A Program to Broaden Participation in Computing Majors

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Abstract – Mississippi State University (MSU), like many other institutions across the country, has seen a significant decline in the number of computing majors since the early 2000's when the Dot Com crash caused many students to shy away from majors involving computing. In addition, the diversity of the students who have remained in the field has decreased in two ways. First, female students make up a smaller percentage of majors in these fields. Second, the percentage of underrepresented minorities has decreased significantly. Therefore, MSU's computing departments (Management and Information Systems, Computer Science and Engineering, and Electrical and Computer Engineering) combined forces in 2010 to propose an NSF funded Broadening Participation in Computing program that would work with the state's large community college system to recruit more students into these computing related majors at MSU. This program received funding in the spring of 2010 and has run two successful Summer Computing Experience programs for this targeted group. This paper presents an overview of the program components and discusses the assessment results so far for the program.

Keywords: Broadening Participation, Computing

Background Information on Broadening Participation Program

In spite of projected job growth rates from the Bureau of Labor statistics [2] in computing fields of 20-34%, enrollment and student interest in computing fields has dropped among high school students entering college. By some estimates, interest in computing fields lags projected job openings by a factor of five [1]. Noteably, the decline among women has been even sharper than the overall decline [6]. The NSF Broadening Participation in Computing (BPC) program, now called Computing Education for the 21st Century, is aimed at projects that seek to provide innovative ideas for attracting and retaining more students in computing majors as well as broadening the participation of women and underrepresented groups in these fields.

A significant decline in computing majors observed at Mississippi State University (MSU) matches the nationwide decline in these programs. Enrollments in Computer Engineering, Computer Science, Software Engineering and Business Information Systems at MSU in 2007 were less than half of the peak enrollment in these majors in 2000 (1082 in 2000 compared to 437 in 2007). In that same period, the percentage of women in these programs fell from 26% to 14%. Similarly, underrepresented minority enrollment dropped from 31% in 2000 to 23% in 2007.

In Mississippi, a significant number of high school graduates begin their post-secondary education in one of the state's junior/community colleges. Only about 16% of these students transition to a four-year college or university following their enrollment in the community college. This rate is even lower for women and underrepresented minority students.

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In 2009, MSU's computing departments submitted a collaborative proposal to the BPC program which proposed development of a program to engage community college students in a summer computing experience between their two years at the community colleges in Mississippi. This program aimed to both increase the interest of community college students in computing majors and to increase their rates of transferring to a four-year institution and completing a degree in one of these majors.

Overall BPC Program Components

The overall goal of this program is to increase the numbers of students completing four-year degrees in one of MSU's four computing majors. This program includes components for developing relationships with the community college instructors and advisers, recruiting students into the summer program, the summer program itself, and then follow-up activities to encourage the eventual, successful transition into a four-year school.

Recruitment and Acceptance Into Program

At the initiation of MSU's BPC program, the project PIs worked to establish contacts and relationships with the state's fifteen community colleges. While some pre-existing relationships existed with some community colleges, they were absent in others. The PIs made email and phone contact with community college computing teachers, as well as counselors and advisers. Information – in the form of a two-page handout with links to more information on the project's web site – was distributed to community college students through these contacts.

In year 1 of the project (the summer of 2010), the PIs had funding for twelve students. The summer program was advertised to all fifteen of the state's community colleges. Twenty summer program applications were received, from seven different community colleges. Twelve students were admitted, including two African-American females, three African-American males, and seven Caucasian males. (One student did not, in the end, arrive for the program.)

As indicated as a part of the student's acceptance into the summer program, they served as the program's "ambassadors" upon their return to their community colleges the following fall. They were charged with distributing information about the following year's summer program. Thus, for the second year, the program utilized established contacts through teachers, counselors, and advisers, as well as through the year 1 students.

In year 2 of the project (summer 2011), the PIs had funding for twenty students. Thirty applications were received from twelve different community colleges. Twenty students were admitted, including one African-American female, three Caucasian females, five African-American males, and eleven Caucasian males.

For year 3 of the project (summer 2012), the PIs have funding for thirty students. Information about the program has been distributed to all fifteen of the state's community colleges. Applications will be due early in the spring semester.

Summer Program Components

Students participating in the summer program are on campus for MSU's first summer session (normally the month of June). Students are housed with other MSU students who are enrolled for the summer term, although they are clustered together in adjacent rooms and have roommates who are also in the program. Part of the summer experience is aimed at making them feel comfortable on the campus so that they will be more likely to want to return after completing their community college degrees. We have two student mentors (one male and one female) who are also housed in this dorm with the student. In each of the first two years of the program, both mentors have been African -American MSU students.

We hold an orientation session the evening of move-in day where students get to meet each other and the faculty members involved in the program. Most of the activity of the summer takes place in two classes (described below). Students also have access to the student recreation center on campus and some weekend activities are planned for students who stay on campus for the weekend.

Program participants are provided a stipend in addition to their housing and tuition being paid. We ask that participants not work nor take classes at other institutions while participating in the program. During the second summer we had two students who attempted to work or take classes and this interfered with their ability to fully participate in the program.

Follow Up Components

We asked students who participated in the summer program to present at least one program at their community colleges the following year about their experiences in order to encourage future participants. We have had mixed results with this expectation. Once the students leave the program, there is no incentive for them to follow through on this commitment when they return to their home campuses. By far the most successful interaction arose from the attendance of one community college instructor to the program in the first summer. This faculty member has been a wonderful asset for recruiting students from his campus to the program. We are working to involve more of the community college faculty directly in the recruitment process as a result. However, this has also not proven to be very effective as the community college faculty typically have little time for activities outside of their classes. Even the partner schools that were part of our grant process have not been as actively involved in recruitment as we would like. We did get significantly more applicants the second summer and were able to have representatives from twelve of the fifteen campuses around the state. We have two MSU students working to stay in contact with the participants this year to both encourage them to continue to think about transitioning to MSU as well as to encourage them to talk to their fellow classmates about the program and helping to recruit additional students from their campuses. (One of these students has served as a summer program mentor, and the other was actually a community college student who participated in the 2010 summer program.)

Summer Class Details

The major part of the summer computing experience is the two MSU classes that the students take as part of this program. The iPhone programming class engages students in the computing fields through technology familiar to the students. The Leadership class exposes students to the breadth of career opportunities available in computing, familiarizes them with basic college survival skills, and introduces them to university services which can help them successfully transition to MSU or some other four-year school. Each of these classes is a three credit hour course. In the summer session, each class meets for two hours every day.

iPhone Programming Class

The iPhone programming class assumes relatively little prior programming experience, but it does not start absolutely at ground zero. It is assumed that the students have basic skills in some type of problem-solving and computer programming experience. All work in the class may be done in groups of up to three students, which does afford the opportunity for some students with greater prior experience to help classmates.

While the main focus of the class is on standard concepts of object-oriented programming, it is the connection with the iPhone and iPod Touch that effectively engages students in the material. This class is specifically designed to attract students to computing majors. As such, the class aims at “fun” programming, including programs that utilize:

- graphical components for input and output (text fields, buttons, radio buttons, switches, etc.)
- scrolling table views to present long lists of data
- spinning “pickers” for displaying and selecting dates, pictures, and other data
- images, video, and audio
- animation that flips views to the left and right as if flipping a playing card,
- touches, taps, gestures, and other movements that are part of the iPhone user experience
- core location services (embedded GPS) and Google maps
- the Apple app store to provide an automatic international distribution channel for applications developed in class by up-and-coming entrepreneurs
- and more!

In summary, this class attempts to use the excitement of iPhone programming to attract new students to computing majors.

Leadership in Computing Class

The leadership in computing class has four main objectives. The first is to expose students to a broad range of computing topics and career opportunities. Secondly, the class works to familiarize students with the services on the MSU campus that can help transfer students transition to the university environment. The third objective is to give

students some skills necessary for general college success. Lastly the course includes a group project to let students get used to the idea of working in teams and to let them develop a creative project that they can share with their community college classmates and instructors when they return to their campuses.

In order to expose students to the broad range of computing topics and career opportunities we utilize a number of guest speakers who have completed degrees in computing then transitioned to a variety of careers. We have had speakers from our own Information Technology group on campus, regional technical companies such as Adtran and Bomgar, government employees from the Corp of Engineers Engineering, Research and Development Center in Vicksburg, and a former student who completed law school and works as an attorney in the Jackson, MS, area. In addition, we used hands-on activities from the Computer Science Unplugged [4] website as well as videos from the Ted website (for example Pattie Maes [7]), senior design teams from MSU and other technology-based YouTube videos to motivate the students. Some of these ideas came from examining the pilot implementations of the CS Principles courses [3]. Hands-on exercises in our Forensics Training Center and in network security complement the informational sessions.

The MSU services part of the course introduces students to resources on the MSU campus that support student success. Guest speakers from the cooperative education office, career center, financial aid, the library, and other units discussed services they provide to students. In addition, tours of the facilities for each of the cooperating departments as well as the High Performance Computing Colaboratory let students see the facilities they will be using should they transfer to MSU and the opportunities for research involvement that are available. We also provide information on the academic requirements for the four computing majors at MSU and discuss the differences between these majors to help students transition into the correct major when/if they matriculate to MSU.

Student success lectures include topics such as study skills and time management. In addition, lectures on leadership and teamwork help prepare students for the group project in addition to helping them develop skills that will be useful in other settings. A lecturer from our psychology department does a session on visual memory and helps students develop skills that will help with their studying in all subject areas.

Finally, the students spend at least half of the class once per week working on group projects. The first summer these projects were iPhone apps. These projects were fairly challenging for the students and in the second summer we moved to Scratch programming in the leadership class and had the students develop their own application in Scratch for their group projects. The projects are presented to the class as the final exam for the session.

Assessment Results

Both formative and summative assessment of the program has been performed. The formative assessment has been used to improve the summer program components each year the program is offered. In addition, summative assessment has been used to determine the effectiveness of the program both on changing attitudes of the students about careers in computing as well as determining the rate at which the summer participants transition into four-year computing programs after completing the summer program.

Pre- and Post- Assessment Results

A twenty-five question survey about various aspects of computing including the students future plans to major in computing was given to the students upon their arrival and then again at the end of the program. Each question asked the students to respond using a 7-point Likert scale where 1 indicated strong disagreement and 7 indicated strong agreement with the statement. Table 1 shows the results for the thirty-one participants in the first two summers. Note that in some cases a negative change in mean is actually a desired goal depending on the particular question that was asked. Questions 2-7 are related to self-efficacy in computing. They show mixed results since questions 6 & 7 were worded where a low number was better. Questions 8 & 9 deal with the students' perception of computing as a skill they would "show off." The answers to these show a positive impact of the program. Questions 10-13 relate to perceptions of gender differences in programming. These questions show an improvement as a result of this program in terms of the students' feeling less like computing was male dominated after the program. Questions 14-16 deal with the students' perception of computing as a worthwhile and career. We saw some of the largest gains in these questions. Questions 17-20 are meant to assess the feelings of students as to the relevance of computing to their lives. There was little change in these perceptions from before to after the program. Questions 22-25 deal with how challenging students find computing problems. The students seem to find more challenge after the program but were less worried about being challenged. Overall these results indicate that this group of students

already had strong feelings about their abilities before the program started. Since the program was targeted at students studying computing at the community college, this is not surprising.

Table 1. Pre- and Post- Assessment Means

Question	Pre-assessment mean	Post-assessment mean	change in means
1. I plan to major in computer science, computer engineering, software engineering, or business information systems.	6.19	6.32	0.13
2. Generally I have felt secure about attempting computer programming problems.	5.48	6.19	0.71
3. I am sure I could do advanced work in computer science.	5.52	6.16	0.64
4. I am sure that I can learn programming.	6.45	6.55	0.10
5. I'm no good at programming.	2.48	2.58	0.10
6. I don't think I could do advanced computer science.	2.06	2.58	0.52
7. I'm not the type to do well in computer programming.	1.87	2.16	0.29
8. Being regarded as smart in computer science would be a great thing.	6.48	6.58	0.10
9. If I had good grades in computer science, I would try to hide it.	2.26	2.03	-0.23
10. Females are as good as males at programming.	6.32	6.65	0.33
11. Studying computer science is just as appropriate for women as for men.	6.61	6.81	0.20
12. It makes sense that there are more men than women in computer science.	3.32	3.45	0.13
13. I would have more faith in the answer for a programming problem solved by a man than a woman.	2.71	2.42	-0.29
14. I'll need programming for my future work.	5.94	6.39	0.45
15. I study programming because I know how useful it is.	6.00	6.35	0.35

Question	Pre-assessment mean	Post-assessment mean	change in means
16. Knowing programming will help me earn a living.	6.10	6.58	0.48
17. Computer science is a worthwhile and necessary subject.	6.45	6.58	0.13
18. Programming is of no relevance to my life.	1.68	1.81	0.13
19. Programming will not be important to me in my life's work.	1.90	1.97	0.07
20. I expect to have little use for programming when I get out of school.	2.00	2.06	0.06
21. I like writing computer programs.	5.68	6.13	0.45
22. I am challenged by programming problems I can't understand immediately.	5.23	5.58	0.35
23. The challenge of programming does not appeal to me.	2.00	2.35	0.35
24. I do as little work in computer courses as possible.	1.61	1.71	0.10
25. Computer science has been my worst subject.	1.94	1.97	0.03

Formative Assessment Results on Summer Program

In addition to the overall assessment of changes in students' perceptions about attending four-year schools and majoring in a computing discipline, we also wanted to provide formative assessment of the summer program itself so that we could make improvements with each year of the program. Surveys were conducted at the end of each summer program that asked students to rate on a 5-point Likert scale each of the program components both in terms of the importance of the topic to the program and the effectiveness of the presentation of the material. There were also open-ended questions about the different aspects of the program such as the timing of the program, as well as its overall effectiveness of achieving the goals of the program relating to exposing students to careers in computing and helping them to plan for transition to a four-year school.

The results from the first summer's program were very positive. The particular sessions that the students viewed as not being particularly important to the program included the sessions on student organizations, the library, and MSU's learning center. These sessions were eliminated in the second summer of the program. In addition, one aspect of the program that the students felt was very important was a panel of computing professionals that we had the first day of class in the first summer. We got numerous comments though about the fact that this did not provide the students enough chances to interact with the professionals. In the second summer, instead of having a single panel of professionals, we had different professionals come in at different times in the summer. This gave the students more time to interact with each of these professionals individually which the students rated as much more effective in the second year. Another session on Internet marketing was rated as important the first year but was not seen by the students as being effectively presented. The second summer we had the students do some examination of effective web sites on their own, but this also did not seem to work well for this topic.

Two sessions that did not rate very highly the first summer were continued the second summer because the PIs felt the material was important for the students. One was a session on visual memory presented by a psychology faculty member. The first summer's students did not find this presentation to be useful. Upon reflection it seemed that they did not take this particular topic seriously enough and therefore did not get the benefit from the techniques discussed. The second summer, this session was rated much more effective. The leadership class instructor spent more time setting the context for this lecture which helped the students to take it seriously. The second session in this category was the ethics presentation and an ethics paper the students were required to write. The first summer this presentation focused more on hardware issues which did not seem to resonate with the students. The second summer the presentations focused more on software issues and issues that were more relevant to the students such as downloading music and software copyrights. This session was still not rated very highly by students in terms of its importance (although the scores for effectiveness improved). It could be that these students are not yet ready to appreciate these issues.

Overall the students were unanimous in their evaluations that the program provided them with more information on computing careers and made them more likely to want to transition to a four-year school upon completion of their associate degrees. They found sessions on the university curricula in the four majors to be very helpful in planning for their future at the community college as well as after transition into the four-year school.

Qualitative Study

A three-year qualitative study is currently being conducted to better understand the inhibitors and enablers of the community college-to-university (CC-to-Univ) transition. Results from this portion of our program are intended to improve retention rates for CC-to-Univ transfer students who major in computing and information disciplines. The sample will consist of computing and non-computing majors. Computing majors will include students who have and have not participated in the BPC program. The longitudinal data will consist primarily of students' verbalizations about their progress through their junior and senior university, and how they feel it relates to their community college experiences. Data collection began in fall 2011, with four students participating so far. We expect to attract more participants in the coming years. We hope to interview each participating student four times, once during each semester they attend MSU. Verbal protocol analysis will be used to examine the data.

The study draws on Flaga's [5] framework of the CC-to-Univ transition, which is based on five dimensions (learning resources, connecting, familiarity, negotiation, and integration) across three university environments (academic, social, and physical). Flaga's framework was developed from cross-sectional data. Our longitudinal approach, therefore, is expected to extend Flaga's framework by identifying when and the extent to which the five dimensions and three environments come into play over the transfer student's junior and senior years. We expect to identify trends that can help community college and university personnel better prepare, assist, and accommodate transfer students in the CC-to-Univ transition.

Preliminary results from our first round of data collection indicate that Flaga's framework is a useful tool for identifying some of the inhibitors and enablers of the CC-to-Univ transition. To date, identified challenges include: (1) discovering available learning resources and where they are located in the university's physical environment; (2) connecting with faculty and students in the academic and social environments, respectively; and (3) feeling "comfortable" in MSU's physical environment. Other problems described by our participants that were not explicitly part of Flaga's framework include feelings of liminality (i.e., perceptions of being "betwixt and between the positions assigned and arrayed by law, custom, convention, and ceremonial" [8, p. 95]). For example, one participant described a "weird feeling" about how he fit into life at MSU. Even though he had earned enough credits to be a junior, he nonetheless felt "like sort of a freshman" because he was still "new to campus." These feelings of liminality may be amplified as students transition into more difficult junior-level university classes. As one participant (an accounting major) noted:

> *At community college you do well in all your accounting classes and you love it. But here, you're questioning, do I really want to do this? Or...if I'm not happy now doing it--is this something I want to do for the rest of my life? And that's definitely something I'm stressed about, because you don't want to do something just because you're halfway through it.*

While of limited sample size, the qualitative data is nonetheless interesting for several reasons. First, findings from the qualitative data sometimes conflict with results from our formative assessments. For example, participants in the formative assessments stated that BPC sessions on student organizations, the library, and MSU's learning center

were not particularly important. However, our qualitative data suggests that transfer students appear to gain a better appreciation of the importance of these dimensions of the CC-to-Univ transition after only a few weeks or months at MSU. This conflict suggests that quantitative surveys for our program--and probably those of others--must be judiciously interpreted. Indeed, the BPC program faculty has taken this approach, as evidenced by their retention of lectures on visual memory and software issues in spite of low ratings in formative assessments.

The qualitative data also suggests that transfer students employ a variety of strategies to better manage their transition. One common strategy is to parse their academic, physical, and social environments into manageable chunks. That is, instead of trying to learn everything about a particular environment, they focus on only the most important parts. For example, students were confident in their knowledge of relevant features of their environments (e.g., where their classes are held and meals are provided), but they also admitted that they still did not know about many other parts of the campus.

The BPC program does appear to help students address problems in the CC-to-Univ transition. The first participant mentioned above--the only one who completed the BPC program--described his BPC experience as "probably the most helpful thing" for adjusting to life at MSU. Some of the benefits resulted from campus tours, field trips, and various topics covered in the BPC classes. Other benefits were more indirect but nonetheless important. This same participant related that one of the things he liked best about BPC was the students, whom he described as "pretty amazing." He had reconnected with two of them after moving to MSU, thus helping to build his social network. He also expressed a satisfactory comfort level, which is problematic in at least one other non-BPC participant. It remains to be seen, however, just how this camaraderie will benefit the participant as he continues to transition to MSU.

Conclusions and Future Work

Although the assessments so far indicate that students do enjoy the program and indicate they are more likely to transition from the community college to a four-year school, we must continue tracking these students to see if they indeed do make this transition successfully. Three students from the first summer are currently enrolled at MSU. Two enrolled immediately after the summer program and one began in fall 2011. They have had mixed results academically indicating that we still have work to do on the transition process. In addition, we do not yet have support from our institution to ease the transition of these students to MSU. They are required to apply for admission again, which places an extra hurdle in getting them to MSU. We are working with our admissions office on streamlining this process for participants in this program.

Getting support from the community colleges in terms of nominations of students and communications from the instructors has been difficult at times. We have good relationships with some community colleges but others have been difficult to establish connections with. We will continue to work on these relationships as this is likely to provide the most long-term benefit in terms of transitioning students to MSU in computing majors.

Operating the summer program is fairly cost and labor intensive. Most of the students in the community college system would be working if they were not attending this program. Therefore we have had to pay the students' tuition, housing and meal costs as well as awarding a stipend to offset what they could have earned. Future programs might be more sustainable if they were shorter in length and did not interfere with the students' ability to have summer jobs. More follow-up with the students is needed to determine if there is a more sustainable and attractive format that would offer similar benefits for the participants.

Acknowledgements

Funding for this work was provided by NSF's Broadening Participation in Computing program, Grant #0940470.

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