Work in Progress - BEST Middle and High School Robotics - Workforce Development Innovation

George Blanks
Auburn University, blankgw@auburn.edu

Abstract - BEST Robotics, Inc. is a non-profit, volunteer-based program headquartered in the Ginn College of Engineering at Auburn University (AL). In fall 2010, over 900 schools and 13,500 students will compete at 41 "hubs" (local, licensed competition sites) in 16 states. BEST is a project-based program that helps industry develop its future workforce. BEST students become competent in what industry needs in its workers: experience in "design-to-market" product development; teamwork; project management; leadership development; and analytical, decision-making, and problem-solving skills. The program is free to schools; any school can participate. Teams of students are provided equipment used to power their robots and raw materials with which to build them. In addition to robotics, teams compete in oral presentations, technical writing, educational exhibit design, CAD design, and other areas. As a result of participating in BEST, students better understand the practical use of math concepts and applied physics; solve real-world engineering problems; understand what engineers do; and receive recognition and acclaim typically reserved for their peers in sports. BEST is increasingly being developed in various states in partnership with local and state workforce development initiatives; and it has a powerful and direct impact on local schools, companies, and communities.

INTRODUCTION

Take plywood, PVC pipe of various sizes, threaded rod, a box filled with screws and other hardware, an irrigation valve cover, piano wire, aluminum paint grid, a bicycle inner tube, something called a "micro-energy chain system," an assortment of other odds-and-ends, and give it all to a team of students with the challenge to design and build a functioning, competitive robot in six weeks. What do you get?

You get BEST ("Boosting Engineering, Science and Technology") Middle and High School Robotics, an annual six-week long, school-based, fall competition that is the second largest and fastest growing program of its kind in the U.S.

The BEST competition has been described as the merging of the excitement of a high school basketball game, the strategy of a chess match, and the intellectual challenge of a science fair. Add to that hundreds of screaming fans, pep bands, cheerleaders, mascots, a deejay, and the pressure of a competitive sporting event, and it becomes clear that BEST is unlike many other programs of its kind.

PROGRAM OVERVIEW

In 1992 during an "Engineering Day" open house at Texas Instruments' (TI) facility in rural Sherman, Texas, engineers Ted Mahler and Steve Marum were giving plant tours to groups of local high school students. During the tours, students watched a video of a robotics competition at the Massachusetts Institute of Technology and commented that they wished they could have a similar competition in their community. The two engineers decided that day to host such an event the following year. What the two did not foresee was that the first competition held in Sherman, Texas in 1993 would lead to where it is today.

Since its start in 1993 with 14 high schools and 220 students in rural North Texas, BEST has impacted tens of thousands of students. Headquartered in the Samuel Ginn College of Engineering at Auburn University (AL), the program will mark its 18th year this fall and it is estimated that over 900 schools and 13,500 students will participate at 41 "hubs" (licensed local competition sites) in 16 states.

What started as a one-time event has become a national program. The organization now seeks to impact students, schools, and communities nationwide by providing a life changing experience that unlocks students' imagination, develops their competencies, and helps them discover their potential.

Its mission is straightforward: engage, excite, and inspire middle and high school students to pursue careers in engineering, science, technology, and math through participation in a sports-like, science- and engineering-based robotics competition.

The core values of the program have not changed since its founding:

- Students are the sole participants, primary decision-makers, designers, and builders.
- Any student may participate as long as they meet their school's eligibility requirements.
- There is no registration or participation fee.
- Equipment and materials are provided at no cost to participating schools.

- Any school may participate regardless of type, size, location, or socioeconomic status.

BEST began with a simple, single objective: provide students in rural North Texas with a fun and challenging extracurricular engineering activity. Now, its core objectives are more encompassing and national in scope:

- Provide students with a real-world engineering experience that incorporates the practical application of math and science.
- Help students develop leadership, project management, team-building, and organizational skills.
- Develop students' self-confidence and competence through project-based and self-directed learning, decision-making, abstract thinking, and problem-solving.
- Enhance classroom learning and thus impact K-12 Science, Technology, Engineering, and Mathematics (STEM) education.
- Prepare students to be technologically literate and better prepared to enter the workforce.

THE BEST COMPETITION

I. Educational Game Theme

Each year's competition (i.e., game) is based on a real-world engineering application with an educational theme. Examples of previous competitions and challenges include: "BEST Fever" (DNA separation); "Transfusion Confusion" (nanotechnology); "2021: A Robot Odyssey" (NASA's Mars Rover Project); "Just Plane Crazy" (lean manufacturing); and "High Octane" (alternative fuel production).

II. The Robotics Division

Each team is tasked with designing and building a remote-controlled, semi-autonomous robot capable of accomplishing defined tasks and engineering feats as required in the game. Teams that participate at every BEST hub receive the same identical kits: a "Returnables Kit" of equipment used to power the robot they build and a "Consumables Kit" of raw materials from which to build their robots. The robots they build can only be powered with the equipment provided in the Returnables Kit; it can only be built from the parts provided in the Consumables Kit. The finished robot cannot weigh more than 24 lbs. and must fit within a 24-inch square cube.

Each team must submit a *Project Engineering Notebook* that documents the process and planning used to design, build, and test its robot.

The actual competition is a series of three-minute matches with four robots per match competing against each other to determine which robot scores the most points in performing certain tasks. A seeding round determines the top eight teams that advance to a semi-final round. Winners of the semi-final round advance to the championship round.

In addition to competing in the game challenge, the robotics teams compete for the Founders Award for Engineering Design and the Most Elegant, Most Photogenic, and Most Robust robot designs.

III. The BEST Award

Teams that compete in this optional competition are judged on the following: *Project Engineering Notebook*; oral presentation; educational exhibit; judge's interview; spirit and sportsmanship; and robot performance. Winning the BEST Award is considered the highest achievement any team in the competition can accomplish.

This award provides opportunities for students to compete who otherwise might not be interested in building a robot, thus making BEST a school-wide program. Those students with interests in public speaking, website design, CAD design, videography, photography, graphic design, and art find their niche in this award.

COMPETITION EVENTS

I. Kick Off Day

Kick Off Day is exactly what its name suggests: the beginning of the fall competition season. Each hub brings together the teams signed up to compete, typically at the same venue where the actual competition will be held six weeks later. At the event, the year's game rules and playing field are introduced for the first time to the teams. Teams also receive their kits of equipment and materials. Most hubs also conduct tutorial sessions on such topics as wiring, tool safety, soldering, proper use of the equipment, team organization, and the like. From this point forward, teams have six weeks to prepare for the competition.

II. Mall Day

Mall Day is an optional event for schools that takes place on the Saturday of the fourth week of the competition. The hub sets up the playing field at a local mall and teams are encouraged to sign-up for driving practice time slots throughout the day. While the primary purpose of the event is to practice driving their robots, most teams come to conduct "industrial espionage" – sizing up the competition and "borrowing" ideas from those teams that have effective, functioning robots. The event is also a way to generate community interest in the upcoming game. Hubs usually invite television and newspaper coverage to help promote the competition.

III. Game Day

Six weeks after Kick Off Day is the actual competition, or "Game Day," which takes place in a local gymnasium. Besides the robotics competition taking place on the floor of the gym, the BEST Award competition is being held. Judges

grade the Project Engineering Notebooks, oral presentations, and educational exhibits. Typically, over 50 volunteers serve as judges for both the robotics and BEST Award competitions.

IV. Regional Championship

Teams that win the robotics and BEST Award competitions at their local hubs advance to a regional championship, which is held in early December at one of several sites. Just as BEST hubs are set up within districts, so, too, are the regional championships. There are currently three championships for winners of the 41 BEST hubs.

V. National Championship

Winners of the regional championships in both robotics and the BEST Award advance to the National Championship, which is held each April in the Dallas Convention Center.

UNIQUE PROGRAM FEATURES

Several features of the BEST program make it unique and distinguishable from other robotics competitions.

I. Middle and High School-Based Program

Unlike other robotics competitions, BEST is strictly school-based. After-school, extracurricular youth organizations like Boy Scouts, Girl Scouts, 4-H, and Boys and Girls Clubs may not field teams in the competition. Any school – even home schools, provided they are recognized as legitimate schools – may participate. Each school may only enter one team.

BEST is a middle *and* high school competition; that is, middle and high school teams compete against each other, which is unique among robotics competitions. BEST includes both in order to create a feeder program from middle to high school. By engaging middle school students in as early as the sixth grade and exposing them to real-world engineering challenges, the chances of inspiring them to become engineers, scientists, and technical professionals increases. Furthermore, if successfully engaged early enough, these students are encouraged to take the requisite math and science courses necessary to enroll in engineering school.

II. Use of the Engineering Design Process

BEST teachers and mentors receive training on how to use the Engineering Design Process (EDP) to help guide the students through the design-and-construction phase of the competition. Use of the EDP not only provides students with a practical means by which they can solve complex design problems and issues, but it also provides them with a real-world tool they can use in virtually any problem-solving situation. Furthermore, students are exposed to what engineering students learn in engineering school and what engineers use in their jobs.

III. Volunteer-Driven Organization

Over 4000 local volunteers participate annually in the program, serving as local hub organizers, event personnel, competition judges, and, most importantly, mentors for participating teams. Organizations typically represented among volunteers include local, county, and state government and departments of education; businesses and industries; civic groups; military branches; professional engineering societies; and academic departments and student clubs at colleges and universities.

Volunteers also serve on BEST's twelve-member board of directors, which is comprised of hub directors, industry representatives, educators, and engineers. BEST has two part-time employees: an executive director and an administrative assistant.

IV. Team Mentors

The most effective aspect of the program is the role that engineers and other technical professionals serve as mentors for the robotics team. While the students on the team make all decisions and perform the actual work of building the robot, the mentors act as guides that shepherd the students through the six weeks process of design and construction. Their role is also vital because they serve as models of what real professionals do in their everyday work. By working side-by-side with an engineer from a local industry, students better learn what engineers do and thus engineering is "demystified."

V. Community-Based Impact

Each BEST hub has a defined district in which it operates. Where there are multiple hubs per state, each hub's district covers several specific counties. By serving schools within a defined district, the hub has a direct impact on schools in local communities. By utilizing local volunteers to help run the competition and mentor local teams, the program also has a direct, positive impact on the communities themselves.

VI. Licensed, Independent Hubs

BEST's Board of Directors licenses use of its program primarily to colleges and universities, although any organization, company, or group of individuals may apply for licensure. Licensees pay $2000 per year to host the competition and use the BEST name and annual game materials.

Each hub is self-sufficient; organizers must raise their own funds and provide the manpower and other resources to run the competition. Potential licensees must submit a written request that includes the names and signatures of core steering team members; defined district of coverage;

proposed budget; list of potential sponsors; fundraising plan; and projected number of teams it plans to host its first year.

The BEST organization has neither a marketing director nor a marketing plan. It prefers to grow by word of mouth in order to manage its growth, ensuring that those groups of individuals that seek to start a hub are committed to sustaining it over many years.

2009 STUDENT DEMOGRAPHICS

Results from the annual Student Demographics survey that is conducted by the hubs through the primary teacher of each BEST school are provided in the table below.

These figures are based on results reported by 712 BEST schools for 12,527 students that participated in the 2009 competition at 35 competition sites in 13 states.

TABLE I
2009 STUDENT DEMOGRAPHICS

Survey Category	Percentage
Gender	
Male	66%
Female	34%
Robotics Team - Male	79%
Robotics Team - Female	21%
BEST Award Team – Male	58%
BEST Award Team - Female	42%
Likely to pursue STEM career (all students)	
Most Likely	58%
Not Likely	42%
Most Likely – Male	72%
Most Likely - Female	28%
Race (optional reporting)	
White	58%
African-American	18%
Hispanic	14%
Asian-American	7%
American Indian	2%
Other	1%
School Participation	
High Schools	56%
Middle Schools	37%
Home Schools	7%

AN INNOVATIVE WORKFORCE DEVELOPMENT ALLIANCE

In a report of the findings of its 2008 STEM Education and National Security Conference, the Heritage Foundation reiterated a common theme among government, industry, and education leaders: if the U.S. is to be globally competitive, it must have an educational environment that attracts students to careers in STEM. Industry needs to be encouraged to get involved in the classroom through innovative partnerships with educators and schools **[1]**.

Industry leaders have long bemoaned that there isn't a more organized and effective effort to attract K-12 students to jobs in engineering- and technology-related fields. Manufacturers in particular need a future workforce that is technologically literate, yet they have limited means to impact education for working directly with the education system **[2]**. The goal of improving students' awareness of engineering and the work of engineers can be of great benefit not only to business and industry, but also to our society, because engineering is central to technology development, and technology influences the well-being of society **[3]**.

BEST creates a dynamic alliance between industry and education to create a "pipeline program" that helps industry develop its future workforce. Such an alliance reaches across corporate, city, and county lines to develop a community based program that reaches schools—and students—in a wide swath across a region of the state. A single BEST hub typically hosts 20-30 schools—over 1000 students—from at least a 50-mile radius of the site.

BEST is less about building robots and more about teaching students how to analyze and solve problems. What BEST students learn is what industry needs in its future workforce and what communities need in its future leaders.

REFERENCES

[1] Heritage Foundation. 2009. Improving U.S. Competitiveness with K-12 STEM Education and Training. Washington, D.C.: The Heritage Foundation.

[2] Stephens, R., and E.V. Scott. 2003. Ensuring Workforce Skills for the Future – The Birth to Work Pipeline. Report prepared for The Boeing Company. Available online at *http://www.cpec.ca.gov/completereports/externaldocuments/birth_to_work_pipelinev50.pdf.*

[3] NAE (National Academy of Engineering) and NRC (National Research Council). 2009. Engineering and K-12 Education: Understanding the Status and Improving the Results. Committee on K-12 Engineering Education. Washington, D.C.: The National Academies Press.

AUTHOR INFORMATION

George Blanks is Executive Director of BEST Robotics, Inc. and Director of K-12 Engineering Outreach in the Samuel Ginn College of Engineering, Auburn University (AL).