The Use of Hands-on Science Kits to Develop Interest in the Engineering Program at Sweet Briar College

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Abstract

Sweet Briar College, a liberal arts and science college for women in central Virginia, has an on-campus engineering major, only the second at a women's college in the United States. In an effort to publicize this new program, to communicate the excitement and creativity involved in engineering, and to show the relevance of science to high school students, we have implemented an outreach and recruitment program consisting of hands-on science kit visits to area high schools. The current version of the science kit is a plastic cup based speaker which plays music from a cd player or iPod. Engineering Program faculty members and college students visit area high school physics, mathematics, and engineering classes and guide the students through the process of building their speaker. Each student gets to keep their speaker. The kit contains directions, two cups, magnet wire, a strong magnet, a speaker jack, sandpaper, and rubber bands. Students are encouraged to be creative and redesign their speaker and to find ways to increase the performance. Students are amazed at their functioning speaker and are excited to show their friends outside of their class. The kit is nicely packaged with a prominent Sweet Briar logo along with a website address. The website shows Sweet Briar women actively doing science and engineering projects and is a gateway to information on engineering as well as the other science programs at the college.

One challenge in making visits for outreach and/or recruitment to high school classes is the state standards-driven testing environment which has become increasingly common. A benefit of our outreach program is that the underlying physics concepts in how the speaker operates are actually common standards (ex. basic circuits, electromagnets, sound waves). We have found that high school teachers are eager to have us visit them with these kits as opposed to having a faculty member lecture on the design process, for example. We also find that being on campus with the kits gives us access to guidance counselors and other administrators at the high school. Guidance counselors can have a substantial effect on young women's choices in education and as a new program, this network of teachers and other professionals is crucial for the effective communication of the advantages of attending an engineering program at a small women's college.

Students are asked to submit an online questionnaire on the speaker kit activity and their attitudes on women in science and engineering. Students are encouraged to complete the

questionnaire as all students that fill it out are registered for the drawing of an iPod. Preliminary results from our assessment will be presented.

Introduction to Engineering at Sweet Briar College

Founded in 1901, Sweet Briar College is a private and independent four-year liberal arts and sciences college for women, located in central Virginia. Sweet Briar has approximately 660 students in residence from 42 states and 21 foreign countries. The college recently instituted an Engineering Program that offers the B.S. in Engineering Science and B.A. in Engineering Management. The first class of students began in the fall of 2005 and we plan to seek ABET accreditation with our first graduating class. The Sweet Briar Engineering Program offers an engaging and supportive environment for women. Our small average class size of 8-12 students allows for a unique level of faculty/student interaction and promotes learning inside and outside of the classroom. Our educational approach includes frequent group and individual projects and a high level of interaction with local industry, including a required summer co-op experience. This focus on "learning by doing" gives our graduates the strong analytical, organizational, and leadership skills that are critical to success in industry or graduate school.

The program stresses an interdisciplinary approach to mechanical and electrical engineering with a particular emphasis on problem solving at the systems level. We are confident that this interdisciplinary approach best prepares our graduates for employment in a technical environment in which the lines between disciplines are no longer clear. Another distinctive feature of our program is a required course involving an international or regional design project. This course focuses on responsible problem solving in an appropriate societal context. This course is generally taken in the junior year by engineering majors and is open to students outside the engineering program. Students effectively form a small, non-profit business to raise money, formulate strategy, and engineer a solution to one or more problems faced by a less-advantaged segment of society.

As a new engineering program in a nontraditional setting (a woman's liberal arts college), spreading the word about the opportunities for engineering education at Sweet Briar is critical to our success. One tactic to increase our visibility has been the implementation of the hands-on science kit outreach project. By visiting high school classes, we not only are able to interact with high school students, but, perhaps more importantly, we can talk with high school teachers and guidance counselors. We also leave program newsletters and program information cards with the teachers and counselors.

Outreach Program Design and Implementation

Part of the challenge to implementing any high school in-class outreach activity is finding activities which are fun for teenagers, rich in content, and provide opportunities for further experimentation. Other key parameters for the project include designing an experiment that is inexpensive enough to allow students to keep the materials when they are done. Perhaps most importantly, the activity should be related to technology in which high school students have an interest. We are also constrained by the 40-60 minute class period. Taking these parameters into account, we chose a project in which students construct a speaker that can be used with a personal mp3 or CD player. Students construct the speaker from inexpensive materials. In doing

so, they have a chance to explore the physics of how speakers function and to experiment with alternative speaker components. The speaker-kit project was based on directions for the "Cheap-O Speaker" from CPO Science (www.cpo.com). Students are encouraged to pose and then answer their own questions as they work with the kits.

As of March 2008, we have built speaker kits with approximately 400 high school students. The engineering program faculty members lead students through the building process and engineering majors from Sweet Briar help the high school students. We encourage our engineering students to be active participants and role models, particularly for the female high school students. To date, we have visited area high school physics, calculus, and engineering drawing courses with this science outreach project.

At the beginning of the speaker-building project, each student is given a kit that contains directions, two cups, magnet wire, a strong magnet, a speaker jack, sandpaper, and rubber bands. Directions for the kit are available at www.engineering.sbc.edu/speakerkit.htm. Photographs of the speaker kits and a completed speaker are shown in Figure 1. In general, students take 20-30 minutes to build their speaker. Students either bring their personal iPod or we provide CD players and CDs for use in testing their speaker. In general, a variety of trouble shooting occurs as students build their speaker. After students have made their speaker operate, the faculty members pose several questions to the group with the goal of encouraging further investigations from the students. For example, each kit comes with two types of cups; students are asked which cup results in a louder speaker and why they think this is the case. We prompt students with questions about the role of the coil. We ask why they needed to sand their wire and what role does the cup play in the design. We also provide other materials to experiment with such as soup cans and glass containers.

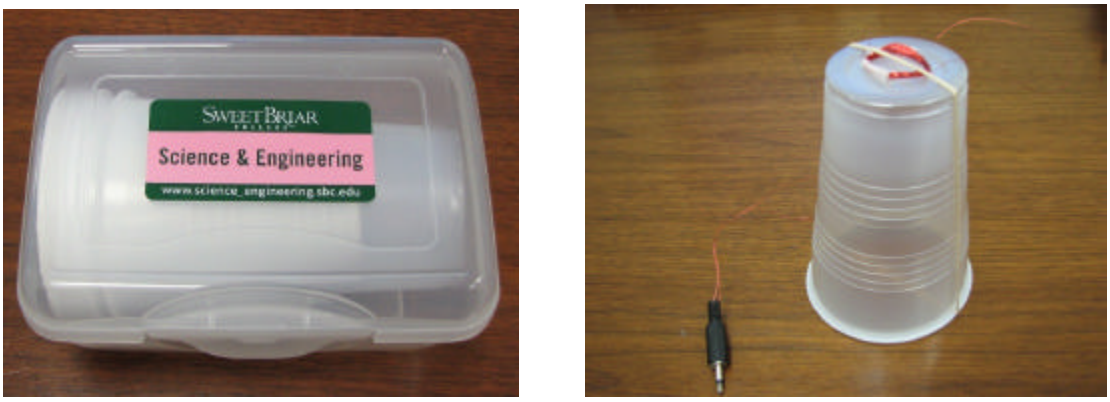

Figure 1. Photographs of Speaker kits

Students are encouraged to be creative and redesign their speaker and to find ways to increase the performance. This type of open ended inquiry excites students and often leads to creative designs. These include using the plastic box, a rolled-paper tube or their own ear as a speaker cone. We also discuss each of the components of the speaker and lead a discussion of the physics behind speakers. Students are amazed at their functioning speaker and the excitement in the classroom builds as students after student gets their speaker to work. Students are also anxious to show their speakers to friends outside of their class. We stayed at one particular high

school and saw students showing other teachers, their friends, and even school administrators their speaker.

The speaker kit is packaged with a prominent Sweet Briar logo along with a website address. Again, this is an important part of branding our engineering program and maximizing the advertising effect of the activity. The website (www.science_engineering.sbc.edu) shows Sweet Briar women actively engaged in science and engineering projects and is a gateway to information on engineering as well as the other science programs at the college. The high school students are also given items including Sweet Briar Engineering pens and a current copy of our program newsletter which highlights recent program activities.

After implementing this project over two semesters, we feel that there are improvements we can make to the recruiting aspect of our interactions with high school students. We plan to add follow-on activities to this outreach effort. We understand that one time, short duration strategies such our speaker kit activity are not particularly productive at attracting students to STEM fields without follow-on activities which later engage these students. We plan to strengthen this outreach effort and increasing the recruiting aspect of this project by having Saturday Girls Engineering events which include participants from these high school visits.

In addition to benefits of creating the network of high school teachers and the interactions with students, this project has resulted in important publicity for our engineering program. The Lynchburg News and Advance and the Winston-Salem Journal both ran a story on this project. Given the challenge of publicizing our new engineering program, this type of publicity is important.

Assessment of Outreach Project

High school student participants were asked to fill out an on-line survey that included questions about their views on math and science and their beliefs about their own potential in these areas. Students were also asked about the speaker kit activity. We encouraged students to participate with the survey by raffling off an iPod to those who completed the survey. In general, students viewed the activity positively. Although we only have preliminary data from these surveys, student responses suggest the presence of an unusual, although not unheard of, paradox. Female students overall report that they do well in their math and science courses, making great strides in erasing the perceived gender gap in these fields reported in the AAUW report (AAUP, 1992). What remains though is that despite objective evidence that they are doing well in these classes, and that they have enough original interest to take them, females still seem to see math and science as something that "other people do."

In our survey, female high school students reported that they: (1) did well in both math and science, (2) that they have the capacity to do well in college, (3) that "someone like them" would do well in college in math and science. However, when asked how THEY would do in college math and science courses, their responses become substantially more pessimistic. This downturn in self-expectations, despite evidence to the contrary seems to be an unfortunately all-to-common disconnect which may contribute to the resilience and propagation of negative stereotypes about girls in math and the science (Lee, 1994; Ridgwell 2003).

Conclusions

We have described a hands-on science kit outreach project that is implemented in one hour class periods in high schools. The goal of this project is to create a network of teachers and counselors that will advise their students about the benefits of the Sweet Briar Engineering Program. Another goal is to create excitement for science and engineering amongst high school students. We plan to initiate follow-on Saturday engineering activities to increase the recruiting aspect of this project. An initial assessment of student attitudes suggests that female high school participants have negative self-expectations in math and science. As we implement our follow-up Saturday activities, we will determine how these additional sessions affect student attitudes.

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