

The Botball Educational Robotics Program: Engineering outreach for middle school, high school and college students

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Abstract

This paper will describe the Botball Educational Robotics Program, an engineering outreach program that uses the activities of designing, building, and programming robots to engage students in the fields of engineering, science, technology, and math. Botball was originally designed for middle and high school students, but a collegiate division was added last year to allow students to continue their involvement after graduation and to give university students a hands-on engineering and computer programming project. A recent study shows that about one-third of the middle and high school Botball students surveyed felt that participating in Botball had influenced their career choice; and of those who were influenced, ninety-four percent decided to pursue a career in a technical or engineering field. A discussion of how colleges and universities are using Botball as an engineering outreach and recruiting tool is included.

Introduction

In 1997 a high school student who was a single mother at a continuation school, signed up for the Botball Program at her school to earn some extra credit towards graduation. She learned about robots, but more importantly, she learned she was good at programming and mechanics, and that she enjoyed designing the robots. She got so excited about robotics that she went out and got an internship at NASA.

An alternative school with a low graduation rate and a poor attendance rate adopted the Botball program as a hopeful measure to try to keep their students engaged. The students involved in the program showed a 100% attendance rate, and more students signed up to do the program the following year. Being on the Botball team became such a coveted position that students had to sign and uphold behavior contracts in order to be allowed to participate. This school now graduates students who go on to good colleges, several even going on to the University of California at Los Angeles and Berkeley. In the words of the teacher, "This was never heard of before – it never happened."

Gavin K., a student at Carnegie Mellon University writes, "Looking back at the two years I spent in high school on the robotics team working mostly on Botball, I can hardly imagine where I would be if I had not been on the team. I'm typing this from Carnegie Mellon University where I'm a freshman studying electrical engineering and robotics, I'm

pretty sure that if it weren't for Botball I wouldn't be here, or if I was, I would be studying something else. Botball sparked my interest in robotics, I always thought robots were cool, but I never imagined I could make one until Botball.”

Botball is a program that appeals to a wide variety of students and gets them involved in a complex, open-ended engineering challenge. It is a versatile activity used by gifted programs and magnet schools as well as alternative schools.

General Program Description: The Botball Educational Robotics Program

The Botball Educational Robotics Program is a national program implemented in regions across the country. Botball is a program of KISS₁ Institute for Practical Robotics, a 501c3 not-for-profit educational outreach organization with the mission to use robotics as outreach for engaging students in learning the practical applications of science, technology, engineering and math. Our goals in doing Botball are threefold:

1. to create more technically literate students and teachers;
2. to encourage more students to go into science, engineering, math, and related fields;
3. to use robotics to engage students in engineering, science, and math, and help them understand how and why they can use the tools of math and science to do important and creative work.

Botball uses the activities of robot programming, design, and construction as well as website development to get students excited about being on the creative side of technology.

Our strategy in pursuing these goals involves providing both a short and long term approach towards improving the effectiveness of schools in teaching science, math, and technology. Specifically, we educate teachers and arm them with engaging, cutting edge reusable robotics equipment along with curriculum support so that they can reach more students in the long run and use the equipment to teach more effectively in the classroom. The competitive aura of the Botball Tournament brings all these elements together in an exciting and highly effective way for the current year's students. The reusability of the equipment and professional development for educators help create a long-term effect with possibilities for impacting upcoming students for years.

The Middle and High School Botball Process

Botball is a team activity, with generally about 5 – 15 people on a middle or high school team, although we have heard of several teams with up to 40 participants. (They generally select a smaller “performance team” to be in the pit area during the tournament). There are seven main parts to the middle and high school Botball Process:

1. Research & Design Robotics Website Challenge
2. Educators Hands-on Workshop
3. Design/Build/Program Project
4. Documentation Website

¹ KISS stands for the engineering acronym: Keep It Simple Stupid.

5. Regional Tournaments
6. National Conference
7. Reuse equipment for other projects

Schools, clubs, community groups, and home-schoolers have all successfully participated in Botball. A team begins the Botball process by registering for the program at our website in the summer or fall. There is a fee of \$2300, which includes all participation in website and robotics activities, all robotics materials and software (which are reusable), attendance for up to two individuals at the educators hands-on workshop, tournament T-shirts, and technical support throughout the season. Our fundraising efforts generally yield enough scholarship support that no team is turned away for lack of funds.

In fall, we announce the topic of the national Research and Design Robotics Website Challenge. This is an optional part of the program involving Internet research on the current year's topic, creation of a website around that topic, and display of students' designs of original technology at the websites. Past topics have included designing a robot to assist an astronaut on Mars, designing a robot to collect ice from the lunar poles, and designing assistive robotics for a chosen disability. Welty and Puck¹ highly recommend connecting technology to human needs and activities in order to keep girls more engaged, and the Research and Design Robotics Website Challenge attempts to connect the creative act of technology design with real human issues.

Botball kicks off the robot-building season in spring with a hands-on professional development robotics workshop for educators or team leaders. At this time they receive a customized self-contained robot kit to take back to their students with everything needed to design, build and program up to two small autonomous₂ mobile robots.

The middle and high school student teams then have about seven weeks to design, build, and program a pair of small, autonomous mobile robots to play the current year's tournament game. Students must also document their project management elements, such as goals and milestones, division of labor, strategies, etc., and enter these in a Documentation Website that is part of the competition. At the end of the seven weeks a regional double-elimination tournament is held, open to the public, and trophies and certificates are awarded for the best robots and websites (both Research and Design Websites as well as Documentation Websites).

Botball is a national program with educator workshops and regional tournaments across the country. In 2004, Regional Botball Tournaments were held in Oklahoma, Texas, Arkansas, Georgia, Northern and Southern California, Greater DC, New York/New Jersey, Pennsylvania, Midwest (Indiana), North Florida, New England (Massachusetts), and Hawaii.

As part of the Botball Program, we also hold a National Conference on Educational Robotics (NCER) featuring the National Botball Tournament. Botball teams from all regions are welcome, regardless of how they scored in their regional tournaments. The

² Autonomous robots do not use remote control. Instead, students use foresight, strategy, and a real computer programming language, "Interactive C", to preprogram the robots to behave in a specific way based on feedback from the sensors.

NCER is a conference designed specifically for students and teachers. In addition to invited speakers (usually nationally known robotics engineers), the students and teachers themselves present papers, give robotics demonstrations, and learn from one another during networking sessions. Because they are having a good time, it is hoped that this conference gets students even more interested in going on to higher education in technically related fields. The NCER offers opportunities to publish that may also add significantly to their college applications.

The overwhelming feedback we get is that educators reuse robotics kits either as part of robotics, physics or general science classes, or as part of an afterschool club. Many teachers have told us that by participating in Botball they got the equipment and training to then start a robotics club or new classes at their school. Several have mentioned that students took the robots apart after the competition and started from scratch again to build robotic projects for science fairs.

Collegiate Botball Challenge

Collegiate Botball works somewhat differently than the middle and high school Botball Program. Participants must be enrolled in at least one undergraduate or graduate level class in spring. There is no educator workshop. Instead, each year's game challenge is described at the Collegiate Botball website in winter. This provides college professors with an opportunity to use the Collegiate Botball Challenge as an in-class activity throughout spring. At the website is a parts list of all allowable materials, which teams may gather on their own or purchase from KISS Institute.

Rather than holding several regional tournaments, there is one national Collegiate Botball Tournament that takes place at our National Conference on Educational Robotics over the summer. The event also serves as a chance for middle and high school students to see the validity of Botball during post-secondary education.

Survey Results

Students were surveyed at the National Conference on Educational Robotics in 2003. Student survey results², analyzed by the Statistical Consulting Center at Virginia Tech, indicate that that year's students were 69% male and 31% female. About 78% of students described themselves as White, and about 15% were Asian, with just over 4% Black or African American, and about 3% Hispanic or Latino.

Results indicated that 88% of students surveyed felt that Botball was one of the best things they'd done in school. About 75% participated in Botball as an after school club, and about 25% participated as part of a class.

In responding to questions comparing how they felt about the usefulness of science, math, and technology before doing Botball to how they felt about these topics after their participation, survey results showed that for technology 78% felt more positive, 1% felt less positive, and 21% were unchanged. For science 58% felt more positive, 3% less positive, and 39% were unchanged; and for math, 31% were more positive, 5% less positive, and 64% were unchanged.

About 26% of the students surveyed had not yet decided on a course of study before they participated in Botball. Of these, 100% said they had now decided to choose a technical, math, or engineering field.

About 31% of Botball middle and high school participants felt that Botball influenced their career choice. Of these, 94% indicated that after their Botball experience they would now choose a career in a technical field.

Discussion

The surveys were taken at the National Conference on Educational Robotics and therefore did not include the full 250 teams who participated in 2003 regional tournaments. The survey results show Botball participants to be overwhelmingly white and male. Based on staff observation however, more girls and non-white students appeared to be present at the regional tournaments than traveled to the National Conference. Unfortunately we were not able to survey all students across the country who participated. Efforts to reach out to more girls and minority students are being made, however more work is needed to make this successful. In the future, more efforts will be made to survey all students who participate in Botball, not just those who go to the National Conference.

For those students who reported that their opinions regarding math, science and technology were unchanged, it is not clear from the surveys how students felt about the topics beforehand. The same can be said of those 74% students who already had decided on a course of study and the 69% for whom Botball did not influence their career choice. Botball participants are a self-selected group and may already have been planning to go into science, math, or technology-related fields. Future surveys will seek more detailed information regarding pre-Botball opinions and career choices.

Botball as engineering outreach

From a university standpoint Botball is a wonderful thing. We have students from many different high schools in the area who, due to interest in Botball, wind up coming and doing robotics, electrical engineering, or artificial intelligence at the university as a result. They jump right in our AI and robotics classes and robotics clubs and other kinds of things. Eventually many wind up graduating with jobs in aerospace engineering, AI, and robotics -- things like micro air vehicles (flying robot planes) and all sorts of other wonderful stuff that comes out as a result. We're here helping out at Botball every single time both because it's fun to volunteer and because it's the best way we can get new students to be involved in robotics in college when they graduate from high school.

Sean Luke
Assistant Professor,
George Mason University

Rose-Hulman University, the University of Oklahoma, University of North Florida, University of Hawaii, Mercer University, and George Mason University are just some of the institutes of higher learning where faculty are very involved with the Botball Program.

In addition to the Regional Botball Programs hosted by various universities, institutes of higher learning can use the Collegiate Botball Challenge that takes place at the National

Conference as a form of outreach. High school and middle school students cheer on the college teams, and spend a great deal of time interacting with them. The college students serve as role models to their younger counterparts. We are also aware of various professors who scout talent at both the regionals and the national event, taking the opportunities to highlight their own institutions and “marketing” them to the highly capable high school students right then and there.

Perhaps the engineering outreach possibilities are best summed up by Will Elliott, NASA Project Specialist at the University of Arkansas, Little Rock:

UALR feels fortunate to have a recruitment tool such as Botball. Not only does Botball help UALR recruit high school students by introducing them to studies in Systems Engineering and Engineering Technology, but it's beneficial to the state itself. The state of Arkansas ranks 49th in technology and science according to the latest study conducted by the Milken Institute. By providing a program like Botball, we are making a choice to improve our state. We (UALR) want to be seen as a leader by bringing students interested in technology from across the state to UALR. Having the opportunity to host the Regional Botball tournament has allowed us to showcase many of the aspects which set us apart from other institutions. From a recruiting perspective, this is of great value!

Bibliography

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Author

CATHRYNE STEIN is the Executive Director of KISS Institute for Practical Robotics, a national, nonprofit educational organization. Ms. Stein is also a founder of the organization. Under her direction, KISS Institute has developed several national programs, including the Botball Educational Robotics Program for middle school, high school and collegiate students, as well as the Robots in Residence Programs for elementary and middle schools.