BEST/STEPS: Hands-On Education and Recruitment of Underrepresented Groups

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By the time students enter college, lack of rigorous high school coursework can eliminate engineering as a potential career path[1]. Bradley University has developed new summer camp program designed to attract students to engineering and to interest students in taking high school courses needed to pursue engineering. The campers were members of underrepresented groups selected with the input of representatives from local public schools and industry. The purpose of the camp, sponsored by the Society of Manufacturing Engineers Education Foundation, was to introduce the campers to fundamental scientific and engineering principles, to basic manufacturing processes, and to the application of these principles through engineering analysis to predict the behavior of a physical system. The central theme for the camp was building a model rocket from manufactured components to "shoot a field goal" as the final activity. Campers engaged in the manufacture of the components and the study of basic principles (Newton's Laws of Motion, aerodynamic drag, thrust, weight, etc.) necessary for prediction of the flight path of the rocket. In preparing for the launch, each camper built and ground-tested a rocket. The campers used a Bradley University developed, PC based, rocket trajectory prediction program to determine the rocket launch location (distance from the goal) and the launch elevation angle prior to their launch. The predictions were based on measured values of rocket mass, engine thrust force, and rocket drag force. The camp staff included high school teachers, volunteer engineers from local industry, and engineering faculty. The pedagogical challenge in the design of the camp program was to develop an appreciation for engineering analysis and modeling in an audience that lacks the necessary mathematical sophistication. This paper reports on the development of the camp curriculum, recruitment techniques for underrepresented campers, interaction between high school instructors, professors and volunteer professionals, the manufacturing activities, the testing activities, the prediction software and the program successes.

Introduction

Engineering summer camps are gaining in popularity across the nation as a means to get younger students interested in pursuing engineering careers [see, for example, 2-7]. The Society of Manufacturing Engineers Education Foundation sponsored Bradley's adaptation of *STEPS for Girls* (Summer Technology and Engineering Preview at Stout for Girls), a University of Wisconsin – Stout camp [7]. Bradley's adaptation, *BEST/STEPS* (Building Engineering Students for Tomorrow/STEPS), changed the intended audience (previously 6th and 7th grade girls) and the curriculum (previously R/C airplanes) from the Stout camp. This paper reports on the BEST/STEPS camp's curriculum, audience, personnel, and successes.

The Bradley University College of Engineering and Technology hosted a week long camp for 35 ninth and tenth grade high school students to introduce them to engineering. The campers were from the city of Peoria and the large majority from groups that are underrepresented in engineering. Since the high school course choices made by these students, even with the help of counselors, can effectively eliminate engineering as a potential career path, the activities of the camp were designed to provide an opportunity for the campers to participate in engineering activities and identify the importance of understanding math and science to engineers [1]. They were also intended to introduce engineering principles, basic manufacturing

processes, and elementary techniques of engineering analysis. The camp was intended to expose these campers to the discipline of engineering at a time early enough in their academic career so as to influence their choices of math and science courses in middle school and high school.

The students for the camp were solicited from a group of students previously identified as showing promise in math and science abilities by their junior high school teachers. The group included 25 young women and 15 young men; all except one from populations underrepresented in engineering. The campers were divided into four groups by gender and with the guidance of knowledgeable middle school teachers. These teachers also participated as counselors for the camp.

The central theme chosen for the camp focused on the physics of flight and rocket flight in particular. The theme served to unify the content and activities of the camp. This theme was chosen based on the background of the staff, the facilities available on campus, and the ability of the subject to interest the campers. Manufacturing processes were introduced for fabricating parts of the rockets. Theory was introduced that was used to model the trajectory of the rocket's flight. Experimentation procedures were introduced that tested the performance characteristics of the rockets. Each camper was provided an Estes Alpha III rocket that was radically customized by the campers during the build process. Each camper chose one of size nose cone designs, one of four fin design, determined the locations of the fins, and finally decorated their rockets.

The camp spanned five days and contained four parallel but asynchronous curriculums, one for each group. The first day focused on manufacturing processes. The second day focused on theory and rocket building. Testing the rockets and flying paper airplanes was spread over the third day. The computer predictions, rocket decorating, and stability testing were performed during the fourth day. The last day was reserved for the launch and closing ceremonies.

The goal for the week was for each camper to build a custom rocket, study the characteristics of the rocket system with ground tests, use the experimental data and scientific principles to predict the trajectory of the rocket, and finally launch the rocket to validate the predictions. The mission objective for the rocket flight was to launch from somewhere on a

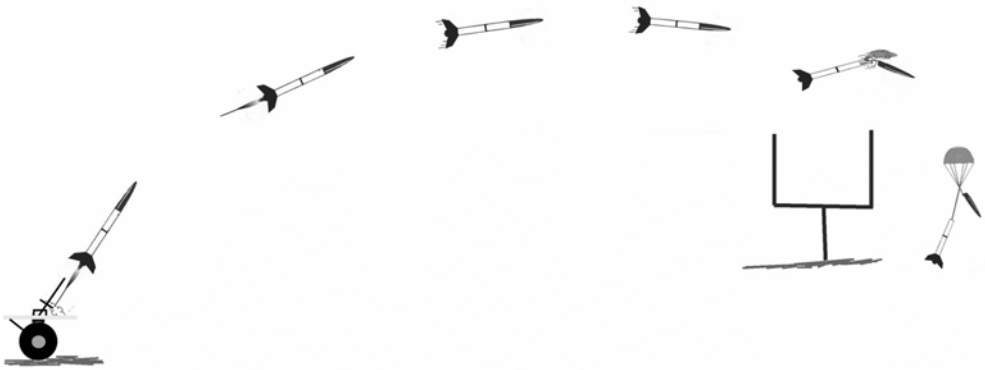


Figure 1: Rocket flight mission objective

football field, pass through the goal posts, and land in a square target region behind the goal posts. The campers were required to enter the experimental data for their rocket into a prepared spreadsheet to determine the yard marker for the launch and the launch angle. (See Figure 1.) On launch day, the campers launched their rockets for the first time and in accordance with their predictions. A referee on the end line signaled a successful flight.

The manufacturing processes that the campers experienced during the week also contributed to the central theme of rockets. The campers cast an aluminum base for the rockets in the campus foundry. Each camper used a metal lathe to shape, then drill, and tap the base to support the rocket. A nose cone for the rocket was designed and visualized using CAD software. The nose cone was cast using polyether foam with a mold produced on a rapid prototype machine. Fins for the rocket were produced using an injection molding press or cut from balsa wood sheets. The campers also programmed and operated a robotic arm as part of these activities. All of these activities required a hands-on, interactive participation of each camper.

An important part of the camp activities throughout the week was exposing the campers to practicing engineers. Volunteers from Caterpillar, Inc. served as mentors for the camper groups as they moved through the week's activities. These volunteers were predominantly from groups underrepresented in engineering. Because of the relatively small group sizes, the campers also developed a good rapport with the participating faculty and staff.

Curriculum

The camp curriculum was intended to introduce the campers to basic manufacturing processes, to fundamental scientific and engineering principles, and to the application of these principles through engineering analysis to predict the behavior of a physical system. The pedagogical challenge of the curriculum development was to create a course set that would interest 9th and 10th graders, expose them to manufacturing and engineering and motivate them to continue to study math and science. The importance of four years of high school math and four years of high school science was emphasized. The camp curriculum centered on the goal of building a model rocket from manufactured components to "shoot a field goal" as the final activity. This section explains the major features of the curriculum: manufacturing processes, math and physics theory, rocket engineering, software, and launch day.

Manufacturing Processes

The first section of the curriculum was designed to expose the campers to a variety of common manufacturing processes. In each session the campers learned about typical uses of the manufacturing process and then participated in a hands-on activity involving that process. The processes that were covered included rapid prototyping, CNC machining, injection molding, casting, machining, and robotics.

Rapid Prototyping

In the rapid prototyping session the campers learned about the computer modeling and machining of prototypes. For the hands-on component the campers were introduced to Solid Works, a 3-D graphical modeling program. Each camper designed his or her own nose cone for the rocket. Due to logistical concerns these nose cones were not manufactured. However, the demonstration continued with showing the campers a rapid prototyping machine. A laminated object manufacturing (LOM) machine makes models out of cut layers of paper and glue. The

LOM machine was used to create molds for 8 varieties of nose cones that the campers could use. Each camper selected a nose cone style. Then, the campers participated in molding their own nose cones. The nose cones were created by spraying the LOM mold with a release agent and then filling them with a two part, rigid, polyether, foam solution. In less than 3 minutes, the campers each had a nose cone that they would be using for the rocket launch.

Injection Molding

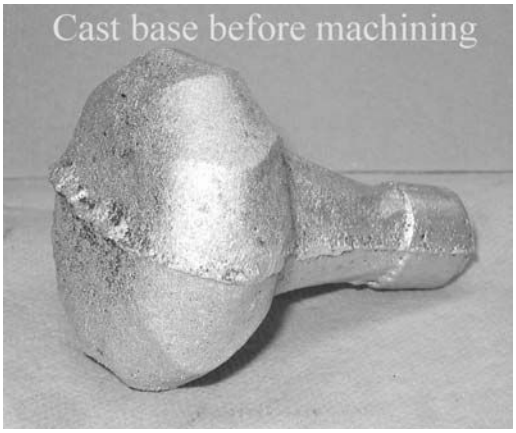
The campers explored CNC machining and injection modeling in a single session. In the CNC machining component, the campers learned basic commands used to program a cutting tool. The campers then each attempted to write a program to engrave BU on a key chain. This component exposed campers to the concept of programming a machine to make a metal mold. The next step was to take the mold to an injection molding machine. In the second hands-on component of this session, the campers each pushed the buttons on the injection molding machine and then popped out a key chain fob to take home. This session related to the rocket theme, since this same process was how the rocket fins were made.

Casting

In Bradley's Foundry the campers explored metal casting. The campers learned how a Solid Works model was turned into a metal base to hold their rockets. The campers were shown how the model from the LOM machine became the pattern for the casting. The campers were introduced to different casting components: patterns, drags, copes, molding boards, sprues, runners, gates, and risers. The campers then followed a procedure for preparing the mold. The campers made a green sand mold of both sides (the molding board and the cope) of the pattern using hand rams and a leveling bar. This session culminated in the furnace room with the pouring (by a faculty member and shop technician) of molten aluminum (1350° F) from a crucible into the campers mold. After ten minutes cooling time, the campers were given their rocket bases (Figure 2).

Machining

In the next session the campers took their rocket bases to the machine shop. The campers were taught the basics of turning on a metal lathe. Under close adult supervision, each camper



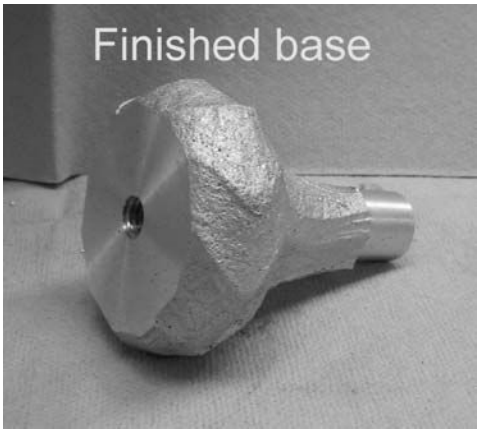


Figure 2: Cast and Machined Rocket Base

took their raw rocket base casting and performed five machining operations. The campers first faced the bottom of the base to make it flat. Next, they drilled and tapped a hole in the bottom – this would be used later to attach the base to a trophy. The campers then turned off the lathe and repositioned the base in the opposite direction. Next, the campers again faced the end (mostly for aesthetics). Finally, the campers turned the base to get the end small enough to fit into the rocket tube. Once the rocket bases were machined, the campers could further embellish them by burnishing, polishing, painting or any combination thereof. The result of this session was that each camper had made by his- or herself an aluminum base to hold their rockets (Figure 2).

Math and Physics Theory

In preparation for modeling the performance of the rocket system and prediction of the trajectory, classroom instruction was provided that described the fundamentals of flight and rocketry. Though the campers were had experience with the geometry and physics of trajectories as taught at the grade school and high school freshmen levels, the camp emphasized these topics in relation to the principles governing stable rocket flight. The theory was covered along with hands-on experiences. The following sections describe the camp's use of robotics for geometry and spatial coordinate systems, elevators for Newton's Laws, and paper airplanes for center of gravity/center of pressure stability discussions.

Robotics

The robotics session exposed campers to robotic applications ranging from manufacturing robots to space robots to nanorobots. Following this discussion the campers were introduced to the robots in Bradley's Robotic Laboratory using a six-axis industrial robot, a four-axis industrial robot and various small robot kits. The campers were taught the concepts of robot control with both programs and teach-pendent movements. In the hands-on component, the campers made the robots pick up and stack a set of blocks. The campers gained an appreciation of geometry and spatial coordinate systems from the robotics session.

Newton's Laws of Motion

Newton's Laws of motion were discussed in a classroom setting. This discussion included their application to the flight of a rocket. Newton's second law was described as the basis for calculating the trajectory of the rocket by relating forces acting on the rocket to the mass and acceleration of the rocket. The forces considered in the model were thrust, weight, and drag. The campers were shown how to calculate velocity using the acceleration and then calculate displacement using the velocity.

The analytical model was based on Newton's Second Law of Motion:

$$\Sigma \mathbf{F} = (1/g_c)(m * \mathbf{a}). \qquad (1)$$

The mass was described as the instantaneous mass of the rocket. The forces were described as the thrust of the rocket motor, **T**, the weight of the rocket, **W**, and the aerodynamic drag, **D** (0). The instantaneous acceleration, **a**, of the rocket is described as function of forces acting on the rocket, the mass of the rocket, at time, t.

$$\Sigma \mathbf{F} = m*\mathbf{a} = \mathbf{T} - \mathbf{W} - \mathbf{D} \qquad (2)$$

So the acceleration of the rocket could be determined as a function of time.

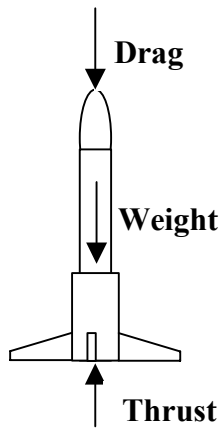


Figure 3: Forces acting on the rocket

$$\mathbf{a}(x,y,t) = \frac{\mathbf{T}(x,y,t) - \mathbf{W}(t) - \mathbf{D}(x,y,t)}{m(t)} \quad (3)$$

The acceleration was described as the rate of change of the velocity.

$$\mathbf{a}(t) = d\mathbf{V}(\mathbf{x},\mathbf{y})/dt \quad (4)$$

or

$$\frac{\Delta \mathbf{V}(t)}{\Delta t} = \frac{\mathbf{T}_y(t) - \mathbf{W}_y(t) - \mathbf{D}_y(t)}{m(t)} \quad (5)$$

or

$$\Delta \mathbf{V}(t) = (\mathbf{T}_y(t) - \mathbf{W}_y(t) - \mathbf{D}_y(t))*(\Delta t/\, m(t)) \quad (6)$$

The velocity was then described as the rate of change of the position. The velocity was related to the instantaneous displacement of the rocket, x & y,

$$\frac{\Delta \mathbf{S}(t)}{\Delta t} = \mathbf{V}(t) \quad (7)$$

or

$$\Delta \mathbf{S}(t) = \mathbf{V}(t) \bullet \Delta t \quad (8)$$

The campers were not required to derive these equations of motion, but they were shown how these equations were used to calculate the trajectory of the rocket. They were exposed to the concepts of forces, vectors, acceleration, velocity, and displacement. Emphasis was placed on the idea that the reliability of the analytical model directly related to a good understanding of the forces; thrust, drag, and weight as they changed through time starting at the instant of launch. The campers were told they would be conducting ground-based component testing to measuring the thrust and drag forces and the mass of the rocket.

In a separate classroom session the campers were also exposed to consequences of Newton's laws through experiments. The campers were shown how Newton's law related weight to mass. They were also shown how an elevator would accelerate either up or down when operated. With this understanding, they were shown how changes in acceleration caused by the motion of an elevator would influence their weight when measured using a scale. The campers performed experiments in several elevators on campus measuring their apparent weight when the elevator accelerated up and down. The experiment and classroom session gave the campers an appreciation of how Newton's laws affect rocket flight.

Flight Stability

A short lecture described the concepts of stability, the center of gravity, and the center of pressure. Paper airplanes were used to provide hands-on experience with these concepts. Demonstrations showed how changing the center of gravity on a given plane (using paper clip weights) would improve or worsen the plane flight. The campers were given time to experiment and to create paper airplanes for an afternoon competition. The campers gained an appreciation of flight stability.

Rocket Engineering

Together the rocket design and testing are 'rocket engineering'. During the discussions about the theory of rocket fight, the campers were told they would be performing experiments to measure the aerodynamic drag and weight for their custom rocket in addition to the thrust that would be provided by the rocket motor. They were informed that they would insert the data they recorded from the experiments with their rocket into the program to calculate the rocket trajectory. Under the supervision of the faculty, the campers built their rockets, conducted the experiments, and recorded the data.

Rocket Assembly

Each camper was given an Alpha III rocket kit as a basis for assembling his or her custom rocket. The campers customized the rockets by choosing one of six different nose cone shapes and one of four different fin designs. The shape of the nose cones was changed from the Alpha III shape to increase the frontal projected area and, as a result, drag. All six nose cone choices had the same frontal area, but each design had a unique profile with different drag characteristics and weights. The new fin designs increased the fin area and changed the shape from that of the original Alpha III rocket. The choices for the fins did not have the same fin area or similar weights. These choices affected the performance of the rockets by changing the drag coefficients, changing the mass, changing the locations of the center of gravity and the center of pressure. This high level of customization motivated the testing and affected the launch locations; see description in the section "Launch Day." Each camper was also allowed the freedom to decorate the rocket to his or her personal taste. At the launch, none of the rockets were the same. Even rockets that used similar parts had different weights so each camper was required to make a unique prediction for the trajectory of the rockets.

The groups of campers were divided into teams of two for rocket assembly. Each camper was given a set of instructions that gave step-by-step procedures. While each camper was required to build a custom rocket, each camper team was required to share tools and help each other. During the assembly process, each camper chose a nosecone shape and color, chose a fin type, and decided the number of fins to be mounted on the rocket (from 3-5). Many campers

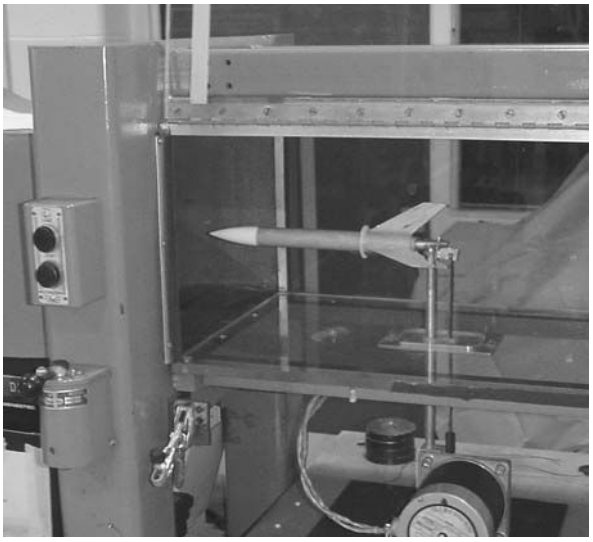


Figure 4: Model rocket mounted in the subsonic wind tunnel

were already incorporating some of the lesson that they learned in the theory sections while they were building their rockets by intentionally choosing lightweight components, fins with large profile areas, and aerodynamic nose cones so they could achieve long flights. Many of the components were fastened using hot-melt glue so that the rocket assembly was essentially complete after one extended session. The teams were guided through the assembly process by the faculty and the volunteers.

The day following the assembly, each camper decorated his or her rocket. A session was held at a local craft store where the campers painted, glittered and applied stickers to their rockets. After this session, each rocket was unique.

Wind Tunnel Testing

The aerodynamic drag forces on the rocket were measured using a subsonic wind tunnel. Each of the rockets was mounted on a wind tunnel sting instrumented for lift and drag measurements. Figure 4 shows a rocket model mounted in the subsonic wind tunnel. The maximum velocity of the wind tunnel was about 120 mph, higher than the expected peak velocities for the rockets. The campers were required to use their data in terms of the dimensionless parameters: Reynolds' Number, Re, and drag coefficient, C_d. The campers worked in teams of three; one camper operating the wind tunnel, the owner of the rocket recording the drag data, and a third as an observer. Each camper measured the drag force on his or her custom rocket at three different velocities. The remainder of the group calculated the drag coefficients using the recorded data.

Rocket Motor Thrust Testing

Each group measured thrust forces generated by the rocket motors were measured using a thrust stand shown in Figure 5. The rocket motor was mounted inverted on top of a load cell. The output of the load cell was measured using a computer controlled analog-to-digital (A/D) converter. The sampling rate of the A/D was 1,000 samples per second. The campers mounted the rocket motor, initiated the ignition, and captured the raw data. The campers applied a calibration function to the raw data to convert the measured voltage to a force measurement. The

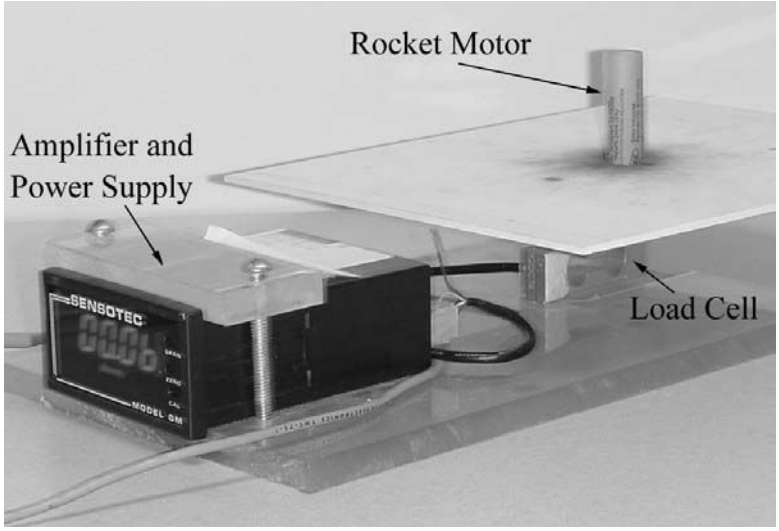


Figure 5: Rocket motor thrust stand

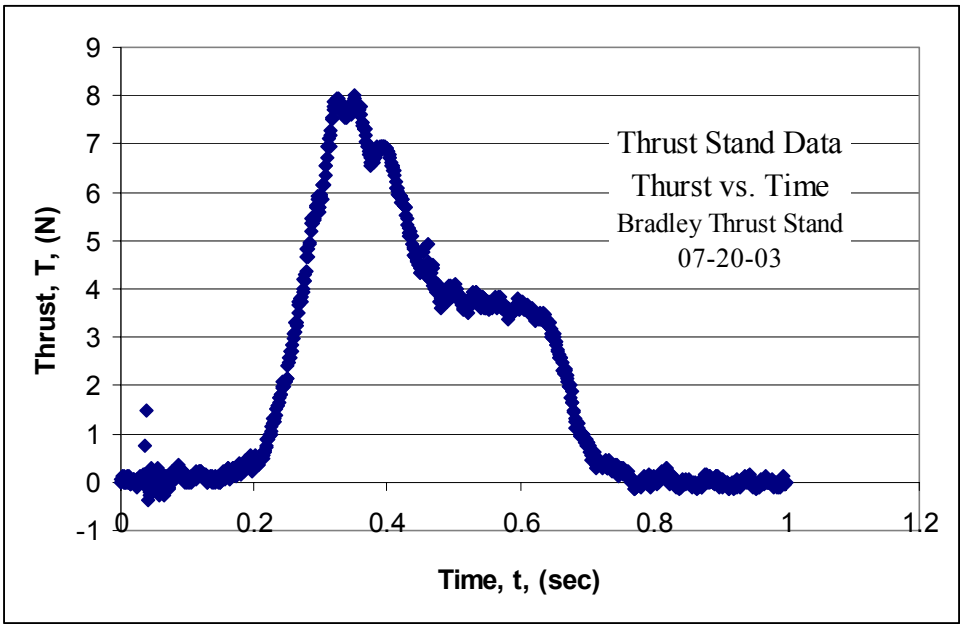


Figure 6: Typical measured rocket motor thrust

campers also recorded the time between ignition and the detonation of the ejection charge. This time was used to indicate the end of the flight because the parachute would be deployed. An example of the rocket motor thrust data is shown in Figure 6. The campers were informed that they should expect some variability in the thrust output of these rocket motors and this variability could affect the agreement between their predictions and the actual rocket performance.

As part of the thrust measurements, the campers measured the weight of the rocket motor before and after firing. This data was included in the model predicting the trajectory of flight. The weight of the rocket body was recorded after the rocket assembly and stability testing.

Stability Testing

The last experimentation activity for the campers involved trimming the rockets for stable flight. Stability of the rockets is achieved when the center of gravity of the rocket is closer to the nose than the center of pressure. Each camper was required to find the center of gravity for his or her custom rocket by balancing it on a knife-edge. They attached a string to the rocket at the center of gravity and the rocket was swung in a large circle using the string. If the rocket flew nose forward, the rocket was judged stable. If not, mass was added to the nose of the rocket to move the center of gravity forward. Because the stability testing was the last step in building the rocket prior to launch, moving the center of pressure rearward by changing the shape of the rocket was not feasible. After the stability test, the weight of the rocket was measured again. The campers recorded this final weight for use in the trajectory prediction.

Software

The culmination of the rocket engineering section of the camp was to determine the angle and distance that the camper would use to attempt to shoot a rocket-field-goal. For this engineering analysis, the campers used a Bradley University developed, PC based, rocket trajectory prediction program. The campers had to enter the results from their rocket testing experiments: a table of wind tunnel speed and drag force from the wind tunnel experiments, a file of force measurements from the thrust stand experiments, rocket and motor mass measurements and area measurements of their nose cones (Figure 7). The software used all of that information and Newton's law to predict the trajectory of the rocket.

Though the campers did not manually perform the calculations, the calculation methods stemmed from their theory sessions. The basic equation is Newton's 2nd law, the sum of the forces equals mass times acceleration. The acceleration is then integrated to find the velocity and integrated again to find the position. As a trajectory problem, this analysis is in two dimensions. The forces in the vertical direction are weight and the vertical components of the drag and thrust. In the horizontal direction the forces are the horizontal components of the drag and thrust.

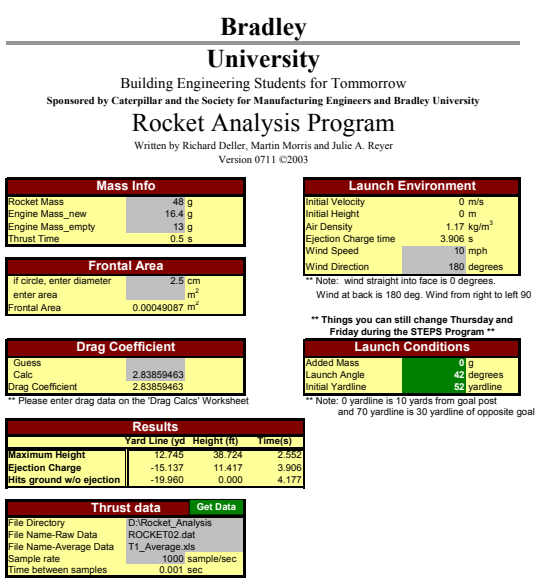


Figure 7: Sample Input Screen from Software

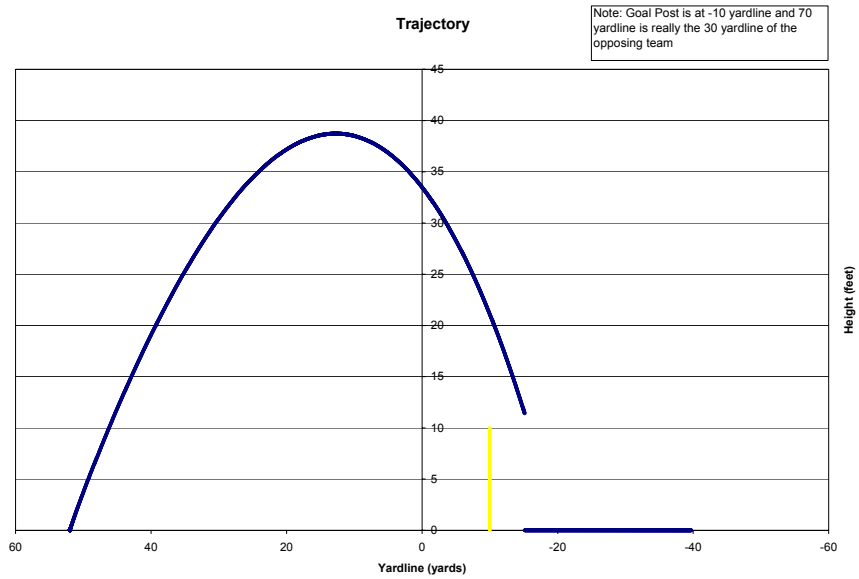


Figure 8: Sample Trajectory Screen from Software

Once the campers had entered all of their experimental data, an initial predicted trajectory was calculated. The results, displayed both numerically and graphically (Figures 7 and 8), indicated to the camper whether his or her rocket would make a field goal if shot from the default position of the 50 yard line of a football field at an angle of 89 degrees. Because this was essentially shooting the rocket straight up, none of them started with a good launch condition. At this point the campers had to examine – mostly through trial and error – the effects of the remaining variables. The campers were allowed to (1) add more weight to their rocket, (2) change the launch angle, and (3) change the yard line from which to launch the rocket. At the end of the day, each camper had decided the launch angle and position.

Launch Day

The final day of camp was Launch Day. The event, held at a local football stadium, brought together the campers, their parents, the mentors, the counselors and the faculty. Using specially designed carts as mobile launch platforms, each camper setup their rocket on the computed yard line with the computed launch angle and then attempted to shoot a field goal. Of the 35 campers, 20 actually made field goals. The rest were generally wide of the mark. Only 2 rockets ended short of the goal line. The event showcased the different rockets – no two looked anything alike and the distance that they were fired ranged from 90 yards to 30 yards. The event also demonstrated the interest and diversity of the campers – many were nervous and some wanted to change their launch position, though the faculty encouraged them to trust the calculations. The faculty will not soon forget the intensity of the campers' determination and their excitement and joy as they skipped/flew down the field to retrieve their rockets. Each camper received their rocket and rocket base mounted on a trophy, a certificate of participation and stickers designating their competition successes (4 varieties from the paper airplane competition and 4 varieties from the rocket competition).

Personnel

The BEST/STEPS camp brought together campers, counselors, engineering professionals and engineering faculty. The mix was a major factor in the success of the camp. The campers were divided into four groups, two male groups and two female groups. Each group had a same-gendered counselor and a volunteer engineer. The groups rotated through the activities in the curriculum. Faculty members conducted between one and four activities each. The following sections discuss the makeup of each group.

Campers

Identifying interested, underrepresented high school campers was an important challenge for the camp. The target campers are generally from lower income families and are members of gender and racial groups that do not tend to pursue engineer as a career. For this first year of the BEST/STEPS program, the graduates of Destination Technology^{SM}, a Caterpillar, Inc., sponsored math and science program for underrepresented 6th though 8th grade campers, provided an initial target group. The skill level of the camp was set based upon these campers abilities developed from their two or three years of participation with that program. Future camps will not have the luxury to completely rely on the Destination Technology^{SM} to identify campers.

Camp Counselors

In order for the campers to learn the lessons from the faculty, the campers could not be distracted by unruliness, gang wear and talk, or social distractions. The task of the camp counselors was to eliminate these detractions and maintain the learning environment. The choice for counselors was therefore critical to everyone's enjoyment of the camp. The counselors were all public school teachers who had previously worked with the Destination Technology^{SM} program. The counselors knew the campers and were able to separate campers with potential conflicts. Furthermore, the counselors could contact the parents of any difficult camper or in extreme cases expel the camper from the camp. Each counselor supervised ten or fewer campers and there were no serious problems.

Professional Engineers

Volunteer engineers from local industry, specifically Caterpillar, Inc., served as mentors for the camper groups as they moved through the week's activities. These mentors were predominantly young professionals from groups underrepresented in engineering: women and African-Americans. The mentors provided additional supervision to certain camp activities, such as machining, and also participated with the campers in the activities – 5 mentors even built and decorated their own rockets. Though their impact cannot be easily measured, the mentors were an important factor in the success of the camp.

The recruitment of professional engineers was greatly influenced by the participation of their employers. Caterpillar, Inc., provided release time to ten engineers to participate in the camp. Mentors could participate for an afternoon, a day, or multiple days. The mentors that were able to participate for the entire week developed stronger relationships with the campers. In several of the campers' surveys, the campers highlighted the importance of the participation of the mentors in non-academic activities. Sited favorites include the canoe splash-fight with the mentors and counselors and beating the mentors and faculty at bowling.

Faculty

Bradley University's College of Engineering and Technology provided the faculty (as well as the facilities) for the BEST/STEPS camp. The faculty was selected by their expertise, ability to work with the younger campers and their ability to work together. The faculty's responsibility was to develop the curriculum, teach the concepts, supervise the hands-on activities as well as serve as mentors to the campers. Faculty also participated in the social activities with the campers.

Assessment

A multi-level evaluation of the camp curriculum was performed. The Society of Manufacturing Engineers Education Foundation provided standardized entrance and exit surveys for the girls enrolled in the camp. The survey results showed that the girls had a positive experience and many stated in the free response section that they "hope I can be in this camp again!" The camp counselors each wrote the assessment of the program. Finally, the faculty each provided a summary of their sessions and a list of recommendations and changes for the sessions. Based on these assessments several changes are underway for the 2004 camp. These include an increase of the instruction time (by reducing the social activities), addition of a 'free time' component so that campers can choose to pursue their favorite subjects, and additional curriculum components, including electrical and civil engineering components. The assessment tools will be used again to gauge the progress of the camp's development.

Conclusion

Bradley University has developed a new summer camp program designed to attract campers to engineering and to interest campers in taking high school courses needed to pursue engineering. This paper has outlined the development of the manufacturing and the testing activities, the prediction software, and the recruitment of the personnel involved in the camp. The camp that was created focused on rocketry and exposed campers to manufacturing, engineering and experimentation. The formula was to tightly interlace all of the varied sessions with the rocket theme, as well as balance theory and hands-on activities in each session.

The recommendations for the camp program include the development of a tracking mechanism, a second curriculum and a self-sustaining financial model for the camp. A tracking mechanism could indicate whether the camp influences the long-term math and science choices of the campers. The state of Illinois requires two years of math and one year of science for high school graduation. Methods that increase camper participation are highly encouraged. Since the BEST/STEPS program includes two years of campers (9th and 10th graders), the development of a second high school level curriculum to alternate with the rocket curriculum outline in this paper would encourage campers to participate in the camp twice. This could help to reinforce the math and science lessons and the potential of engineering as a career. Finally, the current BEST/STEPS camp was developed with a grant from the SME Education Foundation. This grant program is for three years. Long-term success of the camp depends on the development of a financial model that will continue to allow low-income campers to participate and yet be a self-sustaining camp program.

From the perspective of the sponsors and faculty the camp was a success. Most importantly for a summer camp, everyone had fun!

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