The Future Scientist and Technologist Club

An Interactive Qualifying Project Report

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by

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Chad M. Farrell Jr.

And

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Mitchell B. Riley

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Professor Kenneth A Stafford,
Major Advisor

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Professor Bradley A Miller,
Co-Advisor

Abstract

Mitch Riley and Chad Farrell ran a design and engineering-based after school club called The Future Scientist and Technologist Club at a Worcester Public High School in attempt to persuade students to consider pursuing a career in engineering. This year's club was a modified and improved continuation of a similar program that has taken place the previous two years. This IQP will be used by Professor Wilkes as it is part of a larger research project he is currently undergoing.

Acknowledgements

First and foremost we would like to thank Amanda Cox who kept this whole program together. She was part of this IQP last year and ran the larger program involving all five Worcester Public High Schools this year. Without Amanda putting in a tremendous effort to keep this IQP together, there may not have been another Mentoring Program IQP this year. Along with Amanda, the other people truly responsible for the formation of this project are Mathew Duncan and Brian Dorchik who first piloted this project two years ago at our Worcester Public High School. Another great thanks goes to our advisor at the high school. This advisor put in much effort this year. She personally brought kids into our program, helped us post flyers all over school promoting the club and even organized the usage of some of Doherty's limited supplies to be used in our program. Also, without the guidance and patience of Professors Kenneth Stafford and Bradley Miller, this IQP would not have come together as smoothly as it did. Again, thank you to everyone that assisted us in our IQP this year, we truly appreciate it.

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History of The Future Scientist and Technologist Club

This year will be the third year of the after school club involving Worcester Polytechnic Institute and a public Worcester High School. The club name in the first two years has been *The Future Scientist and Technologist Club*. The program was initiated in the spring of 2006 by two WPI juniors who had been working with the city of Worcester to establish better engineering-based programs for local high schools. After meeting heavy resistance from the city as a whole and the individual high schools within Worcester themselves, the IQP team was running out of options. While talking to the administration of one of the Worcester Public High Schools, one of the students was informed that the school had a program called the Engineering Technology Academy (ETA) already in existence. Since the ETA was an already existing, advanced version of the original program that the students were trying to establish, the two WPI students decided to focus their attention towards this school. The IQP students discovered that the ETA was essentially a separate school within this high school. This meant that the engineering and science based classes of the ETA were not available to students who were not involved with the ETA even though they went to the same high school, in the exact same building. After some discussion with the ETA teachers and the school administration again, a compromise of all goals was devised. An after school program at the school would be created, welcoming all students, ETA or non ETA, that would emphasize the challenges and joys of engineering while persuading the students to pursue an education in engineering. The school loved the idea, and it ultimately met the original goal of the IQP.

By the time the IQP team was able to establish the program, there was only about a month left in the WPI school year, excluding summer classes. The program was rushed. There were five meetings in two and a half weeks. In these five meetings the IQP group had a robotics demonstration, an interactive Computer Aided Design (CAD) demonstration, a space discussion, and a demonstration of engineering and video games. The number of students attending these meetings ranged from about nine to 15. This was a small number, but respectable considering the program was rushed, and had little time to spread its name. The first year of *The Future Scientist and Technologist Club*, run by Duncan and Dorchik, ended not long after it began but was a strong foundation for the years to follow.

In the 2006-2007 school year two new WPI juniors acquired the responsibility of running the program. These students were able to conduct more preparation for the program. The goals were to run an after school program available to all the students of the high school that would conduct hands-on engineering-based experiments to gain the interest of any student curious about, or considering pursuing an education in engineering. A sub goal was to attract and maintain female students to the club as the field of engineering is profoundly dominated by males. On average, roughly 20-25 students attended these meetings with a high of 35 students. Females generally accounted for about 40% of these students (Norton and Cummings).

These two WPI students, Chris Norton and Orry Cummings, had a total of seven meetings over seven weeks with the Doherty students. Per suggestion from the previous year, meetings were held on a once weekly basis, conforming to the hectic after school schedule of the interested high school students as well as possible. The engineering-based experiments conducted included an egg drop, chocolate asphalt, physics-based roller coaster design lab, WPI admissions discussion, simulated building design using LEGOS, and a trip to WPI.

The egg drop is a very common but fun science-based design experiment. The design must take into consideration acceleration vs. time, gravity, wind resistance, material, size, and how to cushion and protect the egg upon impact with the ground. There are infinite solutions, although they can be limited by allowing only certain materials to be used. Exploding eggs is exciting and entertaining for high school aged students. Keeping them excited is crucial to attendance of the club and ultimately achieving the goal of persuading them to attend college studying engineering.

Chocolate asphalt was one of the most popular experiments from last year. It was requested that the students pretend that they were making asphalt, such as a road, using melted chocolate, M & M's, and other small edible treats to be used as aggregate. The goal was to design a mixture of the materials given to create the strongest mixture possible. After completion and discussion the kids were allowed to take their chocolate asphalt home and eat it.

The roller coaster lab focused on physics in the design process. A roller coaster has to be fun, and give the sensation of floating (very low gravity), yet be safe. It has to follow the laws of gravity. At the top of a loop, the upward force has to be at least equal to, and in reality greater than, the force downwards due to mass times acceleration. The students designed their own roller coasters and calculated forces to ensure that they felt confident that if they were to ride their own roller coaster, they would survive.

The LEGOS building experiment was really quite interesting. Given as many LEGOS as the students wanted, it was requested that they design and build a building to be a given height and be able to withstand a horizontal force applied by wind. A strong fan was used to apply this wind. To add a realistic twist to the experiment, each piece of the LEGO set was given a price and the teams were given a budget. A point system was used to evaluate the designs and the winners were given a special prize.

On the day when the WPI admissions workers gave the presentation to the class, the various kinds of engineering available were discussed. Most students knew of mechanical and civil engineers, but not many knew of chemical engineers or biomedical engineers or other less discussed forms of engineering. Also discussed were the important classes to take in high school if the students wished to go to WPI or any college to study engineering. Unlike a liberal arts college education, engineering does have a fair amount of prerequisites that must be complete in high school.

The field tip to WPI, although it sounds like it would be a lot of fun and interesting, did not go as well as had been hoped. It was surprisingly difficult to keep 25 high school students entertained, and even with special presentations at WPI being the focus of the field trip, the students lost interest and concentration. Another field trip to WPI has been discouraged by the club advisor at the high school.

Finally, one of the biggest recommendations from the past two years has been the final class pizza party. End the club on a fun note. Get pizzas, don't plan a lesson, have the kids do the final survey and discuss what they liked and didn't like about the club. This can be used to fulfill the IQP goals and be a fun, informal discussion session to end the club (Norton and Cummings).

From the two previous years running this club, a few key elements have been present:

-it needs to be thoroughly planned out,

-it needs to be well organized,

-the student coordinators need to know the material very well,

-experiments and designs performed must be hands-on and engaging, and

-use groups of two to three students for design teams.

This means the students really get to think. They get to be involved. It is interactive instead of lecture-based. Allowing the students to see the successes and failures of their designs demonstrates that the math classes and science classes they are currently taking or will take shortly really will be important if they decide to become an engineer. Lastly, simply have fun. Don't be just a teacher, be a peer. We need to do our best to get to know the kids and work with them individually and have a good time building bottle rockets watching some soar high and others get destroyed by wind resistance and the acceleration. Have fun pouring chocolate asphalt and getting a little messy. This is what the kids like and will make them more willing to give us the information we are looking for from them, and also will strongly influence them to continue an education in engineering.

Main Text

The Problem Our Club Solves

In recent years there have been several concerns in the engineering field. First of all, as technology and the capability to produce structures and machines have increased so rapidly in recent decades, there has been a demand for more engineers. The highest demand for college graduates recently has been technology-related and business degrees, with the demand for engineering majors perceived to increase (Byko).

In addition to the eternal necessity for engineers, there is a desire and need for female engineers. Even as the female to male ratio of college graduates has grown to 57% female, the engineering field remains heavily male dominated (Marklein). In most engineering colleges, the majority of faculty and students are male (Landers). The benefit that females can generate in the engineering field is still unknown as their percentage is so small (Macdonell-Laeser). The results of engineering are substantially influenced by personal creativity. Creativity varies for everyone and is often very different between males and females. Involving more females in engineering would establish a wider creativity pool for design, adding completely new elements to modern machines, structures, and products (Macdonell-Laeser).

From these known issues it was our goal to establish a program that would first and foremost influence younger students to consider pursuing a career in engineering. Secondly, the program wanted to cater to what the females want to do, if possible, and increase their interest in the engineering field.

See References for full source citations

Evolution of Goals

This IQP was piloted two years ago at a Worcester Public High School by Matthew Duncan and Brian Dorchik. Starting a project such as this with little to no information about what this project could or would become, they set a few goals that they wished to accomplish through their time undergoing this project. However, as time went by, their goals and aspirations changed.

Duncan and Dorchik had hoped to work closely with the school guidance councilors to develop a survey to give to the students. They also had planned on dealing primarily with sophomores and juniors and formulated their survey with this idea in mind. They planned on giving all the students the same survey and separating the sophomore and junior surveys to be analyzed differently. The surveys filled out by juniors were to be handed over to a third party who was doing a "replication study" to be analyzed and compared to results from the previous year, 2005. The surveys collected from sophomores would then be taken to be examined to find a "pool" of 12 to 18 students who would be considered for what Matthew and Brian called 'coaching.' According to the 2006 team, coaching "would be centered on how to use the student's junior and senior years in high school, both academic and extracurricular, so as to enhance their chances of college admissions to a technical school" (Duncan and Dorchik). Brain and Matthew wanted to approach the project this way because they wanted to compare the data of sophomores and juniors to see if students in the tenth grade were too young to ask about career aspirations. However, they were unable to follow through with their project they way they wanted due to problems with the school and the project had to be temporarily suspended. The project was revived with different goals shortly thereafter. The coaching aspect of the project was turned into a WPI student and high school faculty advised after school club. This club was named *The Future Scientists and Engineers Club.*

With the change of their project, came a change of their goals. Matthew and Brian stated that their new main goals were to get students excited about their future careers and to help them achieve their goals. As this project is continued every year, it seems that these goals were upheld, along with a couple others that include: encouraging students, who previously did not think a career such as this was possible, with the help of this tutoring program, to create awareness of gender equity and to also create a better balance of men and women in different careers, particularly engineering. However to attract more interest and students, the club name was changed to *The Future Scientists and Technologists Club.*

Much has changed since Duncan and Dorchik first piloted the project, but we still kept the basic ideas in mind while the project continued. Coming into this project, we had an advantage over the projects of previous years because we had the ability to look back upon those previous projects as guides to our own project and make it better than those of the past. Last year’s project expanded into the five major public high schools in Worcester and our goals are closely related to those of last year.

Goals

When we began the project this year, we had many goals in mind. Many of them we hoped to carry over from previous years and we formulated a few new goals of our own. Our first goal, which was strongly recommended from previous years, was to make contact with, and start a good relationship with our advisors here at WPI and also our advisor at our specific Worcester Public High School. This was a goal completed last year and the first step to completing our project this year. Starting off on the right foot with our advisors was necessary to launch this year's IQP. As advised by the previous IQP's we would be working very closely with our advisors throughout the project and would need their help in many areas. We planned to continually meet with our advisors here at WPI at least once a week, while staying in contact electronically almost every day.

Our main goal this year was to introduce the many aspects of engineering to the students at the high school in a fun and interesting environment, while possibly encouraging the students to consider engineering as a career choice. Most of the students that attended this club were a part of the ETA or Engineering and Technology Academy, having some background knowledge in the subject. There were also some kids who were not a part of the ETA, and consequentially, had very little knowledge of engineering. By introducing different engineering fields and their respective responsibilities, all the students, regardless of past experiences, learned something new and exciting.

Even though the club name is The Future Scientists and Technologists Club, we focused more on the engineering aspect. We decided to introduce engineering to the club members in a fun, non-lecture format. We hoped to entice the students' minds and make them think about the possibilities within engineering. The best way to interest the students' in the subject seemed to be doing hands-on experiments that not only help the kids learn, but also relate the experiments to real life situations. The hands-on experiments were a recommendation of Duncan and Dorchik's and was great advice. In their IQP, they discovered first hand that lectures were not the best way to spark the students' interest and therefore suggested hands-on projects. We planned to have short lectures and discussions about each of the projects in the first part of the class. With basic background information the students would then be able to use their creative intelligence to work on their projects. The second part of class included designing and building the projects. We planned to relate the experiments to real life problems to get the kids' to start thinking like professional engineers think. It was as if they were solving an actual problem. By creating the best possible design, they would be solving a problem to the best of their ability.

The second part of our main goal was to encourage the students to consider pursuing a career in engineering. Throughout the existence of our club, we promoted students to consider going to school to study engineering which is the first step to becoming an engineer. By exposing students to the fundamentals of engineering we taught the kids what to expect if they did, in fact, choose to pursue engineering. With the help of surveys, we asked them questions about engineering to see how much the students actually knew about engineering. Then we reviewed the survey questions with the students and told them the answers to any questions they might have had. Also the different experiments showed the club members the aspects of engineering to hopefully interest each student.

Our next goal was to successfully continue this project from last year and to hopefully improve the club by using the previous year's IQP as a guideline while also using their recommendations. We had new ideas for this year's club but we also had many questions. Some of these questions were answered from the IQPs of previous years but others we hoped to answer ourselves throughout the lifespan of the project. We wanted to run a successful club first and foremost. In order to do this, we planned everything as much as we could before the club had even begun. We wanted to know beforehand which experiments we were doing, how long each experiment would take, and when we could do each project. To turn this club into a successful program that will hopefully return next year, we kept the kids involved and made it worth their while to come to the meetings. Food and beverages seemed to be a good idea and we hoped it would attract newcomers and keep the students busy while we discussed our topics at the beginning of each class. Fewer interruptions meant that learning potential was at its max and that leads to success.

Free food was one way to have a consistent number of students attend our meetings but we needed something more. The hands-on experiments were what attracted the students so we used exciting projects that were informative and also multistage. Multistage projects are projects that, by definition, have more than just one part or stage. We did not want to have experiments this year that would take just one meeting to complete. If we had done that, the kids would have been more likely to skip a class because in their minds, skipping a class would only be missing one project. Multistage projects take longer than just one meeting to complete and therefore require time, effort and commitment. If we had one meeting per week and one of the experiments takes three meetings, then it would take three weeks to complete. The projects were engaging and exciting and the kids wanted to be there for every class, especially if it was to finish a project they had been working on for a couple weeks.

Another goal of ours was to teach the students how to work well with each other, more specifically how to work well in groups. In the real world, engineers often work in teams to facilitate the projects they work on and apply a wider basis of knowledge. The more people the less chance of getting something wrong and therefore the greater the chance of success. Teaching the kids how to work well in groups on engineering-type problems will not only help them to better understand what it is like to be an engineer, but it will also help with any job they might have as adults. With the kids working in teams on projects, they rely on each other for the completion of the project, which gives each individual more motivation to come to each class.

In addition, all the projects were a competition. There were enough teams to see a variety of designs and we encouraged the students to design and build their devices to be better than the other groups'. In real life the best design wins the bid. Best can be defined as highest quality, cheapest, most practice, or other ways but the best design as specified by the goals, wins in real life. The same concept was applied to the club.

While we had a good understanding of what we wanted to do with this project in terms of experiments and scheduling, we also wanted some input from the students. In order to continually collect data throughout our IQP, we created a survey which was distributed on the first day of class and a similar survey that was handed out on the last day of class. These two surveys were formulated so we could obtain and compare the data from the first set of questions to the data from the second set of questions. We also gave simple and short surveys completed by the students throughout the course of the club. These surveys were analyzed to retrieve feedback from the students. This feedback included: the number of kids coming to each meeting, the percent of ETA students that came and the male to female ratio.

In past years, this project was funded by the Advisory Committee for the Status of Women (ACSW). They chose to sponsor this project because of the gender inequality in the work place, especially when it comes to engineering. A major goal, not only in our club but in the work place, is to have more gender equality. *The Future Scientists and Technologists Club* was a chance to raise awareness of this issue. We hoped to maintain, if not increase, the number of females attending our club. After all, if females attend our club, we feel that there is a greater chance that they will consider engineering as a career choice.

The wonderful thing about experiments is that even if you do not succeed, you can try again. You now know a method that does not work and you can build upon that. Sometimes experiments take scientists/engineers years to complete and only after failure can one succeed. We tried different experiments throughout the course of the IQP and talked with the students about the failures and successes of each completed project. By asking them what went wrong, we asked them to recollect their thoughts on their design and figure out what worked and what did not work. Not only did this help determine if they would like to retry the experiment/project in future years, but also analyzing what went wrong and what needs to be improved is essential in engineering.

Perhaps our second most important goal of this year's IQP was to take notes and record everything done this year to help future groups participating in the same IQP.

What we really wished to accomplish by writing down notes was to continue this project next year and for years to come. We tried to provide information about our project, along with information from previous projects in order to help in any way for next year. Information includes what worked well for us and what did not, which projects the kids liked and which ones to possibly stay away from. It also includes which methods worked best for certain projects, when to do certain projects and a general outlook on the project to give future WPI students considering this project an idea of the work and the effort needed to complete this project.

Since this IQP is part of a greater IQP that is in progress by Professor John Wilkes, there was even more reason to succeed. We needed to run this club successfully and gather as much information as possible. By recording our notes and compiling them into a recommendation section, we have not only made it easier for future IQPs to continue this project, we have also made it possible for Professor Wilkes to continually collect the information he wants. With future groups presumably taking our advice, they will continually collect the same type of data and John Wilkes will have information that can be directly correlated. He may want data to compare the different high schools in Worcester since this project is taking place at the five major high Worcester Public High Schools. Or he may want to collect as much data as possible to compare the different grades. He may also want to get information about demographics for his study.

Aside from taking notes to be written in our recommendation section, another way that we intended to continue this project was be to get more teachers involved. Getting teachers involved would not only give the club a better chance of surviving next year but it would also allow for the club to extend past the time frame of our IQP. This year, we were only able to continue the project until the end of C-term but had we been able to get more than just our advisor at the High School involved, these teachers could have continued the club until the end of the year. If this goal had been successful, the high school advisors would be able to begin and end the club when the WPI students are not completing their IQP at any of the Worcester Public High Schools.

Actions

Our club, The Future Scientists and Technologists Club, with the students from a local Worcester High School met 11 times. The club started on October 4^{th} with an introduction class. The introduction class was followed by four different design experiments lasting for nine meetings and then concluded with the 11th meeting as a survey and discussion session to gather information and suggestions for next year. The second class was a one week activity bringing us to the end of A-term. We explained how electric motors work, and had the students build their own electric motors. The break came at a bad time for the club, especially because the high school students did not have a break. However, it helped us because we were able to become acquainted with the students and then had extra time to plan for future classes.

In B-term, the club started with a four week activity where the students learned how a truss works. They were then given materials to design and build their own bridges, which were eventually tested with known loads. The seventh and eighth classes were dedicated to bottle rockets. The students learned about aerodynamics and the conservation of momentum. In addition, they learned several ways to keep an object in its path of motion to maximize its distance. Then they designed and built bottle rockets which were tested and discussed. The final activity, constituting classes nine and ten, was an egg drop. The students were given instruction about acceleration vs. time, distribution of forces, and special tips to keep a fragile egg safe during an impact after free fall. After given time to design and build their devices, the students' devices were tested and then discussed. The 11th and final class was a discussion class for us to give closure to the club and gather information to help conclude the requirements of the project.

Introduction Class

After several meetings with our advisors at WPI, a teacher in the ETA (Engineering Technology Academy) and our high school advisor for the club, we agreed on the first club date to be Thursday October 4, 2007. On October 4th, we arrived at the school just before the final bell and began setting up. The goals for this class were to meet the students, introduce ourselves along with our project and our project goals while also gathering information from the students. We distributed an initial survey consisting of questions related to grade, gender, interest in engineering, knowledge of engineering, and family influence towards engineering. When the surveys had been completed we discussed the name of the club. The official name, *The Future Scientist and Technologist Club* is too plain and although descriptive, not personal. We brainstormed with the students for several minutes but the students did not seem as interested as we had hoped in creating a new personalized name for the club. It was their club. We thought they would like to name it themselves but after a few ideas, the students lost interest. We then asked the students what they would like to do for club activities. They had a few suggestions of which only a couple were serious, but generally left it open-ended. It was pretty clear that they wanted hands-on activities that were engaging and fun, but generally left it up to us to surprise them.

At this point, we had gathered our information and were looking to introduce the students to the general themes of the club: the design process and engineering. To do this, we used a Discovery Channel video giving case analysis of horrific design failures and their consequences. The video included the Tacoma Narrows Bridge, a large stadium roof that collapsed, and several other large design blunders. At the conclusion of the video, we discussed the video design failures with the students. The goal of this discussion was to realize that one of the best ways to design new structures or parts is to examine the failures of previous designs. The phrase success through failure is often used to describe many current products. The students asked questions and we had a ten minute discussion. Surprisingly the students had a solid understanding of what had happened to the failed designs. At this point, the designated hour time period for the club had elapsed, so we concluded the class by giving a general schedule for the club and reminding the students to come the same time next week.

Electric Motors

The following Thursday, October 11th, we ventured back to the high school to complete an electric motor design and construction lab with the students. The goals for this lab were to teach the students the basic principles of electric fields, poles, electromagnets, and physics. After a 15 to 20 minute introduction and lesson on how electric motors function, while passing around several real electric motors, the challenge was given. The students were to design and build the fastest and smoothest-running electric motor possible with the given supplies. The class broke down into groups of two to three students and each group was given exactly the same supplies. A lab handout detailing all the parts given and the instructions explaining how to build the electric motors was given to each group. The lab handout had pictures to facilitate the students' building process.

Since the students all had the same materials and the overall construction was similar, the design element was crucial. There were only a couple of elements that could be altered to improve or hinder the productivity of the motor. The coil could be different diameters but since each group had the same amount of coil wire, a large diameter coil meant a coil that was not as thick. The height of the coil above the magnet was also up to the students. Additionally, the construction ability of the students was a large factor in determining the success of the electric motor, especially when it came to building the axis that the coil rotated on. Below is a picture of one of the electric motors:

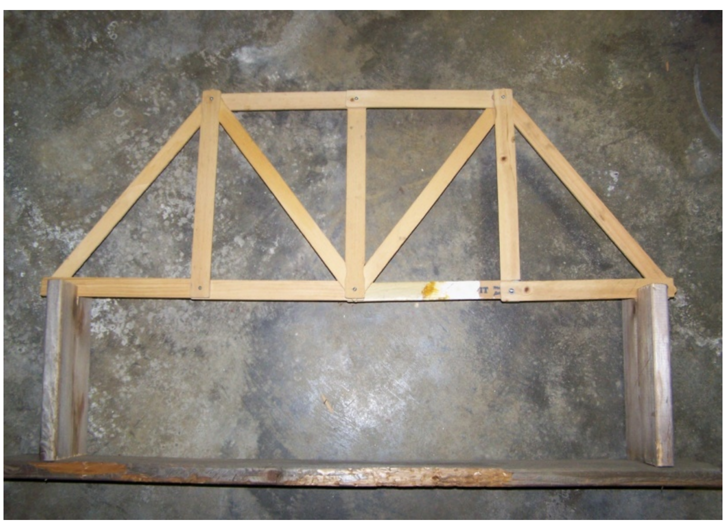
Figure 1: The Electric Motor Final Project

Unfortunately, this class ended prematurely because our high school advisor had to leave early, which we did not discover until briefly before the meeting had to end. This meant that only about half of the ten motors were able to be fully completed and even these groups did not have time to try different setups to increase the working ability of their motors. The winner of the competition was never discovered but the students had fun and learned about simple physics and electric motor principles. The class concluded with a very brief introduction to bridge building which would be the next several classes.

Bridge Building

The third class was October 25th, two weeks after the second class because WPI had fall break. This class was the first of a four-class-lab introducing trusses and designing bridges. The goals for this particular class were to introduce and teach about trusses, tension, compression, the strength in triangles, and the geometry of a bridge. To meet this goal, we used a truss made of paint stirrers. With this fresh in the students' minds, they synthesized potential designs so construction could begin the next class.

Figure 2: Our Model Truss Used To Show How a Truss Functions



The truss was approximately one foot high, and three and a half feet long. It was the equivalent of one side of a bridge, and essentially two dimensional. The truss was designed so its members could be quickly removed to see how the truss would fail when loaded in different locations. This allowed the club to have an open discussion about what the bridge will do when loaded with certain members missing. We asked the students which member to remove and what they thought would happen when the truss was loaded without it. The students responded and each member was separately removed. Would the truss fail and is the member that was removed in tension (pulling) or compression (pushing)? The students were correct that the truss would fail in every instance except one, and were about 75% correct regarding tension and compression. We were able to show that all the top members of the truss were in compression, and all the bottom members of the truss (the road way) were in tension. The diagonal pieces in the middle of the truss were either in tension or compression depending where the load was placed on the truss. We were impressed that many of the students realized that when the load was placed in one spot the selected member would be in compression, but if it was moved to the next joint on the truss it suddenly became in tension.

The one time the class was genuinely confused was when the vertical member in the middle of the truss, which was attached at the top only to the horizontal members of the truss, was removed. This member is known as the ‘zero member’. Without it the truss was able to function perfectly until the geometry of the truss was changed where it failed very quickly. The students did not seem to understand the concept until we demonstrated and the truss failed or worked accordingly. Once the students seemed to have a solid understanding of a truss, triangles, tension, and compression, we gave the students about 20 minutes to come up with potential truss designs of their own. We told the students they would have only straws and hot glue for materials, the bridges needed to span two feet, and that they would be on a budget. To prevent the students from limiting their designs to imitate our model truss, we drew several alternative truss designs on the board. After all, limiting possible solutions to a problem is one of the first steps towards a bad design. After working briefly with each group of student designers, we reminded the groups to consider the material. Straws are very strong in tension, but not as strong in compression. We stressed the importance of taking this into consideration in the design and construction process. This class was concluded by introducing the next class, which was to be dedicated entirely to construction.

The club met again one week later on the first of November. This class started with a very brief introduction of the materials given and a more detailed description of the budget. Also, with the hot glue guns in use, there was short safety brief to minimize injuries. Each group collected 50 straws, five glue sticks and a hot glue gun. The straws and glue sticks consisted of $575 of the allotted $1000 budget. One member from each group came to the front, collected their materials and then filled out a budget sheet and the building began.

This class was dedicated entirely to construction while we walked around working with each individual group giving construction pointers and last minute design tips. The students realized that the designs they had derived from the previous class, that had looked so good on paper, were significantly more difficult to build than had been anticipated. The conversion from two dimensional to three dimensional was tricky for some teams to overcome. Luckily, we were more experienced builders and were able to give some advice for the students to work through the problem. Unfortunately however, this class was extremely small, especially considering the importance of this meeting.

There were only 15 students present. Apparently there was a large deadline for a project the following day for the ETA students, which generally constituted about 75% of the club members. Although many of the usual kids were not present, they were in the building and stopped by to say 'hi' and let us know that they would be at the club the following week. We also had three new kids giving us encouragement that the club was still attracting new members. Even still, with the kids that were present, only about half were completely focused on building their bridges. We had planned on testing the bridges the next class but realized that this goal was virtually unattainable with any reasonable success. We made the decision to postpone the testing an extra week to allow for another class dedicated to building. The goal for this week's club, being heavy construction, was not reached due to lack of students and student motivation. This was disappointing but should be expected at times in a high school after school club. This class ended stating the goal for next week's class: to finish all construction for testing the following week.

The following week began the same way the first week of construction ended. There was a brief introduction for the students that were unable to attend the first building class. At this class there were 33 students present which was just more than twice as many present at the previous class. More budget sheets were distributed as more teams were created and our goals were re-stated. We needed the students to finish their bridges this class for testing next class. Even though we were concerned that the students would not take this class as seriously as they needed to, we were proven wrong. It was as if we had an entirely different group of students that were completely dedicated to building and finishing their bridges. The students worked both diligently and efficiently for the entire time and there were approximately seven bridges completed by the end of the class. Several others were still in progress and needed a little work at home over the next week. Overall, we were very pleased with the students this class and the meeting was concluded with a reminder to the students that the following week the bridges were going to be tested, whether they were finished or not.

The fourth class of the bridge building lab was devoted entirely to testing the bridges and analyzing how they failed. Our goals were to truly demonstrate the impact a good design has on a structure. Everyone had equal materials and equal amount of time for design and construction. The only difference in the final products was the amount of effort put towards the building and quality of the design and construction. Our results were better than we could have hoped for.

There were eight bridges tested, including our own. Each bridge was placed between two desks. During testing, precise weights were slowly applied to the middle of the bridge on what would be the road surface. Before each bridge was tested the students were asked what they thought of the design and how much weight it might hold. As it turned out, the results were very hard to predict as some bridges held significantly more than they appeared that they would while others held significantly less. As the bridges were weighted until they collapsed, we began to see different kinds of bridge failures. After each bridge collapsed we had a brief discussion with the students to understand why it failed. Understanding why things fail is crucial for correcting the problem in future designs. The bridges failed in three major ways. Some failed in compression, often the diagonal straws on the ends of the bridge bearing much of the load. Others failed when joints pulled apart because they were not sufficiently fastened or in one case, fastened at all, and thirdly, they failed because of their shape. At least one bridge leaned significantly to one side and tipped over before the truss itself failed.

Figure 3: Mitch Placing Weights in Middle of a Student's Bridge

The students' bridges held between 800g and 1900g, including one bridge that lost the strength of one entire side of its truss almost immediately because the students forgot to glue one joint. While primarily using the remaining side of the truss, the bridge still held 800g which was quite impressive. As each bridge failed differently, the students were really able to understand the significance of a solid design and also proper construction. Without a good design, the construction quality is virtually useless and without good construction, the quality of the design is trivial. The students had a lot of fun this class and everyone learned a lot about the design process and the significance of a good design.

As an added perk to our project, one female, who did not have time to complete her bridge in class and did not like the progress she made with her bridge, completely redesigned and rebuilt her bridge at home and took third place among the students' bridges.

Bottle Rockets

The next club activity was a two week session on bottle rockets. Bottle rockets were a good way to examine one of the most basic physics equations: P=MV (momentum= mass*velocity). In this equation, the momentum of the body at rest is the same for everyone, 0 kg*m/s, as the original rocket was at rest. What the students had control of was the mass portion of the equation which would ultimately control the velocity portion of the equation as well, assuming the design allowed the rocket to reach its potential velocity. We also explained that the conservation of momentum is what made the rocket travel. The momentum of the water out of the bottom of the rocket was equal but in the opposite direction of the rocket itself. Therefore if the water being pushed out the bottom of the rocket had a momentum of 100kg*m/s towards the ground, the rocket had a momentum of 100kg*m/s towards the sky. With this momentum, if the rocket weighed 10kg, its maximum velocity would be 10m/s. However, if it only weighted 5kg, the maximum upwards velocity would be 20m/s, twice as fast.

After the physics principles were explained and the students were able to grasp the conservation of momentum, we taught the principles of aerodynamics. When the bottle was empty its mass was minimal and air resistance was high. To keep the bottle going straight would require additions. Possible additions discussed were nose cones to reduce drag, tail cones to reduce the vacuum, although they were not practical for this experiment, and fins and wings of different sorts. The final insight we gave was rifling to keep the rocket straight. We discussed how a rifle itself works and how gyroscopes work. With this final insight the students set off to design and build their rockets.

Figure 4: One of The Students Holding a Rocket

The next class was dedicated entirely for rocket testing and discussion of results. Similarly to bridge building, we needed the students to analyze and understand the failures of their rockets to truly understand their designs. Although we had not given the students quite enough time for most groups to finish construction, we were pleased to see that four or five groups had done extensive work at home on their rockets. In total we had approximately ten rockets to launch. We had planned on using a set distance from the launcher to locate the students and a device to measure the angle from the students to the maximum height of the rocket. This would have allowed us to find the height of the rocket but weather and student distractions prohibited us from accomplishing this. We were able to discuss each rocket with the students before we launched it to see what they thought of the design and how well they thought the rocket would fly. The students' predictions covered a broad range from "it is going to work perfectly" to "the rocket is going to get demolished immediately." There were several rockets that we would have predicted to work well had the construction been slightly better. The designs were good, the weight was kept low, but the fins were not fastened well enough.

In the end, just about all of the students' rockets ripped apart, which they enjoyed watching but this also left them slightly disappointed. To demonstrate that proper design and construction will launch a rocket several hundred feet in the air, we launched our rocket. It was a simple design using fins that were securely fastened to create the rifling motion of the rocket and a medium sized nose cone. It worked perfectly traveling easily five times as high as any other rocket and leaving the students amazed.

We concluded the class with discussion of our successes and failures. The discussion was similar to the discussion of the bridges. The students realized that some of the rockets were designed well, but poor construction resulted in premature rocket demise. Other rockets were simply not well-designed, limiting their ability from the start. The rocket that flew the highest was not only a well designed rocket, but it was a simple design that was easy to build and was built well. This class concluded the club for the WPI Christmas vacation.

Egg Drop

Upon our arrival back at school, we started the final project: a two week long egg drop lab. Our goals were to teach the students about acceleration vs. time, force distribution, and how to design a device to incorporate these tasks. The first thing to consider was how to minimize the amount of force on the eggs. This can be derived from the simple physics equation F=MA. The force is the dependent variable depending on the mass and the acceleration. In this case the force is minimized with a smaller mass and smaller acceleration. The way to do that is to keep the mass of the device down and have a minimal acceleration. To do this we instructed the students to create a device that would allow it to slow down for a relatively large period of time. Put more simply, the device needed a cushion of some fashion that would give and compress or crumple as the device hit the ground. This would increase the time of the negative acceleration (slowing down) and minimize the A in the F=MA equation. The students had a difficult time understanding exactly what that meant as most of them had not taken physics yet, but they understood the idea to give the eggs a cushion with some form of material that would give as it landed. The expression we stressed to the students was to 'maximize the impact time while minimizing the impact force.'

Another important concept was to distribute the force on the eggs as evenly as possible. An egg is actually very strong, and can take a large force when distributed evenly across the shell. It is a similar principle to wearing a helmet. The human skull could easily be crushed if hit with a blunt object, but with the use of a helmet to distribute any force, the skull remains unharmed after impact. The students understood this aspect well. In order to get the students to think of this project as an actual engineering problem, we related the drop to a car crash. We showed a few brief videos that included two car crashes and a segment from the television show *Sport Science*. The *Sport Science* clip was a segment about head injuries in sports and fit very well into our egg drop discussion as we related the human in a car to the eggs in the egg drop device. With the information given to them by both the videos and our discussions, the students were ready to design and build. However, at this point we were pretty much out of time so it was up to the students to build their egg drop devices at home. This is a little more difficult and was not our goal, but with time constraints, it was a reoccurring reality.

The next week was testing week. Due to the fact that some students had been busy, about half of them had forgotten to build an egg drop device. When told they would be given approximately 20 minutes at the beginning of the class for construction, three groups were formed and students eagerly jumped at the opportunity to take part in the drop. All three groups finished a device. In all, we had seven dropping devices. The goal for this class was similar to previous testing days. The students were to predict the result before the drop and then analyze the result after the drop and the success or failure of the device.

In the end, four devices, including ours, were successful at keeping both eggs intact when dropped from a height of ten feet. Once again, the students realized that some of the best designs are the simplest designs. One of the devices that worked used bubble wrap to wrap both eggs individually and then taped the wrapped eggs together. It was a simple design with good construction and worked perfectly. Some of the other designs were more elaborate but poorly built and failed. One of the groups that formed the day of the drop managed to put together a well-built device. At first look, this device seemed as if it would instantly fail, but everyone was proven wrong as their contraption worked to perfection. They used every principle we had taught them and since it worked, it pleased both the group and us as mentors. Even though some of the students still did not have the most solid construction for their egg drop, all students were slowly realizing how construction caused much of the failure and that construction quality truly is a very significant portion of the success of the design. Even though most groups had inconsistent construction, the students really seemed to enjoy themselves during this project. The joy on their faces as their devices came to a crashing halt was truly memorable. We would have loved to take pictures from this project, however one of us was unable to attend the meeting and picture taking was just not possible.

Our design was simple, easy to construct and against everyone's predictions, worked perfectly. We used a large can that was half filled with sand when two eggs were placed inside and then filled the rest of the way with sand. There is no real increase in acceleration time in this design but it distributed forces evenly throughout the egg rendering two unaltered eggs after the impact. This concluded the final lab for the class and we reminded the students that the next class would be the last club meeting and would include a discussion session with pizza provided.

Pizza Class

The following class was the 11th and final class meeting on Thursday February 7th, 2008. The purpose of this class was to remind the students of our goals for the club, to discuss the success of the club and possible suggestions for next year. We also wanted to give a couple surveys to the students for us to analyze and gather information to help conclude our IQP and examine the success of the final project. One survey was based entirely on the egg drop, while the other was more general and focused on the club as a whole. Once the students were all in the classroom and settled down, we distributed our final surveys along with the egg drop survey. All three of our advisors were present for this meeting due to the importance of the final class. The students then completed these two surveys and returned them. After all the surveys had been returned, the students were allowed to grab some pizza and beverages that we had provided and our discussion began. For about half an hour we discussed with the students what they liked about the club and what they didn't like about the club. We discussed what they expected of the club vs. what the club was and what they thought of our design labs and what we could have done differently. Discussion slowly ran thin as we were taking notes and had collected all the information we needed. We thanked all the students for their participation and dedication and adjourned the club for the year.

Results

When we first started the IQP this year, we had many goals in mind and many ideas of how to fulfill those goals. However, as time continued and we had the club running, those ideas changed and adjustments had to be made. Our main goal was to introduce the many aspects of engineering to the students at our given Worcester Public High School in a fun and interesting environment, while possibly encouraging the students to consider engineering as a career choice. Basically, we wanted the students to understand everything we were teaching them about engineering. We also wanted them to be engaged with our activities and stay committed to the club. On a week to week basis, there were anywhere from 12 to 33 students, mostly a core group minus a few we gained along the way.

We feel that we accomplished our main goal and we also feel that we did it correctly. We wanted to introduce the aspects of engineering but also keep the students engaged. We needed to do this in a safe, fun and interesting environment. Of the four projects completed this year, all were hands-on and successful. We followed our plan by introducing each topic at the beginning of class and then starting each activity towards the end of the class. If needed, the activity would be finished in the following meetings. The short lectures gave the students basic background information and included everything from short video clips of car crashes to physics equations to describe what happens when we launch our bottle rockets.

Each activity was related to a real-life topic or project that engineers work on. Our first project, the electric motor, was definitely something engineers work on. Our motors were not as extravagant as current motors but the students had to figure out the project with the mindset of an engineer. The straw bridge building was very similar to a real truss bridge and we showed the kids pictures of different styles of trusses. The bottle rockets were used to teach the students basic physics principles and equations and after we launched the rockets we discussed what we had done. The students finally realized what the equation (P=MV) meant because they had seen it work in person. The egg drop was related to a car crash, where the students had to build something that would protect the egg, similarly to how engineers that work on automobiles design to protect the passengers inside from sustaining injury. By quietly combining engineering, physics and mathematics into fun experiments, the students were able to learn in a fun environment without even realizing that they were learning.

One of our goals when coming into this school year was to establish a good relationship with our advisors at both WPI and our Worcester Public High School. We planned on meeting with our advisors here at WPI about once a week to discuss new information and continually update them on our progress. This goal we met very easily and successfully. Professors Kenneth Stafford and Bradley Miller proved to be a large part of our success in running the club, assisting us with our goals and working through our entire IQP. Our advisor at the High School was also a huge help and her efforts were considered just as, if not more, important to the existence of the club as our advisors at WPI. Professor Stafford and Professor Miller were our motivation and guidance for the social science aspect of the program. Our high school advisor, on the other hand, was a large help facilitating the project by keeping the students interested and updated week to week with afternoon announcement reminders. She was also crucial for maintaining equilibrium inside the classroom, keeping the commotion to a minimum. We are truly grateful for all of their help.

Our next goal was to successfully continue this project from last year and we believe completed this goal with great satisfaction. On the last day of our meetings, where we handed out a couple surveys and gave the kids pizza while we had an open discussion about the club, the students all seemed disappointed that we would not be continuing the club into the spring. We could not continue because of our time constraints with the project at WPI and the kids fully understood but wished it did not have to end so early. We had planned to run the club successfully by:

- having interesting hands-on projects every week,

-extensively planning our schedule for the club, and

-providing food and drinks for the students.

We succeeded with fun and exciting projects as the kids loved every project we did and most kids requested that they be done again next year. The food and drinks were actually more of a factor than we had hoped. At the beginning it seemed as if kids had come merely to have free food and see what the club was about. This gave us a chance to talk to the kids and get them both interested and involved. Just as hoped, the food at the beginning of class came in handy for two reasons. Number one, after a long day of school, students were most likely tired and hungry and what a better way to attract people than free food and drinks. Reason number two was that while the kids were keeping their mouths busy with food, we could begin each class with a short lecture without being interrupted. The food successfully kept the students quiet while we lectured for the first

20 minutes or so which allowed for little interruptions. We continually had new members to the club and the food was partially to thank for that.

When we went to our first meeting with the high school club, we gave a quick survey and told the students what we hoped to accomplish with the club. We did not have a definite schedule on a calendar for the students but we did have a good idea of what we wanted to do and when we wanted to do it. A few bumps along the road however prevented us from running the club exactly how we had planned. We had originally planned on a field trip to WPI with the students, as it was recommended by previous IQPs. Our high school advisor however did not think it would be a good idea due to the amount of planning required and the result of last year's trip where professors were irritated by the high school students' non-stop commotion. We were actually saddened on the last meeting when many students told us they had wanted to come to WPI to experience a real college campus. We did not do this because they did not speak up in class when we considered the trip. However, even if every single student wanted this field trip to the n^{th} degree, we had a feeling that our high school advisor would not have allowed it. Also a few meetings were cut short because of time constraints and one meeting was actually canceled by our advisor because she had an appointment she could not miss. This pushed us back a little but did not affect us negatively.

At the beginning of the club we had also planned on having, along with the hands-on experiments, at least one lecture by a WPI professor and a demonstration of a computer operated 3D router like machine that the high school has in one of the engineering rooms. The 3D router plan never got off the ground because we could not find anyone who knew anything about the machine at the high school to assist us with the basics and this was considered a failure. We were upset with this because many students had expressed interest in this specific activity. The lecture by a professor was to be a demonstration and lecture from our WPI advisers Professor Stafford and Professor Miller, but due to scheduling issues with the club and vacations it was decided that it would be best not to use this particular demonstration. At this point there were not enough club dates left to get another professor presentation for the club so this goal was never reached.

In order to add to the consistency of the club, we thought multistage projects would be a good idea. We originally thought that if we did a new and different project every week, students would be more likely to skip a meeting because it was only one project they would miss and there would be many others. By giving the students activities that took longer than one week to complete, more time and effort would be required on their part. This idea was only partially successful. It worked because the students wanted to come every week to complete their work on each project. They wanted to finish what they had started. This also gave room for students who had missed a meeting on a project to catch up with the class. It was not fully successful because students often missed one week of a two week project which made it very difficult for the these students to have the desired participation level. Many students missed classes because of prior engagements to other clubs and/or transportation issues. We feel that if we had done single week projects they still would have missed classes. We found out that multistage projects were, in fact, a good idea on the last day of our club. When asked what to change for next year, many kids expressed the need for projects to be longer and more involved. They wanted projects that would keep them entertained for a few weeks, which was exactly what we wanted to hear as that had been our goal while planning most of the activities.

Working in groups is very common for the average engineer. The more people in a group, the more experience and knowledge present and therefore the chances of an innovative successful design are increased. Groups that contain too many people, however, have a more difficult time coming to agreement and that is not what we wanted to achieve. We wanted to give the students a taste of the engineering world so we had them work in groups of two or three. This taught the students how to act in a group and how to respect each other's ideas. For the most part, the students seemed to work great with each other giving their own input to each project within their respected groups. Working in groups also adds to the consistency of the club, making kids not only come for their own benefit, but for the well being of the group. We feel this was a large part to our success.

For our own research, we felt it was necessary to give the students surveys from time to time to collect data about what the students were thinking. We originally planned on giving a survey every couple of weeks just to see how they felt about the club and what they liked or disliked. We eventually came to the conclusion that we would give the students an initial survey on the first day of the club, a final survey on the final day of the club and a survey after the completion of every project. The initial and final surveys were directly compared to obtain results on how much the students learned overall and if we had encouraged them to consider engineering as a career choice. The other surveys were exclusively about each individual project and gave us feedback accordingly. This feedback included: the number of kids coming to each meeting, the percent of those kids that were freshmen, sophomores, juniors and seniors, the percent of ETA students that came, the male to female ratio, the students input to each project, their suggestions for future clubs and also to find out how much they actually learned from doing each activity. On our very first meeting, we asked the students to brainstorm some ideas for a new group name instead of *The Future Scientists and Technologists Club*. We thought asking the kids to choose their own name and asking for their input was a great idea because even though this was our project, it was their club and they should have a large influence on what goes on in their club. These results will be discussed later in this section.

A large goal of ours was to attract females to our club. We not only wanted to attract them, but interest them enough to come back every week to our meetings. A large problem in the engineering field is the small number of female engineers. While the number of female engineers in the workforce is increasing, the ratio of male to female engineers is still very much uneven. The Minerals, Metals and Materials Society (TMS) released an article in their Professional Preface last year about this exact issue. They claim that this small number is due to isolation in the workforce. These female engineers have no one to relate to and therefore feel isolated. They also claim that we do not need to attract more females to the field of engineering, but rather to keep the ones that are already in the field. The TMS states that "even at schools with the highest numbers of women enrolled in their engineering programs, the percentage of women students rarely extends over 30 percent." They also talk about how females only account for 19% of undergraduate engineering students in the United States. The number of female engineers is going up however and they give numbers to prove it. The TMS claims that currently, only 9% of engineers are made up of women, compared to a mere 2% in 1978 (http://www.tms.org/Students/ProPref/9802/WomenEngineers.html). As a part of this project we would have like to have raised awareness about this issue and try to address it ourselves. This is one goal that we did not accomplish. Our goal was to attract females to the club, but looking back, we made no specific actions to do so. We never had any activities designated specifically for the female population. Our activities were generated more towards touching on many types of engineering and making the projects as fun as possible for the students with the hope that females could come. It was not thought through enough and the time constraints were, again, a large disappointing factor.

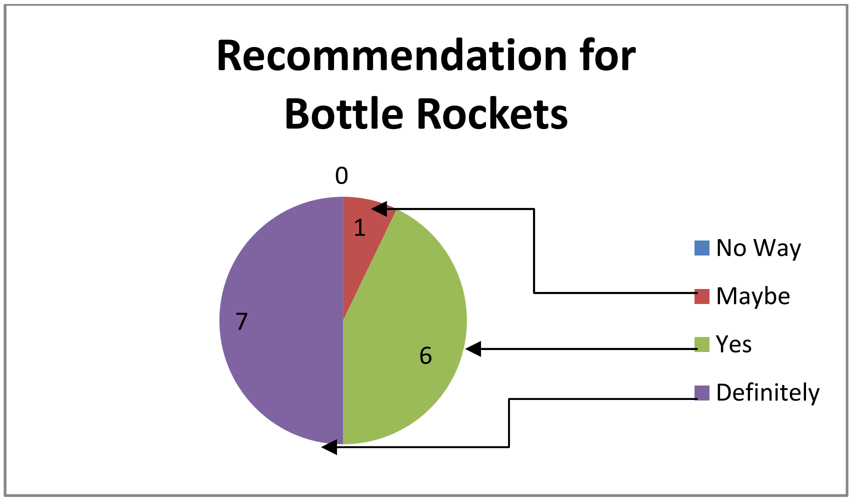
As we are training to become engineers, we know the importance of realizing our failures and using them for guidance and help in the future. This is what we wanted the students to also understand. We knew that each project would not have a success rate of 100% and therefore there would be failures. After each separate activity was tested we had an open discussion with the class. We talked about what caused the structure to fail, what could have been changed to prevent this and also why each successful project worked the way it did. By asking the students what went wrong, we were asking them to look back into their design and construction and truly understand their design. This is important not only in the world of engineering but it is also useful for everything they will do. Realizing one's mistakes and moving on is a large part of life and we hoped to give the students a little guidance with this subject. Surprisingly, during discussion about each project failure, the students were able to correctly identify what went wrong. Often, they were also able to figure out how to fix it if they were to retry it.

Another important goal was to record and take notes throughout the course of the club to enhance the club overall. By taking notes, not only were we helping ourselves by determining how to approach certain aspects of the club or finding out what not to do, we would be filling in an outline for mentoring IQPs to come. Much of our findings will be discussed in the Recommendation section of our IQP. The notes we took were made from survey results, reactions to projects and anything said in class that we thought would be helpful. This was useful because we were not exactly sure what kind of information would be useful in the greater research project with Professor John Wilkes. We continually took notes. In that manner, we succeeded in helping Professor Wilkes.

Our last goal was to try and get more teachers at our High School involved in our club. With more teachers than just our advisor involved in the club, the club would be able to continue through this school year. Those teachers could then start the club at the beginning of next year before next year's IQP group could begin. Sadly, this goal never even came close to completion. Our high school advisor discouraged us at the beginning of the project when we first met with her but we decided to try anyway. She told us that no teachers would want to stay after school with us especially since there was absolutely no funding for this club and they would not be getting paid any extra if they did participate. For a simple example, we needed information about the 3D router and continually asked our advisor. Every time we asked her, she would respond by telling us no one knew how to run it or they did not know where the cables to hook it up were. It was as if the teachers knew we were trying to do a great thing for not only the club but for the school but were not even willing to help us figure out where to start. If this is the case, the school has a very productive learning device that will never be used because the teachers do not have the funding or ambition to take the first step towards using the machine. This device was not part of our advisors department so there was not much she could do personally to help except ask upon other teachers.

All of the activities we planned for the kids were well received by the club. Some more than others but it seemed that everyone loved each project we worked on. Overall, the most liked project was the bottle rockets. On the final survey, we asked which project the students liked the most and 62% of the class responded with ‘bottle rockets.’ Not only did we have a very fun time in class building these rockets, but the students took a personal interest in designing their individual rockets to be better than everyone else’s. There were many different designs and some students even took the time to take their projects home and decorate them. One group spray painted theirs to look significantly better than everyone else’s while another group hot glued a Dunkin’ Donuts logo on the side of the rocket for entertainment. It seemed that everyone took a serious interest in this project because it was something they had never done before. They all wanted to see how it would work and how high they would fly. Each group also wanted to have the best rocket meaning there was serious competition between groups. To determine if this project was a success we asked the students on the survey for the bottle rockets if they would recommend this activity for next year. The results are as followed:

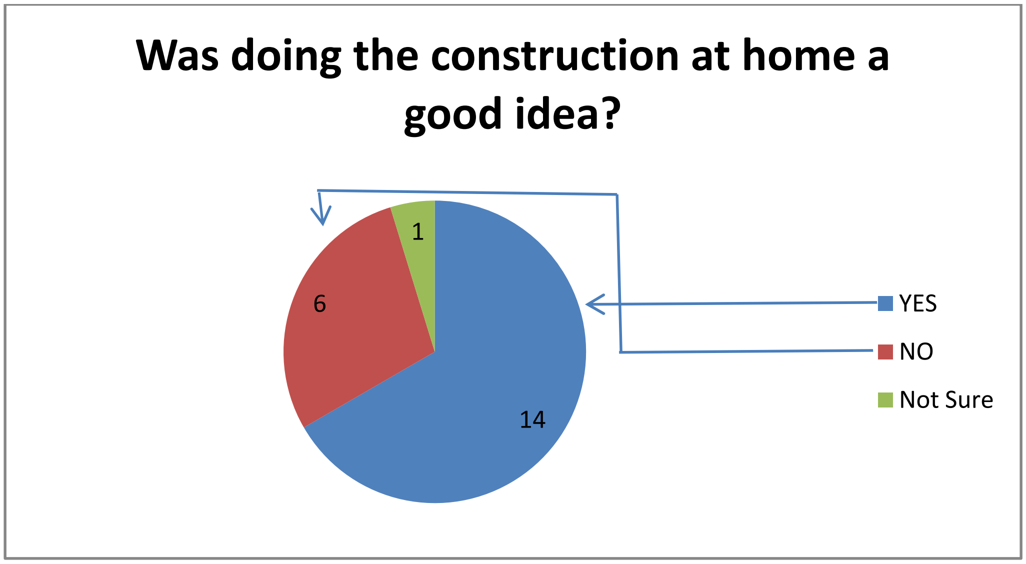
Figure 5: Recommendation for Bottle Rockets to Be Done Next Year



We also asked the students how much they had learned from this project on a scale of 1-10 and the average answer was 7.5. As sort of a two part question, we asked the students to name some important aspects to consider when building a rocket and 13 out of 15 students wrote down at least one important point, such as weight or aerodynamics, while the other two left this question blank. We were very pleased with these results.

The project that received the most praise other than the bottle rockets was the egg drop. This was the only project repeated from last year and fittingly, the students loved every bit of it. Apparently there is something exciting about watching an object fall with the anticipation of explosion and destruction. This project received 24% of the votes for best project on the final survey. Even though it seemed that the students put a great deal of effort into their contraptions and each group thought they would pass, they took great pleasure in watching their eggs break. The thing that we were worried about but wanted to test was at-home construction. We did not know if making the students build their contraptions at home would be a good idea but it turned out okay. We even asked them on the egg drop survey if they had like the idea of doing most of the construction at home and they responded:

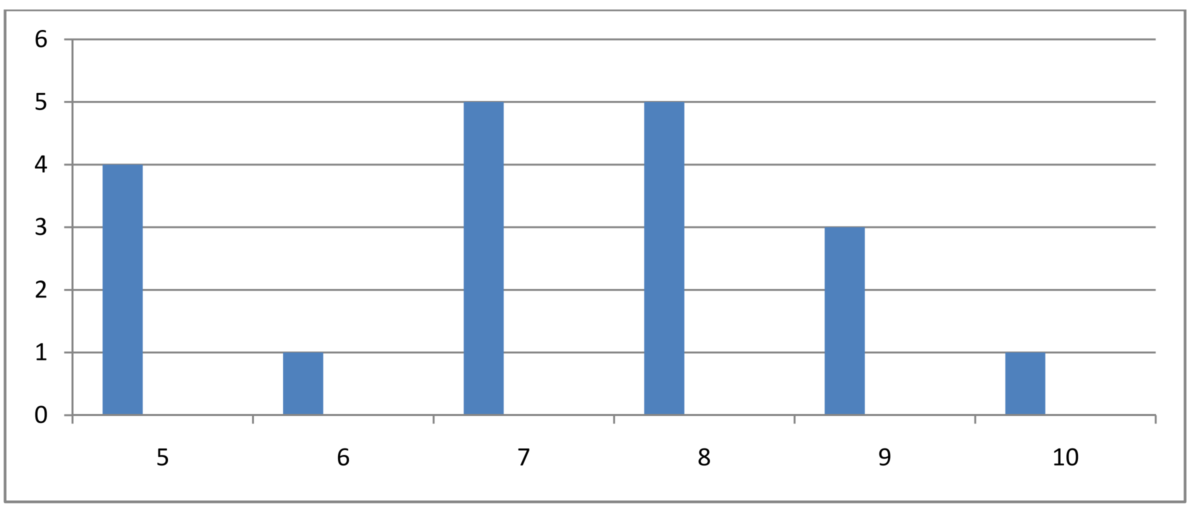
Figure 6: What The Students Thought About Doing Construction at Home



In the egg drop survey, we asked them a difficult question and gave them four options to choose from. All of these options were extremely similar, making the question even more difficult. Sixty percent of the students got this question correct and we feel that 60% on a difficult question with four possible answers is enough to determine success. If we had asked this question before our discussion on the egg drop the percent of students who got this question right would have statistically been about 25%.

The Bridge building classes seemed to be a class favorite while in progress but our results proved otherwise. Even though everyone had fun with the bridge and everyone would recommend it for next year, only three out of 21 students selected bridges as their favorite project. We were extremely happy to discover that the only open-ended question we asked on this survey, "what it means to be in tension/compression," was correctly answered by 80% of the students who took the survey. When we first began this project we gave the students lab handouts that included the materials they could use and we put a price on each item. The only items they could use were plastic straws and hot glue. Each additional glue stick and/or straw used would cost money from their budget. In order to get additional supplies, the students would have to bring up their lab sheet and we would mark down the cost of each item taken and it would be subtracted from their budget. This method however was eventually discarded when many of the groups lost their budget sheets. At least half of the groups did not even use all of the original materials allotted to them that only consisted of $575 of their $1000 budget. From this we achieved our overall goal of keeping material distribution even but more through the student group's inability to use all the material given to them in the construction time than with the budget sheets. The last question we asked on this survey was how much the students had learned from our discussion and testing on a scale of one to ten and they answered:

Figure 7: On a Scale of 1-10, How Much The Students Learned From Bridge Building

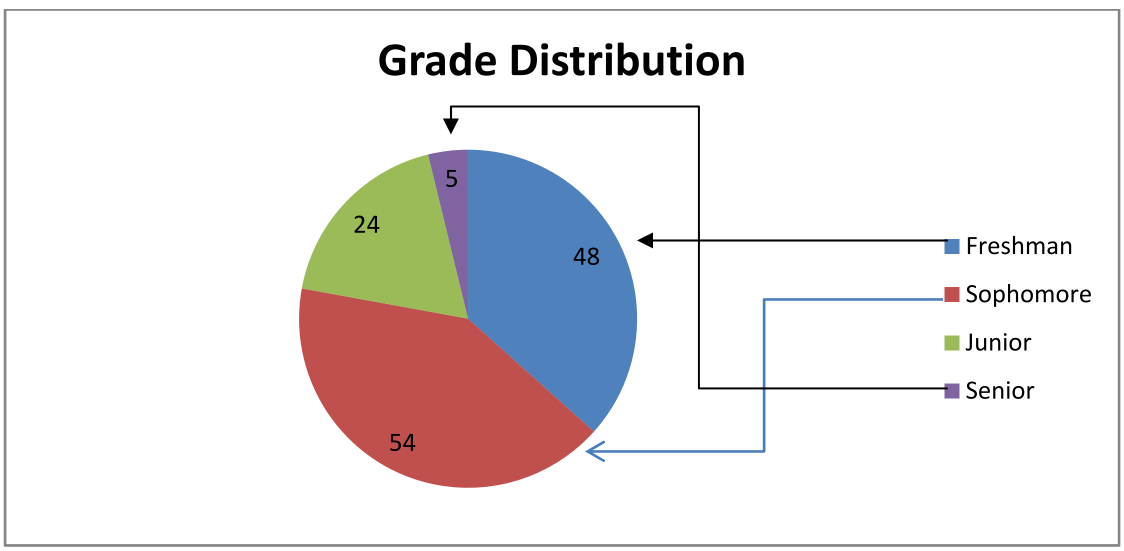


↑ # of students 5-10 on the scale

It seems like a shame to call it this but the least liked project was the electric motors. This may be because it was only a one week project or because not much was involved in it. Other reasons include the fact that the only class we had for building the motors was cut short or maybe it was because it was our first project and we were still learning the best interaction method with the students. When given a scale of one to ten and asked how challenging they thought building the electric motors was, the average answer was an eight. One good thing that came out of our club was the spread of our club's name from our members. After the completion of the motors, we gave them the second survey of the club and we asked them if they had mentioned this specific experiment to anyone outside of the club and 83% responded 'yes.'

Our most useful way of obtaining information and concluding our results would be to look back at the class attendance sheets, summaries, and surveys. However, some of the attendance sheets were collected by our advisor at the high school and we were left without some statistics for some classes. On average, we had 22 students at each meeting with about 15 (68%) of them being male and the remaining 7 female (32%). The distribution of grades on average is displayed below:

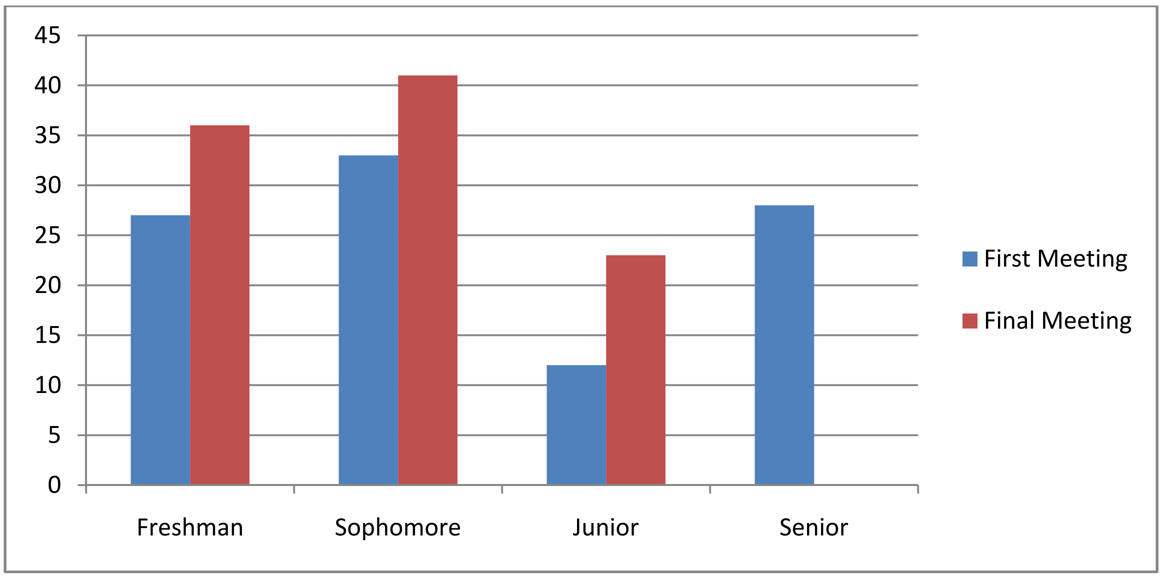
Figure 8: Total Number of Students From Each Grade That Came To The Club



Also, with the average number of students per class being 22, 72% of them were in the ETA.

Even more useful than looking back at our project surveys, would be to compare the initial surveys to the final surveys. When we wrote the final survey we tried to base it on the initial survey as much as possible to obtain both qualitative and quantitative information that could be directly compared. One thing we noticed was that throughout the course of the club, the average age of the students decreased and our data proves it:

Figure 9: Average Age of Students at Initial and Final Meetings

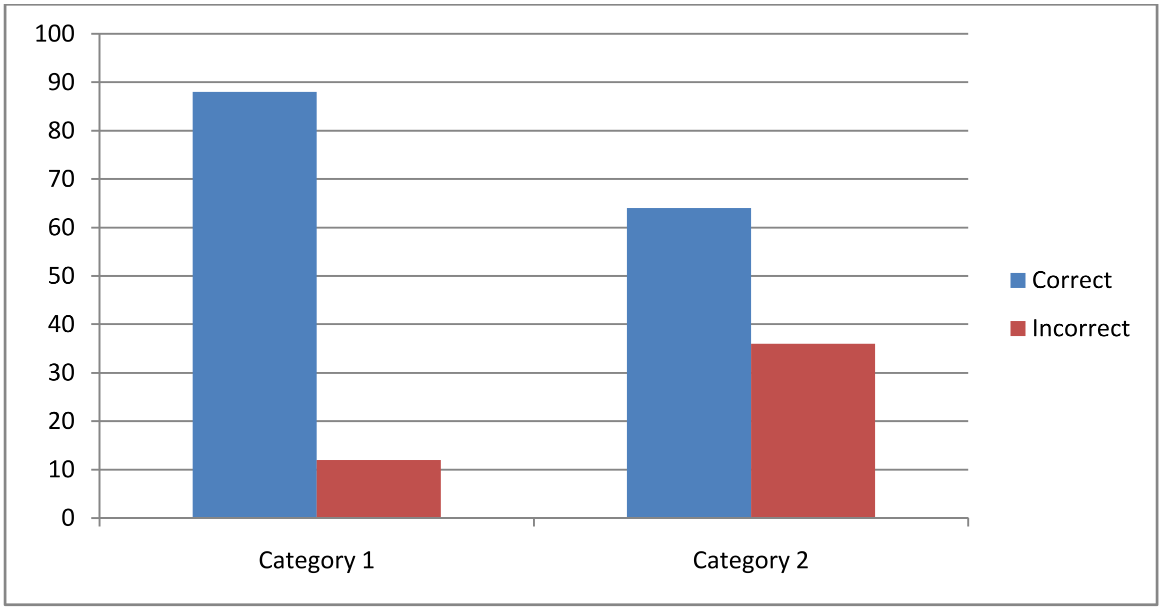


↑ Percentage

This drop in average age can be attributed to attraction to the club by the younger grades. It may also be due to the older students having sports in the late winter including volleyball and indoor track. The gender equality also became worse throughout the course of our club. The percent of females in the first meeting was 39% compared to 23% in the final meeting. This is most likely due to the fact that we did not willingly do experiments that would entice females. They would have preferred activities having to do with biology or another type of science but we were not able to do that and therefore, we did not succeed with this goal.

Another question that was asked in both surveys was an open-ended question asking the students to give the meaning of engineering. The very first survey contained 88% correct responses to this question while only 64% of students got it right on the final survey.

Figure 10: What is Engineering?

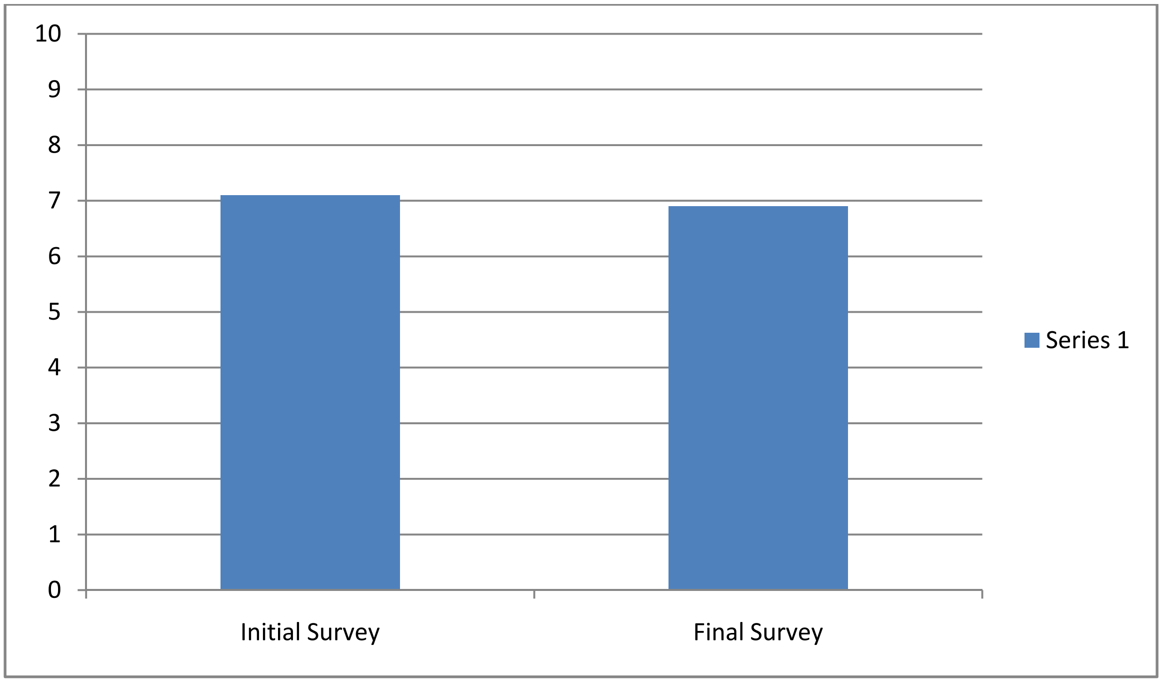


This may be due to the drop in average age of the students. The older students, that may or may not have been part of the ETA, could have known the meaning but the younger students that became involved in the club towards the end did not know the meaning. Also, a lot of these questions were never filled out and left blank and had to be marked wrong. This could also be due to the students just wanting to fly through the survey and not take the time to answer an open-ended question. At the final class the students were given two surveys and a couple of them complained about the surveys being too long. Thus, skipping open-ended questions is definitely a possibility and would severely hinder our results.

In order to see how many returning students we had from the previous year, we asked the students if they were returning members on the initial survey. Forty-eight percent of students said they had been members last year while 52% were newcomers. On the final survey, we wanted to see how many students had stayed with the program for at least two years. Of the students who attended the final meeting, 59% said they were members last year. This is more evidence that we successfully continued the program into and throughout this year. We also found out that about 27% of the students at the final meeting were not present for the first meeting. This suggests that we attracted new members along the way. This was not exactly a goal of ours, but it is definitely a positive aspect. It does however relate to the consistency of the club, which was one of our goals.

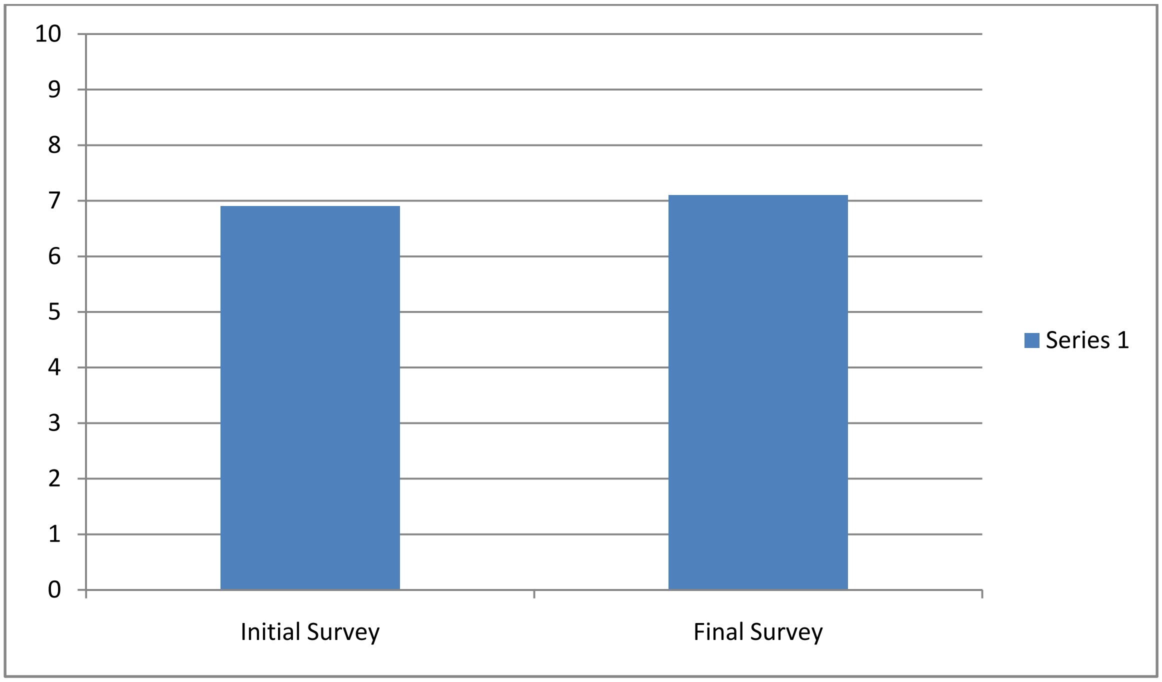
As part of our main goal, we wanted the students to consider pursuing a career in engineering. We asked the students to rate their thought of becoming an engineer on a scale of 1 to 10 on the initial survey and the class average was a 7.1, compared to a 6.9 on the final survey.

Figure 11: On a Scale of 1-10, How Much The Students Would Consider Pursuing a Career in Engineering



This data conflicts with our view that we successfully persuaded the students to consider engineering as a possibility. The drop of .2 means the results are essentially the same as the initial survey, but we were looking for a significant increase on this question. We feel this data is skewed however because there were three girls who each recorded a '1' on that scale because they did not want to become engineers, but they did love our club and attended as much as possible. Without these three answers, the resulting mean would be an 8.1 and would indicate that we successfully changed the students' minds to consider engineering as a career possibility. Merely on accident, we asked this question twice on the final survey with slightly different wording and to our astonishment the average was only different by .1. This helps prove the validity of the survey takers. In addition to asking the students if they would consider becoming an engineer when they grow up, we asked them if they would consider going to an engineering-based college and the results were quite similar. On the initial survey the mean was a 6.9 compared to a 7.1 on the final survey. The mean did rise, just slightly but it did increase. This indicates our goal was completed.

Figure 12: On a Scale of 1-10, How Much The Students Would Consider Going to an Engineering-Based College



Conclusion

After some initial confusion about what made this project more than a simple service project, we decided that we would still complete the project we would just need to add a research component. This meant we would need to gather information from the students to have documented results when our project was completed. To have results you have to have goals and objectives upon which to base the results. Thus, we started synthesizing goals and writing them down.

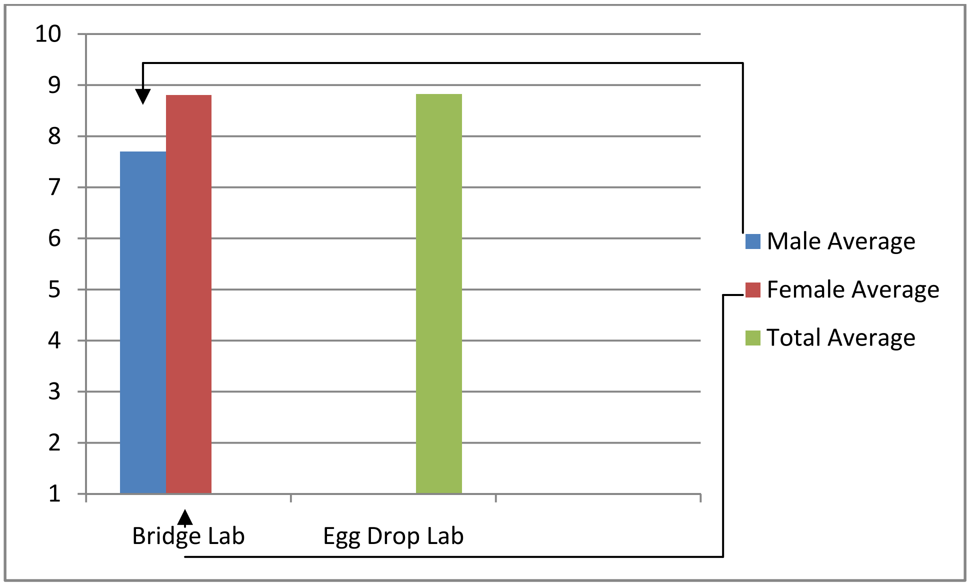
When our major goals were on paper, we decided to rank them from our highest priority to our lowest priority. At the top of our list were a couple goals that we really wanted to accomplish, felt we could accomplish, and would leave us feeling successful if we were to accomplish them. A main goal was simply to have fun with the students. If the students attending our club were not having fun they would stop coming. If they stop coming, the rest of our goals would be completely out of reach. To accomplish anything we deemed productive, we needed the students to enjoy coming to the club every week. If we could accomplish this goal, one of the next most important goals was to influence the students towards pursuing an education and possibly a career in engineering. To do this we realized we needed to expose a variety of kinds of engineering to the students. Not all engineers want to be civil engineers or mechanical engineers. To persuade as many students to consider a future in engineering, we needed to use experiments that were fun and hands-on. Another one of our large goals was to gather information that we could give to the students who run the club next year to help make next year's club as successful as possible. This goal could be reached simply by observing what worked well and what did not and by getting feedback from the students. These suggestions will be discussed after the conclusion. This was the last of the goals we thought were most important. Other goals we had that were less significant were to get more females involved, stress the importance of teamwork for design success, and possibly get the club to be self sustaining within the high school.

With all of this in mind we made a tentative lesson plan for each class before the first club meeting. This schedule had a few alterations as the club progressed, but was a strong plan to fall back on when needed. Upon coming back from our fall break, we attended a meeting with the students from the other IQP groups doing very similar projects at other public high schools in Worcester. It was not until this meeting that our IQP fully made sense. We learned of Professor John Wilkes's research project and how everything fit together. Unfortunately, we realized this a little too late and decided we did not want to alter our goals to match Professor Wilkes's goals exactly, but there was overlap between his goals and ours.

Our results for the four project surveys were convincing and exactly what we wanted to see. With the individual surveys after each activity the students generally understood the major concepts we were trying to teach. For example, one of the concepts we stressed in bridge building was the direction of force for each member of the truss. The force will either put the member in tension or compression. When we asked the students what it means for a certain link of the truss to be in tension or compression, nobody knew. On the survey after the lab was complete we asked the students what tension and compression meant, and 16 of the 20 kids answered the question correctly. This meant that they were learning our main points. We also asked how much they enjoyed the lab and the average answer for males on a one to ten score was a 7.7 while it was 8.8 for females. Not only did they learn a lot but they really enjoyed the lab. In addition, all 20 students recommended it for next year. We could not have asked for better results. Our main goals were to have fun, and persuade the students to consider pursuing engineering, and these results prove they had fun and learned a lot which can be correlated to the students desiring to become an engineer. As stated earlier, we feel our results on the final survey shows this if we remove the three surveys from the girls who answered 1 because they had fun at the club just did not intend to be engineers. It was interesting that the female average was a full 1.1 higher than the male average was. Granted the female group was only six students, which is not large enough to have extremely accurate results, but it still suggests that females might be more apt to follow a civil engineering path than a mechanical engineering path. Also quite possible is the simple solution that the high school boys just like to see things move and crash and the bridges were designed to remain static.

Similarly, with the egg drop lab we asked a difficult question regarding time and force upon impact (see appendix under Egg Drop Survey for exact question). The answer was to minimize the force on the egg and maximize the acceleration time as it landed to keep the egg safe. Sixty percent of the students answered it correctly while probability would say only 25% would answer correctly with random guesses. For a difficult question, we were very pleased with this result. The students said they liked the lab an average of 8.82 on the same one to ten scale. This class was 75% male and the average was higher than with bridge building quite possibly because there was more destruction and the male students certainly made it clear that they liked destruction. Either way, it clearly shows that the students were having fun and learning at the same time which meets our goals perfectly. For the students to even consider a career in engineering, they have to have fun with our experiments and understand the concepts we were discussing.

Figure 13: On a Scale of 1-10, How Much The Students Enjoyed The Egg Drop and Bridge Building Labs



We felt quite confident that we were completing our main goals of having fun, introducing types of engineering while getting the students to considering engineering and gathering advice for next year's club. Two out of our three secondary goals were not quite as successful however. We had hoped by doing these hands-on, fun activities that more females would come to the club, but we were wrong. Actually, our female attendance decreased.

Figure 14: Number of Students at Various Classes During The Club

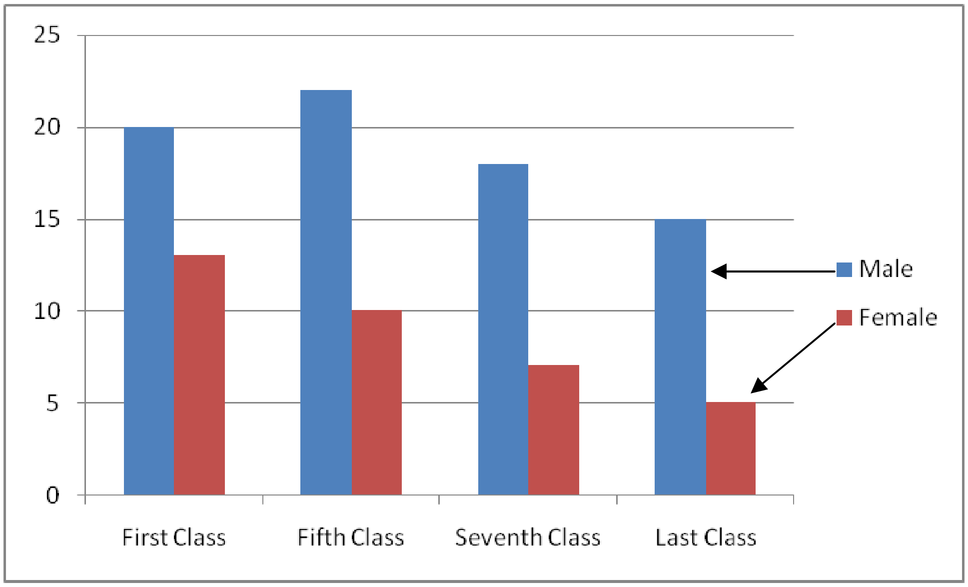
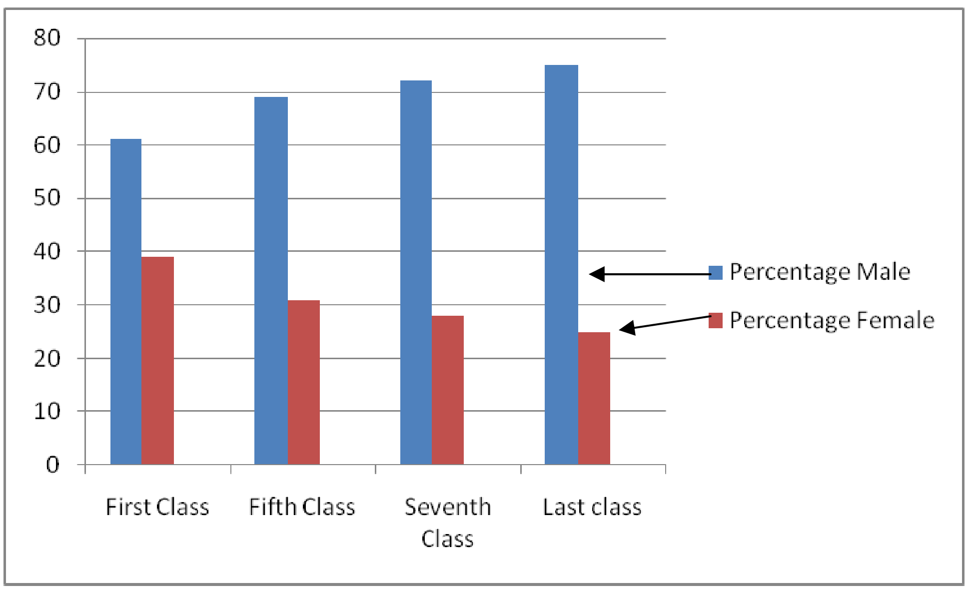


Figure 15: Male to Female Ratio at Various Classes During The Club



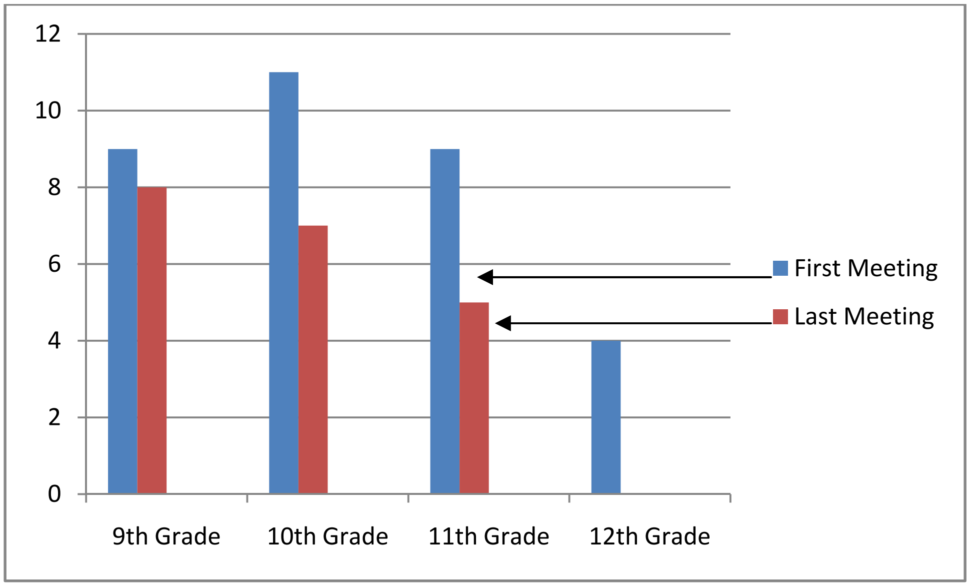
These charts clearly show that not only did the number of females attending the club decrease steadily, but so did the percentage of female students. We were slightly disappointed to see this, but since this was a secondary goal and not one of our primarily goals, it was not a significant concern.

The second secondary goal that we found no success in was the self-sustaining club goal. Our advisors suggested we discuss, with teachers, the possibility of them being involved with the club so next year WPI students are not needed. The teachers could run the club by themselves and for the entire year if desired, instead of the shorter time that the WPI students can run the club. This goal never even came close to becoming a reality. The teachers expressed no interest in working extra without compensation. It was really quite discouraging. It makes us realize how lucky we were to have such a great advisor who did not get paid to stay after school with us and help run the club. We planned and controlled everything; our advisor simply had to be there as the adult in charge and to help keep the students in control. We do not see this goal ever becoming a reality without some form of incentive for the teachers.

The one secondary goal we were able to accomplish was teamwork. It is a reality not just for engineers but for many careers. We thought it would be a good idea for the students to work in groups on their projects and it would also reduce the amount of materials we would need. The students always worked very well in their groups. Most groups were just two or three students but others were as large as five. The group work overall was a huge success and made it much easier for us. We can spend more time with groups if there are ten groups of two or three students than if there are 25 individuals.

When we received the results of our final survey and compared these results to the results of the initial survey, we were surprised. We did not get the exact results we expected and certainly not the results we wanted. There were seven fewer kids at the final meeting with a much higher percentage of males.

Figure 16: Number of Students That Attended The Last and Initial Meetings

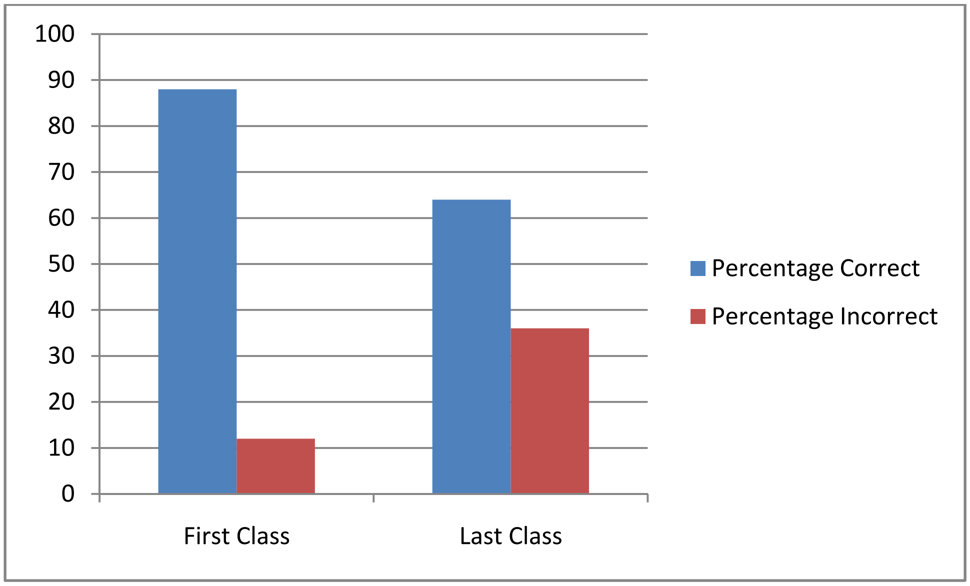


As this chart shows, not only did the number of students decrease, but so did the number of older students. At the first class the number of freshmen, sophomores, and juniors were about the same, with a few seniors. By the end, the club was primarily freshmen and sophomores with a few juniors and no seniors. Our club numbers were up and down from a low of 15 to a high of 33, but generally the numbers were between 20 and 25 which was a perfect size for the two of us to handle. With each additional student past the optimum number of 25, it gets more difficult for us to spend time with each group of students. Having an idea that this would be about the number of students we would have, we did not choose to increase the club size as one of our goals.

On the first and last survey, we asked the kids what they thought engineering was in their own words. Here are the results:

Figure 17: Percent of Students Who Correctly Stated What Engineering Is

at Initial Meeting Compared to Final Meeting



Sadly 88% of the students had an answer that we called correct on the first survey and on the final survey only 64% had an answer we accepted. We accepted answers that included but were not limited to using the design process, developing new products, and designing. We did not expect them to have the perfect definition, just something that let us know that they had an idea what engineering was. We never fully gave them our definition of "problem solving using technology" until the final class. We wanted them to develop their own definition through our labs, but somehow, the results were worse on the final survey than on the first survey. We are not sure exactly how this happened. A possible reason is that as the club went on, and especially at the final meeting, the students were much younger on average than the original meeting where we gave the first survey. We had a pretty consistent core group of kids at the end that seemed to really know what they were doing and we thought they would have a solid definition for this question. Eighty eight percent correct is high for the first survey. We might have expected that for the final survey, but the results seemed to be opposite of what we expected.

Although we did not accomplish every goal we set for ourselves, we believe that we accomplished our main goals. We would have liked to have seen the average on the final survey regarding desire to pursue engineering higher, but we were able to reasonably conclude why it was not. We also would have liked to have more females involved, but we did not choose the right tactics to draw in females to the club. We are pretty confident that we accomplished our main goals and even some of our secondary goals, and with this we can call our IQP a success.

Suggestions for Future Clubs

First and possibly most importantly, start early. Of the IQP groups working at five different Worcester schools, we started the earliest and had things moving quite quickly. However, it would have been nice to have had the third meeting before our fall break to really get the kids hooked before a week off. We only had two meetings and then a week off which we think may have hurt our participation a little.

Next, hands- on activities are a MUST. The students don't like listening to lectures, and would not be a good audience for a lecture anyway. They are hard enough to keep on task when doing hands-on activities and a lecture would probably put them to sleep. The students seemed to respond pretty well to a brief introduction, roughly 20 minutes, to figure out what they were supposed to do before they were turned loose.

The students seemed to like the longer projects. All but one of our projects was multi-week projects which the kids said they liked best. It gave them more time to design, build, and tinker with their product. As an added bonus, hands-on projects that are edible were a special request from the students for next year. Last year the group did a chocolate asphalt lab that the students loved. Also, when doing the projects, consider the weather!!! We should have done the bottle rockets earlier in the fall instead of in December when there was snow on the ground. The students did not like going out in the cold and our advisor almost did not let us launch the rockets.

This year, we did most of the construction in class, but a small portion of the building and finalizing was done at home. There were mixed reports from the students about this. The students that were very dedicated had no problem doing work at home while others did not like having to finish their projects at home and simply would not do it. They just tested their product in partially completed form. Sometimes it worked better than other times such as bottle rockets. For the bottle rockets several groups made new rockets at home, while bridge building only one group did any work at home.

We focused our club more towards the design aspect and engineering even though the name was The Future Scientist and Technologist Club. Even if this is the route other groups choose to follow, to get more females involved you need to make more connections to the sciences. Possibly a project related to biomedical engineering, or even simply a chemistry or biology experiment to spark the female interest. Another suggestion, have a female WPI student working in each group because female students respond better to female instructors.

Although the students generally answered that they would like to do the projects again next year they told us in our discussion that maybe one project repeated from this year would be plenty. A good variety of projects is important to keep the club interesting. If the egg drop is the repeated project, make it difficult, possibly three eggs or find a really high location to drop it from. The students also told us that they would like the club to go further into the spring. We are not really sure how this is possible as the WPI IQP is only three terms, but it is something to consider. Also, they said coming back for three meetings and then ending after Christmas break did not work well. As soon as they were back into the flow, the club ended. WPI has a month off but the high school only has about two weeks which means they have two weeks of school when we are on break where there is no club.

The general consensus was that the students liked our club and liked the way we ran it. We came up with the ideas. We gave them the option to give us ideas but they did not have many suggestions. I'm not sure if they simply liked our ideas better or they liked being surprised. There were some suggestions for computer based projects. We tried to fit a CAD lab in but could not come up with the necessary resources at our high school. The small groups of students worked really well and the kids liked working in groups. In addition, it will save you money in supplies if the kids work in groups as opposed to by themselves.

As far as scheduling the club, the students suggested having it twice a week next year. This would give significantly more time. We had eleven meetings and twice a week could potentially double that. However, our advisor at the school immediately shot that idea down. She is very busy and would not be able to supervise twice a week, and no other teachers are willing to supervise at all. Also, it is difficult enough to find a day that works well for everyone. Finding two days would be near impossible. What would likely happen would be a group of kids that comes on one day and another group of kids that comes on the other day with a few that make it to most of the meetings. The attendance would probably be hit or miss. Also, it was difficult enough planning many of the activities with a full week to plan. If a future club did two classes a week, the IQP students would be incredibly busy planning all activities!! Our advice is find the best day possible that works for most students and stick with one day a week.

Finally, the last two major pieces of advice are keeping the club consistent and make a tentative schedule that can be passed out at the first meeting. Try hard to avoid skipping weeks. It is tough to have the club when WPI is on vacation, but missing random weeks ruins the consistency of the club and confuses the kids. Although difficult, conforming to their schedule may not be a bad idea. One of the biggest suggestions was to have a schedule to pass out on the first class listing every day the club is going to meet. We did every Thursday which we thought was consistent enough but a few Thursdays we were on break, or they were on break, or our high school advisor canceled the club and the students got confused. Make a plan and try very hard to stick to it, at least regarding the days when the club is going to meet.

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Appendix A

Topic Ideas

Future Scientists and Technologists Club
Topic Ideas

1) First meeting- Introduction, survey, video of engineering marvels/failures and a talk session.

2) Bridge Building

    a. Introduction with model to demonstrate how forces are distributed
    b. Building of the bridges
    c. Testing the bridges with After Action Review.

    Materials: Straws (preferably not the ones with bends), hot glue, hot glue guns, and scissors.

3) Discussion of engineering

    -Introduce the major fields of engineering and a brief explanation of what each type of engineer does. We would probably use power point so we would need a computer and projector.

4) Robotics

    One class demonstration, bring in robots to program and let the students drive them and get them interested in robotics.

5) Rockets

    (This was approved but would require permission slips which take a few weeks to get completed)

    -Discussion of physics, wind resistance, stability.
    -Building the rockets
    -Launch the Rockets then conduct After Action Review
    Materials: Motors, launch pad, building supplies, scissors, glue.

6) CAD

    -Have WPI instructor/professor come to Doherty to give the kids a demonstration. Have students work in small groups on the computer to design a fairly simple three dimensional object. If possible use the “Machine” to physically construct the object that the students just designed. This would probably be a two week topic.

7) Conclusion

-Final Survey
-Talk session with the students to see what they liked, didn't like, what worked well and what didn't work well. This would be a small, fun, informal get together with the students almost like a ending party.

Appendix B

Surveys and results

Future Scientist and Technologist Club
Initial Survey

In your own words, what is engineering?

List as many types of engineers as you can think of:

____

____

____

____

____

____

____

____

On a scale of 1 to 10 how heavily have you considered pursuing a career in engineering?

1 2 3 4 5 6 7 8 9 10

If the average high school graduate earns approximately $21,000 in their first year and the average liberal arts major earns approximately $31,000 in their first year and the average 4 year college graduate earns approximately $40,000 in their first year, where do engineers fall on this pay scale on their first year out of college?

$25,000 $33,000 $40,000 $47,000 $52,000 $60,000

What percentage of man-made objects does engineering have an influence on?

10% 25% 35% 5 0% 60% 75% 85% 100%

Are you related to anyone involved in engineering? Which relative?

If yes, on a scale of 1 to 10, how influential have they been in you considering engineering?

1 2 3 4 5 6 7 8 9 10

Do you think there will be a continual need for engineers? Why?

On a scale of 1 to 10, how important are engineers to public safety?

1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, how strongly have you considered going to college to study engineering?

1 2 3 4 5 6 7 8 9 10

Why did you come to this meeting today?

What do you expect out of this program, and what would you like to see or learn?

On a scaled of 1 to 10 how much does engineering interest you?

1 2 3 4 5 6 7 8 9 10

Survey Results
Initial Survey

Question 1: Gender
Males: 20 Females: 13 Total: 33 Kids
25 students (75%) were in the ETA and 8 were not in the ETA (Engineering Technology Academy)

Question 2: Year in school
Freshmen: 9 Sophomores: 11 Juniors: 9 Seniors 4

Question 3: Involved in program last year
Yes: 16 No: 17

Question 4: What is engineering?
Most of the students had a basic idea what engineering was. A few were not exactly sure, and at least 8 had a pretty good definition of what engineering is.

Question 5: Engineer types
Zero: 2 One: 6 Two: 2 Three: 5 Four: 5 Five: 11 Six: 1 Seven: 1

Question 6: Things Engineers work on
Common Answers: Cars, bridges, buildings, machines, computers, roads

Questions 7: Considering pursuing a career in engine ringing.
One: 1 Two: 1 Three: 0 Four: 3 Five: 4 Six: 3 Seven: 3 Eight: 7 Nine: 8 Ten: 3
Average= 7.03
The most common was nine.
Question 8: Money related

Question 9: Objects affected by engineering
23 of 33 students answered 100% and seven answered 85%

Question 10: Any relatives in engineering
No: 16 Yes: 17
Eight of the yes answers were fathers, and most of the rest were uncles with only one mother.

Question 11: Of 17 yes answers, how influential were your relatives towards engineering
One: 5 Two: 0 Three: 1 Four: 3 Five: 4 Six: 1 Seven: 0 Eight: 0 Nine: 2 Ten: 0
This is quite a bit lower than we had expected. We expected a lot in the range of 6-9.

Question 12: Continual need for engineers?
Yes: 32 No: 0 Not Sure: 1

Question 13: Engineers to public safety
One: 0 Two: 0 Three: 0 Four: 0 Five:0 Six: 1 Seven: 1 Eight: 5 Nine: 8 Ten: 18
The students seem pretty aware of the importance of engineers to public safety. We expected answers to be in the five to seven range.

Question 14: Considered going to engineering based college?
One: 0 Two: 2 Three: 1 Four: 2 Five: 3 Six: 3 Seven: 4 Eight: 5 Nine: 8 Ten: 4
Average: 7.125
We kind of expected this. We are dealing with mostly ETA students and the ETA aims towards engineering.

Question 15: Why did you come to the meeting today?
Most kids came to learn about engineering, because they had fun last year, and for college applications. Some said Ms K "heavily" convinced them and one girl came because she thinks WPI guys are cute. How can we argue?

Question 16: How much does engineering interest you?
One: 0 Two: 0 Three: 2 Four: 1 Five: 2 Six: 0 Seven: 6 Eight: 4 Nine: 9 Ten: 8
Average = 7.73
This is about what we expected, mostly on the upper end of the spectrum.

Electric Motor Survey

1) On a scale of 1-10 how much did you enjoy building the electric motors?

1 2 3 4 5 6 7 8 9 10

2) On a scale of 1-10 how challenging was building the electric motors?

1 2 3 4 5 6 7 8 9 10

3) Did you finish your motor in class?

Yes No

4) If no to question 3, did you finish your motor at home?

Yes No

5) Would you recommend this project for next year?

Yes No

Bridge Building Survey
11/29/2007

On a scale of 1 to 10 how much did you like the bridge building and testing lab?

1 2 3 4 5 6 7 8 9 10

On a scale of 1 to 10, how difficult was the bridge building lab?

1 2 3 4 5 6 7 8 9 10

What does it mean to be in tension?

What does it mean to be in compression?

Would you recommend this lab for next year?

Yes No

On a scale of 1 to 10 how much did you learn from this lab?

1 2 3 4 5 6 7 8 9 10

Bridge Building Survey Results

Question 1:
Male: 7.7 average
Female: 8.8 average

Question 2:
Male: 6.5 average
Female: 3.5 average

Question 3:
Male: 11 students had it right while 3 did not
Female: 5 students had it right while 1 did not

Question 4:
Male: 11 students had it right while 3 did not
Female: 5 students had it right while 1 did not

Question 5:
Male: all 14 recommend it again
Female: all 6 recommend it again

Question 6:
Male: 7.5 average
Female: 7 average

Bottle Rocket Survey
1/24/2007

Male	Female		
ETA	Non ETA		
Grade			
9	10	11	12

List some important things to consider when designing a bottle rocket.

Did your rocket succeeded? If not, why not?

What helped the last rocket go significantly higher than any other rocket?

On a scale of 1-10, how much did you learn from this experiment?

1 2 3 4 5 6 7 8 9 10

Would you recommend this project for next year?

No Way! Maybe Yes Definitely

If you could build another rocket, what would you do differently?

Doherty Memorial High School
Future Scientists and Technologists Club
Final Survey

1. Gender Male Female

2. Grade
   Freshmen Sophomore Junior Senior

3. ETA Yes No

4. Did you come to this after school program last year?
   Yes No

5. Were you here for the first class?
   Yes No

6. What percent of the classes do you think you attended
   __________%

7. In YOUR OWN WORDS what is engineering??

8. Considering the design projects we did, what are a few things that engineers might work on, besides cars and buildings?

____

____

____

9. After being a part of this program, on a scale of 1 to 10, how heavily would you consider becoming an engineer?

   1 2 3 4 5 6 7 8 9 10

10. On a scale of 1 to 10, how heavily has this club influenced your answer for question number 9?

1 2 3 4 5 6 7 8 9 10

In a positive or negative way? (circle either positive or negative)

11. On a scale of 1 to 10 how strongly have you considered going to an engineering based college?

1 2 3 4 5 6 7 8 9 10

12. What was your favorite Project?

Electric Motors Bridges Bottle Rockets Egg Drop

13. During which design project did you learn the most?

Electric Motors Bridges Bottle Rockets Egg Drop

14. Would you recommend doing any of these projects next year? Which ones and Why?

15. What can this club do differently next year to attract more females to the club and raise female interest in engineering?

16. Was this club what you expected? Yes NO

17. What would you have done differently?

18. What did you like and dislike in this years club as opposed to last years club?

Final Survey Results

Kids: 21 (one did not fill in attendance sheet so we don't know his/her info)

9^{th}: 8

10^{th}: 7

11^{th}: 5

12^{th}: 0

Male: 15

Female: 5

ETA: 15

Non: 5

4. What do you want this club to be called next year?

Given answers: Proton, Engineeries, Osiris Club, The engineering club, Doherty Voice of thought, Science bowl, Build to win, Too smart Too Furious, Future Millionaires, Future Geniuses, FSTC, WPI Club, Engineer Kids, Techoes, Destruction crew, electrons

5. Did you come to the program last year

Yes: 8 No: 13

6. Where you here for the first class?

Yes: 15 No: 6

7. What percent of Classes do you think you attended?

Average: 82%

8. In your own words, what is engineering?

Correct: 12 Incorrect or no answer: 4 Partially correct: 5

9. What might an engineer work on?

Some given answers: Bridges, Airplanes, rockets, computers, roads, weapons, software, medicine.

Most kids put down a bridge which was one of our projects but most kids had at least a couple answers. Two kids did not put anything, but most kids seemed to have the basic idea.

10. After being part of program, how heavily would you consider being an engineer?

Average: 6.8, of the five females present, their selections on the 1 to 10 scale were, 1, 1, 7, 7, 8, being an average of 4.8.

11.On a scale of 1 to 10 how heavily has this club influenced your opinions, and in a positive or negative way.

Average: 6

Positive: 16	Negative: 0	Neither: 5

12. How strongly have you considered going to an engineering based college, 1 to 10?

Average: 7 Most of the answers were 7-10 range, a couple girls put 1's which really hurt the average.

13. How heavily have you considered perusing a career in engineering, 1 to 10?

Average: 6.6666

14. What was your favorite project?

Electric Motors: 0	Bridge: 3	Bottle Rockets: 13	Egg Drop: 5

15. In which project did you learn the most?

Electric Motors: 1	Bride: 11	Bottle Rockets: 6	Egg Drop: 3

16. Would you recommend doing any of the projects next year? Which ones?

Yes: 21	No: 0

Electric Motors: 8	Bridge: 13	Bottle Rockets: 14	Egg Drop: 11

Many people put several answers and some put all of them.

17. Select 5 of the 12 topics you would like to work on next year.

(gender based question, results to come)

18. Was the club what you expected?

Yes: 16 No: 3 Neither 2

19. What would you have done differently?

Some answers: More projects, more pizza, more club dates, More organized (?), Different better projects, Have the club go longer into the spring, Do rockets when weather is better, For the students to be more quiet and respectful so its more fun for everyone (we agree). A lot of kids said they would not have done anything differently, they liked it.

20. What did you like and dislike about this years club as opposed to last years?

Some common answers:

Like: This year was more organized, actually learned something this year, this year was more open, like it all, the new projects were good, atmosphere and environment was good.

Disliked: Started too early (time of year), wanted more projects, students were not consistent with the attendance.

Many of the answers were blank since 8 of them were freshmen.

Initial Results to Final Results
Direct Comparison

Direct Comparisons between Initial and Final Surveys

33 Kids	22 Kids

Gender:

Initial	Final
61% male	77% male
39% Female	23% Female

(females dropped possibly because we focused more on design and engineering than on science and Bio)

Grade in school

9th: 27%	9th: 36%
10th: 33%	10th: 41%
11th: 12%	11th: 23%
12th: 28%	12th: 0%

(Club got younger because some seniors had sports and other had been to the club for the past few years)

What is engineering (in your own words)

Correct: 88%	Correct: 64%
Incorrect: 12%	Incorrect: 36%

Did you come last year?

Yes: 48%	Yes: 59%
No: 52%	No: 41%

(27% of the kids at the final meeting did not come to the first meeting meaning they heard about the club, liked how it sounded and decided to join)

How heavily would you consider pursuing a career in engineering?

Avg: 7.1 Avg: 6.9

How heavily would you consider going to an engineering based college?
Avg: 6.9 Avg: 7.1

One question on the final survey we accidentally asked twice with slightly different wording and the average on one was 6.8 and 6.9 on the other which helps prove the validity of the survey takers.

Appendix C

Lab Handouts

Bridge Building Lab

Safety: The hot glue is very hot and will burn you if you touch it. The tip of the glue gun is also very hot. AVOID contact with these. Move slowly and always think before you squeeze something or put your hot glue gun down somewhere.

In this lab your goal is to build the strongest possible bridge that spans a distance of 24 inches, or 2 feet. This means that the bridge must be slightly longer than 24 inches so it will not simply fall in the gap that it is supposed to span. You are given a budget of $1,000. Each straw costs $10. Each Glue stick costs $25. You are given a pack of 50 straws and 3 glue sticks to start your construction. This means that you have already spent $575 of your $1000. You have an additional $425 to spend. You can purchase all glue or all straws but the best choice may be a combination of both.

The bridge we have built consists of 77 straws and 5 glue sticks for a total of $895. Yes, we could have used more pieces and probably made our bridge stronger, but in all design projects, time is very important, and we decided we had spent about as much time as you will have, so we stopped.

The joints of the straws can be difficult. The best way we found to make it work was to slit the ends of the straws in various ways to get overlap. Simply butting the straws end to end will make a weak joint.

Mitch and Chad will be walking around to give you suggestions and answer questions. Your designs may be harder to construct than you think. Everything looks easy on paper. When building, think tension and compression and build accordingly. The straws are very strong in tension, but not very good in compression. You may want to reinforce certain major compression areas.

Our goal is to test these bridges next class.

Have fun and GOOD LUCK!!

Egg Drop

1/24 and 1/31

Your task is to design an egg drop that will protect two eggs from a free fall drop of an undetermined height (hopefully in the school gymnasium). Feel free to work in groups or individually. Use past experience with egg drops, and any other knowledge to help you design and build this device. Remember basic physics principles when designing. Good luck!

Hint: Think about how a helmet works to protect your head.

Rules:

Your egg drop device must safely secure TWO eggs upon impact after the drop

Your entire egg drop device must fit into a box that is one cubic foot (12'' x 12'' x 12'')

Air resistance must not be a large factor (no parachutes)

You may use any materials that you feel will help your eggs survive

Your device must be able to be easily opened so you can load your eggs and we can inspect them after the drop