year 1 ($t=3.357$, $p = 0.008$) and Year 2 ($t=5.391$, $p=0.002$), students have reported that their experience in INSPIRED has had a significant positive impact on their development in these areas. A p value less than 0.05 is considered significant.

II. Transitioning Students to Graduate Study or Careers in Computing

The Computer Science faculty developed a list of Learning Outcomes which they feel are critical for students to accomplish to make a successful transition into the Computer Science field. This list was used to develop the Learning Outcomes Questionnaire to evaluate student readiness for transition into advanced studies or placement into prestigious job placement. The questions specifically focus on the influence of the INSPIRED Program on their readiness. The INSPIRED students reported significant increases in their level of readiness during their participation within the program for both Year 1 ($t=2.942; p=0.032$) and Year 2 ($t = 2.552, p = 0.038$).

Three INSPIRED students graduated in the first two years. A Latino male graduated in the spring of 2008. He began taking some Master’s level classes and continued to work with INSPIRED students on a limited basis as a graduate mentor. The other two graduated in the spring of 2009. A Caucasian female was hired as a part time IT worker with the university library in the summer and began working on an MBA in the fall. She reported that she felt the MBA program would provide her with training towards a career in project management. The third graduate expressed a desire to attend graduate school and an understanding of its importance, but for financial reasons planned to work for a few years before applying to graduate school. This young Philippine single mother of two started a career working as an Online Producer for the local newspaper.

III. Attracting Students

INSPIRED students reach out to middle school, high school, and university students in a wide variety of formats. Off-campus events include participation in career days of local high schools and science days of local middle schools. On-campus events include talking with prospective students at Open House and entering students at Week of Welcome and New Student Orientation. Students also conduct demonstrations and workshops at on-campus events like MathFest! and Sally Ride Festivals. Our most intensive events are computing academies for middle and high school students.

It is difficult to measure how effective these interactions are in attracting students to computing. Assessment has focused on the impact that workshops have on stimulating the interest and knowledge of prospective students, as described below.

THE MOST SUCCESSFUL STRATEGIES

I. Strategies for Retaining and Transitioning Students

On the Self Assessment and Learning Outcomes Questionnaires students reported the degree to which each of the program components had a positive impact on their personal and professional development in 18 areas. Students rated the 18 areas from the two questionnaires on a scale of 1 to 10 for each of 7 program components. Higher score indicated greater impact of the component. Figure 3 shows the range of total ratings for all 18 areas, with 18 being the lowest possible total rating and 100 being the highest possible total rating. The median ratings are also marked on the chart.

With the highest median student rating, the outreach activities were reported to be the most beneficial overall in enhancing students’ personal and professional development. The interactions with faculty mentors and peer mentors were also rated as having a strong impact on overall development. The greatest variability within INSPIRED students’ ratings was found in the area of research, with some students rating the research activities as having a strong influence on development and others rating it as less helpful. It appears as though a few students are not experiencing the potential value of the research activities. The diversity in team member experience levels and readiness to participate in research together with the time-consuming nature of the outreach activities are believed to have influenced perceptions of the importance of research activities. Overall, the career counseling activities were perceived as the least helpful of the program components. This is partially due to the inability of some students to participate because of schedule conflicts.

Here are some students’ answers to the question, “What do you see as the greatest strength of the INSPIRED Program?”
• “It strengthens confidence and ability in CS. The program helps strengthen teamwork and knowledge by having both more experienced and less experienced peers than themselves.”
• “Outreach – reaching out to local kids.”

II. Attracting Students

Hands-on workshops in Sally Ride and INSPIRED computing academies had a measureable positive impact on middle and high school participants.

Lamar University hosted its first Sally Ride Festival in Spring of 2009. The festival features astronaut Sally Ride and is designed to attract young girls to science, math and engineering. INSPIRED team members led two 45-minute workshops in robotics with a total of 39 young girls participating. A teacher, a principal and one boy also participated. Team members taught participants to program Lego NXT robots to ‘dance’ to music.

The Sally Ride Event Manager gave us the following feedback from their assessment:

“On a scale of 1-10, your workshop was rated a 9.4. ... they all enjoyed the workshop and would participate again. Every student who filled out a form said they were much more positive about science now than they were before after attending your workshop and the festival. Also, <the teacher> rated the workshop very highly... noted that the workshop was very age appropriate, kept the students engaged the entire time and thought the activity of trying to get one’s robot to dance was very interactive and well thought-out.”

The team conducted three one-day computing academies for middle school students in 2009. A total of 73 middle school students, 39 of which were female and 23 of which were minorities, participated in the workshops. INSPIRED team members taught programming concepts through hands-on workshops in programming Lego robots, creating animations using Scratch, and creating web pages, as seen in Figure 4.

Strong increases in computer-based knowledge were noted among the middle school students participating in the academies. Significant increases in self-perceptions of computer science knowledge were found on pre- and post-academy questionnaires (t=8.86, p<.000). Middle school students’ self-reports of knowledge gains were supported by the significant increases in performance on knowledge based quizzes from the three content areas completed before and after participation, as seen in Figure 5. A large percentage (66.2%) reported that their interest in computer science increased as a result of participation.

INSPIRED also conducted one five-day computing academy for high school students. Eighteen students from 6 schools participated. Eight were females, and 12 were minorities. In 5 four-hour afternoon sessions students learned to program robots to navigate a maze autonomously. The robots were programmed in Java, and instructional materials emphasized programming concepts like algorithms, data types, sequence, selection and repetition. Students also learned how to create web pages and talked with guest speakers about careers in computing and preparing for college. A formal assessment found that students participating in the workshops experienced a significant increase in both interest in and knowledge of computer science.

LESSONS LEARNED

I. Growing Pains

Our first year team included 7 undergraduates, 3 of whom were seniors and 2 of whom had previous experience in research and outreach. In Year 2, four new members were added to our team, all of whom had no experience and were taking first and second year courses. The inclusion of less experienced students placed more of a burden on the experienced team members, who had to tutor and train the new team members. Some of the old team members felt that new members did not make enough of a contribution.

As the number of people in the program grew, the need for organization also grew. Students reported that trying to keep everyone on task was more difficult. This placed more demands on the faculty mentors in terms of directing and monitoring the actions of the students.

We plan to make some changes to improve this situation. Our approach in Years 1 and 2 was to have a...
student coordinator for each event. In Year 3 we will have a student coordinator and a student mentor for each event. The mentor will be a student who has previously been a coordinator for the event. The mentor will compile a to-do list of instructions to be followed by the coordinator and monitor the coordinator’s progress. The coordinator will update this list and become the mentor for the next coordinator. This will help document our procedures and provide for a smoother transition. It should also allow us to engage new students in more activities and so even out the work distribution.

Our outreach activities also grew in size and number. We hosted three middle school academies for 73 students in Year 2 versus two middle school academies for 25 students in Year 1. Our high school academy grew from 7 to 18 participants. We hosted two Sally Ride Festival workshops for the first time in Year 2. All of these factors resulted in more time being devoted to outreach and less time available for research. We will not host more than three workshops in Year 3. We will also attempt to involve our students more actively in research. Those with less experience will do literature reviews and write annotated bibliographies.

II. Recruiting Students for Academies

It is natural to assume that local high school partners are the best source of participants for high school academies. This has not been our experience. We were unable to get a partner for our first academy in summer of 2008 and as a result had only seven participants. We did establish a partnership with a local school for the Summer 2009 academy. The partner promised to provide ten to fifteen participants but provided only one. Advertising yielded an additional 6 students. The remainder of our 21 participants for the Summer 2009 academy came from Boys’ Haven and Girls’ Haven of Beaumont, which are residential facilities for children from elementary to high school ages who come from difficult home lives. Our strategy for next year includes developing partnerships with other organizations, such as Girl Scouts.

Our experience with middle school partners has been mixed. One school has been our partner for three academies and reliably has provided a good group of participants each year. Two other middle school partners provided far fewer participants than promised. We will likewise look to partner with other organizations for our future middle school academies.

III. Career Counseling

Of all the support activities INSPIRED students reported that the Career Counseling Sessions had the least impact on their overall personal and professional development. In Years 1 and 2 representatives from our Career Center presented information to INSPIRED students on job search and interviewing techniques. Some students were not able to participate because of schedule conflicts. In Year 3 we will require that INSPIRED students participate in more Career Center workshops and place more emphasis on writing resumes and mock interviews.

RECOMMENDATIONS

We recommend the method we have successfully used of having teams of undergrads participate in outreach activities. Having university students participate in outreach not only helps attract youth to computing but also helps develop the university students both personally and professionally. Having students work in multi-level teams builds in peer support and peer mentoring and promotes student-to-student interactions that can enhance retention [11].

Computing academies can increase kids’ interest and knowledge of computing. High school academies are much more challenging and require more resources than middle school academies. The instructional materials are more difficult to develop. Undergraduate assistants who are not adept at programming in Java must be trained before the workshop. It is also much harder to get high school participants for the academies because many students, especially girls and minorities, have already decided that computing is not for them. The academies also must compete with summer jobs and residential camps. For these reasons we recommend starting with middle school academies, which are much easier to organize and conduct.

The time involved in organizing academies for kids can be a deterrent to those who would like to have such programs. The easiest way to conduct hands-on computing workshops for middle and high school students is to plug into existing programs. This will allow you to concentrate on providing the content and instructors for the workshops and leave the work of organizing, advertising, student recruitment, and assessment to others.

Computer Science undergraduates can easily develop instructional materials for and teach hands-on workshops for middle school kids. All of the materials for the INSPIRED workshops were developed by undergrads, many in independent study courses, and undergrads taught all of the workshops. Developing and teaching the workshops helps develop the undergrads’ communication and presentation skills, and the undergrads love working with the kids. In our workshops, an INSPIRED student demonstrates how to do each step, and the kids follow along, with undergraduates helping the kids as needed. Undergraduates with limited experience can help because all the needed information is presented by the person teaching the workshops.

If you cannot plug into existing programs, students can help with organizational tasks as well. INSPIRED undergraduates organize the workshops and academies under direction of the two faculty mentors. This not only eases the burden on the faculty but also gives the undergrads valuable experience in handling responsibility and developing organizational and leadership skills. For more information on organizing, conducting and assessing one-day computing academies for middle school students see [12]. Some of the materials used in our academies, along
with a wealth of other instructional materials for kids, are accessible from the BPC portal, www.bpcportal.org.

INSPIRED students are paid to participate in outreach activities with money from the BPC grant. However, many have said that they would participate even without pay because they enjoy working with kids, helping others, and providing good role models to youth. Members of the local ACM student chapters and honors students who are required to do service may be happy to volunteer for these activities. Another possibility is to charge fees to cover the expenses of conducting the workshops.

CONCLUSIONS

The INSPIRED program has experienced great success during its first two years, but serves only a small number of students. The small number of students serviced reflects the need for programs such as NSF’s BPC for enhancing the field of computer science by broadening the diversity of its members with greater inclusion of female and minority participants. The rippling impact that these few women and minorities have as role models and mentors to younger people, we believe will continue far beyond our program. We believe that the strategies that have proven successful in our program may be adapted and used successfully in other programs. This program generalization may be limited by the small scope (small number of students) in which it has been implemented.

Our overall strategy of engaging students in team research and outreach does appear to be successful in retaining and developing students. Two out of three INSPIRED students who graduated during the program’s first two years started taking graduate courses, and the third started a career in computing, which is a good start on the program’s goal of transitioning students to advanced study or careers in computing. While it is too early to say that our outreach activities have attracted students to computing, we can say that they have increased students’ interest and knowledge in computing.

The most beneficial components of this multi-faceted program appear to be participation in outreach activities, interactions with faculty and peer mentors, and research. Although participation in research has had a strong influence on some INSPIRED students, others have not yet benefited fully from participation. Expanding research activities to provide interactions that can benefit even the most inexperienced students will maximize the impact of research on all the INSPIRED students.

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