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FUTURE SCIENTISTS AND ENGINEERS CLUB

An Interactive Qualifying Project Report
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by

Eric DeLuca – edeluca@WPI.edu

Charles Fradella – cfrad86@WPI.edu

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Professor John Wilkes, Advisor – jmwilkes@WPI.edu

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Introduction

This report covers the process of launching a “Future Scientist and Engineers Club” at Burncoat High School, the high school in Worcester that features the Dramatic and Fine Arts Academy of the Worcester Public School system. The WPS Engineering and Technology Academy is at a different high school across the city, namely Doherty High School. Thus a comparison of the reaction in these two different student bodies with different local “cultures” is possible. A group of ten WPI students embarked on a project in which their main objective was to encourage interest in the fields of engineering as well as the sciences in all five public high schools in Worcester. They worked in teams of two.

This group based their common project on an aspiration survey that was administered to the junior students in these same high schools two years earlier. The survey results indicated that the students interested in science and engineering as careers had not concentrated at Doherty, drawn by the ETA. There was a slightly higher level of interest at Doherty, but Burncoat had a similar proportion of students interested in a technical career. The Burncoat data indicated a slightly lower than average proportion overall, but this high school also had the most balanced group of technically interested students by gender, with a 60 – 40 male advantage, as opposed to the 80 – 20 male advantage found at the other high schools.

One year ago efforts were made to pilot the Future Scientist and Engineers Club idea at Doherty and North Highs (North high has multiple small schools, but is known for its Heath Profession Academy). The plan for both clubs was approved – but belatedly and only The Doherty team was able to extend its project and actually run a shortened month long pilot program the first year. However, the pilot was a success, and especially successful in that the image of engineering was changed from only Mechanical Engineering, Robotics and CadCam, to include Civil and Environmental Engineering and Biomedical Engineering. The result was a powerful surge of interest in the club by the females of Doherty High, though the WPI students forming the club had trouble telling if they were the minority of 25% females in the ETA program or a whole new group of females drawn to the club by word of mouth. Consulting with the high school faculty advisor, after the fact, they were told that all but one or two of the 15 females at the final meetings (which were majority female meetings) were ETA students. In order to be part of ETA, you have to declare an interest in the technical field (and commit to a series of courses) in the 9thgrade. One cannot join the program later than that.

So, at Doherty, among students that had already committed to exploring the possibilities in engineering and science early on by participating in ETA, the club activities provided an opportunity to interact with engineering student role models. This opportunity had greater appeal to females rather than males, but it is worth noting that Brian and Matt, the club organizers were non-stereotypical examples of future engineers

These findings set the stage for a comparison to what will happen the first time a club is attempted at Burncoat high school in a comparative study. There is no pre-existing structure to support the students with technical interests at Burncoat, but there is evidence that females are a disproportionately large part of the pool of potentially interested students.

For want of an alternative, our project advisor emailed the principal at Burncoat, told him of the prior pilot program at Doherty, announced plans to go city wide in the 2006-2007 school year, and asked him if he wanted his school to participate. If he did, he had only to have a suitable club advisor from the high school faculty contact us. A broad hint was left noting that the North High advisor this year would be a WPI graduate.

The principal did want to have his school participate, or at least not be left out. It fit into some of his plans for the school and a second academy for the school was under consideration for the business and computer oriented students. Indeed, the arts academy was not flourishing due to budget cuts. Other academies were run by high school faculty, but the arts program was based on the participation of outsiders from the community. For a while, some were paid to provide the enriched program. Now he was down to those who could afford to volunteer. In short, the chance to consider a new theme for an academy was well timed. A WPI graduate math teacher was located and “volunteered”. Within ten days of the requests arrival, the Burncoat club was a go. As a way of distinguishing between the ten student group running the larger club initiative and

the team of two going to Burncoat, “the group will refer to the 10 students as a whole, and “the team” will refer to the Burncoat Team.

The group based its initial objectives on what the Doherty pilot program had set out to do the prior year. We set our goals at wanting to reach at least as large group of students the first year, and intended to pull off a field trip to WPI (which was planned by last year’s group, but they never succeeded in doing it), and to have an entertaining as well as informative set of presentations.

Though the advisor at the Doherty high club had contacts at most of the Worcester high schools, she did not have a contact at Burncoat high school. This proved to be a problem, since attempts to make contact with a high school via central administration had cost the prior group a three month delay. When central administration asks a teacher to advise the club after school, the union rules apply. That means they have to be paid a specified amount – and if it wasn’t budgeted the year before, this is hard to do. Budget limitations were especially problematic if you want money for buses to take the students on a field trip. Only if a teacher asks to run a club it, and waives their pay, can this discussion of budgets and long lead time be circumvented. Hence, networking teacher to teacher was a huge advantage to the other teams in getting their clubs started up more rapidly than ours. The decision to circumvent Central Administration and go directly to the school principal was made after a 3 month delay. It worked surprisingly well, but had some side effects to be discussed later. The volunteer teacher can hardly ask for a travel budget that first year, so the group planned to raise that money from another source.

The first objective of our Future Scientist and Engineers team was to set up a club at Burncoat High School to support those already interested in engineering and science as a career and promote the idea among those interested in exploring this possibility. By promoting engineering and science as a career choice at Burncoat, our team intended to present the option of engineering and/or science as a desirable career choice for average people, not just for “brains.”

Our initial group plan was to ask several WPI professors to give presentations to the high school students. However, for various practical reasons, the group plan evolved into our becoming presenters of the material that was thought to be important, though the teams planned to present at each other’s clubs in the various high schools. Each team would also come up with several plans for meetings after talking to the club advisor at their high school and the students.

Some of the proposed meetings included the Chocolate Asphalt Presentation, a Lego tower building contest, a bridge building contest, Terraforming Mars, and a Space Presentation at the Ecotarium in Worcester. Though several other of the group’s ideas were not developed, were not selected, or were not popular amongst the high school students, the high school students did like, and the WPI teams did succeed in delivering most of them including the Lego’s Tower Challenge, the Bridge Design, and the Chocolate Asphalt project.

A second objective was to promote engineering and science careers to students at high schools where the curriculum may not include much exposure to engineering techniques and concepts, even in the science and math classes. For example, Burncoat High School is known through the city for having a strong arts program, and implementing the club into their school opened some of the students' eyes. They were being subconsciously channeled toward a liberal arts concept of what college would be like because the high school that they attend is well connected with arts oriented institutions and lacked connection to an engineering college. The one existing outlet for the technically inclined high school student was a Robotics Club that was entering a competition. However the principal was arranging for an Engineering class to come to the school at about the time our request arrived.

A third objective was to promote WPI to these high school students. This objective is important due to the fact that a series of high school clubs of this type benefits WPI's local outreach as well as its student diversity campaign. The WPS student body is nearly 50% minority students. Burncoat high school is not known for sending many students to WPI, but the student body is racially diverse, drawing from working class and lower middle class neighborhoods, as well as a lower income housing project. Those interested in engineering are also disproportionately female, compared to the other high schools. Further, the WPI music, dramatics, other arts and sports programs would benefit from a link to this arts oriented "magnet" high school if people with both Arts and Science interests were located. We wanted to attract students interested in both the arts and

science/technology to WPI specifically as well as engineering more generally. The prior aspirations survey findings indicated that this pattern was especially likely to occur among minority students.

As a side note, involving the principal at Burncoat led to involving all of the high school principals, as they meet monthly with the superintendent – and they wanted to know why this was not a top down initiative. The idea derived from a prior plan to have WPI students assist the guidance offices in advising and coaching students expressing an interest in a technical career put together suitable high school program to support engineering college admission. Guidance was not enthusiastic, so the proposal to shift to an after school club had come from someone at central administration. The principals were told this was really a long time dream of one of the female ETA faculty members. Hence, the contact in central administration knew that when he was trying to "save" the Doherty "coaching" project the year before due to lack of interest in Doherty guidance and had no funds to pay for an after school activity. He was reasonably certain she would volunteer. The question was whether Doherty needed a club given that ETA was present at Doherty. Funding a club for those students hardly made sense. The case for such a club was being made based on the aspiration survey findings that only half the students at the school interested in technical fields were in ETA, and that females were less likely to be part of ETA than males, probably due to the need to firmly commit as a 9th grader.

So, only the administrator who had seen the aspiration survey results considered the club a reasonable thing to try at Doherty. For him the club would

be a different venue designed to serve the non-ETA Doherty students, especially the females. Thus, he connected the WPI students and the ETA faculty member, who he knew would probably volunteer to advise this outreach effort. His plan was to promote this as a way for the ETA staff to meet the non-ETA students interested in engineering careers and see how they got missed.

The aspiration survey that raised all of the questions was sponsored by the City Managers Advisory Committee on the Status of Women, so gender equality was very much on his mind was he read the Handler and Hogan report on the survey , and supported first the guidance office coaching concept, and when that failed, proposed the idea of a faculty run after school program.

The upshot of the discussion of the clubs was that the principals started getting involved in who the club advisors would be at their institutions and several of the “network” friends of the Doherty ETA faculty member were no longer the “point of contact” between WPI and the different high schools. Our problem circumventing the administrative line of authority for financial reasons had ripple effects through the system. However, the net impact was positive. All the clubs were on their way to having official endorsement just short of a budget. Without that, they were not “policy”, but they now had the “blessing” of the principals as a group, and were viewed as a system wide “experiment”.

The Meetings

Meeting A – Initial meeting with Advisor

Objective

The objective of the initial meeting at Burncoat High School was to meet with the advisor for the group, Mike Juneau. Mike was recruited for this project as previously described. Mike presented himself to us as being very interesting in creating this program at Burncoat High School. He seemed quite interested in bringing new concepts to his students, and our team seemed to be on its way to creating the proposed program. The three of us also were to decide on the days and times for the meetings, as well as how many meetings to plan for. We also wanted to get to know Mike a little bit before the actual meetings began. This would help us with planning the program's final details. There was no time to execute all the ideas the 10 of us had come up with, so Mike could help us select the ones to develop and present.

Description of the Meeting

The meeting began with the introduction of everyone. Discussion topics included what days and times would best fit everyone's schedule. We decided that Wednesday, right after, at 2 PM, school would be the best time. The only drawback was that both of us, the club organizers had class at 3 PM on Wednesdays, so the meeting could only be about 45 minutes to an hour long.

We also discussed, during this meeting, how we would be getting the word out about the club. An aspiration survey was discussed, however considering the time frame the group was now working with, along with assurance of participants by Mr. Juneau, the survey idea was dropped as unnecessary. We decided that we would make flyers and take home information sheets. We then proceeded to drop off these fliers at Burncoat High the next day and let Mike and the Assistant Principal, Ms. Stone, do the advertising. We later learned that other club organizing groups had been asked to do more, for example, to appear in science classes and describe their plans for the club.

Results

The meeting resulted in our getting to know the advisor for the club. We learned that he graduated from WPI with a Bachelor's Degree in Electrical Engineering. He was an Engineer for several years but then decided to become a physics teacher. He had a passion for teaching and helping the students understand a field he always enjoyed himself in.

Conclusions

This meeting was very beneficial as everyone got to meet and get this project on its way. Many things were learned with this meeting, including what times seemed to be reasonable based on our schedules, as well as the schedules of existing groups (i.e. Robotics) whose meetings would decrease the number of participants able to come to our program if they conflicted.

Meeting 1 – Introduction/Egg Drop

Objective

This was the first official meeting that we had with the students of Burncoat High School. The main objective of this meeting was to introduce ourselves, as well as introduce the group project and its purpose in coming to the various high schools. Our attendance expectations before talking to our advisor had been anywhere from 10 to 15 students. When speaking to Mike Juneau a day earlier, he informed us that approximately 20 students had signed up to come to the meeting. We were prepared to give some brief descriptions of what engineering was like, what kind of problems and information it dealt with, as well as the differences between the kinds of engineering. After this discussion, the plan was to leave the floor open to any and all questions the students might have about why we were there, and what plans we had for this after school program. After we had answered all questions, the plan was also to discuss the possible topics for the following 7 meetings. Also presented was the idea of an egg drop for them to think about for the next meeting. This egg drop idea along with the rules would be presented to them to see if they could create a good protection system for dampening an impact by the next meeting. This would conclude the first meeting.

At the Meeting

The turnout of the first meeting was about as originally expected, with 15 students coming to the meeting. The ratio of male to female students, however, was quite far from what we had expected. There were only two female students who came to the meeting, and this was a great disappointment given aspiration survey results suggesting that 6 of 15 would be more in proportion to the actual pool. The balanced number of students who were attracted from each class, however, seemed to be a great success. The meeting included 4 freshman, 4 sophomores, and 7 juniors. The other clubs were reporting few juniors, mostly freshman and several sophomores. Our draw was throughout the student body.

Results

The second meeting began rather smoothly, with the introduction of ourselves as well as laying out the overall purpose of the meetings planned this far. Next were the descriptions of different kinds of engineering, including mechanical, civil, electrical, as well as some concentrations included in these majors. Description of what specialists in these fields do in the real world, and explanations of how common concepts are likely to be applied in different fields were also given. The students were then encouraged to ask questions they had about any of these topics. There were several questions asked, and some of these questions included:

- What grades are necessary in order to become enrolled in an engineering school?
- Is there any difference between an architect and an engineer?

- Will there be any visits to the WPI campus?
- What types of salaries are typical of the different types of engineering?
- What sort of presentations will be given during the time this club exists?

At this point, because of other things that needed to be discussed with the students, we chose to end the question session. The last question gave us the perfect opportunity to turn a discussion of the meeting options we had prepared, and see what their preferences were. After this, the students were given a quick overview of the egg drop contest for them to plan for over the next week. The problem that was presented to them with was to build a protective case for an egg. This seems easy, but the device must be able to withstand a drop beginning at 3 feet from the ground, and moving higher until the egg broke. They were given a list of materials and some other guidelines. We were very careful to make the project seem like it was their choice to complete it, as we did not want to give the impression that this was a class assignment. They have classes and homework every day, and the point of these meetings were not to give the students more work, but to allow them to have fun and learn in their own way. This would give them valuable experience, without it looking like studying or more “work” , however in retrospect, we came to think that this activity was introduced in too casual and rapid a fashion.

Discussion of Meeting One

The meeting was in a relaxed atmosphere, where for the most part, they could ask questions at any point in our presentation. The students seemed to be very interested in what we spoke about, and many of them revealed to us that engineering had been on their mind for quite a while as a possible career. Many of these students seemed quite knowledgeable in and knew at least as much, and often more than we had known about technical careers as freshmen in high school. As we discussed all of the possible meeting activities, one of which included a Robotics Demonstration, we became aware of an already existing robotics club at the school. It had previously been brought up in a meeting, but we did not know what it entailed, who was in it, or any other general details of the group. It turned out 4 of the students who were at this meeting were also in the robotics club. They made it known to us that although robotics might be a good meeting subject at another school; they worked enough on robotics in this club. We decided not to include this demonstration in our meetings. One of the other meetings that the group felt was not hands on or interesting enough was the cams, gears, and linkages meeting. These two ideas were cut from the agenda, but the other ideas were all popular possibilities.

While going through the different possible meetings we would have, there were several topics that the students said they would look forward to and enjoy. The Lego project, which includes civil engineering as well as project management concepts, was a particular favorite. Another favorite consensus

focused around the Chocolate Asphalt, as well as the two original proposed trips to the WPI campus.

When discussing their project for the following week, there were several questions regarding what types of materials could be used, as well as how big the contraption could be that surrounded the egg. There was originally not a limit on the size of the device, but with their question it was clear that there should be limits. We gave them the instructions that the entire container could not exceed the volume of 1 cubic foot. We also told them that it should not be made up of more than 4 different materials.

Overall, we were generally pleased with the amount of interaction the students were giving us, both with their questions as well as their feedback regarding the meetings to come. The students seemed surprisingly well versed in some aspects of the nature of engineering, what engineers do, and their questions and responses were relatively well thought out. We considered this "orientation" meeting important to the continuation of our club as we were oriented as much as they were. We did expect the students to prefer the more hands on meeting ideas and that was confirmed. The expectation was for them to want the Lego and Chocolate Asphalt presentations to be done the most and they had not surprised us with that. The feedback that they would probably not enjoy the robotics demonstration was unexpected. The first meeting was very productive in that we received much information about how much information the students already had on various subjects, as well as final planning information regarding what interested them the most.

Meeting 2 – Egg Drop/Lego Project

Objective

This meeting's overall focus was to test the egg drop 'inventions' that the students had constructed over the past week. We then intended to give them some feedback as to how construction of their devices could have been easier, as well as some techniques that would have assisted in keeping the egg intact throughout the collision. Real world applications of this experiment would be given as well as a way to estimate and think about what kind of physical conditions the egg was being subjected to during the collision. After all was done with the egg drop contest was complete, the next project for the group would be introduced. The next project entailed them using various different sized and shaped Legos in order to build a tower as tall as possible. This tower would be subjected to wind tests using a powerful fan. Each dot that exists on every Lego piece would be considered a dollar spent. This value would be subtracted by the number of inches the tower rose, multiplied by 25. Also added to this final value would be a number (1-3) multiplied by 100. This value of 1, 2, or 3 would be based on what level of fan wind the tower withstood. The final score would then be calculated, and the winner would receive a prize the next week. This project helped the students understand some of the fundamentals of construction, and also helped them to appreciate the importance of cost management.

At the Meeting

The turnout for this meeting was smaller than expected. We were quickly notified that many of the students who were at the previous meeting were working on their robotics presentation at the time. There were 7 total students at this meeting, along with the one female student that was at the previous meeting.

Results

First, we began to look at what the students had created in response to our egg drop problem presented to them during the previous meeting. Since many of the students were unable to come to this meeting, only one egg container was brought to this meeting by a group of 4. Their device was actually a container, which they filled with peanut butter, with the egg inside. When we first looked at this design, it seemed that not much thought had been put into the design process. It seemed that giving projects to the students to work on at home and not at the meeting was a particularly bad idea. We now felt that the meetings should not involve any homework, and felt that the students agreed, given the amount of effort they put into this egg drop project.

Despite its aesthetic problems, the container filled with peanut butter actually worked very well, and the egg easily survived the fall. The biggest problem with the design was due to an implicit assumption about what the exercise symbolized. Although it worked quite well, it was nearly impossible to remove the egg from the container due to the peanut butter. We explained that in terms of engineering, if this was some sort of payload which needed to

withstand impact (like a delivery of a device to a celestial body), it would undoubtedly have to be removed from the container. This is the reason their design, despite meeting the specification, would not be used in the practical engineering world.

After the egg drop experiment, we began to give the students their instructions for the Lego experiment. The students were split up into two different groups, and we wrote the mathematical formula of scoring on the board. As they began building their towers, we walked around the room and tried to give them some tips about how the bottom structure of the tower should look. Some ideas were how to strategically place their pieces so that they could get the highest score. Time had gone by a little faster than we had expected, so we quickly got the groups to finish the towers they had constructed. The towers were then tested, as well as measured.

There was a problem with the level of wind being blown at the towers to test them. The fan was not able to knock over any of the structures, so it was amended by creating another level of testing. This level was worth 5 instead of 1, 2, or 3, and it was us blowing on the tower as hard as we could. This thinned the ranks of those still standing. After testing all of the towers, the scores were added, and the winner was announced. Next, the students were asked if they had any questions about the process of designing the towers, and how this applied to real engineering processes.

Conclusion

Overall, we believed this meeting had kind of a rough start. Since there was only one design for the egg drop situation, and also that design was a relatively poor one. We were disappointed. Still, we believe that exercise could be a good one in introducing problem solving in an engineering situation if carried out like the Lego towers. However, there would have to be time limits, materials provided and supervision. Also, it should have been a contest like the towers project.

The students had a particularly good time constructing the towers. We believed it was about as accurate a representation of the design process that could be done in such a constrained environment. The student's designs were good for the most part, however many of them designed their tower to look good, and did not realize that the point system would represent cost and determine the winner. The small turnout allowed us to give close attention to each of the teams as they worked out their designs. Thus, we could give them some timely coaching about how to design their towers. We witnessed at least some of the student's measuring the vertical length of the pieces, which allowed us to praise this evidence of attention to a contest criterion on their part. If we could change anything about the meeting, we would have found a much stronger fan for the wind test. We also might have tested the strength of the tower in the vertical direction, or possibly with some sort of impact.

If we had time for another one hour meeting, we would have tried the egg drop again and devoted the entire hour to designing a holder for the egg drop

using materials in the room. Since only a few of the students completed this task, we feel they pretty much missed out on one of the meeting concepts. Nevertheless, the students enjoyed themselves while designing the Lego towers, and with this enjoyment comes interest. The presentations must be enlightening as well as entertaining. They must want to do these projects, and not feel as if they are forced into doing them, especially in an optional after school program.

Meeting 3 - Chocolate Asphalt

Objective

The group's third meeting was the chocolate asphalt meeting. Asphalt is a material made from rocks, called aggregate, and tar. When more aggregate is added to the material, it gets stronger, but less malleable. The mixture needs to be malleable to allow for the change in temperature to take its course on the roads. The asphalt used on roads can be simulated using chocolate as tar and other candy for aggregates. For the meeting, Hershey's chocolate bars, peanuts and shredded coconut were used as the ingredients. The shredded coconut proved to be a better aggregate than the peanuts were, but since the students got to eat their mistakes, no one objected to learning this by trial and error.

At the Meeting

The group met for its third meeting with an attendance of 11 high school students. The students were excited about this meeting because they knew that we were doing the chocolate asphalt experiment. During the meeting, the students were each given their own personal Tupperware container and an oversized bar of chocolate. On a desk, the aggregate material was laid out so the students could choose what they wanted to used. They were advised to try to make the mixture strong, but they did not have to use anything they did not want to eat. The chocolate bar was placed in the Tupperware, and then the Tupperware and chocolate bar were placed into the microwave. After a little bit of

trouble, as in burning some chocolate through the plastic Tupperware, the chocolate began melting well (it was taken out after one minute and stirred around). The students added their aggregates after the chocolate was all melted and then let it cool. The high school students really enjoyed the chocolate asphalt meeting, mainly due to the fact that they were learning while they were eating.

There was a good mix of students present at the meeting. The group had students from three different grades, freshman, sophomore and junior classes. There were still only two females in attendance, which was a disappointment. None of the high school students at this meeting were first timers. They had all come to the meetings before, which indicates that we were not still growing but at least there was some interest sustained one in the club, as well as in engineering.

Results

The meeting began with us teaching the students about asphalt and its attributes. We also spoke about the differences between cement and asphalt. We asked the high school students questions to try to get them involved in a brief discussion about the differences, but only a few students answered our questions.

This meeting showed the students some essentials of Civil Engineering. This type of engineering deals with construction of streets and buildings. The students loved the idea of making chocolate into something that can be compared to asphalt. The students learned in general how asphalt is made, the

differences between asphalt and cement, and the different qualities and advantages of both of them. They learned that asphalt is made of tar and aggregates, and it is very ductile (which is strong and malleable), perfect for New England temperatures. They also learned that cement is very strong but brittle, which means that near perfect conditions are needed to use it. Though cement is more appealing to the eye, it is not practical for use in the Massachusetts area for roads. For this experiment, it would have been ideal to have about two hours to complete this task. This is so because after the asphalt is made, the next step would be to test it. With this project, it takes so long because the chocolate must cool before testing, and due to time constraints, this was not possible. Hence, we had to leave the testing up to the high school students and their advisor, to be conducted the next day using each other's chocolate and to see what the differences were when they used different aggregates.

Conclusion

Overall, the chocolate asphalt meeting was one of the most successful meetings the group had. The demonstration successfully taught the students about some aspects of Civil Engineering and asphalt in general. The students responded better when there was a hands on experiment that they were able to take part in. This meeting seemed to really stimulate the high school students to appreciate engineering. The students seemed to want to know how these road materials are made.

This meeting was very simple and easy to run. After some research on asphalt and cement (both Charlie and Eric are Mechanical Engineers), we were ready to lead a discussion on the differences and the different advantages of both materials. This meeting theme and activity is highly recommended for later groups if the program continues. You don't have to be a civil engineer to do something with this idea.

Set up and clean up for this meeting was rather simple. The project is meant to be done in a longer time frame than we had, and using different materials. Instead of Tupperware, it is recommended that future presenters use a ceramic bowl to melt the chocolate, then to pour it onto a cookie sheet. The cookie sheet is used so the students can roll their chocolate asphalt with a pin roller, to flatten it out. This is done to release all the air bubbles and make the composition stronger. The reason this was not done in our case was because of time constraints. We could not allow for the chocolate to cool on the cookie sheet as it is supposed to, so we chose to make the chocolate in Tupperware so that the students would bring it home and throw out the Tupperware after they are done with it. We have no idea if any of the chocolate actually got home after the next day. It would have if we had more time to complete the project.

Meeting B – Space Conference

Objective

The space conference was a WPI Student Pugwash sponsored event. They wanted to bring the high school students from all five different high schools to increase the audience for their space conference. The space conference was a presentation of different college project groups that focused on space topics, such as growing potatoes on the moon. There were also a few presenters other than WPI project students, who spoke on developments in the field of space and space technology, but they were scheduled after the high school students had to leave. The idea of having a space conference and presenting it to high school students was to show them that people their age are the ones that will be going to space and following through on these ideas.

At WPI

The conference was held at WPI, and began about 11 AM. The students got to WPI about 9 AM, and after gathering outside Morgan Dining Hall, the students were brought to Olin Hall room 107 for an Admissions presentation. The students had a 45 minute presentation by the admissions departments of WPI, Clark and Holy Cross. This was to show the students the requirements to gain admission to any of these schools and how to do a technical major at each. They learned about the different majors and the careers you can have coming from

WPI. After the Admissions meeting with the students, they took a tour of the campus with admissions tour guides. The tour guides were helped out by our club's advisor, Mike Juneau, a WPI graduate. The tour guides did their job, but Mike would tell them his memories and experiences in each building as well.

Then the students were brought to the Space Conference. The conference began with multiple IQP groups that had some trouble getting their ideas and thoughts across to the audience. The projects were very interesting and the IQP students did a good job with their projects, but not with the presentations based on these projects. Most of the high school students had a hard time paying attention and getting interested in the presentations. The high school students were not the ideal group for an audience because of their relatively short attention spans. When the Pugwash supplied lunch came around, all organization dissolved, but it is not important to go into details of those problems in this paper. Though the trip to WPI had its faults, it was an overall success. One can take from the experience what a good field trip designed for this audience would look like

Results

There was a lot for these students to learn by coming to WPI for the tour and Space Conference. It was also a good time for WPI to do a little bit of hometown recruiting. When the students were asked about the trip to WPI, they responded "We loved the first half," referring to the admissions presentation and

the tour. The Space Conference was a good presentation for us to watch, but it just did not appeal to the high school students that were there to watch it. It was too sophisticated and too high tech and intense for them. If the projects were simpler, or the groups presented them in a more simple way, the high school students would have found them interesting. High school students are smart and can have an interest in these types of things, but if it is not presented in a way designed to meet them half way, they usually can't relate to it. They usually have more interest in going places and seeing new things, especially colleges they are thinking of attending.

The students gained knowledge of WPI through this trip. They toured campus and saw all of the different buildings, and found out about the different majors. At the admissions presentation, they gathered more information about WPI and its advantages. They also learned a bit about the ongoing space research and development effort. They learned about agriculture on the moon and harvesting of Helium-3 for use on Earth as the fuel for fusion reactors. They would have not heard about these topics anywhere in Worcester but WPI.

Conclusion

The trip to WPI was very beneficial for the high school students. They got to experience a day at college, without needing to do homework or being graded. They toured some buildings devoted to different fields of technology and hopefully got some knowledge that could help them decide what would be

involved in going to a technical college to pursue a career. A whole day touring WPI as admissions presents the school and labs, and presentations by each department, possibly in those labs, would be more beneficial. The high school students really enjoyed the part of the trip that was the admissions presentation and the tour. Another recommendation is to only open the trip to the high school students who had come to previous club meetings. Some high school students were there more for a day off school than a trip to WPI. It is also recommended to give the students a simpler lunch, such as pizza or prepared sandwiches. The layout of prepare your own sandwich buffet style lunch that the space conference had was not appropriate for them and caused mass confusion. It just took too long and the buses were due to arrive soon. This kind of trip is highly recommended, but with a different format.

Meeting 4 – Bridge Design

Objective

The design of a bridge can either be complicated or straight forward. Suspension bridges are very hard to design because the runners and the towers have to support the weight of the entire bridge. Suspension bridges are the best choice for long bridges, so these types are usually very long. Some bridges are very easily designed, especially simple trusses which can be very short bridges with no added supports. Though the bridges may be simple to design on paper, real bridge designs aren't that easy to predict the behavior of, because of all the added factors that you need to account for. Whether the variable weight of cars or anything crossing the bridge, and water flow all change the balance of stresses. Our goal was to produce a challenge that was manageable but suggested the interactive complexity of constructing a real bridge.

At the Meeting

This challenge was presented to the high school students at the end of the chocolate asphalt meeting. The students were told that they were to make a bridge out of Popsicle sticks of two different sizes and glue. We suggested that they look into the different types of bridges during the week, before building the bridge the next Wednesday. The specifics of the bridge were to be:

- Bridge must be able to support a specified weight

- Bridge is to be made from given materials (popsicle sticks and glue), but any tools can be used to make the bridge
- Bridge must be one foot long
- Bridge must have two sets of vertical supports

The students came back the next meeting full of ideas and suggestions, but attendance was a disappointment, with only 6 students showing up. Still we built bridges by challenging all of the students to a bridge-off. Our specifications were the same as the students. They would compete with us. Our bridge was a simple, lightweight bridge with the vertical supports at either end. The middle was made from horizontal supports attached to the vertical supports, and the “ground” was made from sticks facing the opposite direction of the other horizontal supports.

The students had a little different idea. Their bridge was to be made with many trusses. They argued and bickered all meeting long, and didn’t get much more than the flat surface done at the meeting. Some of the students met a few times during the week and finished their bridge. The bridge was made with criss-crossed Popsicle sticks that started at one vertical support on one side and ended on the other vertical support at the other end. The students’ bridge was very strong and met all the criteria set up in the previous meeting. The test on the students’ bridge was 16 textbooks on top before it finally broke. Our bridge was not tested at the meeting, due to an unforeseen accident. It failed an extreme stress test before we could find what it’s the actual strength was (a roommate stepped on it while the glue was drying). By default, the high school students won.

Results

This meeting was very hands on and a very good meeting for the high school students. They had a good time putting together their bridge together and deciding the best way to build it. We suggested that they draw the bridge before building anything and that helped them decide which the best design of the ones they considered was. They thought about somehow setting up a suspension bridge, and also talked about having a bridge with just vertical supports. They also decided on the best way to design the flat bed of the bridge. Their final result with 16 high school textbooks stacked on top was very impressive. The reason for the failure after 16 textbooks was the bridge tipping and putting too much weight on one leg of the bridge.

This meeting was focused mostly on a type of Civil Engineering. This type of engineering seems to be an easy type for the students to appreciate and find interesting as 9^{th} to 11^{th} graders. We were able to teach the students by considering several types of bridges, looking at ours, and trying to beat it. They only constructed one but looking at two ended up giving them some experience (and knowledge) about general Statics. They realized to support a weight they must design for all of the reaction forces involved (forces and torques). They realized that the bridge may crack in the middle if there is too much weight, even if the legs can support it. These are essential principles for most types of engineering.

This theme and activity worked so well that it is recommended for future years. It was very hands on for the high school students, and that concept seemed to be their favorite type of activity oriented meeting. The students excelled at this meeting, but we think that the less successful “egg drop” project they did earlier in the year set the stage for this success. This time they were willing to do “homework” and seriously prepare for the test.

Conclusion

This meeting was a bit risky as it started out competitive, but went very well for both the students and us. They “took us on” and had success in designing a good bridge and, after a slow start, a few of them completed the task in overtime on their own. The meeting taught the students a few essentials of engineering involving how to design something and test/analyze it. This process is essential for those thinking of becoming an engineer. The students realized designing something once and focusing on optimizing one part is not good enough. The design needs to be tested multiple times and all the sections need to get attention during the design process. This challenge also helps the students work with each other to create the best design. All that is needed for the meeting is two different size Popsicle sticks, Elmer’s glue, and some drying time.

Meeting 5 – Final Meeting/Pizza Party

Objective

There were three simple objectives for the final meeting with the students of Burncoat. First, we wanted to ask them several questions about how much they enjoyed the club, how they thought it could be improved to be more informative and useful as well as fun. The high school students also deserved a sort of reward for attending the meetings, so this was done with a pizza party.

At the Meeting

For the last meeting, we informed our advisor, Mike Juneau, that we would like anyone who has been to any of our meetings to come. We had 8 people come to this meeting. We had planned for 12 because we were offering free food and no work. Both of the participating girls at this meeting were at this meeting, however, so we'd get to debrief them.

Results

First of all, before the food was served, we asked the students who came to answer a few survey questions. They were asked how much they enjoyed the club and what could be done to improve upon it next year. They said that they thought that the club was a very good idea, but that if it had started earlier in the year, it could have been better attended and more successful. We agree with this assessment and suggest that, if the project is continued, the next team

should start during A-term rather than B-term. Although taking care of each of the meetings ourselves allowed us to get to know the group better, we also believe that getting professors and other WPI project students to give presentations or run those associated with their majors would allow for more diverse and revealing meetings. For example, neither of the Burncoat team members are Civil Engineers, but roads and bridges are themes we used. The students also asked us if we would be heading the meetings next year, and we informed them that although we would be unable to attend, another group would probably be recruited to continue developing the club next year.

Conclusions

The students seemed to enjoy the final meeting, partly because they had no work to do but could reflect back on some common experiences. Other than feedback, we took the comments as personal compliments. They were not going to learn anything new at this meeting, but would get to celebrate a successful set of meetings. Their answers were serious and it seemed as if they honestly cared about the continuation of the Future Scientists and Engineer Club meetings in following years.

Summary of the Club Experience

Most of the delays in getting this project going were associated with our trying to communicate with possible presenters at WPI on the faculty. We focused our early efforts on trying to get other people to do our presentations for us, and in the end these efforts went for naught. We were not going to be coordinators as we originally thought, but presenters. Not a single faculty member of WPI appeared at these high school meetings; however we still believe the project was largely successful with us as role models. Despite the time we put into attempting to get WPI faculty members to do presentations, we still believe that it will be worth it next year to try to do so again.

The presentations we actually gave were hands on, fun, and relatively informative, but still light on engineering. We lack the specific knowledge that only a graduate or someone who has worked in the business for many years would have. We also lacked any funds or physical apparatus, such as a Van de Graf Generator to create lightning. Reusing presentations that professors of this school or other schools may have developed for this type of audience would upgrade the program. When we have presentations that use Popsicle sticks for materials, and then we are shown the robots that they are using in their other clubs, our presentations are seriously outclassed. Moving the demonstrations to the WPI campus to be part of a WPI field trip may be another good idea, if it is impossible for any WPI faculty members to attend meetings at the high schools.

After giving up our efforts in finding someone to do presentations at the high schools, the ten of us decided to begin the process of finding contacts at our high school that would be interested in advising this program. We ended up with a WPI graduate by the name of Mike Juneau. The process of finding our advisor was quite different from the other high schools.

Burncoat, we did not have personal contact with a person inside the school, such as Kathy Kambosos's teacher network, which extended to three other high schools. For this reason, Burncoat was the only high school where our group went "through the front door," and directly contacted the principal, John Bierfeldt. The process was simple after this, because Mr. Bierfeldt found our advisor for us, Mike Juneau. He seemed to be quite excited to get this project going, so we set up a meeting with him as soon as possible. This meeting took place near the end of C-term 12 weeks into the project of 21 weeks. At this meeting, we went over each of the possible meetings with Mike, much like our initial meeting. His enthusiasm to start immediately was much to our liking. We quickly set up a date to begin, after discussing what presentations would be best for this club.

Getting the club set up was surprisingly easy, thanks to the administration of Burncoat High School. All it really took for the club to get started (possibly because of the prior approval by the assistant superintendent in charge of secondary initiatives) was a quick meeting with the vice principal, Mrs. Stone. This meeting took place in her office, and we basically just explained what we were trying to do, and when we would like to be doing it. After constructing a few

poster boards and some notes to post up on walls, all we could do was wait for our first meeting and hope for a good student turnout. Mike was very helpful in the process of getting some students to come to our meeting as well. He made daily announcements over the intercom, and asked many of his math students to come as well. The teacher network was enough to spawn a small club without our doing a series of presentations in the science classes (the team at North High was asked to do this).

The concept of what our club would be was relatively unchanged as the process went along. For the entire time, we had focused on getting a single club meeting per week, after school. We had planned on having most of the presentations given by respectable practicing engineers or faculty members of WPI. This proved to be impossible at the time, so each of the 5 teams took it upon themselves to think of meeting ideas and create presentations. Although many of the meetings were relatively good, mixing in some other people presenting may present less difficulty for future WPI students in this program. We would encourage them to do no more than half the presentations themselves.

One major aspect of the meetings that was different from the original plan, although there was little we could do about it, is that we did not reach as many upperclassmen as we aimed for with these presentations. For the most part, we originally were planning on targeting students that were juniors and seniors, close to graduating from high school. This plan was formulated so that the presentations could be relatively advanced, and that these concepts could be fresh in their minds as they approach college admission. This goal had to be

changed, because most of the students attending our meetings were either sophomores or freshman. The number of total attendees at the meetings barely reached 15, so we did not reach a large audience, and we did not attract many females. We had to work with what we had, but despite this limitation we accomplished something for the future by getting the 8 younger students interested in the club and exposed to these concepts at a younger age. The juniors were not consistent attendees for some reason, which may have included their involvement in the school's Robotics club. These eight students may be the nucleus of a larger group next year. We were initially unaware that at Burncoat High School, there are some currently offered Engineering classes (we were told this was only happening at Doherty ETA). Hence, we believe the younger students we reached will be more likely to take advantage of the technical classes offered as electives. They will have an opportunity to continue their learning of the field, even if this club program does not continue in the future.

Given more time to advertise in the school, we would have liked to explore some more incentives designed to appeal to female students in the pool of students interested in technology. We are told that by the 11th grade, one in three is considering a medical career. We had no knowledge of the biomedical field so had no means of doing a presentation on it but it would have been a natural. Although with the problems involved with getting faculty to present, getting the program set up, and creating meeting ideas, it was not possible to set any things in motion to try to recruit more female club members. We were struggling to keep up a 10 member average for the meetings. Looking back, it seems that there

should be a way to attract more females to the group meetings. At Doherty, the club had an advantage in bringing more females to the group. The club advisor was a woman, Kathy Kambosos, who made sure that the girls of the school knew engineering was not just for men. This advantage led a lot of females to attend the first few group meetings and they continued to attend after they found out what the meetings were all about. This advantage was not present at Burncoat. A recommendation for Burncoat, if a female advisor, or co-advisor cannot be found, would be to have at least one female WPI student help lead the meetings. This would role model to the girls of Burncoat that females really can and do become engineers or scientists. It was upsetting not having more females attend because of a previous survey done at Burncoat showed that the student pool at Burncoat with technical interests was 40% females.

A large problem we had, which limited the group's ability to create meetings as well as general resources, was the lack of a project budget. Presenting an appropriate request to WPI in order to get any type of reimbursement proved to be quite difficult and, in the end, was never accomplished. This presented a large problem, particularly in the process of transporting the students from their respective high schools to WPI for the space conference. In future programs, spending less time on detailed meeting plans and doing a general budget as part of the proposal based on just topics for meetings properly presented to WPI with a funding request would be beneficial. This is by far the most important issue to attend early on, and was the largest problem the group as a whole was presented with in planning its own field trip. If

the group had more than just personal funds, the meetings would have been much better and the project presentations to the high school students could have been more interesting. More important, Admissions and the Pugwash group would not have taken control of the field trip – with mixed results

In the end, our overall goal was to present various levels of high school students with information and presentations of engineering concepts that arise in the world today. We wanted to show them by analogy what type of things they would be doing if they chose engineering as a career later on in life. We wished to show them that engineering is a fascinating, fun, as well as profitable field. Sparking interest in this field was what we came to these schools to accomplish, and we believe that our team did just that. Although no faculty members were able to present, we believe that with our presentations of many concepts in both an interesting and fun way, we achieved our goal.

It seems as though the most obvious type of engineering to use as illustration is from the mechanical field. Stressing this probably makes it less appealing for females who may be interested in something such as biomedical engineering, environmental engineering or chemical engineering. These meetings should show the high school students several different types of engineering other than mechanical, and it would be more likely to attract a different group of students, who may be interested in technology, but may not know it yet. We basically covered mechanical and civil engineering, pretty traditional fare, and attracted primarily males.

Comparative Analysis

Burncoat and Doherty Comparison

When you look at all five of the high school clubs established in Worcester, there is an interesting comparison between them all. An especially interesting comparison is one between Burncoat High and Doherty High. This is so in many different ways as well. Some of these ways include how the club was set up, the small schools that the high schools offer and the people who attended the clubs.

Since Doherty had a club set up a year before all of the other clubs, they had an easier time setting up the present club. They had an internal contact within the school, Kathy Kambosos, who was very excited and helpful with the club and who was also associated with ETA. She helped Doherty set up their club, and also helped set up the other clubs at other schools. The way she did that was by assisting the group in finding potential advisors without going through the principals at other schools. The only school she was unable to help at was Burncoat. The reason for this was because she did not know anyone on the faculty at the school. As noted earlier, the Burncoat team was forced to go through the “front door” to set up the club. We had to contact the school’s principal, who was John Bierfeldt at the time, through our advisor. This was risky, as it could have provoked budgetary debates, but turned out well because John Bierfeldt went to a Worcester Principals’ meeting and asked the other Principals why they did not mention this club initiative to him at the prior monthly meeting.

He liked the idea, but what was the policy? The benefit of this meeting was that the uninvolved Principals found out about their clubs and decided to encourage the grassroots initiative. No one was getting paid, so what was the downside? If this did not happen, the other clubs may have succeeded, but with the help of the other four principals, the clubs were much better positioned. His actions made the club a city-wide project with help from the school system, and possibly a better set of advisors.

Burncoat is also interesting due to the aspiration survey results. The survey showed that, citywide, 23% of the male students and 5% of the female students had expressed interest in Engineering and 4% of the male students and 5% of the female students showed interest in Physical Science. The survey also showed that 21% of the students interested in Engineering citywide came from Burncoat, and 24% of those interested in Physical Science did as well. This is not higher than Doherty, which would be expected due to the Doherty advantage in having the ETA program, though it is more interesting because it was a 60% male and 40% female split, as opposed to Doherty, which had a split of 80% to 20% favoring males. This showed that Burncoat had a relatively high proportion of females who were interested in engineering or science as a career. This was a good sign, because females are not as likely to report wanting to pursue technical careers as males in the city as a whole. We thought we had a special opportunity for a female friendly club. This may be because of widespread misunderstandings about engineering as a career. Most students looking for careers tend to see engineering in terms of its mechanical or civil engineering

concentrations. Engineering and Science also includes fields such as Environmental Engineering, Biomedical Engineering, Biology, Chemical Engineering and Chemistry, which are fields with a higher percentage of female participants. From the survey conducted, females responded with highest levels of interests in the medical and science fields. Biomedical engineering and biology are both fields which pertain to the medical field. Some students enrolled in the WPI Biomedical Engineering major are planning on pursuing a career as a doctor after undergraduate school. Setting up the Future Scientists and Engineers Clubs at these high schools would e instrumental in helping the females who responded to this survey, and everyone else who does not know the broad range of majors within engineering, see that engineers and doctors cooperate on assuring public health.

At Doherty the club established during the previous year had many advantages in finding females to come to the meetings. The reason for this was because the advisor of the club was a teacher at the school, was in ETA, and was a female. Her name is Kathy Kambosos. She is a science teacher and a former engineer. She wanted all of the females in her classes to know about the different types of engineering which may interest them. She advertised the clubs in her classes and promised a good time and a good learning experience. This helped the WPI students that advised the club at Doherty because it got a lot of students to the initial meetings, and they did a good job at keeping them involved. The only problem the first Doherty club had was that many of the males at the first meetings did not keep coming. They dropped out, but the females did

not. The females expressed a great interest and really displayed an interest in the non- mechanical and non-robotics side of engineering. Engineering is a predominantly male career, and needs to recruit and promote more women engineers. WPI has an enrollment of 2861 undergraduates in 2007, and only 26% of them are female, up from 17% in 1990. With more groups and clubs in high schools that express the different types of engineering and make sure the females of these schools hear of these different types, female enrollment should increase in technical schools.

Another comparison point may be the small schools within the different high schools. The small school that Burncoat high offers is a fine arts school dedicated to the visual and performing arts. It is surprising to find that the school that hosts the arts small school has so many students interested in science and engineering. Doherty has a small school curriculum that concentrates on science, technology and engineering. Having a response from Burncoat that shows so much interest in engineering shows that parents and students do not consider what they may want to do for their future after high school as they decide where to enroll in high school. This may be because it is hard to anticipate what your career goals will be after high school while still in the ninth grade. Also, students that realize they may want to pursue an Engineering career after the ninth grade are out of luck, because students can't join ETA after ninth grade. The club at Burncoat helped in two ways. It gave students a chance to consider this possibility as 9th graders and be informed about it while it was not too late to transfer to the ETA program. It also supported those who wished to stay at

Burncoat who were beyond the point of being able to transfer. Our club was mostly 10th and 11th graders. By then the students are starting to think about colleges and thus their futures after high school. About 25% of our attendees were 9th graders. Most other after school clubs had higher proportions of 9th graders.

There is also a public high school in Worcester called Mass Academy with a highly selective admissions process. Mass Academy is a public high school for 11th and 12th grade students that have a strong science and engineering background. Mass Academy is closely associated with WPI, in that as 12th graders, they take WPI classes on campus. Though Mass Academy is a great school, it is not accessible or appropriate for every student interested in Engineering. Still, since it is a public school with no tuition, in Worcester it is important to let students know that they could transfer there after sophomore year. That makes 9th and 10th grade oriented support and information programs in science and technology especially important. If there were programs or clubs at the other public high schools that encouraged the Science and Engineering fields, all of the students who have some interest in Engineering, could hear of options such as ETA and Mass Academy and even if they do not take advantage of them, get some support in deciding what they would like to do with their futures, and getting into a technology oriented college program after high school.

Both of the schools' clubs being compared in this study have had their successes. Doherty has had the greatest overall success this year because the club had the most meetings and had a good attendance at all of them. On the

other hand, it was in its second year as a club. We should compare the Burncoat experience to Doherty's first club year, but it is worth nothing that in addition to the meetings, the students who came to the Doherty club meetings continued to come to the meetings. The meetings consisted of approximately 30 students and there was a 60%-40% male to female ratio. This is notable since ETA is about 75% male, so this was a female friendly club. The pool of science and technology interested students at Doherty is also 75-80% male. They were disproportionately attracting females.

The male students did not stop coming to the meetings after the first one like they did in the Doherty Club the previous year, which is a success in itself. In the first year the Doherty club was more like 20 students attending each meeting and the males drifted away. By the end the club meetings were 75% to 80% females, mostly from ETA. The team this year connected with the males without losing the females. Kathy Kambosos, the high school advisor, thinks this is because the WPI student organizers were athletes from WPI football who connected on that level several of with the athletic oriented ETA males, sending counter-stereotypic engineer role models was key to the clubs' success.

Burncoat also had its share of success. Though the average was not 30 students, and the female to male ratio was nowhere near even, there were other successes that the club can claim. We were able to set up a first year club and have 7 meetings, whereas the other first year clubs, such as South and Tech, had only about half that many. The club was difficult to set up due to the lack of contacts within the high school, and still we were able to find an advisor and set

up a personal relationship with him, Mike Juneau (WPI alumnus, former professional Electrical Engineer) rapidly. The club also presented the students with several different presentations and we had fun at the meetings and, avoided being completely outclassed by the robotics club, which cut into our attendance.

At meetings such as chocolate asphalt and a Lego tower challenge, we asked the students to plan on a piece of paper and then actually build different structures. They experienced the useful exchange of ideas possible when a plan could be visualized, critiqued and coached. Along the way we learned that engineering classes are coming to Burncoat and the principal wants to do more in the technology area. So far his plans fall short of setting up a new small school. Hence, the club can support the students that gather in that class in the future. Burncoat's success in moving in this direction helped by the fact that Burncoat, like Mass Academy/WPI, has a robotics team and seems to want to continue it. About 25% of the students in the club were also on the robotics team. We were warned away from having the Robotics demonstration we had planned. However, such a club has it's danger it is the only image technology has in a school.

The point at which the Doherty club succeeded with women in its first year was the moment when it challenged the Robotics and Mechanical image of engineering being presented by ETA and introduced civil and environmental and biomedical engineering. The mention of those fields led to a lot or questions, mostly from females. The success of these clubs and the reactions by the students show that such opportunities for interaction are crucial to bringing a

more balanced image of the range of technical fields to students in the Worcester school system. If these clubs were set up and supported at every high school, the city would have more students going on into science majors and attending technical colleges. It would also help achieve social diversity in the technical profession. The key is to show women that they are welcome in the Science and Engineering fields, and that for those interested in service careers and the medical professions, there are more possibilities than being doctors and nurses. For instance, a biomedical engineer, designing prosthetic devices or an organic chemists working to end world hunger developing new medicine, does not have to get into medical school after completing college. They can work in the field with a Bachelor's degree or a Master's degree. However, majoring in Chemical Engineering with medical applications in your Bachelor's Degree is not a bad way to get the attention of the medicals school admissions committee.

Burncoat and Worcester Tech Comparison

The experiences that were encountered by the Burncoat high team and Worcester Tech team were very different. Burncoat High School's main focus in academics is the arts, so there is no technically orientated student pool to draw from. Indeed, the only thing going is the Robotics club, which was in competition with the Burncoat club at some times. The group at Worcester Tech had a much different experience, mainly because Tech is a vocational high school. Few of these students expected to go to college. Each student's main priority and focus was learning a trade and becoming knowledgeable in a certain field to get Craft

union jobs. This means a large percentage of students are going to part time jobs right after the high school day ends. The Worcester Tech Club's WPI advisors were quickly alerted that an after school program would be nearly impossible. The group was offered the option to give their presentations as labs during a physics class once a week, which provided a rather unique experience for the club team. This meant they had a captive audience. Nothing they did would have any effect on the sex, age, or number of students that were present at their activities but they had a known audience every week. The key to success was keeping the teacher happy by engaging the students. Although this limited the team in reaching all of the interested students at the school, and also required some to be present who weren't interested in a technical career, it also guaranteed that a good number of students were going to see their presentations. Because Worcester Tech is a vocational school, the curriculum at Worcester Tech consists of one full week of normal classes, which is followed by a full week of work experience. The student body is split in half, so half of the students were in school one week and the other half was working. Because of this, one group saw the presentation one week and the next group saw the same presentation the next week. This sharply limited the number of club events, dropping the number from eight to four. However, teaching to the same students two weeks in a row meant 40, rather than 20, students would see each one. Also, it opened up some new possibilities. Although the group was only able to have four different meetings (eight meetings total), they were able to give each one twice, which allowed for improvement between runs.

This experience was completely unique amongst the five different groups. If a certain meeting went especially well, the Worcester Tech team knew that they would redo this event for a new group the following week. They could also do more research and make some logistical improvements to develop their presentation skills with these specific topics. If a meeting seemed not to interest the students a great deal, the meeting could be scrapped and replaced with a different one.

The type of student they were developing physics labs for was also different from that in other clubs. Many of these students at the time of the creation of this Future Scientists and Engineers program were not considering college as an option. The students were at this school to learn a trade and then to use this trade in a working job straight out of high school. Therefore an important opportunity was set in front of the Tech team. They had a possibility of reaching students who were interested in mechanics and physics but had never really considered college in their future, let alone a career in engineering. Further, they were juniors – and this was the critical moment if they were to apply to college. At this moment walks in two college student role models, with access to WPI admissions, talking about a field trip to WPI. The administration was skeptical and tried to skip the event. The students would not hear of it - they insisted on going, and did.

In this respect, Burncoat had an experience that may be directly opposite to Worcester Tech. Though the WPI students did make flyers and take home sheets for parents, the advisor, Mike Juneau, did a lot of advertising for the group

in class and spoke about his days at WPI to his students as they walked the WPI campus – Tech was having a class field trip for its juniors. Though the number of students reached at Burncoat was significantly smaller, it can be said that the proportion of students previously interested in engineering as a possible career was significantly higher. This was all new to the Tech club, a new possibility.

The WPI students earned their keep by meeting the demand of the teacher to drop some of the preplanned Engineering contests and come up with a real physics lab in a week. By keeping the teacher happy they got the program approved for a repeat performance. So, the Burncoat group not only had a smaller number of students at their meetings, they also had to do activities suitable for the typical 9th, 10th and a few 11th grader that were into robotics. One of these problems is that we had to pitch to the 9th graders for fear that some of the younger students may have found the materials coming along with the activity a little too advanced. At the level of the concept we were presenting them with, while some were at the right level for the 9th graders and too basic for the 11th graders.

It seemed that although the same core group of students was present at most of the meetings, they were a group that worked together in other classes as well as in other after school programs. Simply put, we tapped into only a few school cliques with students who were already interested in engineering and were looking for enrichment activities. Hence, Burncoat's curriculum was not the best fit for them. They should have been in the ETA program. In retrospect, we

should have asked them if they had ever heard of it or considered transferring across the city to be part of it.

The main point behind the analysis of the pitfalls that the various teams encountered is that giving the same program to students in such completely different situations is not advised. Much more could have been accomplished in both of these schools if its club organizers could plan taking into account the type of students they would be working with. We should have known about their differing levels of interest, previous knowledge concerning the concepts, as well as the percentage of college-bound students at the school. Simply put, a two person team may not be sufficient to develop ideas, create and establish contacts, as well as have good presentation of these ideas for so many different audiences. Information is needed from the students that cannot be obtained through a survey of juniors. One needs to go and meet the students and have in-depth conversations regarding the agenda while it is still fluid in order to know what would interest them. For example, Engineering Management was a concept which interested the Burncoat students; however it may not have been particularly interesting to the students of Worcester Tech. In future iterations of these Engineering clubs, the fact that these students may have completely different situations and interests must be accounted for far before the two person club team is finalizing its plans. We developed these activities in a “vacuum” of information without access to the high school faculty advisor. We went to five different high schools with the same list of proposed activities and are lucky things went as well as they did. Differences in the club experience can be

created through earlier interactions with the advising teachers, more information about the teaching setting of each club and proposed techniques and the concerns of the specific principals or administrators within the school. How the club will interface with existing programs also needs to be considered. The differences in student bodies, even in such close proximity, are astounding and must be taken into account. If this is done the next wave of club organizers will be able to create a much more beneficial and interesting atmosphere for each of the different high school version of the Future Scientists and Engineers Club.

Discussion of Results of Comparative Analysis

The results of the clubs were very different at each school. The Burncoat club had success for a first year club, but did not have great success with the breadth of our recruitment program. The clubs averaged about 12 students, and we saw about 15 different students throughout the course of seven meetings. The greatest failure of the Burncoat team was the light attendance of female members. Throughout the meetings, there were only two females who came to the meetings. This is a large difference from the results of the aspiration survey which suggested that this club should have had a spilt closer to 60-40 (male vs. female) in the pool of juniors.

Two clubs, which were not compared in this analysis, had considerable success in recruitment. These clubs were the North and South teams. The North team was in its second year of planning as an after school program but its first year in operation. The club had an attendance anywhere from 10-20 students per

meeting, and it ranged from a 50-50 split to a female dominated club. One reason for this gender equality success could be the presence of a female faculty member who co-advised the club. This situation sounds somewhat familiar to the Doherty club which also had a female advisor and had disproportionate attendance of female students.

The other club that had a success in recruitment was the South High team. The South High team would have had 4 meetings including the WPI field trip but missed the trip so only had 3. The club had an average of 12 students at each meeting, and was able to recruit a group of students that was one third females. This is a bit better than the ratio suggested by the gender ratio of 1-3 in South high's aspiration survey. This relative success can partly be attributed to the female Principal at South, who fully endorsed the club and helped in any way she could. They had good posters and advertising as a result. Another positive recruitment statistic of the South high team was that towards the end of their meetings, they were reaching more working class and Hispanic students as well. The reason they could not reach more Hispanic students was the time constraint. In only 3 meetings, they reached 24 different students who attended at least once. They considered "turnover" in their average of 12 attendees a problem. We consider that a success and wish we had the same "problem."

Drawing from these conclusions, it is safe to say that the best way to recruit females to the club is to have a female advising or fully endorsing the club. Of all the after school clubs (Burncoat, Doherty, North and South), the only club to fail in recruiting females effectively was the Burncoat team. This can

mostly be attributed to the lack of females involved in the club marketing which is partly a role modeling effort. Female teachers and principals visibly in support and openly recruiting seems to be the key to success on the gender equity part of the Club agenda. We had the administrative support of a female assistant principal, but she stayed in the background. Without visible females, you need a WPI student who is female co-advising your meeting to have a chance of success. We had male WPI students, a male advisor and a male principal as the visible advocates – and drew a mostly male club partly borrowed for the existing robotics effort.

Conclusion

The situations and problems that were encountered by the different Future Scientists and Engineers Clubs varied considerably from school to school but all 5 teams took the same plan and agenda to their assigned school. As information concerning what group of students can be reached and for what period of time they can be reached change, the goals of the group must be adapted to the situation. One must get to know the group they are trying to reach and if they are reaching them, then decide what method may be the best to reach and teach this age ad kind of student. Although several significant goals were reached by all groups, how and what they achieved differed in many ways.

Several groups were extremely limited in the number of meetings they were able to have. Other groups were limited in other ways, which is evident in the case of the Worcester Vocational Technical High Club. They were unable to meet after school, and so had to essentially take over a physics class lab for an hour each week. This is not what they had planned. Each of the problems that were encountered required a revamping of what the group thought was possible. They also had to rethink what they thought would be most beneficial to the group they were meeting and hopefully reaching.

A general goal that was set before the entire ten person team when the IQP began was to attempt to reach a significant portion of female students and support their interest in the various fields of Engineering. There were several pitfalls that led to the changing of this plan. For many groups, such as the Burncoat team, finding an advisor proved to be relatively difficult. With the

remaining time, we were simply unable to specifically target female students, mainly due to the fact that the overall number of students attending the meetings rarely broke twelve, and the low point was half of that. The other clubs meeting after school, except the Doherty team, were also struggling to stay viable, and could not afford to make themselves seem specific to any small group, simply because the students' numbers would have most likely plummeted. Only North High's club seems to have beaten the odds and reached a heavily female audience. Burncoat and South did what they could, but the job was first to start a club and to make it female friendly afterwards, if possible.

Another common goal of all of the groups was to encourage interest in Engineering as a career under serious consideration for these students in their future. Although it was achieved to varying degrees, this goal was generally accomplished by all five groups. Each group's students were different by grade level and gender, which resulted in varying results. In the future development of these after school club programs, treating all ten WPI students as a single group with a common program would be a large mistake. Each school needs to be looked at and evaluated on its own.

Another way to improve the program is to arrange earlier meetings with the high school staff. Given the varying levels of knowledge and interest, an effort to meet a group of high school students before any attempt is made at curriculum development would be wise. If experience leads one to expect a 9^{th} and 10^{th} grade club, find ways to interact with that age group and evaluate their knowledge relative to the presentations that are being considered. One wants to

use the most appropriate strategies for the situation one finds in the school one is assigned to work with.

Recommendations

We wish to close with some more specific recommendations for students starting a high school club, especially a team continuing the effort at Burncoat High. At Burncoat, an advisor has already been found. Many things could be done in retrospect that would have made the entire process much easier. First, this project may be much better off starting in A-term. If it began in A-term and ran until C-term, there is no problem related to when the WPI school year ends and vacation for the high school students can be accommodated. If necessary, the project could be continued into D term in order to solidify any loose ends the groups had with the clubs. Having the clubs in several different schools is, without a doubt, a terrific idea, as the groups are reaching many more kids with the same concepts, but the clubs needed to be tailored to the local realities.

Secondly, reaching WPI for funds regarding a modest “honorarium” the advisors at each of the schools, transportation of students to WPI (if necessary) as well as paying for materials necessary for presentations should be one of the first main goals of future groups. Reaching this goal quickly will allow for a much easier process of finding a faculty member at the high school to advise the club. Although all of the groups were able to find a willing advisor, no one can know what will happen in the future. The goal should be to get their clubs into the WPS budget, rather than the WPI budget, so that the club high school advisor gets paid.

Future groups, in general, should have a much easier time getting these clubs set up in the schools, because contacts have already been established and

most have an interest in continuing these clubs in future years and are part of the regular staff of the school. This should allow future groups to focus much more on getting appropriate WPI people to lead or support presentations in the schools.

Some smaller recommendations would be to get the students from different high schools together, to get them acquainted, and to have a larger, possibly more fun meeting. Another would be to plan a field trip to WPI that is geared just for the high school students. This would include an admissions meeting, a tour, and short presentations from departments. Some recommended presentations would be a robotics presentation, physics presentation, a gaming presentation and any others that would help the female students connect with this career. Biotechnology and Civil-Environmental Engineering seem to be the key to this issue. Also, faculty needs to be recruited to help the WPI students present at the high schools, possibly different ones at each high school.

A final recommendation, and one that would not be that difficult to accomplish, is creating some sort of publicity and recruitment in the schools in order to build a more balanced ratio of female to male students in the clubs. At Burncoat High School, the ratio of male to female was generally along the lines of 7:1. We believe this could be greatly improved, with only a few poster boards or messages on the intercom to improve publicity to everyone. Creating a more balanced set of topics to portray these concepts will generate more interest in the female populations regarding engineering as a career. Personal invitation to key students might also be arranged with the assistance of the science faculty, math

faculty and guidance department. Starting with ten males and ten females known, or believed, to have this career interest under consideration would be a better way to start.

Appendices

Appendix I

Letter to Kathy Kambosos:

November 5, 2006
Kathy Kambosos
Doherty H.S.
299 Highland Street
Worcester, MA 01602

Dear Mrs. Kambosos,

I am writing this letter to introduce a team of ten students that have registered for the project offered by John Wilkes and Liz Tomaszewski to expand and improve on last years high school clubs project. This project would work off of the project that Brian Dorchik and Mathew Duncan set up last year, but we will now have a larger team setting up five teams of two students to send to each major Worcester High School. We would also like to start earlier to make more meeting times possible.

Our group consists of juniors in both mechanical and civil engineering. Most of us are also football players at WPI and involved in the fraternity system. We are looking forward to working with kids in the same place we were three of four years ago thinking about what we are going to do with our lives and considering engineering as a possible career. We would all like to share what we have learned at WPI to help these students potentially interested in engineering to pursue their goals and give them a better engineering knowledge base as they move towards college. We can share about the college culture and community life as well as the academics, but will not be trying to "sell" WPI per se. Still we want to make WPI resources available to the clubs.

As we develop our proposal we will want your perspective on how things went last year at Doherty. We have read Dorchik and Duncan's report and it made us optimistic about what can be done this year.

We also want to know what you think about the idea of approaching the other schools about similar clubs. Would you be able to provide names of people at other Worcester high schools who can advise clubs and do you think the ETA should "sponsor" the clubs at other schools as an "outreach" program? We also want to talk to you about whether running the sophomore survey was valuable enough to do again maybe in a required science class.

I hope we can meet soon to discuss the club and how it will be moving forward this year. We are really excited to get the club going and start teaching kids some basic engineering.

Sincerely,
Nick Ambrosino, George Chyoghly, Orry Cummings, Eric DeLuca, Charles Fradella, Matt Frasier, Alan Ngo, Chris Norton, Keegan Richey, Timothy Souza

Appendix II

Proposal Draft #1 - The Worcester Future Scientist and Engineer Clubs:

Last year Duncan and Dorchik (June, 2006) ran a pilot project at Doherty High School on the possibility of establishing Future Scientist and Technologist clubs in the Worcester Public Schools. This year that pilot program has been expanded into five teams of two students that will be setting up clubs at five different high schools, Doherty, Burncoat, North, South, and Worcester Technical High School. Advisors have been designated at all the schools and they will start in WPI's D Term, at the latest. This would make time for a two month long program with one meeting a week with a field trip to WPI included as one of those meetings.

Some of the meeting topics last year such as a general overview of the different areas of engineering and a robotics demonstration would be included again in our meetings. Also our group has been working with our advisor John Wilkes on many new ideas for meetings such as presentations on assistive technology, materials, space exploration, asphalt properties and mixing, and a design challenge. These proposed meetings show many different aspects of engineering and the high school club advisors have responded well to most of them. Some of the advisors like Joseph Marzilli and Brian Morse of North High are both WPI alumni and have agreed to advise the club there at North, with or without "overtime" pay. However, most of the principals are saying that no pay is available, and not all advisors can donate their time.

To fund this club each group member is going to contribute seventy five dollars over the course of our three term IQP. We would like to ask WPI to provide one hundred dollars for each group member to supplement the a donation of seventy five dollars of our own. Thus each two person team will have a "WPI" budget of three hundred and fifty dollars per term. Along with the money WPI and our group is supplying we will also ask the Worcester Public School system to match WPI's investment to the club of two hundred dollars per club. This would give us a budget of two thousand seven hundred and fifty dollars for the five clubs. This allows for over twelve hours of time with the high school advisors to the club. We would like to spend eight of those hours in the club and four for outside meetings with the advisors to organize for meetings, and go on a field trip.

The main resource requirement for the club project involves union rules for WPS teachers. They must be paid thirty dollars an hour for "overtime" – after hours teaching and advising. Last year the WPS first promised the money for two clubs and then rescinded the offer. To protect the project we plan to fund the club for a minimum "honorarium" from WPI of two hundred dollars, per advisor and still have seven hundred and fifty for busses to have a field trip to WPI. This will cover an hour a week for seven actual club meetings, and five meetings to plan, debrief, and do other things such as recruit and assess. A request will also be submitted to WPS for a two hundred dollars per club, but that will be to cover transportation for a second field trip, special events, and other expenses including a party for the last club meeting. These are things we can do without if we have to do so, though they would greatly enhance the program. Thus, if WPS again runs out of funds and cuts all the "frills", the project can go forward on a "staff" and WPI trip only budget. If they come through each club will have an five

hundred and fifty dollar budget. We expect to cost share the project with WPI, as noted above.
We believe that this project could be very important for the city of Worcester, and help WPI enhance the engineering profession. Many people would garner the benefits of these clubs. All ten of us are eager to get started. If we want these club programs to be as extensive as we explained we must know we have advisor pay and can get to WPI at least once at the time of a student Pugwash conference on space technology and the return to the moon tentatively scheduled for early April. We know we can get these clubs off the ground, if we can get the WPS faculty advisors to commit enough time without your assistance we will not be able to assure them that they will get al least token payment for their time, and get to use WPI resources at least once.

Appendix III

Proposal Draft #2 - The Worcester Future Scientist and Engineer Clubs:

Last year Duncan and Dorchik (June, 2006) ran a pilot project at Doherty High School on the possibility of establishing Future Scientist and Technologist clubs in the Worcester Public Schools. This year that pilot program has been expanded into five teams of two students that will be setting up clubs at five different high schools, Doherty, Burncoat, North, South, and Worcester Technical High School. Last year a field trip was talked about but was never actually done this year a field trip to WPI was made possible by our IQP team. Our field trip included an admissions talk about WPI and the projects program, an admissions guided tour of campus, and the pugwash space conference. The pugwash space conference showcased many WPI IQP groups which did projects on the future of space. The presentations showed new technologies being developed now and what a future space station on the moon would look like and how it would function. The trip was set up to excite the students interest in engineering which is the clubs main goal and also to get the students interested in a career in new space opportunities as an option for their future. This field trip brought about eighty students from the Worcester high schools to WPI and further stimulated their interest in engineering. Our team thinks that this was a very valuable experience for the students and wants this type of trip to be done annually.

We are requesting that WPI reimburse our group for the busses for the trip which totaled three hundred dollars. All other expenses of the group have been covered by our group members themselves and have definitely amounted to the two hundred and twenty five dollars that each member is supposed to spend for the three term IQP. We would greatly appreciate the help of WPI in funding for the busses to lessen the strain on us for money. Without this help it would be very hard to get the clubs next year to organize and follow through with a similar trip to WPI. With the momentum we currently have with these high school clubs it would be a shame is the IQP group next year working with these clubs was not able to achieve this field trip again after the success we had this year.

Appendix IV

Recommendation By Mike Juneau:

June 20, 2007

Burncoat High School
179 Burncoat Street
Worcester, MA 01606

Dear Sir:

Eric DeLuca and Charles Fradella performed admirably as team leaders of the Burncoat High School Future Scientist and Engineers Club. They were always well prepared and extremely diligent when dealing with the many aspects of running a successful club. Additionally, they were very knowledgeable and genuinely interested in discussing the numerous topics with the students.

Eric and Charles were a tremendous help in getting the club formed by providing not only fliers to entice the students to join but also a handout for their parents explaining its purpose and goals. The students really enjoyed the club meetings with the hands-on approach utilized by Eric and Charles. The Chocolate Asphalt, Lego Project Management, and Popsicle Stick Bridge experiments were rated as excellent by the students. The Burncoat High School students also greatly enjoyed the field trip to the WPI Space Conference where Eric and Charles were instrumental in making sure it went smoothly via communication of bus schedules and other logistics.

The first Burncoat High School Future Scientist and Engineers Club was a huge success. Eric DeLuca and Charles Fradella provided excellent leadership while departing wisdom and engaging a group of high school students. These students all have expressed a desire for the club to continue this coming school year.

Sincerely,

Michael Juneau
Mathematics Department
Burncoat High School

Appendix V
Flyer promoting Club at Burncoat:

Interested in Science and Technology?

Then come join us for The Future Scientist and Engineers Club!

Learn and discuss topics in different science fields of science. Some different topics will be design and construction of buildings, computers, and the different science fields.

The club is open to anyone of any grade.

The first club meeting will be March 14th, 2007 in Mr. Juneau's room, D16. Meetings will be held on Wednesdays after that. Please see Mr. Juneau prior to the first meeting to sign up

Appendix VI

Parents Flyer for Club at Burncoat:

The Future Scientist and Engineers Club

Purpose The purpose of the club is to bring an appreciation for the sciences and engineering fields to the Worcester Public High Schools.

Meetings Meetings for Burncoat High will be held in room D16 directly after school on Wednesdays, beginning March 14th. Meetings will be run by college students from WPI[1]. A few examples of possible meetings will be as follows:

Chocolate Asphalt:	Students will learn the composition and structure of asphalt. They will then make it themselves using chocolate.
Building Design:	Students will design a building using Legos. Restrictions and constraints lead them to design the best building possible.
Engineering overview:	WPI's admissions office will give an interesting and general view on different types of engineering.

Why Join? The Future Scientist and Engineers Club is set up to help students learn about the different sciences and engineering fields. Knowledge of these fields could help in making choices for college or choosing your future.

The college students organizing the group are from WPI. We have developed a strong interest in bringing these groups to five local high schools, and leading these groups during meetings. With help from the high school students, we can make these clubs a possibility in local Worcester high schools.

[1] All WPI students have had CORI (Criminal Offender Record Information) checks and have no prior records.

Appendix VII

IQP: Future Scientists and Technologists

Prospective Meetings

1. Chocolate Asphalt
    - Civil Engineering - A basic over view of road construction and different materials used in the process followed by making of asphalt from melted chocolate and other chocolate candy.
2. Lego Project Management
    - Civil Engineering and Project Management- An overview of what a project management and then a construction project with legos. Project goals would include building a tower with legos, surviving a wind test with that tower, and also keeping cost low with the amount of legos.
3. Gears, Cams, and Linkages
    - Mechanical Engineering- A look at many simple devices that are used in all types of machines.
4. Teraforming Mars
    - Biotechnology- Presentation on how different plants could be used to create oxygen on Mars.
5. Computer Science with Professor Gennert
    - Computer Science- A look into computer science from the head of the WPI department. Actual presentation focus undetermined.
6. Rehabilitation Engineering with Professor Ault
    - Rehabilitation Engineering- Look at the design process and helping people with disabilities have as much of a normal life as possible with the help of engineering. More details to be determined.
7. Robotics Demonstration with Ken Stafford
    - Robotics Engineering- A presentation using robots to show in a fun way the ability of robots.
8. Space presentation field trip at Ecoterium
    - A WPI sponsored field trip where WPI IQP presentations will be given at the Ecoterium in Worcester accompanied by a presentation by a member of the NASA Institute for Advanced Concepts.
9. Introduction to Engineering given by the WPI Admissions dept.
    - Overview of all the different typed of engineering accompanied with information about starting salary and the growing market for engineers.
10. Another Field trip to WPI
    - Field trip sponsored by WPI to give a tour of labs on campus and to give demonstrations on computer software unavailable at the Worcester Public High schools.
11. Space Survey results presentation
    - An overview of data gathered from a survey in Pennsylvania and in Worcester High Schools to show what high school students think about space.
12. Pizza Party
    - Final meeting with pizza and soda final questions from students can be answered.