First Year Experience as a New BEST Hub

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Abstract – BEST, which stands for Boosting Engineering, Science, and Technology, is a program targeted towards middle and high school students with the intent to stimulate interest and provide hands-on design experience. The six week robot design culminates in a heads-on game competition. While being energized by the excitement and fanfare of live robotic competition, the program also engages students with visual arts and writing skills, offering awards in areas such as technical design notebooks, school table/booth display, creative design, and team spirit. Lipscomb University's young engineering program responded to the opportunity to become the "Music City BEST" hub for Tennessee. With this commitment, made less than six months before game day, we had to learn and execute very quickly.

Keywords: BEST, robot, Lipscomb

THE BEST PROGRAM

BEST (Boosting Engineering, Science and Technology) originated in 1993 in Dallas, TX [1]. The initial goal of BEST was to foster new interest in the applied sciences in middle and high school students by offering them an exciting team based technical design experience. The centerpiece of the program is robot competition, with a new, challenging game each year. However, the program also engages students who traditionally would not be attracted to a robotics competition by offering and even emphasizing written, presentation, and artistic awards as part of the yearly competition [2].

In fact, the most coveted award, named the "BEST Award", is graded on blended criteria, which includes scoring on the project engineering notebook, a school display with interviews, and team spirit, with only a 5 to 10% contribution for actual robot performance. Broad-based student participation is exemplified in that a typical school team might have up to 60 members, with typically only fifteen or so technical "robot engineers".

New Hub Opportunity

The state of Tennessee did not have a BEST hub until Lipscomb University volunteered to become a host. Dr. Ben Hutchinson, Dean of the College of Natural and Applied Sciences at Lipscomb, became involved with the BEST program in his former position at Oklahoma Christian University. In his new position at Lipscomb, Dr. Hutchinson saw the opportunity to advance the BEST program geographically, promote the engineering professional in our community, and enhance the visibility of Lipscomb's young engineering school, the Raymond B. Jones School of Engineering. In the spring of 2006 Dr. Hutchinson committed to organize a new BEST Hub [3] for Tennessee and host the Fall 2006 BEST competition. In support of his decision, the University provided startup funding of $20,000 (to cover multiple years), plus an engineering school supporter donated an additional $5000.

School Recruitment

Beyond the University's commitment to fund and host the event, the next highest priority was to solicit schools to participate. Because our host commitment was made rather late in the spring of 2006, there was limited opportunity

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to solicit participation in the middle and high schools before the school year ended. With this time limitation in mind, Dr. Hutchinson decided to enlist the aid of the state technology education directors in Tennessee and Kentucky to identify and contact prospective sponsoring teachers. While this was effective in contacting those with established links to the technology education infrastructure, it did not yield the broad-based participation we desired. Dr. Hutchinson furthermore made contacts within the Nashville Metro Public School system and local private schools, though he was unable to thoroughly canvas the entire state. In the current school year, with a longer time runway, we are working to more effectively advertise and enroll participants for the Fall 2007 competition.

BEST Mid-Summer Workshop

To continue the recruitment of participant schools and prepare them for many near-term tasks, a BEST workshop [4] was held at Lipscomb in late July 2006. The workshop was valuable to both the new hub personnel and the school sponsors. At the workshop, held only about six weeks prior to Kick-Off Day, ten prospective teacher/sponsors were in attendance. Organizing and leading the presentation and discussions were George Blanks, Director of K12 Outreach Programs, Ginn College of Engineering, Auburn University, and Mary Lou Ewald, Director of Outreach, College of Science and Math, Auburn University, both seasoned board members of BEST Robotics Inc. and executives at the Southeast Regional BEST hub at Auburn University. Just as valuable, Susan Haddock (math teacher at Austin High School in Decatur, AL) and her husband Joey Haddock offered detailed advice from a teacher and a mentor's perspective respectively.

Although the hub leaders had read web site material and watched promotional videos, in retrospect we now recognize that the meeting was both essential and pivotal in enabling us to organize for our BEST event. Up to that point, we had read through a notebook full of game rules, organizational responsibilities, seemingly endless parts lists, and "to-do" lists. The workshop gave us the setting to collectively wrestle with the myriad details at the feet of four people who collectively had twenty-five "BEST" years of experience. For team sponsors, the workshop helped them grasp the many dimensions of their responsibilities and understand the need for school team sub-groups beyond the robot design team, e.g. engineering notebook, school display, cheerleaders, pep band, and so on.

The BEST Approach to Designing a Robot

The following is a key aspect of the BEST robotic experience: While the competition game and rules are rigorously defined and the robot part set is fixed, the actual robot design is essentially unspecified (other than overall size and weight) [2]. Thus, consistent with this "white paper" approach to robot design, the preponderance of allowed parts used to construct the robot is rather generic. Other than the motors and radio control electronics, BEST uses basic parts found in a hardware store or the odds & ends found in a cluttered garage or basement shop. In contrast to contemporary project kits like Lego® robots, which use “prefab’ed” building blocks, the latitude and flexibility offered with the BEST raw materials reminds me of the way many of us years ago built roller skate scooters, tree houses, and wooden jalopies from whatever we could find in the backyard and buy from the corner hardware store.

Part Kits Logistics

My personal involvement with BEST began with the "nuts & bolts" soon after Dr. Hutchinson committed us to serve as the Tennessee BEST hub. Students build their robot using only parts provided by the hub. While sourced from many diverse suppliers, the hundred-plus types of parts are the same for all schools.

More specifically, the parts are grouped into two separate kit categories: "Returnable" and "Consumable" kits. Returnable Kit parts are used in the competing robots but are returned to the hub after the competition is over. Returnable parts are typically the more expensive parts which are not allowed to be modified, and thus are reusable year after year. Examples of returnable parts are the RC radio and servos, DC motors, speed-controllers, batteries, battery charger, and so on.

The Consumable Kit parts contains 80+ part numbers, typically consisting of plywood, plastic, sheet metal, screws, nuts & bolts, PVC pipe and fittings, and other similar materials. While many, if not most of the consumable kit parts go unused in building an individual robot, no attempt is made to collect the unused parts for reuse the next year. (The relative value of a consumable kit of parts is about $150 as compared to about $500 for the returnable kit.)

Dr. Hutchinson secured an agreement from Nissan Motor Corp in Murfreesboro, TN, to supply consumable parts which could be sourced from the company's parts store. While this executive level commitment sounded great, actually getting plant personnel to fulfill this offer was a different matter. After some attempts to make the arrangement work, in the interest of time I proceeded to source the parts from wherever they could be found at the lowest cost.

The BEST volunteers in San Antonio, TX supplied the exact BOM (bill of material) for the parts kits with suggested suppliers. By early July 2006 we had decided to host a maximum of ten teams for our first year, so I set off to buy ten kits worth of parts.

A major subset of the Returnable parts could be source through BEST Robotics Inc., so we ordered ten sets of these parts. In general, parts ordered through BEST Inc. were shipped directly from the supplier or manufacturer to Lipscomb and were received in a reasonable time. However, the critical DC motor speed controllers were on back order for several months, and teams had to begin their robot build limited to only one controller each. Beyond parts from BEST "central", the remaining parts needed to complete the returnable kits, such as extra servo parts, robot wiring harnesses, and switches, were typically sourced at online hobby stores.

For the much larger Consumable kit parts list, much time was spent checking between suppliers such as Lowe's, Home Depot, McMaster-Carr, and my local ACE hardware store. While a moderate number of parts were either single-sourced or hard to find, most parts could be found in varying quantities from a number of stores. No single supplier consistently had the lowest prices. After spending a few of my summertime days trying to optimize the purchasing source & lot size for each part, I gave up and began negotiating with a friend who was part owner of the neighborhood ACE Hardware store. The basic approach was to find the most cost effective lot quantity available through the ACE supply chain and then negotiate for a reasonable discount off the normal retail price. While not totally cost optimized, using a single supplier for the bulk of the parts offloaded me from having to personally find the best piece price for each part and split the order among several suppliers. This approach served us well when buying thousands of hardware piece parts with an aggregate cost of only about $1500.

Once all the parts arrived (after some six weeks of work), the final job was to build the two kits for each team. For small loose parts, zip lock sandwich bags were used with printed labels detailing the exact contents; eleven loose parts bags in total. Parts such as a box of 100 wood screws were left in their original container. A special size cardboard box was found locally that would handle the odd-sized items, such as the 3 ft threaded rod, as well as the collection of miscellaneous parts. An "assembly line" was set up to fill the cardboard box with consumable parts and a clear plastic tote for the parts to be later returned.

Game Field

As a result of my preoccupation with the myriad parts to be acquired, I initially overlooked an even larger job: Building the 2006 game specific playing field.

The 2006 robot game was titled "Laundry Quandry" [5]. The basic challenge of the game was to see how many "wet" and "dry" laundry pieces (colored bandanas) each team could hang up or take down within a 3 minute time period.

The game field had four quadrants, each with a "back porch" and clothes lines, to accommodate four simultaneous contestants. A gazebo in the center of the game field presented higher clothes lines with the opportunity to score more points.

We had the good fortune of having two college students offer to build the playing field being paid as student workers. Under my direction, we got off to a very naive and unsteady start. Using the game field description in the game rules document, we bought the basic materials and started construction, only to find that we were missing some key details. These key details were available, to my chagrin, in a confidential website document that I did not know even existed at the time. To my amazement, this detailed construction document was a full seventy-four pages thick! At this point I realized that the BEST program was truly a professionally organized and executed project, sophisticated well beyond my initial expectations.

Kick-Off Day

Kick-Off Day [2] is the official start of the six week robot building phase leading to the hub level game day. On that day the air was energized as the secret game field was unveiled, allowing students and mentors to begin musing how they might beat the game. Also the parts kits were distributed, special technical instructions and suggestions were given, and the students were indoctrinated with praise of the scientific and engineering professions.

By Kick-Off Day we had an expectation of a full quota of ten teams. Approximately six had made a full commitment, two had made a statement of intent, and the last two had expressed an interest only one week prior to kick-off day. To our disappointment, two of the out-of-town teams did not attend, leaving us with eight teams.

One could tell from this day whom the likely future winners would be; it was evident in the leadership and organization of the teacher sponsors and their accompanying mentors.

Game Day Staffing

Once Kick-Off Day was behind us, the task at hand was to prepare for Game Day [2] in six weeks. While I personally had overseen the building of the game field and the assembly of the robot parts kits, I realized that I could not directly manage all the diverse roles required to execute game day successfully. At that point I insisted that others be engaged to carry some of the load. To that end, Dr. Fred Gilliam, our Associate Dean of the Raymond B. Jones School of Engineering at Lipscomb, volunteered to take the lead role in staffing game day personnel. Equally important, one of our adjunct teachers (Mr. Michael Colletti) volunteered to oversee the event facility coordination.

Although Allen Arena, Lipscomb's modern sports facility, had been reserved months ahead, we had not done any work regarding game floor layout, audio-visual equipment, power distribution, and so on. Mr. Colletti had previous experience organizing other competitive events, notably a FIRST robotic competition. He personally interfaced with the arena event staff and handled the planning detail, most of us had never even considered. One of his most valuable ideas was to set up a small machine shop at the end of the arena floor, complete with a drill press, a jigsaw, and other miscellaneous tools, to repair or make modifications during the competition (the shop was wisely staffed with a recent mechanical engineering graduate and his craftsman father).

With Dr. Gilliam staffing and training the group of judges and game assistants, and Mr. Colletti choreographing the sequence of events, we were able to face game day morning with confidence.

Last Week Technical Worries

With two weeks to go, I thought the technical matters were in pretty good shape. Two teams burned up speed controllers, but fortunately we had spare parts from the two teams that did not attend kick-off day. All I thought remained was to prepare the scoring methodology for the actual robot competition.

With only eight teams playing a game in which it was difficult to score points, manual tracking and score keeping seemed like the most efficient option. I had read briefly about an automated electronic scoring system, but had relegated its use to the larger hubs and regional competition. We had decided to implement the electronic tiebreaking hardware, but determined that, at least for our first year, general scoring could be inputted manually into an Excel spreadsheet.

Upon inquiring about the supplied scoring spreadsheet, regional BEST personnel encouraged me to use the full electronic scoring system. Their rationale was that this scoring system was thoroughly integrated, from randomly scheduling the teams in each heat to multi-display projection of the running team scores. It would also be the scoring system used at the final competition, the BEST regional.

Not knowing what I was getting into, I decided to dive in and get the full system working. A LabView ® VI was used on the game floor computers to score team points each round, with the tie breaker sensing hardware serially ported into one of the game-floor PC's. The LabView routines were interrogated via a central PC web browser and fed into the main scoring Excel spreadsheet. The current score data was then fed to several remote displays, including the main arena projection system, which required the use of Apache and PHP software.

Although the scoring software was downloadable from the BEST website and was well-documented, I underestimated how long it would take to get it fully operational and become able to efficiently use it. With classes to teach (two new engineering classes this semester) and less than a week before game day, I was starting to panic, and already had thoughts of falling back to a manual scoring system. Once again I was rescued, this time by Prof. David Fann and sophomore student Jonathon Williams, both network proficient computer engineers. Our computer center personnel had no experience with the Apache or PHP software employed for the remote scoring display, but Jonathan had used it previously on his home computer system. Between these two fine gentlemen a computer network of some six PC's and three displays was fully operational by the afternoon just before Game Day. Of course, much credit goes to the BEST volunteer personnel who originally developed and refined the integrated scoring system (though there was a major software patch the week before game day).

Time to Play!

The Saturday before the competition day we held Mall Day [2] at Cool Springs Mall, just south of Nashville. This was an opportunity for the teams to practice on the real game field and evaluate their robot design. A benefit to us as the BEST hub was the publicity received from the crowd that gathered to watch the robots in action. Four local teams were able to participate, though only three had "scoring" capable robots. The more distant teams were at a disadvantage because they were not able to easily attend.

As we made final preparations to set up the arena for Game Day, we realized that we had overlooked the arena being reserved for another event until 6pm of the evening before the game. This oversight cost us some needed sleep. By the time the overlapping event ended and the arena floor was cleaned up it was well past 7pm. We did not finish setting up the playing field and team "pit" areas until after 11pm. Nevertheless, we completed the job and were back by 8am the following day.

In general, the teams arrived promptly and were well-organized in setting up their school displays and giving their robots a final tune-up. However, one local school arrived with their robot still in pieces and an out-of-town team arrived over an hour late. With some disappointment, we started the robot inspection and the first few heats with only six of the eight teams participating. The one local school was never able to get its robot operational and the remote team was able to compete only in the final few rounds.

With four teams competing simultaneously and only six competing robots, the teams cycled through the rounds very quickly (each heat was only three minutes). We conducted twelve preliminary rounds of four competing teams, with three final rounds of the top three seeds coming out of the preliminary rounds. Due to robot breakdowns, there were many rounds with fewer than four teams competing.

As expected, relatively few points were scored. However, the individual team strategies were interesting. For example, one team (which finished in second place) designed its robot to simultaneously hang multiple pieces of laundry on the high lines in the gazebo, but was unable to retrieve laundry (extra points were given for being able to both hang up and retrieve laundry). Another team took a more balanced approach, designing its robot able to hang up one or two pieces and to then quickly retrieve laundry from the lower lines. These two teams battled it out in the final round, with the more balanced attack prevailing.

As the game progressed, only three legitimate competitors emerged. It was impressive that the two middle schools competing came in second and third places. One of the middle schools had difficulty scoring until its robot's grasping hand was modified during lunch. In the final rounds after lunch this team got on track and finished in second place for the robot competition.

It was very satisfying how competing team members offered help in fixing a broken robot or loaned a tool or spare part. In many regards the students were mostly competing with themselves in using new found skills to overcome the challenges of a difficult game. Students really got into distributing and collecting memorabilia such as buttons or logo postcards. At established hubs with yearly returning teams, I understand that this has become a sport in and of itself.

Based upon the number of teams (eight) competing in our Music City BEST, the top two teams advanced to the regional competition at Auburn University, specifically the BEST Award winner and the top scoring team in the robot competition. In the end, the top robotic team, Lipscomb High School, and the BEST Award winner (and third place robotic team), McFadden Middle School of Murfreesboro, TN, were chosen to advance to the regional competition. The second place robotic team, West End Middle School of Nashville, did not advance.

Reflections and Feedback

My Reflections On What We Learned as a New Hub

- The BEST program is a relatively low cost endeavor to stimulate and excite the technical creativity of middle and high school students.
- While staffed entirely by volunteers, the BEST program is professionally organized, planned, and executed.
- It is wise to start a new hub initiative a full year in advance to fully engage prospective schools and organize the hub infrastructure.
- Focus on the learning that is happening, not the points scored and winning the competition.
- Emphasize how non-technically oriented students can participate and enrich the event
- Involve the talents of college students.

My Impressions of What the Students Learned

- Something useful and productive can be designed and built using basic raw materials
- Engineering is a process which utilizes graphic and writing skills
- Education-oriented competition can be just as fun and fulfilling as athletics

Feedback from Sponsors/Mentors On Student Skills

- Before the robot design project, a moderate percentage of the students had used basic hand tools, such as a hammer, drill, or screwdriver.
- Few had familiarity with or had used common power tools (e.g. drill press, soldering iron, jigsaw)
- Essentially none had used measurement instruments, such as a voltmeter.
- During the BEST experience, approximately 80% of the robot design team learned to use the basic hand and power tools (supervised, of course) and perform basic assembly operations, such as gluing wood and soldering wires.

Conclusion

Starting the Music City BEST hub was a challenging experience, particularly given the short time runway we had to plan and execute. The learning curve was steep, even with constant help from regional experts, and technical staffing from the Lipscomb engineering school was very lean during the early months.

While we were disappointed with the final number of competent teams, Game Day was fun and the event executed smoothly. The two teams advancing to the regional competition (one week from the time of this writing) will be competitive and will well represent our hub.

We have endured the first year startup pains. Two months have passed since Game Day and we have forgotten how tired we were. One teacher's quote sums up why so many work so hard to have an event like BEST: "The kids really enjoyed the experience. It has been a long journey from day one, but I can see progress in their thinking, their ideas, and their desire to try those new ideas in an applied manner". So that is why, early in the year 2007, it will be time for all of us to get started again.

References

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