Using Robotics to Excite Students about Computer Science

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Abstract

The paper describes the development and use of a Web site designed to excite students about computer science in an attempt to reverse the nationwide trend in declining enrollments of computer science majors. The Taulbee Survey, conducted yearly since 1974 by Computing Research Association, has reported a nationwide 51 percent decline in enrollments of computer majors from 2000 - 2007.

Robotics and the popular sumobot contests provide the main attraction for the Web site. In a sumobot contest, two robots try to locate and push each other out of a ring, following rules similar to sumo wrestling. The site provides tutorials for six java programming projects that supplement the concepts taught in the Introductory computer science courses, including sequential statements, decision statements, repetition statements, problem solving and object-oriented programming. The target audience for the Web site will be students taking high school AP courses in computer science, as well as students enrolled at technical schools and universities.

The author describes the use and impact of the tutorials in the "Introduction to Java Programming" course during the fall of 2008 and spring of 2009. Future plans are also discussed.

1 Declining Enrollments

Computing Research Association has collected surveys of enrollments in computer majors at 4-year universities since 1974. The graph in Figure 1 [1] shows a dramatic drop of almost 50 percent from 2000 through 2007. This trend has been experienced nation-wide, including universities like MIT and Carnegie Melon, which draw many students from around the world. The trend has also been true in South Dakota.

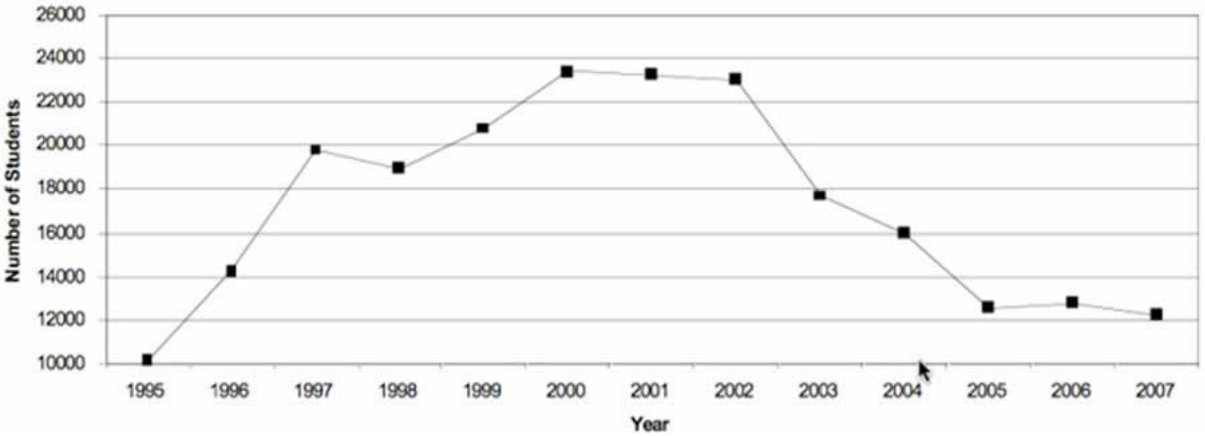

Figure 1: Newly Declared CS/CE Undergraduate Majors at 4-year Universities

The results of the 2007-2008 survey haven't been published yet, but many are hopeful that the figures will possibly rise slightly this year. As shown in Figure 1, the steep 140% rise from 1995-2000 paralleled the Internet Boom and the beginning of the decline coincides with the "dot-com" bust. 2006 – 2008 appear to be leveling and there are hopes that a slow rise in interest may be beginning this year. The decline of women in computer majors is even more dramatic, exceeding 80% between the years 1998 and 2004. [4]

Since 2004, many computer science departments have studied the issues and debated over the actual causes.

Dr. Debra Richardson, chair of the Computer Science Teachers Association (CSTA) Advisory Council, writes: "There is a pressing need for our nation to address the declining enrollment and participation in CS courses immediately and vigorously. If we do not do something now to provide our students with access to the CS pipeline before the college level, our nation will face long-term skills shortages that will have negative effects on both academic and industrial computing." [2] Richardson is also dean of the Donald Bren School of Information and Computer Science at the University of California - Irvine.

The shortage mentioned by Dr. Richardson is magnified by the projections published by the federal Bureau of Labor Statistics. The *Occupational Outlook Handbook for 2008-2009* ranks the fastest growing occupations for the years 2006-2016. [5] "Network systems and data communications analysts" is ranked number one with 53% growth and

"Computer software engineers and application developers" is ranked fourth with 38% growth by 2016. Table 1 shows the actual projection data published in the handbook. [6]

Occupation Category	**U.S. Jobs in 2006**	**New U.S. Jobs by 2016**
Computer Software engineers – System & Apps	857, 000	324,000
Computer Programmers	435,000	-18,000
Computer Scientists and Database Administrators	280,000	60,000
Computer Support Specialists & System Admins	862,000	155,000
Computer Systems Analysts	504,000	146,000
Network Systems and Data Comm Administrators	262,000	140,000
Total combined growth by 2016 = 34%	2,343,000	807,000

Table 1: Projections Data from the National Employment Matrix [6]

2 Possible Causes

Several factors have been cited as contributors to the declining enrollments, including:

- The "Dot Com Bust" in the year 2000.
- Rumors of outsourcing computer jobs overseas.
- Media coverage of corporate layoffs.
- The impression that computer jobs are boring and socially isolating.
- A low level of interest in computer science by women and minorities.
- An outdated CS curriculum.
- Poor marketing of the career possibilities in IT and CS.
- The wide gap between the typical computer game software that students are accustomed to and the elementary software that they are able to develop as a student.

The rise of enrollments during the nineties and the decline beginning in 2000 seems to parallel the growth of the Internet and its bust also beginning in the year 2000. However, the Internet began to grow again in 2004 and continues to grow each year. Enrollments have not followed this latest growth trend.

Another possible cause is the impression that most computer jobs will be outsourced overseas in the future. Only a small part of this impression is true. The Bureau of Labor Statistics predicts that the number of computer programmers will decrease by 5% between 2006 and 2016, primarily due to outsourcing of those jobs to other countries [6]. Although outsourcing is significant, it hasn't impacted the growth of total new computer related jobs in the U.S. Jobs classified as "computer programming" only involve writing the code using designs that have been developed by systems analysts and computer software engineers. The current large demand for systems analysts and software engineers is projected to grow by over 40% from 2006 to 2016. The source of the

mistaken impression about the future of computer jobs appears to be from high media coverage of corporate layoffs combined with low media coverage of future job projections. [3]

Many high school students, particularly girls and minorities, view computer jobs as boring and socially isolating. Three sources for these low impressions have been identified. Some see the career as a "geek job for boys" [7]. Many feel that proper marketing is needed to help students see the profession as a viable, rewarding career choice. Others have indicated that software is so complex today, that students spend too much time learning before they can create anything that even remotely resembles the programs they are accustomed to using. Still others claim that redesigning the curriculum is needed. [8]

Investigation of these events and impressions yields two primary root causes:

- The low level of marketing about the "possibilities of CS and IT careers" has not counteracted the false impressions generated by negative media reports.
- The current curriculum for CS and IT majors causes high attrition and fails to let students feel productive and successful in early courses.

3 Current Projects Attempting to Reverse the Trend

Most projects responding to the declining enrollments have focused on the root causes mentioned above. Many Universities are developing "road shows" as a way of outreach to the K-12 community. In their annual report for 2008, the Computer Science Teachers Association wrote: "The CSTA took on several projects in 2008 to promote and support the teaching of computer science and other computing disciplines at the K-12 level. The group, along with SIGCSE, organized a 'road show workshop' aimed at helping colleges and universities improve their K-12 outreach efforts. Several other CSTA-led workshops and symposia focused on curriculum and leadership initiatives for educators throughout the U.S." [8] Videos from this workshop can be viewed online at http://csta.acm.org/Communications/sub/Videos.html [9]. Some great examples of video road shows can be viewed on youTube from Stanford University [12] and Microsoft Research [13] [14].

WGBH (the Boston-based PBS station) along with the ACM have received a grant from NSF to reshape the image of computing. The $850,000 two-year project will study the images and perceptions of computing held by high school students, particularly Latina girls and African American boys. The goal is to develop and rigorously test messages that would be effective in shifting negative perceptions and create strategies through these messages that will eventually build a potential national campaign to draw interest and young students into the field. [8]

Purdue University sponsored an exciting camp, called SPIRIT, for high school students exploring the "Surprising Possibilities, Imagined and Realized through Information

Technology." Students learn the Alice programming language and use it to create 3D animation videos [4]. The program is described at http://www.itpossibilities.org and the student-created videos can be viewed by searching for the keyword "itpossibilities" on YouTube.

Carnegie Melon University is concentrating a lot of effort on the development of the Alice programming language as a tool to attract students into the computer science major, and to improve retention among those majors. Alice is a simplified scripting language that teaches students the principles of programming in a 3D environment. Alice 2.0 is developed for high school and college students. Before using Alice in their CS1 course, at-risk students averaged a C grade and only 47 percent went on to take the CS2 course. With Alice, at-risk students average a B grade and 88 percent go on to take CS2. A summary of Alice development can be viewed at http://www.youtube.com/watch?v=Nm7bv4wduTI [10]. New versions of Alice provide even more excitement. Alice 3.0, currently in development, will include 3D characters and environments from the commercial program, SIMS 2. Storytelling Alice, created by CMU doctoral student Caitlin Kelleher, introduces junior high and middle school students to programming through building a story. The high level animations in Storytelling Alice enable students to program social interactions between characters. [11] Additional information and copies of the Alice software can be obtained at http://www.alice.org.

4 Our Project

Our project at Colorado Technical University reduces the gap between what the students can develop in their beginning courses and what they see in their real world. We want them to have an enjoyable and successful experience in their beginning programming classes. We have simplified robotics programming by creating a Java class library that simulates a sumobot battle. This allows students to write real Java programs that give simple instructions to program the robot for a match. In a sumobot match, a robot must stay inside a ring as it locates the opponent and pushes it out of the ring. A set of tutorials help the students learn how to program robots as they learn the basics of the Java language. Figure 2 shows a typical sumobot.

Figure 2: A Sumobot by Parallax Corporation ™.

Tutorial 1 is used when students are learning about sequential logic statements. A scribbler robot (made by Parallax Corporation) is used to learn about servo motors and the basic movement commands of forward, reverse, turnRight, turnLeft, spinRight, spinLeft and stop. The scribbler version of the robot also carries a felt-tip marker that can be lowered to start drawing and raised to stop drawing. The students apply what

they've learned by drawing their initials in the center of the sumo ring as shown in Figure 3 below.

Figure 3: The Simulated Scribbler Sumobot Drawing Initials in the Ring

Tutorial 2 is used when students are learning about decision logic statements. They learn to use lookDown commands to check the status of the QTI line sensors and turn back when a white line is observed. They also learn the lookForward command to check the status of the Infrared transmitters/receivers. The status indicates whether the left-eye or they right-eye or both eyes see something. The goal of tutorial 2 is to stay inside the ring and stop when the other sumobot is located.

Tutorial 3 is used to apply the principles of repetition logic structures as they program a scribbler bot to draw a series of concentric squares using nested loops.

Tutorial 4 is used to apply their own problem solving skills to develop a strategy for pushing the opponent sumobot out of the ring after it is located. Figure 4 shows the results of a sumobot match.

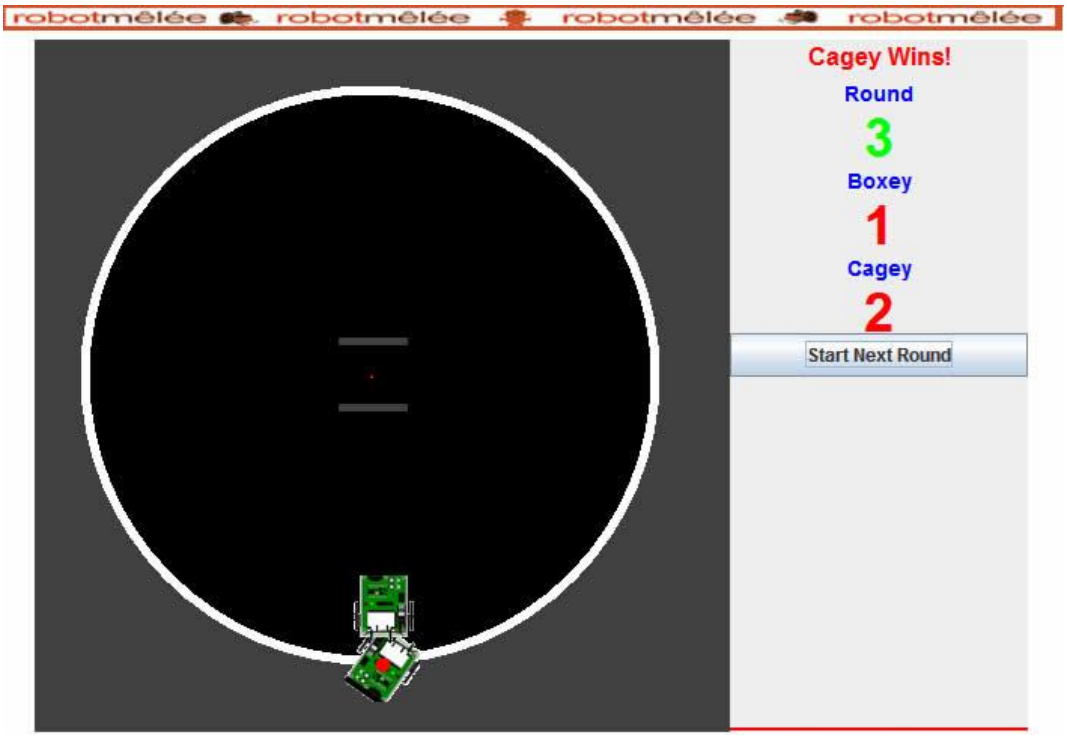

Figure 4: A Sumobot Round Ends.

The other two tutorials will be developed this summer to give students experience in problem solving. Tutorial 5 will help students use problem solving and analysis techniques to create a strategy for the battle and improve the success of their sumobot.

The remaining tutorial 0 will be developed in the future to provide an easy drag-and-drop interface that lets students think about detailed step-by-step processes and experiment with a limited instruction set. This tutorial will precede tutorial 1 to introduce programming concepts while avoiding the pitfalls of language syntax errors. This tutorial will also be targeted for students in grades 3-8.

In each of the five Java tutorials, students are also learning about object-oriented programming. They develop a sub-class called MySumobot which extends the super Sumobot class. They learn that the MySumobot class inherits the command methods or behaviors from the Sumobot class. They can use the inherited methods without having to write the code for those commands. They also learn to use "set" and "get" methods to access the inherited class instance variables for the sumobot (name and mode), They add their own class instance variable, along with appropriate "set" and "get" methods, to store and retrieve the sumobot's version number.

The tutorials were used in the Fall of 2008 with CTU's Introduction to Java course. Students were given the option of completing the Sumobot labs or completing a more typical set of lab assignments. All of the students seemed to grasp the concepts of object-oriented programming more quickly than in the past and their comments about the sumobot labs were very positive.

Currently a Web site is being developed to provide the tutorials online along with an editing and compiling system that will let students develop, compile and run their sumobot classes on the Web site. Our Introduction to Java course for Spring 2009 will use the Web version of the tutorials. Our goal is to make the Web site and the tutorials available for use by high school and college students and instructors by Fall of 2009.

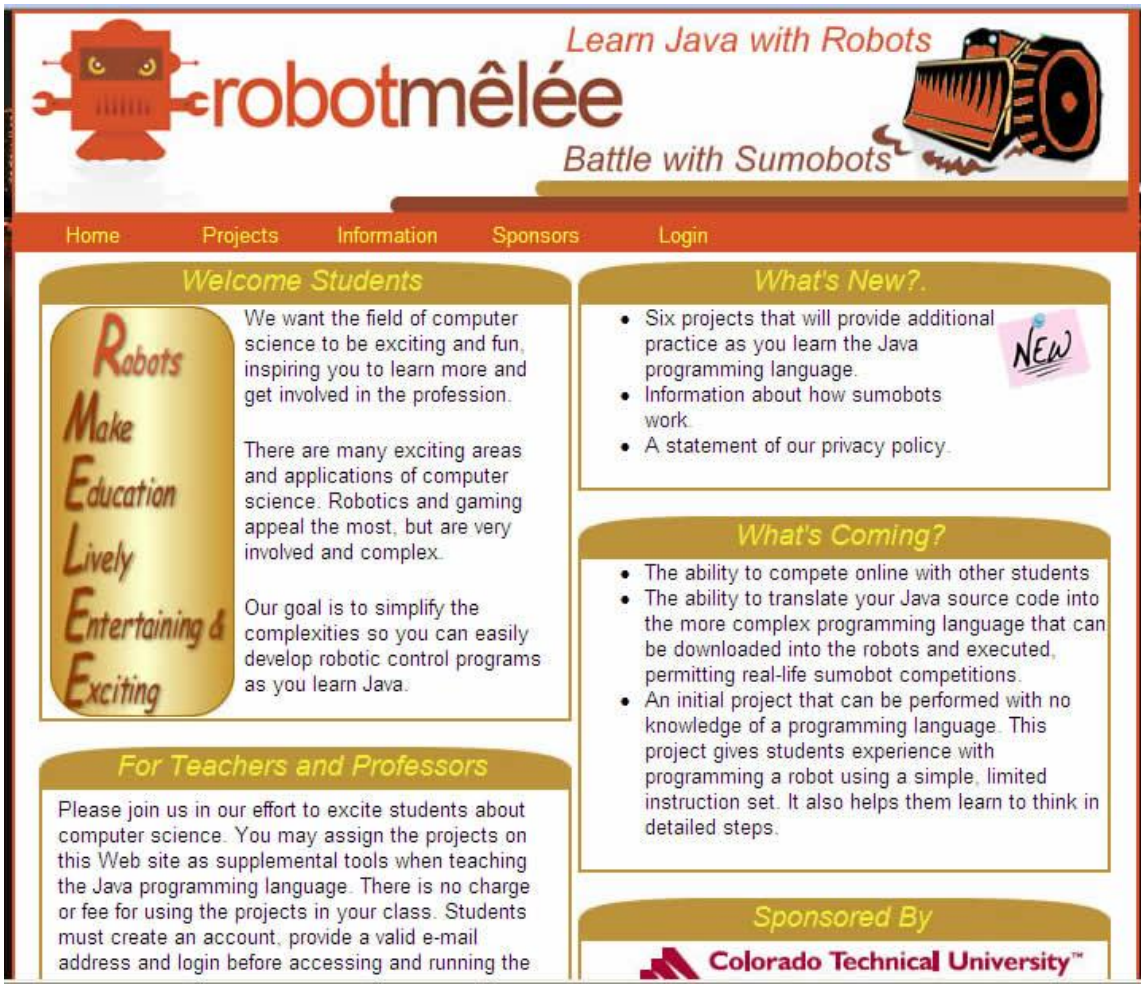

Figure 5: The Front Page of the Current Web site.

5 Future Plans

The first class that used the sumobot tutorials only had six students, hampering reliable projections from the statistics. 75% of the men and 50% of the women elected to complete the sumobot labs over the standard business-type labs. 83% of the class continued on to the Intermediate and Advanced Java courses. Each student that used the sumobot labs was positive about its effects. Their grasp of object-oriented programming principles seemed to be better than that of previous classes. We are excited about continuing with its development. This summer the following features will be added to the Web site.

- Add a form for private input and suggestions from students and instructors.
- Add a privacy policy statement and a "Rules of the Ring" statement.
- Add a security pre-compiler to insure that only sumobot commands and calls to local methods are in the programming of the student's sumobot.
- Add Tutorial 5
- Make the site available at http://www.RobotMelee.org

We hope to find a few college and high school instructors that would assist in the beta testing of the Web site during the fall of 2009. The domain name, RobotMelee.org, comes from our motto: "Robots Make Education Lively, Entertaining and Exciting". If the project demonstrates successful outcomes and generates interest among other faculty, we will work toward the following enhancements.

- Add a moderated blog at the bottom of each tutorial, so students can ask questions, offer their own answers to questions, describe their difficulties with the tutorial, and make suggestions. Entries to the blog will be approved before being published.
- Add the ability to convert the Java code to the modified Basic code that can be downloaded into an actual sumobot.
- Add the ability to compete online against the sumobots of other students.
- Add Tutorial 0 for a drag-and-drop, syntax-free interface to programming a sumobot.
- Let a student upload a personal graphic image for his or her sumobot.
- Organize live competitions and robot programming contests at college campuses.
- Add additional interesting information about robotics, information technology and computer science.
- Convert the program to allow C++ and Visual Basic programming.
- Convert the program to a 3D based graphical display of the battle. Perhaps Alice would be a good platform for this.

6 Conclusion

We are excited about the sumobot project and its possibilities. Students have been able to create software that they enjoy showing to friends and family. Student retention appears to be positive and we are hopeful that the high school and college community will be as excited as we are.

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