

Robocamp: Encouraging Young Women to Embrace STEM

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This paper describes the efforts and results of a plan for actively recruiting students to undergraduate computer science and engineering programs at the University of North Texas (UNT). Such recruitment of students is critical to the country's efforts to increase the number of engineering professionals, and is a priority for the Computer Science and Engineering (CSE) Department at UNT.

Introduction

Computer science and engineering communities have been exploring efforts to attract more students especially women and minorities to computer science and engineering degree programs and retain them once they are there [1]. This paper describes the efforts and results of a plan for actively recruiting students to undergraduate computer science and computer engineering programs at the University of North Texas (UNT).

Students often arrive at the decision to go into engineering because they performed well in mathematics and science in high school. However, they typically lack a realistic understanding of what computer engineering is. Students struggling with the transition from high school to college see very little “real” computer science or engineering to inspire them, and thus they tend to opt out after their freshman year. To address this lack of exposure, the authors designed a series of *portable and mobile* summer computer engineering robotics camps for middle and high-school women students that is described and evaluated herein.

The Problem

Strong math and science education is essential to the nation's economic success and global position as a leader in discovery and innovation. A lack women and minorities who are scientists and engineers, and an acknowledged national deficiency in math and science achievement, point to an urgent need for improvements in the education process. The number of advanced degrees in math and science awarded nationally lags behind those awarded by universities in other countries.

The growing need for well-trained scientists, engineers and technologists in the United States creates a need to focus more intently on improving the outlook of groups typically underrepresented in technological fields, namely women and minorities. The state of Texas has placed a strong emphasis on addressing the current and anticipated shortfall of STEM professionals, with a focus on rectifying under representation of these groups.

The current shortage of women and minorities in technical fields directly correlates to the small number of students that enter college and complete degree programs in STEM fields. Women, for example, earn less than 11 percent of engineering degrees, and only 24 percent of degrees in the physical sciences. The need for innovative and sustained channels for preparing women and minorities to engage in STEM academic pursuits and careers is critical to the future of our state and nation.

The Program

Special summer camps for engineering students are a strategy that has been effective in promoting computer engineering among high school women [2, 4]. Evidence exists that a curriculum developed around the programming of robots can attract new women students, into computer science and engineering. The UNT Department of Computer Science and Engineering created Robocamp to address the need for sustainable new channels to engage young women in activities that prepare them for college programs and careers in science, technology, engineering, and math (STEM) disciplines. More importantly, Robocamp offers supplementary education that motivates and inspires young women's interest in technology through opportunities to engineer robots, design

computer programs and learn about higher education and career opportunities in the STEM disciplines.

The camp programs are organized around team-based, project-oriented activities that utilize a number of mobile resources, including laptops and the BOE-BOT (Board of Education Basic Stamp Microcontroller Carrier Board produced by Parallax). The curriculum consists of open-ended projects that produce observable behaviors and allow students to explore beyond the limits of the defined exercises. Such activities include programming the robots to draw different shapes as creative as the ones shown in Figure 1. Teams explore collaborative and collective efforts as well as independent operations. Working in a team environment encourages the camp attendees to make individual contributions to the overall success of their efforts, regardless of whether their individual strengths lie in problem analysis, system design, construction or programming.



FIGURE 1
ROBOTS CAN BE PROGRAMMED TO “DRAW” AND “DOODLE” CREATING ROBOART AS SEEN BY THESE STUDENTS HIGHLIGHTING THEIR COLLABORATIVE EFFORTS IN USING THE ROBOTS.

The program also uses innovative tools such as the Alice Programming Environment to engage students in the production of animated stories and simple games as well as incorporating interesting robotics experiments and tasks such as Sumobot wrestling and RoboArt, as described above., The camp directors have also incorporated elements of the PBS Design Squad activities to illustrate basic concepts in engineering design and principles of mechanics and dynamics. The robotics summer camp use problem-based learning approaches, similar to those described in [3]. This study clearly demonstrates the significant benefits of teaching students how to think by using a problem-based approach. Beginning in the summer of 2006, the authors developed a mobile laboratory so that the summer camp can be held at several locations, thus broadening and expanding the reach of the camps to traditionally underserved populations and geographical regions.

Sustaining Efforts

Robocamp began with a 2-year grant to the UNT Department of Computer Science and Engineering from the THECB Technology Workforce Development Grant Program. The basis of the grant was to establish an innovative educational outreach program in STEM disciplines. The success of UNT's pilot camp—Robocamp—has since led the College of Engineering to secure additional external support from Motorola Foundation (Robocamp has won two Innovation Generation grants), the RGK Foundation, and the Texas Workforce Commission at levels that supported 12 camps, including camps for young men and secondary school teachers in 2008. More than 240 participants attended camp in 2008, and more than 450 have participated in the program since 2005.

Evaluation and Results

Evaluation is primarily done through a series of surveys as part of an overall evaluation plan. The evaluation plan included both formative measures to provide feedback to project developers, and summative assessment to address project effectiveness. Formative evaluation strategies contribute to the development and implementation of the curriculum. Formative Evaluations were performed at the completion of the camps to answer these questions:

- How do students rate the quality of and their satisfaction with various activities?
- How do instructors, assistants and participants view the usefulness of their activities or participation?

The summative evaluation addressed the quality and usefulness of the completed activities. This data is collected at six month and one year offsets from the end of each camp. Summative evaluation questions included:

- What was the overall quality and effectiveness of the activities based on student and parent ratings and reviews?
- What impact did the camp activities have on the performance of the participants as they return to their secondary school, from both the student and parent perspectives?
- What impact did the camp activities have on the higher education and career plans of the participants?
- What were the demographic characteristics of students enrolled in each type of activity and how do they compare with demographic characteristics of students in the department as a whole?

The first survey is conducted at the beginning of each camp to determine the students' interest in STEM activities and to gather baseline demographic information. The second survey is administered at the end of the camp to assess the level of interest in STEM activities immediately after the camp, with additional surveys completed at six months, one year and two years after camp attendance. These surveys measure continued interest in STEM related topics and establish the effect that the camp has had on participants' general performance in math, science and technology courses and plans for college. The overall success criteria include an immediate improvement in performance in math and science by at least 30% of camp participants and at least 25% of camp participants' eventual pursuit of college degrees in STEM disciplines.

The specific results from both participant and parent surveys show the impact this program is having on the plans and attitudes of young women. The student responses illustrated in Table 1 are based on the following questions:

1. Are you planning to attend college?
2. Did your experience at Robocamp affect your decision on a college and/or major?
3. Has your overall performance and interest in math and science improved as a result of your experiences at Robocamp?
4. Would you be interested in an advanced level Robocamp if one were offered?
5. If a scholarship were available for Robocamp graduates to attend UNT in math, science or engineering would you be interested?

The parent responses illustrated in Table 2 are based on the following questions:

1. Is your daughter planning to attend college?
2. Does your daughter have a strong interest in math, science or engineering topics?
3. Has her overall performance and interest in math and science improved as a result of her experiences at Robocamp?
4. Would your daughter be interested in an advanced level Robocamp if one were offered?
5. If a scholarship were available for Robocamp graduates to attend UNT in math, science or engineering would your daughter be interested?
6. Do you feel that the Robocamp experience had any other positive or negative impacts on your daughter's performance at school or otherwise?

Table 4. Student Post Camp Survey (% of respondents)

Question	Yes	No	Undecided
1	100%		
2	50%	30%	20%
3	82%	18%	
4	90%	10%	
5	90%	10%	

Table 5. Parent Post Camp Survey (% of respondents)

Question	Yes	No	Undecided
1	100%		
2	73%	27%	
3	60%	33%	7%
4	73%	7%	20%
5	71%		29%
6	100%		

These results indicate that the Robocamp experience was very positive as viewed by both the parents and the students, and that the activities enhanced not only interest in math and science, but also performance in these subjects upon returning to school. Many students have now considered altering their initial thoughts about academic programs and careers to give serious attention to STEM disciplines as a result of their camp experiences.

Anecdotal Comments from Surveys

This section provides a few quotes from the post camp surveys of both the students and the parents.

“It opened my mind to considering this as a career” – Student

“Yes, I understand more, and I am even taking a course in robotics, now. I’m actually passing.” – Student

“Yes it affected what I wanted to major in. I wanted to first major in business, now I want to major in computers” – Student

“Yes, right now I take Chemistry and Algebra II/Trigonometry. In Chemistry, I have a 95. In Algebra II, I have a 93.” – Student

“Yes I have been much more interested in science since Robocamp” Student

“I had already known I was interested in math and science, however, my experience at Robocamp further enforced my decision. It also made me think that engineering would be an ideal field to study” – Student

“Most definitely. My high school requires us to take one credit of computer science and this camp helped me choose which course to take. I am also more aware of what people are talking about when they discuss robotics. Robocamp further strengthened my interest in math and science” – Student

“As I mentioned previously, I think the program gave her additional confidence, particularly because it was an all-girls class. Besides being female, she is also quite naturally introverted, so activities like this do help a great deal. I think it has given her confidence and a sense of direction. She is much more likely to discuss her experience at Robocamp and relate it to other things she is doing, whether in school or in extracurricular activities. I recommend the program to everyone I can think of with a daughter who might be interested in science” – Parent

“Yes, her grades improved greatly in math and science” – Parent

“She now tries to think thru the problems rather than just solve them” – Parent

“She, as of right now, is planning on going to college. No college has been chosen but she is interested in engineering (because of last year’s camp!!)” – Parent

“Math was never an easy subject for her, but since last year’s camp, she has been determined to learn all the math she can. She has completed her Pre-Algebra textbook on her own in the past six months. She is EAGER to start Algebra.” Parent

“In the past, Sam always felt like math and science were for ‘smart kids’ and that it had to be boring. Camp changed some of these stereotypes for her. Now that she does not see these subjects as an opportunity to fail, she is better able to focus her efforts and succeed.” – Parent

“Yes. This year she has A/B’s in math and science. We believe that she finally figured out that she CAN do it so as a result she listens and tries harder” - Parent

“Great job! Thanks for bringing highly intelligent individuals to this project that were still able to communicate on a real level with these kids (That was a big concern for me when I initially enrolled my daughter.)” – Parent

Results from a special survey the participants who have since graduated high school are even more encouraging. Approximately 30 participants have graduated high school as of May 2008, 17 of which responded to our survey. Sixteen of the 17 girls are attending college, including 2 at UNT, 1 at Yale, 1 at Columbia and the remainder at various Texas institutions. The survey further indicated that 14 of the 17 respondents are pursuing STEM-related degrees, including Engineering, Biology, Oceanography, Computer Science, Physics, Mathematics and Geology. The remaining three young women are pursuing degrees in Cosmetology, Health Management and Forensic Science. This data suggests that Robocamp significantly impacts young women and their choices as many of them indicated that the program caused them to take a second look at STEM programs and careers during their high school years..

Recommendations

Implementation of programs involving Robotics, Computer Programming and Engineering design skills appear to have a significant impact on the educational and career decisions made by young women. The tools and resources are readily available for this model to be adopted by other academic institutions in partnership with school district, community organizations and youth program in their own communities.

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Author Information

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