AC 2011-2156: BUILDING RELATIONSHIPS BY AVOIDING THE ”SHOW-AND-GO”: A STEM PROJECT FOR HIGH SCHOOLS

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Building Relationships by Avoiding the "Show-and-Go": A STEM Project for High Schools

Abstract

Many current political leaders in the United States advocate an increased emphasis on STEM topics in the primary and secondary school systems. As a result of this focus, there are multiple sources of funding available in the STEM outreach arena. It is tempting to seek funding through these various means and produce what could be labeled as a "Show-and-Go" program. This paper defines "Show-and-Go" as a project with a short-term focus, with little-to-no long term investment. Additionally, Show-and-Go projects focus on the “fun” aspects of engineering with very little emphasis on the underlying fundamental mathematics and science principles. These projects do create a sizable amount of initial interest, but without follow up, those short-term gains can quickly fade.

This paper describes one of several projects developed by the Integrated STEM Education Research Center (ISERC) at Louisiana Tech University. The project described here is targeted toward high school juniors and seniors. Even though this project is geared to high school students, the real gains are made by building lasting relationships with the high school teachers. This paper presents a full description of one of the low-cost projects, with a rationale for the various activities. Topics presented in this paper include material characterization, conservation of energy, communication through various media, teamwork, statistical analysis, and general problem solving. In addition to the paper, resources for the project will be available for download on the ISERC website, ISERC.LaTEch.edu.

Along with the project description, data are presented that reflect the effectiveness of the project toward building lasting relationships with area feeder schools. Since 2004, 74 different teachers from 17 different high schools have participated in Louisiana Tech's STEM outreach programs. Although the primary focus of these programs is to build lasting relationships with the area teachers, over 350 local high school students have been directly impacted by these programs with over 1500 indirectly impacted. The rising enrollment in the College of Engineering and Science at Louisiana Tech University indicates that the direct and indirect impact of these programs on local high school students has created an increased interest in STEM topics in the region in the midst of dramatically falling high school graduation rates in Louisiana. Additional data show that the enrollment of students in STEM fields at Louisiana Tech is increasing at a faster rate from high schools who participate in STEM outreach projects developed by ISERC.

Introduction

Why is it so difficult to recruit students into STEM majors and subsequently retain them? This is one of the fundamental questions in engineering education currently, and will continue to be for the foreseeable future. In 2005, the National Academies on Science, Engineering, and Medicine released their report on the “Gathering Storm[1].” In 2010 they revisited the same topic and released “Rising Above the Gathering Storm Revisited: Rapidly Approaching Category 5”.[2] Both of these reports contain numerous recommendations to increase the effectiveness of STEM education. Some of the more revealing facts provided in this report include the following:

- The United States ranks 27th among developed nations in the proportion of college students receiving undergraduate degrees in science and engineering.[3]
- The World Economic Forum ranks the United States 48th in quality of mathematics and science education.[4]
- Youths between the ages of 8 and 18 average seven-and-a-half hours a day in front of video games, television, and computers.[5]
- According to the ACT College Readiness report, 78 percent of high school graduates did not meet the readiness benchmark levels for one or more entry-level courses in mathematics, science, reading and English.[6]
- 69% of United States public school students in fifth through eighth grade are taught the physical sciences by a teacher without a degree or certificate in the physical sciences.[7]
- The average student intending to major in education in the United States ranks in the 42nd percentile of all students in reading, 41st in math, and 46th in writing.[8]

At Louisiana Tech University in 2004, we began a renewed effort to reach the high school students, and more importantly their teachers, in our region. We began partnering a key feeder school to form a program that would be attractive to students, and effective at introducing them to STEM topics. This partnership led to several NSF grants that helped to grow the program.

Since the pilot program in 2004, Louisiana Tech has been actively partnering with a growing number of regional schools and research centers in order to provide meaningful professional development to high school teachers, as well as engaging projects for their students. It is our opinion that for any effort like this to be successful at least three key elements must be considered. First, the effort must be **sustained**. Second, the effort must be **threaded**. Third, the effort must be **connected**. The project presented in this paper, *Launching into Engineering*, addresses the three key factors listed above, and is part of our NSF-funded TechSTEP program. This is an immersive professional development program for high school teachers who work along with student teams on projects that showcase engineering applications. The students are on campus three weekends throughout the year, while their teachers are on our campus six weekends per year. Our primary objective is to provide teachers with a deeper understanding of STEM fundamentals that they can imbed into their daily classes.

Sustained Effort

When sustainability is mentioned, one most often thinks of the funding. While funding is a concern, sustainability also means a continued effort. It is often tempting to approach STEM outreach in a "Show-and-Go" manner. This approach often provides an initial wow factor, but without sustained follow-up there is no lasting effect. Chubin et.al reported that 77% of K12 engineering programs in the United States focus only on the students, but only 46% focused on the teachers.[9] Not all programs that focus only on students could be labeled as Show-and-Go, but more can be gained by a sustained effort that focuses on the teachers, using their students primarily as a catalyst to encourage teacher interest and involvement. This rationale was fundamental in the development of our TechSTEP program. The *Launching into Engineering* TechSTEP project described herein illustrates this approach in more detail.

TechSTEP consists of a series of three Teacher Workshops, each leading to a Discovery Weekend for students. They are held on Saturdays from 9:00 am to 4:00 pm and are designed around a common engineering or science theme for the year. The Teacher Workshops, led by engineering, mathematics, and science faculty at Louisiana Tech, illustrate practical applications of high school mathematics and science topics. The Discovery Weekends include project-oriented, hands-on engineering and science activities following the same theme as the Teacher Workshops. The culminating Challenge Weekend includes a design competition in which students apply knowledge gained throughout the year.

As opposed to a show-and-go project that typically takes place over one day or less, our projects span an entire academic year with each successive Discovery Weekend building on the previous Discovery Weekends concepts and activities. Teacher Workshops provide the opportunity for us to work closely with our teacher partners and ensure that they develop a deeper understanding of fundamental concepts. Between Discovery Weekends students are motivated to develop a quality design for the final competition by their teammates, by college mentors, by our student success specialist, and by their teachers. The students are often given “assignments” to complete between visits that require them to search out information on their own. Also, the teachers are encouraged to incorporate topics from the challenge project into their own classes where all of their students can benefit from the material.

Threaded Content

A TechSTEP project does not segregate topics into individual compartments with no apparent connections. Rather, multiple strands of different content, both technical and non-technical, are threaded throughout the project. This approach helps link concepts that students (and teachers alike) may not have originally seen as having a common ground. We specifically look for ways to link The Engineer of 2020 skills (such as communication, global and societal issues, and life-long learning) to the project in a real-world setting. These projects follow our u-Discovery model[10]: Initiate Understanding, Broaden Understanding, and Deepen Understanding.

Connected Programs

Establishing and building relationships with individual teachers and administrators in school systems throughout our region is the most critical component to all of our TechSTEP K12 efforts. Our initial TechSTEP program laid the groundwork for building trust among the K12 partners. This close collaboration gives school systems a greater confidence for allowing university faculty to implement new, rigorous, and innovative programs with the teachers and students.

The *Launching Into Engineering* project is one of several projects under the TechSTEP umbrella. This project, along with others under the same program generated enough interest among regional teachers and students that a summer camp was spun off focused on Cyber Discovery.[11] Additionally, teachers asked for a full curriculum for use in their high school classes, and we developed a year-long high school curriculum, NASA-Threads[12], to fill that need. These programs work together to spark and sustain interest in STEM topics among regional students, and possibly more importantly provide resources and connections for the local high school educators.

The following project description illustrates how we are able to accomplish the key elements described above. Consequently, we have developed effective partnerships with 17 high schools that have now become key feeder schools for our STEM programs.

Project Description

Launching into Engineering is a project centered on the ubiquitous catapult. Probably every school in America has tried some version of a catapult project, with varying degrees of success. What makes this version useful for our purposes is the focus on fundamental principles, the intuitiveness of the device, and the excitement generated by a ball flying through the air and landing exactly where you intended it to land.

The big-picture goal of TechSTEP is the development of partnerships with key feeder high schools in our area. These partnerships are formed through a series of three Teacher Workshops, each leading to a Discovery Weekend for students. They are held on Saturdays from 9:00 am to 4:00 pm and are designed around a common engineering or science theme for the year. The Teacher Workshops, led by engineering, mathematics, and science faculty at Louisiana Tech, illustrate practical applications of high school mathematics and science topics. The Discovery Weekends include project-oriented, hands-on engineering and science activities following the same theme as the Teacher Workshops. The culminating Challenge Weekend includes a design competition in which students apply knowledge gained throughout the year.

This project does involve designing and building catapults; however, this is not the typical catapult project where the objective is to build a device that will throw a projectile as far as possible. Instead, our goal is to toss a ball from one catapult to the next, all the way around the room, with no human intervention. Effective communication between teams is critical. Moreover, we do not use a trial-and-error approach to design. Instead, the project relies on the development of underlying mathematics and physics principles so that students can predict projectile motion prior to launching the catapult.

Launching into Engineering is divided into three periods: Discovery Weekend 1, Discovery Weekend 2, and the Challenge Weekend. Regional high school mathematics and science teachers will select four to six students to participate with them in the project. During the course of the project, the teachers will be on campus six times: three times without their students and three times with their students.

The teachers attend a training session at least a week before the students arrive for each weekend. For the two Discovery Weekend training sessions, the teachers will do exactly what their students are going to be asked to do the following week. This pre-exposure to the content serves two purposes, it allows any bugs to be spotted before the students arrive, and it allows the teachers to become more confident in the material.

During the Challenge Weekend, the teachers will "go deeper" with the material, giving them additional information that they can take back to their classrooms. One of our guiding principles is that you teach from the overflow of your knowledge; therefore, it is our goal to provide the teachers with a deeper understanding of the fundamental concepts presented throughout the project. We also will present the teachers with possible directions to extend the project if they want to continue with the discovery in their classrooms.

Discovery Weekend 1


Figure 1. BOE-Bot

Discovery Weekend 1 starts not with a catapult launch, but by randomly dividing the students into small groups. The students are told to exchange contact information and get to know each other. Then the students are asked to divide their small group into two groups. One of the smaller groups is to stay in the room, and the other group moves down the hall. Group A that stays in the room is given a BOE-Bot (figure 1) pre-programmed to play the school's fight song. The other group, B, is given a pre-programmed BOE-Bot, but one without circuit elements assembled on its breadboard. The task is for the groups to communicate with one another through whatever means they have available so that group B can build their BOE-Bot and have it function correctly. Often, the students will use their cell phones, and sometimes they will use their computers to communicate.

The BOE-Bot is used because we have several other projects (pre-college and college level) that incorporate this platform. Any object could be substituted to achieve the same effect. In the past, Legos have been used as the device to be assembled. The point of this activity is not the fight song, or the BOE-Bot, but rather the need for people to be able to communicate effectively. Topics that can be drawn out from this exercise include: being able to correctly name items, being specific with directions, speaking clearly, and patience. We relate this exercise to the catapult through the condition that one team's catapult is going to launch an object to another team's catapult and precise measurements will need to be shared between the two teams. We relate this concept to the real world by describing how globalization has created an environment in which engineers will often need to communicate with foreign (or remote) locations in order to accomplish their assigned task.

The next discussion that arises from this exercise involves professional communication, particularly through email. We discuss the difference between an email between friends and an email between professionals. We give examples of emails that do and do not promote a sense of respect. Topics emphasized include: including a proper subject line, contact information, formality, spelling, and grammar.

After spending five to ten minutes discussing computers, and electronic communication, we show clips from *Frontline's* documentary *Digital Nation*.[13] This video explores the concept of multitasking and other issues associated with our digital-heavy culture. This discussion is used as a starting point to have the students think about the concept of focusing on a topic.

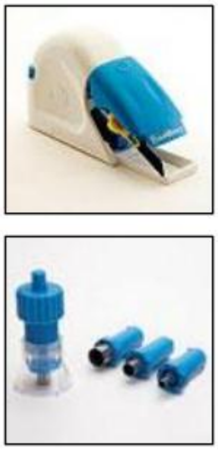

Figure 2. Foam core tools.

At this point, we have spent approximately an hour-and-a-half on material leading up to the catapult. Instead of delving straight into calculations, we have the students build a catapult from plans and parts that we provide. The catapult is largely constructed from foam core; therefore, we spend 5 to 10 minutes discussing techniques for working with the material and tools. We provide tools (figure 2) from FoamWerks (www.foamwerks.com) for use with the foam core material.

The plans provided to the students are simple two-dimensional drawings from a CAD package, and are available on the website. The students are also provided a three-dimensional rendering of the assembled catapult. However, a pre-build catapult is not shown to the students until much later. We want the teams to learn to appreciate the level of detail necessary in a written document in order to convey enough information to complete even a relatively simple task. A completed catapult can be seen in Figure 3.

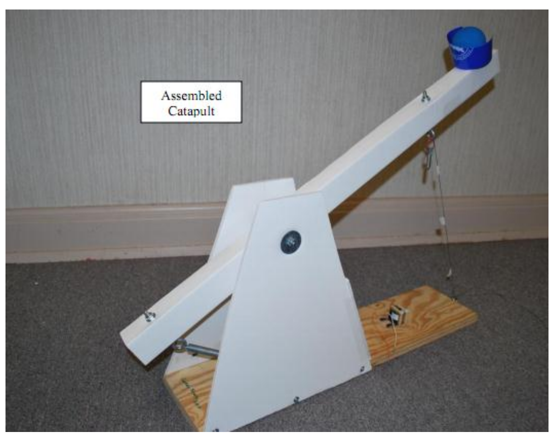

Figure 3. Assembled catapult

Assembling the catapult usually takes the teams through lunch. During lunch, a panel of international faculty, international students, faculty who have worked abroad, and students who have international experience is assembled and the high school students are given opportunities to ask questions about our global society. The panel discusses their experiences with engineering across national boundaries, and any other topics in which the students are interested.

After lunch we begin the process of determining the calculations necessary to predict the flight path of the projectile. We start by asking the students for the equation for projectile motion. Generally, at least one student can come up with something like the equation shown below.

$$y = v_o \cdot t + \frac{1}{2}at^2 \qquad \text{Equation for projectile motion}$$

This equation is typically the one found in a physics class in high school, with a problem statement that says something along the lines of:

> *A football player kicks a football with an initial velocity of 20m/s at an angle of 35^0, what distance does the football travel?*

The next step is for the students to simply solve the equation, during which they quickly figure out that it is not so straight forward in real life. Sometimes, the comment that we "made the problem too hard" will come out. This can lead to discussions about engineering design, and how the real world is a complex system.

For our catapult, the launch angle is not too difficult to determine, if we assume that the ball leaves the catapult perpendicular to the arm. The students can then set their launch angle by attaching a stop cable to the arm of the catapult.

However, the initial velocity is not so easy to determine. When asked, the students can think of ways to use video to measure the launch velocity, or to just test the catapult and measure the launched distance and back calculate the velocity. Both of these methods are valid, but the goal is to *design* the catapult, not *analyze* it. At this point, we introduce the Conservation of Energy as a fundamental concept of engineering and science.

In order to apply conservation of energy, the students must determine how much energy they are putting into the system. The catapult's energy comes from a standard tension spring; therefore, the students must determine the spring constant.

1. The students find and weigh three or four objects of varying mass.
2. The students attach one end of the spring to a stationary object and measure its length.
3. The students then attach the objects to the free end of the spring and measure the amount of stretch the spring experiences.
4. The students plot the data and find the slope of the resulting line.

As an alternative, a material testing machine can be used to apply a tensile load to the spring and measure the deflection. However, we feel that the students benefit more from doing the exercise themselves. Additionally, using the weights and a tape measure is something that the teachers can do in their classroom if they choose to incorporate this exercise into their regular content. This exercise also allows the teachers an excellent opportunity to go deeper with their students if they want to discuss linear regression.

Now that the students have characterized the spring, they are now able to determine how much energy they are storing in the system by stretching the spring. This is an opportunity to "approach the doorstep of Calculus." An explanation of how to calculate the energy stored in the spring is conducted and the resulting equation is presented.

$$Energy_{spring} = \frac{1}{2}k\delta^2 \qquad \text{Resulting equation for energy stored in the spring.}$$

A much more thorough explanation of the derivation of this equation (and the entire project) can be found at ISERC.LaTech.edu.

Knowing the energy stored in the spring is only half of the battle however. Next, the students must determine where all of that energy goes. Some of the energy goes into moving the ball, some to moving the catapult arm, and some to moving all of the hardware attached to the arm. We neglect any frictional losses, although depending on the quality of construction, they may be significant.

In order to calculate the energy transferred to the moving parts of the catapult, a discussion of linear and angular motion is needed. At this point, we typically let the students know that we are not expecting them to have a full understanding of all of the intricacies of a dynamic system, but we want them to understand the overarching concepts of energy and motion. This part of the process requires a discussion of *Moments of Inertia*. Again, a thorough explanation is given on the web site. As part of the calculations for the moments of inertia, the students are also required to weigh the individual components and to calculate the density of the foam core board. These exercises are done during the assembly process.

Another side topic that is presented during this phase of the project is the concept of radians and degrees. Prior to this discussion, students typically do not have an appreciation for the concept of a radian and for the value of pi. This discussion also exposes the arbitrary nature of the value of a degree. Also, this topic can lead into units in general and how some of the more common units were developed, and what it means to have a standard.

Microsoft Excel is used to calculate the expected range of the catapult. The student teams are not asked to generate the Excel file from scratch, but they are not given the file until after the discussion of the governing equations. The student teams are required to input the values of the variables such as the mass of the ball and the length of the catapult arm. An excerpt from the Excel spreadsheet is shown in figure 4.

Once the teams have determined the expected range of their catapult, they setup their catapult to fire a small stress ball at a six inch diameter hoop. The hoop is attached to a ring stand at the expected range. The catapult is clamped to a table in order to eliminate losses due to the catapult bouncing upon firing. The catapult is fired and the results are monitored. Typically, the catapult launches the ball either through the hoop or hits the hoop. A few of the catapults will miss their mark and this leads to discussions about possible sources of error.

The launching of the catapults and discussion of the results ends Discovery Weekend 1. The students have been on campus from 9:00 AM to approximately 3:30 PM. During the time between Weekend 1 and 2, the high school teachers may use this material or similar material in their classes to help reinforce the concepts, but this is not required as part of the *Launching into Engineering* Project.

(2) Moment of Inertia Calculations

m_{ball} =	103.5	g	m_{cup} =	23.5	g	m_{eye1} =	21.1	g	m_{eye2} =	30	g
r_{ball} =	48	cm	r_{cup} =	48	cm	r_{eye1} =	23	cm	r_{eye2} =	36	cm
I_{ball} =	238.5	kg-cm^2	I_{cup} =	54.1	kg-cm^2	I_{eye1} =	11.2	kg-cm^2	I_{eye2} =	38.4	kg-cm^2

$$I = m \cdot r^2$$

h_{solid} =	4.5	cm	Vol_{solid} =	1440	cm^3	m_{solid} =	162.0	g
$h_{missing}$ =	3.5	cm	$Vol_{missing}$ =	840	cm^3	$m_{missing}$ =	94.5	g
L_{arm} =	80	cm						
offset =	12	cm	$\rho_{foamcore}$ =	0.113	g/cm^3	$I_{foamcore}$ =	45.9	kg-cm^2

$$m = Vol \cdot \rho$$

$$I_{catapult\ arm} = \frac{m_{solid}\left(h_{solid}^2 + L_{arm}^2\right) - m_{missing}\left(h_{missing}^2 + L_{arm}^2\right)}{12} + \left(m_{solid} - m_{missing}\right)\left(offset^2\right)$$

Figure 4. Portion of the Excel spreadsheet

Discovery Weekend 2

The second weekend, which typically occurs two months after the first weekend, starts with the students determining how to make the catapults autonomous and more reliable. The autonomous portion will require a computer controlled timer and release mechanism; we will use the BOE-bot for this. Making the catapult more reliable means determining the statistical spread associated with the range of the catapult.

Autonomous Release

In order for the catapult to autonomously launch, it must be capable of catching a ball from the previous team, determining when the ball has landed in the launch cup, waiting for approximately 3 seconds to let the ball settle in place, and then launching the ball to the next team.

The teams will build their catch mechanisms as part of their assignment between Discovery Weekend 2 and the Challenge Weekend. During this second weekend, the teams will be concerned with how to monitor when a ball has landed in their cup. In order to do this, the BOE-bot is used again. This time, the BOE-bot is used to control an infrared pair. The teams are given a basic discussion on how an infrared pair works and are given a program that will control the setup. However, the teams are not given a pre-wired BOE-bot. Instead, the teams are given a pseudo wiring schematic and all of the parts necessary to assemble the circuit.

Before assembling the infrared components in the timing circuit, the teams need a release mechanism. For this task, the teams use a solenoid plunger to hold the arm of the catapult in the armed position, and release the solenoid once the infrared circuit indicates that a ball has landed in the cup. The addition of the solenoid requires a brief discussion of how an electromagnet works. Also needed for this solenoid is a relay. A brief discussion of how a relay is used as an electrically controlled mechanical switch fits nicely with the solenoid explanation.

The infrared detection circuit and solenoid release mechanism are added to the circuit and the BOE-bot is wired to monitor and control the system. A sample of the simplified wiring diagram can be seen in figure 5.

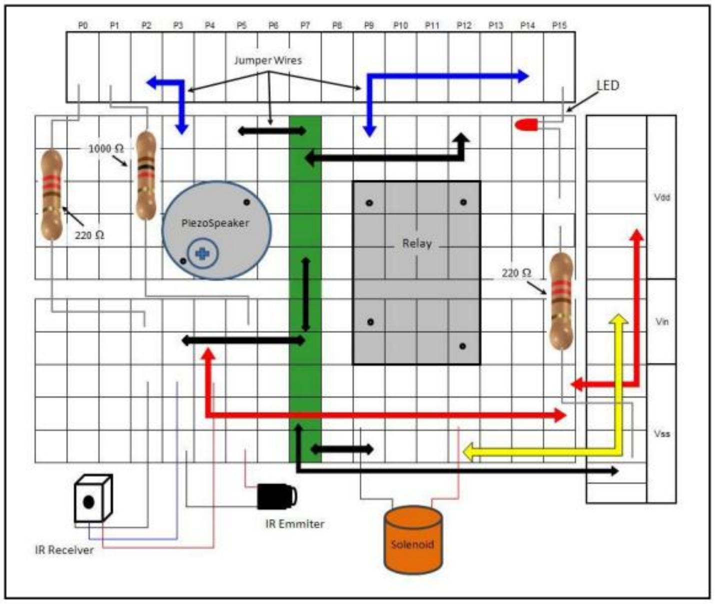

Figure 5. "Schematic" given to the students for wiring the control system.

Reliability

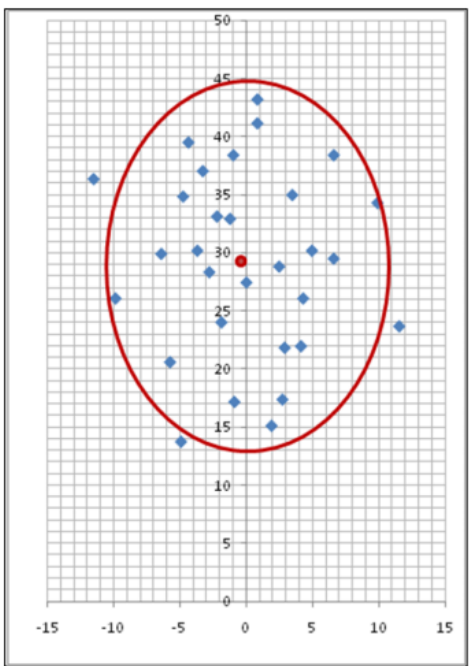

Figure 6. Recreation of a data set from a student catapult.

This set of activities will carry the project through to lunch. After lunch, the students are ready to determine the accuracy of their catapult. In order to evaluate how accurate and precise their catapults are, the students launch their catapult 30 times using the BOE-bot to control the timing of the launches. The location of each shot's landing point is recorded on a large sheet of paper and an XY coordinate system is drawn on the paper. This activity could be used to discuss probability and statistics in greater depth, but for this project a simple explanation of how to put the data into Excel and calculate the standard deviation is all that is required. Two standard deviations are used in both X and Y directions to determine the shape of an appropriate catch device. A recreation of one data set can be seen in figure 6.

Several interesting discussion can arise from this data collecting activity. Occasionally, there is an obvious bi-modal distribution in which either the catapult experienced some type of wear, or other physical change that caused the range of the catapult to be altered.

After presenting the preceding statistical background and data analysis, we leave the design and construction of the catch device entirely up to the students. Our college student mentors for the project are allowed to serve as consultants if student design teams ask for assistance. Thus far the vast majority of student designs have worked well with only minor modifications required on the day of the challenge event. A complete catapult with catch device can be seen in figure 7.

Statistically characterizing the catapult is the last activity for Discovery Weekend 2. The students are given information on what team they are launching to and from which team they are receiving the ball.

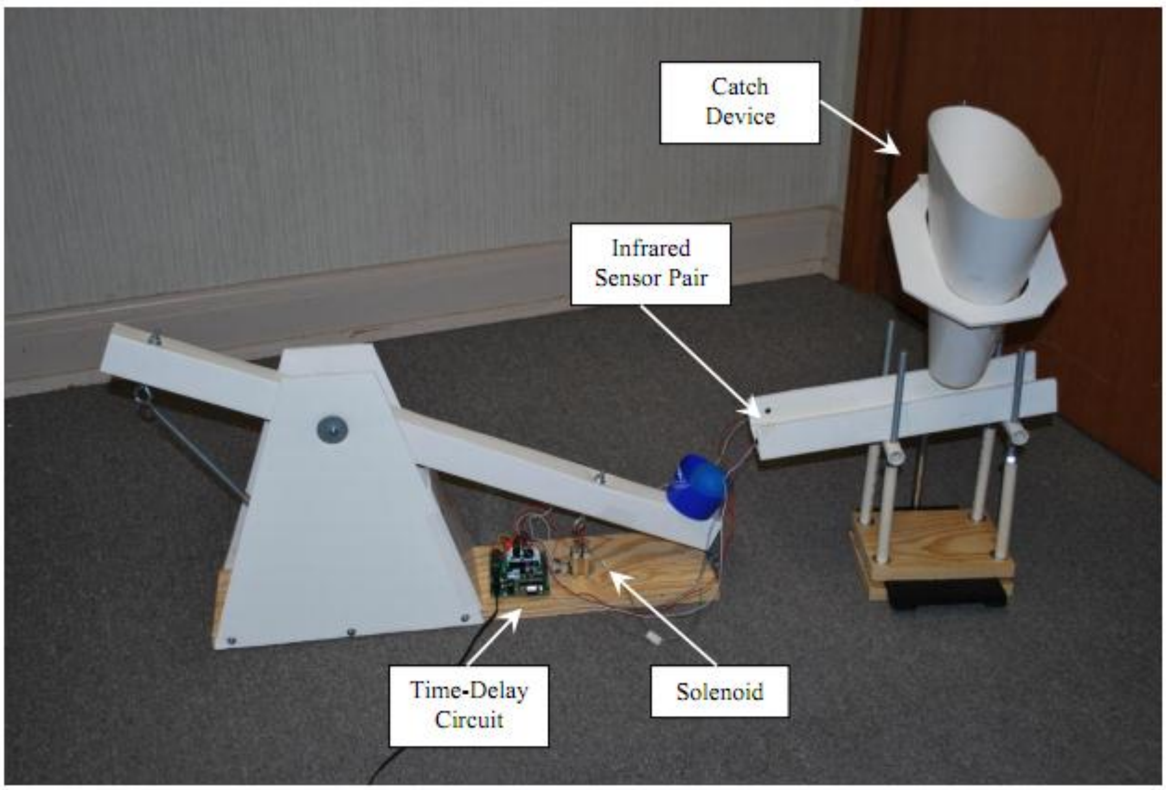

Figure 7. Full catapult system.

Challenge Weekend

The third and final weekend typically occurs 2 months after the second weekend. The Teacher Workshop for this weekend is different from the previous two workshops in which the teachers did exactly the same activities as the students. During the final Teacher Workshop however, the teachers "go deeper" with the material and concepts presented in the first two phases of the project. One of the guiding principles for our projects is that you teach from the overflow of your knowledge. In order for the teachers to be able to teach material related to the content of our projects, we explore the material in greater depth with the teachers on the final workshop weekend.

For this project, deeper topics include methods to use a regular camera and free software in order to accurately measure the launch velocity and angle of the ball. Other topics include more advanced functions in Excel, and the calculus links to the topics surrounding the spring and the moments of inertia for the catapult arm.

The students however, have a different task for their Challenge Weekend. Each team has communicated with the team that they are launching the ball to and the team from whom they are receiving the ball. Using this information, they have designed their catch mechanism to be correctly sized and located so that a single ball can be launched from catapult to catapult with no human intervention. Setup for the catapults typically takes the first hour of the Challenge Weekend.

The teams are usually not successful in launching the ball all the way around the room on the first attempt, but this is to be expected. With a few tweaks and slight modifications, the teams will be able to make a complete or nearly complete circuit. A short wrap up discussion of all that was accomplished is held, and the project is nearly finished.

Before leaving campus, the students are given a tour of campus and some of the housing options. Also, some of the ongoing student projects at Louisiana Tech are demonstrated. These projects include the ASCE concrete canoe and steel bridge, the Shell Eco Car, and the SAW mini baja vehicle. The Challenge Weekend usually ends shortly after lunch.

Results to Date

For this project, the immediate goal is to encourage the students to pursue STEM degrees in college. However, the long-term (and we believe more important) goal is to provide teachers with a more thorough understanding of how to connect their classroom topics to engineering and science, thereby extending the impact of to all students in their classes. To date, the TechSTEP program has:

- directly impacted 17 high schools,
- 49 teachers, 250 high school students, and
- 21 college student mentors.

It has indirectly impacted over 2,000 high school students. All data collected to date show an overwhelmingly positive response to the program from both students and teachers. Over 75% of student participants in TechSTEP have indicated that the program helped them decide to pursue a STEM degree in college.

A few of the questions most relevant to this paper and their ranking on a scale of zero to five (with 5 being “strongly agree”) are identified below:

Q9. I have a greater sense of confidence in taking risks to change the content and the methods of teaching mathematics /science. (4.25)

Q12. I have examined and revised my classroom practices to include information and student projects involving STEM careers. (4.0)

Q14. There will be an ongoing collaboration between my school and Louisiana Tech in the STEM disciplines beyond this project. (4.6)

Q18. I believe that the TechSTEP Program will bring about change that will encourage more students to enter mathematics, science, or engineering professions. (4.7)

Teacher participants were also asked to provide written responses to several additional questions. Perhaps the most important of these questions was "As a result of TechSTEP, what has changed in your classroom?" All responses were very positive. The following is a sample of these responses:

> *"It has changed my teaching style completely. It is the best instruction for teaching that I have ever received!"*

This response is interesting in that we do not give actual instruction on how to teach. We do however, demonstrate various techniques throughout the process.

> *"I do more hands-on activities. Every activity I do makes class more interesting and learning more fun."*

> *"I am incorporating activities for a deeper, better study of vectors."*

This comment is interesting also because we did not do any work with vectors during the project this teacher saw a possible application and took the material that we did present and adapted it to use vectors.

> *"My students who are attending TechSTEP have shown their classmates what we've been doing. They now see how we actually 'use this stuff'!"*

> *"Making sure my students understand that all they do now is connected to what they do in the future."*

Additionally, we have seen marked increases in the number of students enrolling in STEM majors Louisiana Tech University from high schools that participate in the TechSTEP program. On average there has been a 39% increase in the number of students enrolling in STEM majors from participating schools. Table 1 shows the average number of students from eight TechSTEP high school before attending the program and the average number of students after the school began participating in TechSTEP. Only eight schools are shown in this data set as numbers for this year's schools will not be available until the Fall of 2011. Seven additional schools have been added during the 2010-2011 academic year.

Table 1. Enrollment data from participating schools.

High School	Number of years Participating	Average enrolling students before	Average enrolling students after	Percent Change
1	6	8.3	10.0	20.0
2	4	3.6	8.0	122.2
3	2	2.8	3.5	23.5
4	4	5.8	5.3	-8.0
5	2	6.0	7.0	16.7
6	2	4.0	13.0	225.0
7	2	0.6	0.7	11.1
8	4	10.2	10.0	-2.0

Conclusion

After more than six years of TechSTEP and other related programs at Louisiana Tech University, we have come to the conclusion that in order to make a change in the current state of STEM education in the nation there must be a concerted effort placed on partnering with STEM teachers in the local and regional school districts. This may seem an obvious conclusion, however the focus of many political leaders and funding agencies appears to be on testing standards and broad, sweeping programs that will be difficult to implement. We believe that focusing on the STEM teachers of your key feeder schools is the most effective method for making permanent changes in STEM education. Our model includes a focus on a **Sustained Effort** with the teachers to avoid the “Show-and-Go.” We also **Thread Content** throughout our programs so that a participant sees a larger view of what STEM is and where STEM topics are applicable to a variety of situations. Finally, we **Content Programs** to each other in order to provide multiple opportunities for teachers and students to participate in several STEM venues and formats. In all, we have seen a marked increase in STEM enrollments from high schools that participate in our programs.

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