The Undergraduate Experience in Engineering Outreach

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Tuesday, 9:24 am. *No sooner have you sat down at the office computer then a pop up window tells you "You've Got Mail." Throwing off your winter jacket and kicking your backpack beneath the desk, you settle back to see what they've got for you today. Julie wants further information on the Indus River Valley. Pat will be by at 2 to pick up his aquarium. Brian is looking to do an earthquake unit. Do any old activities fit? Closing the email account, you post your freshly jotted notes up on the wall. Turning back towards the room you take a deep breath and look around. Balsa wood trusses are in mid construction on the table. Copies of the Massachusetts and National Technology Standards are piled high on the bookshelves, alongside a few activity notebooks and a bright green Lego kit. A (now dormant) volcano sits in the corner next to Pat's nearly completed ecology aquarium. Sitting back down you can't help but feel content. Surrounded by the accomplishments that represent your impact on the program and the children themselves, you pause for a moment before asking yourself, where do I begin today?*

The National Science Foundation (NSF) GK-12 program is managed through the Center for Engineering Educational Outreach (CEEO) at Tufts University. The CEEO is a nonprofit organization working with area schools to incorporate engineering into preK-12 classrooms. The CEEO supports roughly fifteen different programs. The programs range from a summer camp for middle school students to workshops for teachers and educators.

The GK-12 project is a three-year project focused on pairing graduate-level engineering and computer science students with classroom teachers. The CEEO had six graduate fellows and four undergraduate fellows in the first year of the project, and currently has eight graduate fellows working in the classroom and four undergraduate fellows working with the graduate fellows. Graduate fellows spend twenty hours per week on the project, with sixteen hours (two full school days) per week spent in the classroom of their partnering teacher. The fellows spend their remaining time taking part in seminars relating appropriate educational pedagogy, discussing classroom learning strategies, and interacting with their undergraduates. Undergraduate fellows spend fifteen hours a week working with the graduate fellows to create activities and demonstrations for the classroom.

The undergraduate experience with engineering outreach is understated but highly rewarding. On a daily basis, the undergraduate fellows are challenged and energized by their role in the NSF GK-12 program. Working behind the scenes, the undergraduate fellow's duty is to help the graduate fellows create activities and demonstrations for their classrooms, map various education standards

to corresponding activities, and to continuously develop new ideas into standardized activities. Like any part of the NSF GK-12 program, the program benefits students through the collaboration of all the participants. From students to teachers to graduate and undergraduate fellows, this program creates a network of support that enhances the educational experience of all involved.

The standard format for GK-12 activities includes a title, Massachusetts standards, summary, directions, background information and much more. It was not always so well organized however. The undergraduate fellows have worked over the past three years to provide an easy to follow, yet thorough, project outline. This standardization though a recent advancement affects activities at all stages. Old projects, whether hand written notes, photocopied textbook pages, or outlined summaries, need to be corrected and restructured. Present day activities are drawn up into the proper format but often times require additional support. Background information is provided to help teachers feel more comfortable with the material. Reading supplements sometimes complement student tasks. Interesting extensions add a twist or new direction to an existing activity. Most importantly, each activity is mapped to education standards. Currently the National and Massachusetts science, technology, and mathematical standards are addressed in every activity.

In addition to revising and reformatting the activities, the undergraduates strive to improve the function and distribution of the lesson plans. A comprehensive website provides a database for teachers around the world to browse completed activities. It is the undergraduate's role to upgrade this site on a regular basis. A spreadsheet keeps track of all the standards met under the possible frameworks. Over 500 standards were reviewed and mapped. The database helps the undergraduates assess the strengths and weaknesses of the library of activities. Tallies show them which standards are more heavily supported and which ones need more focus. Finally, the undergraduates review teacher and graduate comments upon the completion of the activity in a classroom. This perspective helps undergraduates see how well their ideas carry into the classroom, and what aspects need to be improved upon. They are always seeking to provide a teacher friendly, highly informative, and enjoyable activity.

It is not uncommon for undergraduates to use information they are learning in their present college classes to create interesting activities for the classroom. For example, two undergraduates, a chemical engineer and a mechanical engineer, created a circuit with a three-way switch drawing on information from an introductory electrical engineering class. This activity will be used in a fifth grade class to help students gain hands on experience with electricity. The students will design their own stoplight, controlled by a three-way switch, which has lights both in parallel and in series. This activity reinforces the concepts of electricity and circuitry for both the fifth grade students and the undergraduates. By giving the undergraduates a simple yet real world electrical engineering problem, they are able to draw on their classroom knowledge and use it in a practical situation.

Along with simply designing a circuit, the undergraduates have to consider many different issues when creating activities. The activities must be easy enough for the students to recreate and they must also be inexpensive and easy for the teachers to understand. Because they work with a

variety of grade levels and schools, undergraduates must keep these concerns in mind when creating activities. For the circuit activity, to keep costs down a three-way switch was created out of a small cardboard box and brass pushpins. Three pins were pushed into the side of the box, and each pushpin was connected to a small lamp with wire. A fourth pushpin was connected to the power source. By touching one of the three pushpins in the box with the fourth pushpin, one of the lamps would light. The design for the switch is simple enough for a fifth grader to build and the materials used are usually found in the classroom or can be purchased for a nominal cost.

The undergraduate fellows are made of a diverse group of engineers. Among the four undergraduates working with the GK-12 program, we have a chemical engineer, a civil engineer, a mechanical engineer and a biomedical/mechanical engineer. These undergraduates bring together their diverse backgrounds to create a well-rounded resource for the graduate fellows. In the past year, the biomedical and chemical engineer created a bioengineering activity, which introduces students to different patented inventions that help people with heart problems and disabilities. This activity demonstrates how engineers affect people's lives while challenging students to design their own inventions to help people. The civil engineer has worked closely with one graduate to develop an activity integrating stress and bending moment into an algebra class. Drawing on material from civil engineering classes, the undergraduate found an inexpensive wood that the students could use to create a plank bridge capable of supporting a hundred pounds without failing. Using algebra and the information obtained by the undergraduate, the students solved for the moment of inertia to determine the height and width necessary for the bridge to support the weight.

Along with drawing from their engineering classes, the undergraduates draw on their own experiences in elementary and high school. Undergraduate fellows are able to provide a unique perspective on engineering outreach. Having recently graduated high school, undergraduates are able to relate more closely with the students they are trying to help. Many of the graduate students have been in the work force for a few years before returning to college for their masters. Although the graduate fellows are the ones who actually go into the classroom, the undergraduates provide much of the support. Undergraduate fellows develop and design activities and demonstrations for the graduates to use in the classroom. For example, one undergraduate drew upon a high school engineering experience to elaborate on a catapult activity.

The undergraduate fellowship is a unique way for undergraduates to learn more about their specific fields. The undergraduates combine both research and real world applications in their job. The undergraduate fellows use their experience in engineering to teach younger students about engineering. To be able to teach and apply engineering you need to have a firm understanding of the material. By using their classroom knowledge the undergraduate fellows prove that they fully understand what they have learned. They are also doing a great service to the community in reaching out to young students. By getting undergraduates involved in engineering outreach, they will be more likely to continue doing outreach later in their careers. Interacting with both faculty and graduate students at Tufts, and local industry people, undergraduates learn how to continue outreach past the undergraduate level.

Engineering outreach also introduces undergraduates to the application of their engineering

background in the classroom. The GK-12 program exposes undergraduate engineers to the possibility of a future in education. Attracting engineers to education could become a powerful tool. Right now most science teachers have little or no engineering background. Teaching students about engineering without having received a formal engineering education is daunting to many teachers. Many teachers participate in workshops and other CEEO programs to enhance their understanding of engineering and different methods used to teach it. Drawing undergraduate students into teaching would alleviate this problem.

Although the GK-12 program opens many doors for engineers, it is not an easy job to have. Undergraduate students have to be able to handle fifteen hours of work a week in addition to a full class load and extracurricular activities. Among the undergraduates working with the GK-12 program, we have a varsity field hockey player, an ASME officer, the Operations Director of the campus radio station, and an officer of the Catholic Center. Fortunately this job offers a unique opportunity for undergraduates to work with a relaxed schedule. Unlike many campus jobs, the GK-12 program offers a flexible schedule. Although the undergraduates are required to work fifteen hours a week, they can work whenever they wish. During the fall, the undergraduate who is involved in field hockey is able to work most of her hours at home and on the weekends. As long as the work is done and the graduate fellows' deadlines are met, the undergraduates have no set hours. Often undergraduates need to fit fifteen hours of work in between classes, tests and projects. Undergraduates often find time in between classes and early in the day to work. Many times they work on the weekends or at night after classes and homework.

The undergraduates rely on teamwork to complete the activities and projects. Most projects involve two or more of the undergraduates. They use each other to brainstorm for activities and demonstrations and to check each other's work. The activities that are developed through the GK-12 program go through a number of people before they are given to teachers. The undergraduates work in teams of two to write the activity, the activity is then read over by one or more different undergraduates and test run to assure the activity's viability. Along with working together to develop activities, the undergraduates combine their different areas of study to develop demonstrations and solve problems that the graduate students give them. The Bioengineering activity is a good example of this combination of different strengths. The chemical and biomedical undergraduate students were able to add their knowledge of biology and biotechnology to the activity while the mechanical engineer was able to aid in the design process.

To supplement the undergraduates' support work during the school year, they have had hands on experience working with students over the summer. For two weeks in July the CEEO runs a Lego camp for students. The camp teaches children to use LEGO's Mindstorm programmable LEGOs (RoboLAB). The children learn simple iconic programming and different building styles for LEGOs. The campers work together to build and program LEGOs that will solve challenges, such as navigating a maze or climbing a steep slope. Working with the campers gives the undergraduates more insight on how children learn and what problems they face. The undergraduates are introduced to many different learning styles throughout the two-week camp. During the all girls week this past summer, the campers were very interested in the musical capabilities of the program and less interested in challenging themselves with the building aspects of the LEGOs. While in the second week of camp, in which most of the campers were boys, the

campers focused more on solving the challenges and building different vehicles. During the first week, most of the campers were intrigued by the challenges and were able to stay busy throughout the week. Unfortunately some campers did not participate or care to learn anything. Three campers in particular stood back from the group. Despite repeated tries by the counselors, the three campers were not interested in learning RoboLAB or building with the LEGOs. Only one girl attended the second week. Her attitude was subdued and reserved. She did not talk to any of the other campers but instead focused on the challenges, but was very talkative and friendly when approached by the female undergraduates. Although there were definite gender divisions, socially all the campers were challenged by the activities offered in camp and enjoyed working to solve them. LEGO camp gave the undergraduates experience working with students and taught them how children learn and what interests them. The undergraduates learned that they need to design activities that engage all students so that every student can take part and learn the material.

A different forum for hands on experience has been the Science Olympiad. Each year five hundred middle school students come to Tufts for the one-day state Science Olympiad competition. Schools send teams of students to compete in different challenges and competitions. Undergraduate fellows help run and judge the different competitions. The challenges range from math problems to building soda bottle rockets. The students use their science and engineering knowledge to complete the different challenges. The Science Olympiad exposes the undergraduates to different activities and challenges that can be used in the classroom. It is also a good guide to what the students are capable of and what they enjoy doing. Working with the undergraduate fellows gives the students the opportunity to interact with engineers and learn more about engineering. Introducing students to undergraduates and people in engineering careers exposes them to new career options, and shows students that engineers are everyday people.

With the various roles that undergraduates play in engineering outreach, their work has become very beneficial to the graduates, teachers and the undergraduates themselves. By developing activities and populating the prek-12 engineering website the undergraduates have created a valuable resource for teachers. Long after the GK-12 program is done and the undergraduate students are gone the website and activities will still be available for teachers to use. By using the undergraduates to research projects and create demonstrations the graduates are able to spend more time in the classroom and working on developing their teaching skills. The undergraduates leave the program with a better understanding of what outreach is and how they can continue to work with children to teach them about engineering. The GK-12 program gives undergraduates a unique college work experience in which they can feel a sense of achievement in having added to a project that will continue to benefit students and teachers after the program has ended.

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