Engineering Technology Program for Girls Ages 9-13

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Abstract
This paper describes a program led by female Engineering Technology students, with support from female faculty, to provide an introduction to Engineering Technology to 4th – 7th grade Girl Scouts through a series of interactive laboratory experiments. The program takes place on our college campus and makes use of four different Engineering Technology laboratories. Each lab activity includes a hands-on experiment, beginning with an overview of the engineering technology discipline and a brief description of the theories related to the experiment. The day culminates with a question-and-answer period between the Girl Scouts and the student volunteers. Having the educational material presented by college students seems to have a much bigger impact on this age group than when the same material is presented by someone older. The combination of enjoyable activities and the opportunity to work with college students results in the girls leaving the day with a more positive view of science than they had when they arrived. Surveys given at the start and end of the day confirm the change in attitudes.

An unexpected benefit to this program is for the college students who volunteer their time for the program. They work together within their own department to develop the activities and facilitate the experiments. They also work with the female students from the other departments in the panel discussion and overall organization of the day. The students gain the satisfaction of influencing the attitudes of the Girl Scouts as well as developing a sense of community with their classmates. The students improve their communication skills and increase their knowledge of their own majors, both of which contribute to confidence when speaking to interviewers.

Introduction
With our ever increasing technology-based society and predicted high rates of retirements for engineers over the next decade, the U.S. needs more engineers. One way to increase the number of engineers is to increase the number of women engineers. Although the percentage of women studying engineering has doubled since 1980, from 10% of engineering bachelor’s degrees awarded to 20%, this percent has plateaued over the past decade. Women make up 46% of the available workforce, but only 9% of engineers are women. Getting women interested in engineering needs to begin early. The gender gap in math and science courses grows as students go from middle school to high school. In fourth grade, girls report the same level of interest in math and science as boys. However, by the time they reach the eighth grade; boys are twice as likely to be interested in science, math, engineering or technology (STEM).
Research has shown that middle school is a critical time to engage students, especially girls, in science and engineering outreach programs. If girls lose interest in math and science in middle school, when social pressures and gender difference become more pronounced, they typically won’t find their way back to the subjects. (Comer, 2005)iii Middle school is a critical transition period. It is where decisions are made that will open or close career options. Math and science are the keys to careers in engineering and technology. If students decide not to pursue these subjects in high school, they are essentially closing the doors to certain professions. Thus our main challenge is attracting middle school students to science and engineering. (Richards 2007, 874-883)iv

A decrease in interest in science and engineering at this critical age indicates there is a problem in the way young girls are exposed to these fields. Best practices for outreach programs for young girls include hands-on interactive activities. The National Center for Women in Information Technology-Promising Practices states that the essential ingredients for a successful outreach program for girls are: ensure that the girls are with their friends or can otherwise feel a sense of belonging in the group to which they are assigned, keep talk to a minimum and action to a maximum, and connect the things they are doing to things they already know or care about.v Similarly, girls excel in learning situations that involve hands-on cooperative strategies with same-sex peer groups which alleviate the feeling of isolation.vi Activities should be gender friendly and involve “learning by doing”. vii

Background
Women in Technology (WIT) is a group that was formed on our campus in 2003 to provide both social and academic support to female students enrolled in engineering technology disciplines. The original objective of WIT was to help retain female engineering technology students with the ultimate goal of increasing the number of female graduates in Mechanical, Manufacturing, Civil, Electrical, Computer, Telecommunications and Packaging Engineering Technology. While the social and academic activities sponsored by WIT have been successful in increasing retention rates of female engineering technology students, the students indicated that they would like to see the program expanded to include opportunities for community outreach. This request by the female students is consistent with current literature on what attracts women to a career. A study by WGBH Educational Foundation for Extraordinary Women Engineers showed that females seek careers that are enjoyable, have a good working environment and where they feel they can make a difference. The female students felt that what was lacking in WIT’s programming was an opportunity to make a difference. When polled, 72% of the students active in WIT (approximately 42% of the female engineering technology students) said that they would like to be involved in an outreach program that involved Girl Scouts.
Planning for the Girl Scout program began in the fall of 2007. It was decided that each of the four engineering technology departments would sponsor a lab activity and it was left up to the students to design and plan the activities. The faculty member’s responsibilities involved procuring supplies, supervising the planning and, most importantly, finding the girl scouts that would attend. The responsibility of planning the program was left mainly to the female students to ensure that they would feel a sense of ownership for the program. Additionally, many of the students involved were former and life-long girl scouts who had a better idea than the faculty members on how to reach girls in that age group.

The program was given the name ‘Girl Scouts in Technology’ and in February of 2008 the first offering of the program occurred with a troop of 9 girls attending. In April of the same year, the program was expanded and two troops, 18 girls, attended. Since that time the program has continued to grow with 36 girls attending in October 2008 and 40 girls attending in February 2009. The success of the program is evidenced in the requests from Girl Scout troops wanting to attend. The program scheduled for April 2009 was full by the end of January.

Program Details
The design of the program for Girl Scouts in Technology keeps in mind the essential ingredients for a successful outreach program for girls.

Ensure that the girls are with their friends or can otherwise feel a sense of belonging in the group to which they are assigned: This program is promoted as a troop activity to increase the probability that the girls will feel part of the group and be with their friends. Many of the other technology badge workshops offered locally are geared towards individuals instead of troops and the girls miss out on the camaraderie aspect that has been shown to be vital to a girl’s view on whether an activity is worthwhile.

Keep talk to a minimum and action to a maximum: With this in mind, the experiments were designed to be hands-on with the girls performing as much as the experiment as possible. This involved letting them use the tools in the engineering technology labs to complete their own experiment from start to finish. The result is two-fold in allowing them to do so. First, they learn proper use of some of the tools and safety precautions such as the use of rubber gloves when handling chemicals and safety glasses when working with concrete. Secondly they feel a greater sense of accomplishment that they did it all themselves and nothing was “pre-done” for them. While we feel that providing theory is an important part of each experiment, the theory discussion is only a small portion of the activity. Theory is presented with colorful slides and drawings and in an interactive manner.

Connect the things they are doing to things they already know or care about: This proved to be a challenge as the girls come from different school districts with very diverse backgrounds in
science. The experiments were chosen to best represent the connection between engineering and objects in everyday life and efforts were made to have the experiments be especially interesting to girls. Wherever possible, the supplies for the experiments were materials purchased in regular department and/or hardware stores to further show that science and engineering can be easily accessible.

The day includes four laboratory experiments conducted in the Civil, Mechanical and Manufacturing, Electrical and Computer and Packaging Engineering Technology Labs. To keep the student volunteer to girl scout ratio low, ideally 1 to 2 or 1 to 3, the girls are broken into four groups and each group does a different activity during each one-hour time slot. Even though the volunteers have to give their presentation and perform the same experiment four times in one day, they are able to give the girls scouts a great deal of individual attention and the girl scouts are not forced to spend much time waiting for somebody to help them.

The Civil Engineering Technology experiment involves the study of concrete. Concrete is a material the girls are well familiar with, but have never really thought of the science behind it. To make this experiment more appealing to girls, concrete is used to make a piece of jewelry. After learning about how concrete is made, the girls are given a recipe to make their own batch of concrete. They use a precision scale to weigh their dry ingredients and a graduated cylinder for measuring liquid ingredients. They are then given a choice of molds to pour their concrete into and a small straw is used to form a hole. The end result is a concrete pendant that can be put on a cord and worn as a necklace.

The second part of the concrete experiment is strength testing. Several different concrete cylinders are prepared ahead of time with different cure times and core materials. The girls take turns hitting the concrete with a sledgehammer to see which cylinders break more easily. They see the relationship between the cure time or core material and the strength of the concrete. This activity always results in loud cheering and clapping. Wearing a hardhat and swinging a hammer gives the girls a true feeling of being part of the experiment and being a real engineer.

There are two experiments that have been performed in the Electrical and Computer Engineering lab. Since the New York State science curriculum introduces electricity and magnetism in 4th grade, the girls are familiar with some of the theory introduced in this lab. This allows for deeper experimentation. In the first experiment, a speaker is made from a plastic cup, a playing card, a coil of wire and two magnets. The girls each make their own complete speaker while learning how it works. All of the speakers are then connected in series to a radio so everyone can listen. As with the concrete experiment, there is much clapping and cheering.
at the moment when the music starts playing in the plastic cup. Building a motor from a battery, a magnet and a coil of wire is the second experiment presented in this lab. Although this is an individual activity for each girl, they each have a motor to take with them and experiment with at home. This experiment shows that an engineering experiment does not have to involve expensive lab equipment.

One of the most important things that the girls (and their leaders) learn in the packaging engineering experiment is that Packaging is a possible career field. This activity begins with a display of antique and modern packages. Included in the display are packages from products the girls are familiar with. Considerations for package designs including costs and environmental concerns are discussed. Computer Aided Design software is then demonstrated and the girls are shown how a flat design is rendered in three dimensions by the software. In conjunction with the software, an automated cutting table is used to cut out the flat design on tag board. Each girl is given a cut design and instructions on how to fold it into a 3-dimensional ‘package’. The packages are picked to be of interest to girls and seasonally relevant. For example, a haunted house for Halloween, a heart-shaped box for Valentine’s Day and a basket for spring. To make this activity of further interest to girls, stickers, decorations and markers are provided for them to creatively embellish their package.

The Mechanical and Manufacturing Engineering Technology experiment centers around plastics. The girls first learn the theory of polymer chains and characteristics of plastic. Then they make bracelets (resembling a polymer chain) with plastic charms that are made from “shrinking plastic” taken from take-out food containers. The charms are measured with high precision calipers and weighed prior to and after shrinking. The girls learn how to use the measuring devices and how to record and compare data. This activity is of special interest to girls as it involves the creativity of making the charms and also having a piece of jewelry to wear as the finished project. The second part to the plastics experiment is the creation of “slime” from white glue, water and Borax. This is another experiment that connects objects from everyday life to engineering and can be performed with common household ingredients. The girls enjoy the slime so much, it is tough to keep them from playing with it for the rest of the day.

The final activity in the Girl Scouts in Technology Day is a panel discussion with the student volunteers and the girl scouts. The student volunteers share their stories of how and when they decided to be engineers, what they like about studying engineering and college in general, what they don’t like about college and some of the challenges they have faced being a female in engineering. The girls are encouraged to ask the students any questions that they may have regarding engineering or college life. Even after the long day of experiments, most of the girls are attentive and engaged during the panel discussion. An example of the impact that this
discussion has on the girls was overheard in February. As one of the girl scouts was walking out
with her mother she excitedly told her, “Mom, two of the girls said that they decided to go into
engineering because when they were my age they liked to take things apart – just like me”.

Results
Each time the program is offered, we receive feedback from both the girl scouts and their
leader which provides anecdotal evidence that the program has inspired some girls to view
science as a fun and interesting field of study. Comments from the girls to WIT include:

“I want to do that when I grow up:”
“I want to be just like you guys”
“You chose awesome things to do at college”
“Girls can be engineers”

Leaders also reported:

“I couldn't help but smile when they were talking about a troop member who opted not to go
because she assumed that it was going to be boring - and the rest of the troop was now
laughing at her for having thought that - because they had so much fun!”

"I can't tell you what a great time my girls from both troops had today! It was really a fabulous
event! From my perspective, it was great because science and technology are not my areas of
strength, and I felt fortunate to have this opportunity to showcase young women in the
engineering field. My co-leaders and I feel strongly about exposing the girls to a wide range of
activities to hopefully spark interest in things they may not have thought about before." 

“Women in Technology did a wonderful job sharing their knowledge and personal stories
about engineering. I think they inspired us all. Please extend a thank you to all of them
for giving up time on a Saturday to spend with us. Their influence is powerful over our troop's
age group.”

While this type of feedback confirmed to us that the program was worthwhile and making a
difference, we wanted to quantitatively measure the success of the program. To do so, we
developed a survey to give to the girls before and after the program to measure whether
participation in the Girl Scouts in Technology Program had a positive influence on the girls’
attitudes towards science and technology. The survey consists of 5 simple questions that assess
their perception of the difficulty of science, their interest in science (boring or fun), their knowledge of what an engineer does, their idea of which gender an engineer is and whether they would like to be a scientist or engineer when they grow up. The results collected so far have indicated that participation in our program can influence a positive attitudinal shift towards science and technology. Some examples of the results are:

I think science is easy: Before 6%, After 20%
I think science is fun: Before 47%, After 75%
I know what an engineer does: Before 15%, After 57%
I would maybe like to be a scientist or engineer: Before 48%, After 69%

In addition to these results, 58% of the girls who indicated in the ‘before’ survey that they did not know that women could be engineers responded that “anyone can be an engineer” in the ‘after’ survey.

The program has proven to be beneficial to both the girl scouts who participate and the engineering technology students who volunteer their time to run the program. As mentioned earlier, the planning and preparation of the experiments is left to the students so that they have a sense of ownership for the activities. This also fosters teamwork among the students in each department as they work together on the experiments. The younger students are given the opportunity to interact with, and thus be informally “mentored”, by the more senior students in their department. In the case of the packaging experiment, the first year students learn from their classmates how to use the design software since they have not taken the class yet. The Girl Scouts in Technology program also requires interdisciplinary cooperation for the overall coordination of the day along with the panel discussion portion. The students have the opportunity to meet students in other engineering technology disciplines and often help out in the other labs to get a better feel for their experiments. These interactions lead to a greater sense of community and belonging for the female students. Preparing the experiments and the accompanying presentations provides the students with an opportunity to improve their communication skills and increase their knowledge of their own majors. The students gain confidence in themselves and also gain satisfaction in knowing that they are making a difference for the girl scouts in attendance.
Although funds are available through a grant to pay students for developing and running the workshops, it has been found that students are reluctant to accept payment for their involvement. When given a timecard to complete for the day, many of the students will refuse to fill it out or request that their pay be put back into the program for supplies. Most respond that they participate because it is fun, not because they expect to get paid. Thirty-two different students have volunteered in this program, with many of them participating in all four sessions to date. This number represents over one-third of all registered females in engineering technology disciplines. When asked what it means for them to participate in the program, the students responded with the following:

“For me, it is a chance to share my love of mechanical engineering and hopefully inspire those who are thinking about engineering to follow their dreams and achieve their goals. “

“It allows me to stay connected to something I’m in, but, this time, instead of being the Girl Scout participant, I’m the program leader/assistant. Besides, it’s fun and it makes me feel right at home.”

“Participating in the WIT Girl Scout events is a chance to help young girls realize the possibilities they have if they decide to pursue a future in the technological field.”

Conclusion
The Girl Scouts in Technology Program, run by female engineering technology students, has proven to be an effective outreach program aimed at 4th-7th grade girls. This program combines fun hands-on activities and scientific theory presented by young female college students. Having scientific theory presented by college students appears to have much more of an impact on girls in this age group than if the material was presented by a traditional teacher. The girls view the college students as ‘cool’ and someone that they can relate to and they realize that an engineer does not have to be the stereotypical nerd that the media makes them out to be.

Both objective and subjective results indicate that this program can influence a young girl’s attitudes towards science and technology and to view science more positively. Participants in this program realize that science and engineering are accessible and understandable to anyone. Some even start to consider science or engineering as a possible career field.

A corollary benefit from this program is for the students who volunteer their time. Participation in this program provides both camaraderie and the opportunity to make a difference. Studies have shown that these are important to women in choosing how they want to spend their time.
References


