Using Robotics to Achieve Meaningful Research Skills in Robotics

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Abstract

In recent years there has been a significant decline in the number of college students choosing majors in computer science or technology related fields. Although this trend is beginning to turn around at the undergraduate level, there remains disparity in the number of under represented minority students who earn graduate degrees as compared to majority students. Additionally, within the United States, there is an achievement gap between under represented minority students and majority students at a time when underrepresented groups are becoming an increasing proportion of the national labor force. This reluctance to study Science, Technology, Engineering, and Mathematics (STEM) disciplines must be confronted and changed if the United States is to maintain a competitive position within the global market. Effective use of learning technologies is vital to solving many of our current STEM learning challenges. Robotics is a growing research area in computer science education. We use robotics as a technology tool captivate and engage students in research in robotics.

Introduction

Robotics has long been used as a tool to revitalize interest in the Computer Science major. Robotics, is a motivational tool, is also a growing research area in Computer Science Education (Caldwell, 2011; Caldwell & Jones, 2011). Used in the Computer Science classroom to both teach hardware and software concepts, robots are being used to attract students to research in robotics at the undergraduate level. Research experiences are considered effective opportunities for encouraging undergraduate students to continue on to graduate school (Dahlberg et al, 2008). Why use robotics? Robotics systems are powerful and affordable. The use of robotics in an educational setting offers the student multiple modes of learning. Not all students are able to understand and retain information through the traditional oral lecture style. Robotic enhanced instruction is presently used across the country and has received excellent reviews. Robotics has been used to successfully teach computing concepts in higher education (Touretzky, 2010). This paper discusses how we use robotics as a research methods teaching tool to captivate and engage students in learning to engage in research.

Benefits of REU Program

Some institutions with a tradition of commitment to undergraduate research have sought to demonstrate the value of their programs by reference to anecdotal data. Most commonly, institutions seek to demonstrate the numbers of former undergraduate researchers choosing graduate school or high-level professional careers. Some of the benefits described include (Seymour et al., 2003):

1. Increased student interest in the discipline
2. Increased recruitment of students of color to study STEM disciplines
3. Critical thinking and understanding how to approach research problems
4. Enhanced career preparation
5. Consideration of a professional career in the sciences
6. Professional socialization
7. Opportunities for professional networking
8. Clarification of a career path
9. Newly developed interest in a career path
10. Confirmation of a career path
11. Affirm decision to enroll in a graduate school
12. Increased research skills
13. Readiness for more demanding research
14. Increased lab techniques
15. Increased contributions to collaborative work
16. Communication and argument skills
17. Ability to assume leadership roles
18. Increased understanding of the research process
19. Appreciation for how scientists think and work on real problems

20. Increased self-confidence in ability to do
21. Increased self-esteem and self-efficacy
22. Improved approach to learning; shift from passive to active learning
23. Become part of a learning community
24. Bonding with faculty research mentors.

Research experience is a growing learning approach in computer science education. Surveys indicate that undergraduate research experiences assist in refining students' interest in research and encourage students who had not considered graduate studies to alter direction toward a Ph.D. (Russell et al., 2007). Research; however, require a high level of self-motivation and a desire for increased learning about a topic. Robotics engages multiple modes of learning, including: sensory, perceptual, and cognitive information processing (Boonthum, 2009; Burhans, 2007; Klassner, 2002). Research is vital to solving many of our current STEM learning challenges. We use robotics as a technology tool to captivate and engage students in research (Touretzky, 2010).

Preparations for a Research Experience in Undergraduate Research

Description of the Pre-REU Program

The Pre-REU program at Winston-Salem State University (WSSU) affords students the opportunity to increase their knowledge and understanding of research methods in a four week summer program. Participants develop skills required to secure a full REU appointment in subsequent summers. The Pre-REU is offered to students majoring in Computer Science or Information Technology with grade point averages of at least 3.0 on a 4.0 scale. The application can be submitted online or hardcopy. The application process consists of submission of an official transcript, a personal statement, and a letter of recommendation from a faculty member in the computer science department. Review of the applications begins after the deadline for receiving the application package. All applications are checked for the above three eligibility requirements. Funding secured from National Science Foundation grants (Advancing Robotics Technology for Society Impact-ARTSI and NC LSAMP) provide housing and stipends for the participants. The typical day consists of morning classes from 9AM -12 PM and afternoon lab time from 1pm – 5 pm.

Peer research mentors consisting of upper level undergraduate and graduate students in the the Computer Science Department, give participants the freedom to experiment, while removing the fear of treading into unchartered territory. Class sessions in research methods, C++, Linux, and robotics fundamentals complete the morning workshops and instructional activities. Afternoon sessions provide an opportunity for participants to engage, apply, and experiment with the concepts presented while completing laboratory activities. Lab sessions require student to solve loosely defined problems; program the iRobot Creates in C++ using the Tekkotsu and Player/Stage Platforms; search the Internet for additional resources needed to implement a solution or correct programming and system errors.

Program Implementation

The robotics focused Pre-REU program was implemented initially during the Summer of 2008. The first cohort consisted of 4 minority students majoring in Computer Science. Since that time 4 cohorts have completed the program. The program is designed to accommodate six rising sophomore or junior students. Table 1 shows participant data by gender f for the student cohorts from summer 2008 – summer 2011.

Table 1. Participants by Cohort

Pre REU Program	Cohort I Summer 2008	Cohort II Summer 2009	Cohort III Summer 2010	Cohort IV Summer 2011
Females	0	1	1	1
Males	4	4	5	5
Total	4	5	6	6

The research mentors observed students who are not enrolled in summer school courses tend to spend more time in the research laboratory. Students are introduced to the dynamics of research during their five week stay. Students are expected to present orally and submit a paper. The oral presentation and paper describe their summer research project and their preliminary results. Students are also required to develop prototypes using existing robotics platforms. The specific research project is designed to match the skills and interests of the students.

Program Observations and Reflections

The Pre-REU program at WSSU has successfully prepared students to pursue REUs at several research universities/laboratories such as Carnegie Mellon, University of Pennsylvania, Duke University, George Tech, Rice University, North Carolina State University, University of Alabama, and the Quality of Life Technology Center at the University of Pennsylvania/Carnegie Mellon. Presently, one student from Cohort I has completed graduate school. Table 2 shows how many Pre-REU participants completed REUs.

Table 2. Pre REU to REU by Cohort

Summer	Pre-REU	REU	Percentage
Cohort I 2008	4	3	75%
Cohort II 2009	5	5	100%
Cohort III 2010	6	3	50%
Cohort IV 2011	6	? Summer 2012	

The summer Pre-REU allows collaboration between faculty and students in an atmosphere different from the normal classroom setting. Student participants learned the basics of conducting research such as how to formulate a research problem; and how to search for supporting literature and resources. In addition, students develop communication skills through their weekly updates about their research projects. The Pre-REU students are expected to present their posters at the end of the summer, during the regular term for the WSSU Research Day, the College of Arts & Science Undergraduate Forum and the Department's Computer Science Day. Student participants are also strongly encouraged to present posters externally at the ARTSI Student Research Conference.

Conclusion

The faculty sponsors have observed that at the end of the four-week program, students leave the program with a strong feeling of accomplishment and efficacy. The Pre-REU program motivates and supports minority student populations who otherwise have limited opportunities to participate in research as undergraduate students. This program prepares a cohort of minority undergraduate students with skills necessary to pursue a successful research career. In addition to working on specific research projects with faculty mentors, students are not only encouraged to pursue REUs at other institutions but to start thinking about Graduate School in areas related to robotics. The Pre-REU program provides a model for other peer institutions to follow in developing young minds for successful undergraduate research. Student participants usually maintain close contact with their summer research mentors during the academic year as they complete REU applications and request letters of recommendation.

This pilot study was conceived as a mean to address the need of preparing students with no exposure to either robotics or research to compete for REU appointments in robotics or other areas of computer science. The researchers addressed some fundamental questions about the structure, participants, and benefits of undergraduate engagement in faculty mentored, research outside of class work. Next steps will afford the researchers the opportunity to formulate hypotheses regarding factors that enable success and test them for validity. Our goal is to clarify the nature and value of structured preparation for common types of undergraduate research experiences. Future investigation will entail questions of "what works", "best practices for specific ethnic groups" and the impact of the experience on pursuing graduate study.

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