THE GOES PROJECT: A SUCCESSFUL OUTREACH PROGRAM THAT INTRODUCES MIDDLE SCHOOL GIRLS TO ENGINEERING

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INTRODUCTION

At Drexel University the Women in Engineering (WIE) Program members are keenly aware of the reality that many young girls do not choose engineering as a career path because they are either turned off science and math or are dissuaded from its pursuit at a very early age[1-3]. The causes are many , including peer pressure, ignorance on the part of teachers and councilors, an inability to impart information about what engineers do, and what is needed to become an engineer, and a general lack of reinforcement and encouragement[4-11]. As a result, Drexel WIE sought NSF funding and Drexel University support to initiate GOES (Girls' Opportunities in Engineering and Science), an outreach effort which seeks to remedy detrimental effects of women's under-representation in engineering by creating an engineering workshop that literally GOES to middle and junior high schools located outside a one-hour radius of Drexel University. The format builds upon the successful experience of the Drexel WIE Program in reaching out to local young women through on-campus engineering career days. The GOES program targets pre-High School students, specifically those in grades 6 to 9, because during this critical stage students finalize their decisions about pursuing high school courses in mathematics and science. The goal of the project is to raise the awareness of these students as well as their teachers, counselors, and parents about the opportunities offered by the engineering profession. The specific aim is to facilitate their interest and motivate the students to pursue science and mathematics subjects which constitute the building blocks of an engineering education[12].

FACILITATION OF THE GOALS OF THE PROJECT

To achieve these goals, hands-on experiments were designed by female Drexel faculty in the college of Engineering, specifically to convey the fun and excitement of applied sciences and engineering. The discovery and exploration element is emphasized to give participants a taste of engineering practice. To ensure that these events have lasting effects on the students, teacher and parental involvement is encouraged, in line with studies that have shown their primary influence on girls' career decisions[13,14]. Another benefit of educator and parent participation is to also introduce them to the practice of modern engineering and the role that women engineers are playing in affecting a fundamental culture change.

A TYPICAL TRIP

Pre-visit Organization

School Selection, Contact, and School Responsibility

Initially school selection was based on previous contacts made by the WIE Program with individual teachers at schools. However, the word has spread fast, both by word of mouth and by various favorable articles in the Philadelphia press, and we now get frequent requests from schools, several each month.
The selected school receives the NSF proposal project summary, which is usually required by the contact personnel to obtain the necessary administrative approval. A letter is sent indicating there is no cost to the school and outlining their responsibilities. Schools are asked to provide a large multi-purpose room (usually the gym) with tables, chairs, a VCR and an overhead projector. They are also asked to notify parents and teachers and to select the 50 students who will be attending the program.

Selection of Students

After the first three visits, it became clear that the original concept of "self-selection" did not meet our goals. Given the opportunity to attend an all day program on engineering, girls responded at a rate of about 10%. To counter this lack of enthusiasm, we developed a flyer for distribution, to describe the program, and spark enthusiasm. When school-selected girls were required to attend, there was as much enthusiasm during the event (if not more). This method was more in keeping with our goal of introducing engineering to all girls just-in-time for the right high school course selections. When girls self-selected, they were in general "good in math and science" and probably would continue with math and science. The objective of the program is to present engineering in time for when girls consider various career options.

Material Preparation, Storage and Delivery to the School

All of the labs were designed to be portable, and are stored in a secure room provided by Drexel. Equipment is stored in the original boxes, and other lab materials such as polymer solutions, k'nex pieces etc. are stored in large, labeled Rubbermaid® containers. Good organization is essential to ensure the smooth running of multiple trips per term. The lab developers have trained undergraduate and graduate students who can set up and also conduct labs when faculty are not available. These students are responsible, under the direction of the project coordinator, to load the van early (earliest was 6:30 am, not a popular time for students!) in the morning of the visit and to unload/load and set up/dismantle the labs at the school. In addition to the labs, ancillary material such as the movies that will be shown, and laminated display posters highlighting famous women in Science are also packed. Folders are prepared for each girl. Each hand-out is copied on a different color paper so as to be easily identified. Together with the day's schedule, each folder contains (1) "Engineering and You" brochure[15], (2) a listing of the Engineering Professional Society and their addresses, (3) "Is Engineering for Me?" -- considerations when choosing careers, which provides a summary of the topics we wish to cover through the day's activities, (4) Movie "do" sheet, (5) Descriptions of the four basic fields of engineering, (6) the difference between engineering and science, and (7) Do I have the Aptitude for Engineering - a list of some of the aptitudes needed for

engineering. Since equal numbers of four different color folders are used, they also serve as a simple mechanism to divide the girls up into four groups for the labs.

A typical schedule for the day

8:30-9:30	Drexel team sets up laboratory and displays
9:30-10:00	*Welcome*: Distribution of name tags, and "Science is Women's work " badges. *Warm-up exercise*: Girls are asked to identify the process of waking up and coming to school and then identify how an engineer may have been involved at each step. *Startling facts and figures*: Girls are asked to guess the % of women in different careers. Salaries are given. *Introduction to engineers*: All the Drexel women in the room are introduced, with their discipline, "This is Mary Smith and she is a Chemical Engineer".. *Movie:* (8:40 minutes) Bikes! Art, Elegance and Engineering[16] The girl are asked to use the movie "do sheet"
10:00-11:30	Two 45 minute lab. sessions Girls are organized into 4 groups of 10-15 and will rotate through the labs. (2 in the morning and 2 in the afternoon)
11:30-12:30	Lunch
12:30-2:00	Two 45 minute lab. sessions
2:00-2:10	Group photograph with all the k'nex designs and judging of the tallest k'nex structure. Photographs are later mailed to each girl
2:10-2:25	Free time. Second visit to lab activity of their choice
2:25-2:45	Wrap-up Revisit "what engineers do" (hopefully more input now) Movie (12 minutes)"Who are Engineers? You?[17] Filling out and collection of evaluation form

DESCRIPTIONS OF SOME OF THE EXPERIMENTS

We have prepared six labs, four of which are taken on a visit. In each case the emphasis has been on fun and hands-on-learning. The labs are constantly evolving, each trip gives us ideas for improvements and additional material. In most cases the material that was initially conceived has been simplified, reducing the amount of information imparted, but increasing the time for the girls to experiment for themselves. We have also noticed that when the girls can take something home, a paper cup "overflowing" with solid foam, a scanned picture of themselves, a bottle of microcapsules containing brightly colored sand, the level of enthusiasm is heightened. We also feel that this will encourage

discussion with classmates, parents and siblings, and extending the positive aspects of the labs beyond the day of the visit.
Extensive lab details may be found by visiting our Drexel University Women in Engineering WWW site at http://berl3.ece.drexel.edu/wie/. Following is a distillation of the labs to give a flavor of the activities. The labs start with information about the particular engineering discipline which would best encompass the activity, and follow with constant interaction between the presenter(s) of the labs and the girls, with carefully directed questioning and encouragement, all the while weaving in information about what engineers do, and need to know. Safety glasses are supplied for all girls.

Engineering Design Lab

This lab was developed by civil and architectural engineers to teach the concepts of engineering design, and teamwork. The girls form four groups and are given a design handout delineating the steps in design, from problem statement through strategy development and prototype construction. They are instructed to build the tallest free standing structure that they can in a given time period using a box of k'nex connectors and rods. At the end of the allotted time, all the structures are compared, and the tallest is kept for entry into the overall contest.

Exploring Multimedia and Computer Networking

With the electrical and computer engineers, the girls are introduced to bits and bytes and writing their names in ASCII. Then they sing, clap giggle and talk into PowerMacs and watch the generation of the waveform, and see how the sound changes with different recording and processing parameters. Discussion can range form medical imaging to compact discs and sound editing to voice recognition.
In the image processing section they can capture images of themselves, or scan them into the computer. They can record a short video of themselves and their friends and watch it appear on the screen. Together with discussions again of medical imaging and image reconstruction they learn about pixels, and how much larger the memory has to be to store a picture.

Chemical and Biomedical Engineering applications of Polymers

With the Chemical Engineers, the girls learn about polymers and cross linking agents on a molecular level. They are directed in an exercise where they themselves are monomer units which join up to be a viscous solution of polymer strands and then set hard when some of the girls are "bonded" between the "polymerized" chains made up of their classmates. They are then introduced to the world of polymeric microcapsules (carbonless paper, [they love to be asked how many of them have a credit card to sign off on], scratch and sniff, perfume samples, pharmaceuticals) and a lab in which clear polymer solutions containing four different brightly colored sands are formed into capsules by dropping them from a plastic syringe into a hardening solution. The girls are encouraged to experiment and make encapsulated strands etc. The capsules are made in small screw cap vials, which can be taken home.

Materials Engineering: Processing and Properties of Materials

This lab is run on alternate trips with the Chemical Engineering lab, and starts with the same exercise of "polymerizing" the group. There then follow two very popular labs in which the girls make foam in a paper cup and slime[18]. The slime can be made to bounce or flow. Then they turn to metals, and play with shape memory wires (Ni-Ti alloy) that they form into any shape, and then place in hot water and see it straighten out.

Ground Water Flow and Pollutant Transport

Many young people are very concerned about protecting the environment, and girls are particularly interested in activities which can be seen as increasing the common good. With the Civil Engineers, they participate in a demonstration of how substances (in this case solutions of food color) travel from the source, through different deposits, and into the ground water. Also they are encouraged to discuss ground water and water quality, properties of aquifers and wells, and the general causes and sources of pollution.

Drills: Design and Manufacture

With the Mechanical Engineers, the groups are again introduced to design. After using cordless drills to put screws in chunks of 2 x 4, and in some cases, when the other groups do not complain too much about the noise (!) compare this with hammering in a nail, they are encouraged to draw a picture of what they think is inside the drill[19]. Next they are instructed on how to open up the drill and look inside. They are asked to place the case on a paper and trace the outline, then to draw the inside of the drill that they see. In this way they are introduced to design and manufacturing and encouraged to discuss economics, and design improvements.

CONCLUSIONS

Without exception, Drexel faculty and students who participate in this program are heartened and greatly rewarded by the intelligence, exuberance and enthusiasm of the girls who take part in this outreach program. Invariably, the schools which we have attended are eager that we return in subsequent years. No schools have expressed concern about presenting the program to girls only, since most educators are very aware of the need to stimulate and inform young females about engineering. With the freedom to be themselves in a friendly supportive atmosphere, the girls display great aptitude and engineering ability. They take enormous pride in their tallest k'nex structure, or rush up to the microcapsule table to make another vial of capsules in the free time. They also give us very useful (usually positive) feedback from the questionnaire which they fill out at the wrap-up session, and many students come up to the instructors at the end of the day to personally thank them for a great time.

In the future we intend to seek funding to enlarge this effort and involve many of the excellent science-based institutions in the greater Philadelphia and New Jersey area, such as the Zoo, Academy of Natural Sciences and the Franklin institute. This will give the

opportunity for extensive follow up. We also would like to develop a mechanism for tracking the girls through high school to see if any of them do chose engineering as a career. In the future, if research reveals that by 6th grade girls are already turned off science, we may have to target even younger students and develop labs for 1-5 graders.

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