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# Final Report

Engineers Change the World: A  
Hands-on Workshop for 13- to  
18-Year-Old Girls  
(2013-028S)



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## **ABSTRACT**

The Center for Transportation and the Environment (CTE) at North Carolina State University (NCSU) and The University of Florida (UF) collaborated with the North Carolina Department of Transportation (NCDOT), and Women's Transportation Seminar (WTS) to introduce engineering, particularly transportation engineering, as a viable career option for girls.

This project used a series of one-day workshops targeted at middle and high school-level girls in North Carolina and Florida. Girls at these levels are taking classes to meet requirements for college admission and they may decide to take more STEM courses if they can see a benefit.

Experiential hands-on activities, speakers, role models, and mentoring opportunities served to engage and inspire. An accompanying website was created to help market the events as well as continue the learning experience by providing resources to supplement the workshops.

A companion piece to this project is to foster the establishment of a student chapter of Women's Transportation Seminar at NCSU to help provide an additional network of role models for younger girls as well as the student members.

## EXECUTIVE SUMMARY

In order to address issues relating to the lack of females in STEM careers, CTE and UF collaborated with the NCDOT, and WTS to offer workshops that introduce transportation engineering and STEM principles to girls middle and high school aged girls. This was accomplished through a total of twelve workshops which reached a total of 253 girls in North Carolina and Florida.

Experiential activities, speakers, role models, and team-building skills were used to introduce the girls to the field of engineering and to encourage them to view science, technology, engineering, and math as something that will be useful to them and have fun applying.

Qualitative analysis of open-ended questions, questions asked by workshop participants, and comments by resource teachers, parents, and engineers from the DOTs and WTS indicated that students gained an understanding of the different types of engineering and learned about the kinds of work done by transportation engineers.

Through a variety of experiential activities that illustrate how engineers work to solve societal problems, they learned how they can apply science and math to solve these problems in a way that emphasizes the excitement of innovation. The teamwork involved in these activities encouraged them to think creatively and work together to solve a problem.

Participants gained first-hand knowledge in transportation engineering through the interaction they had with the female engineers. Through the panel discussions, small group and one-on-one conversations, and assistance with the hands-on activities, participants gained insight from someone who understands the discipline.

Exposure to the concepts presented in these workshops provided the 253 participants with an opportunity to explore engineering careers and interact with professionals in the field. Some may go on to pursue careers in transportation engineering; some will choose different engineering fields, while others will realize the importance of how STEM education can be applied in other technical disciplines.

## CHAPTER 1 BACKGROUND

### PROBLEM STATEMENT

Most women go into science fields that are mostly associated with helping people, such as medical sciences or biosciences. Girls should be encouraged to view engineering as a career that involves helping people – a career where they can have a positive impact on society.

Even though jobs utilizing science, math, engineering, and mathematics (STEM) have outpaced non-STEM jobs and are projected to continue growing, “there are several cultural, social, and individual factors preventing more girls and women from entering and having careers in STEM fields (1).” According to the National Science Foundation, even though more women than men graduate from college with a bachelor’s degree, men earn a higher proportion of engineering degrees. (2) Of science and engineering degrees, women’s participation is lowest in engineering (2). Accordingly, the engineering workforce is primarily made up of white males (2). When looking at women’s participation in engineering occupations, it is about half of what it is in the U.S. workforce as a whole (1). Research shows that girls are interested in STEM as well as STEM careers; however, they need a better understanding of what these careers have to offer and how having strong STEM skills can help them every day. (1)

The National Engineers Week Foundation notes that many young women lack sufficient math and science backgrounds and are not prepared to major in engineering (3). “The reasons are many, including a serious deficiency in educational resources, social pressure resulting from the negative social image of scientists and engineers, a lack of encouragement (coupled with

active discouragement), the dearth of out-of-school science, engineering and technology experiences for girls, and the lack of women role models in the profession (3).”

A study on attrition of women in engineering investigated the factors related to the career decisions of women engineers (4). The study found that women did not leave the field because of family issues such as marriage or children, but rather due to workplace climate (4). As more women enter the workforce as engineers, the male-oriented culture of the workplace will change and women will bring new and unique perspectives that can serve to improve the field.

Transportation is vital to job growth and economic development at the state and regional level. In order to retain a competitive edge, it is imperative to get young girls interested in engineering and to promote the field as a viable and exciting career path where they can have a positive impact.

## **RESEARCH OBJECTIVE**

CTE at NCSU and UF collaborated with the NCDOT, and WTS in a series of workshops targeted at middle and high school-level girls in North Carolina and Florida. Girls at this level are taking classes to meet requirements for college admission and they may decide to take more math and science if they can see a benefit.

Being introduced to transportation engineering and having realistic expectations of the field may spark an interest in all modes of transportation and encourage participants to prepare for a career as an engineer as early as possible. Workshop activities illustrate how developing critical thinking and problem solving skills that can be developed through taking courses in STEM disciplines will benefit them. When girls start preparing for engineering careers early, it

prevents them from feeling that they need to catch up with the boys. They will also already be familiar with the skills and concepts they will need for their university coursework.

As they discover the types of work done by an engineer, a shift in thinking can occur as participants start to view engineers more as problem solvers. The activities illustrate how engineering employs a creative process and in order to work well with others, requires leadership skills and good written and oral communication – skills girls may already feel comfortable with.

Many young people look to mentors and role models when contemplating career choices. Girls may not consider a career in engineering due to the lack of female engineering role models and mentors available to them. Having female engineers available provides an opportunity for the girls to gain first-hand knowledge of the career opportunities available in the field.

## **SCOPE OF STUDY**

CTE and UF used a series of workshops to introduce girls to engineering, with an emphasis on transportation engineering. The workshops used panel discussions, experiential activities, team-building skills, and mentoring opportunities.

The workshops provided an introduction to the field with examples of the different disciplines and the opportunities available in each. Female engineers from NCDOT, FDOT, and WTS participated in panel discussions about transportation engineering and shared personal stories about their education and work experiences.

Girls participated in creative hands-on activities that emphasized team building and creative problems solving. The activities also show how good communication skills can make a task easier and more efficient.

As the participants interacted with women engineers and heard them talk about their goals, ambitions, and experiences, they had opportunities to pose questions.

Creation of the student WTS chapter will provide college-aged women with an opportunity to mentor younger girls while obtaining mentoring and networking opportunities from the local chapter. Having strong role models and mentoring opportunities early on will have a positive impact in addressing workforce attrition problems.

## CHAPTER 2 RESEARCH APPROACH

CTE conducted a series of seven workshops in North Carolina; working with two efforts in North Carolina: “Introduce a Girl to Engineering” and “Transportation YOU” and reaching a total of 174 participants. UF conducted five workshops that they developed and reached a total of 79 participants. A total of 253 girls attended the twelve workshops. Participants were recruited through school resource teachers; others were participants in established programs.

An accompanying website at <http://www.cte.ncsu.edu/engineering/> is available to reinforce the general message conveyed at the workshops and serves as a resource after the workshops are over. Links to state and national resources are available.

### North Carolina

#### *Introduce a Girl to Engineering*

CTE teamed with NCDOT to co-sponsor “Introduce a Girl to Engineering” workshops held in various locations in the state. There were three workshops held: one in Raleigh, NC on February 18, 2014 which hosted 30 girls; one in Winston-Salem, NC on February 20, 2014 which hosted 63 girls; and one in Greenville, NC on March 18, 2014 which hosted 41 girls.

Table 2-1 shows the breakdown by workshop and the total number of participants.

**Table 2-1. Participant Summary for Introduce a Girl to Engineering**

Date	Event	Location	Participants
2/18/2014	Introduce a Girl to Engineering Workshop	Raleigh	30
2/20/2014	Introduce a Girl to Engineering Workshop	Winston-Salem	63
3/18/2014	Introduce a Girl to Engineering Workshop	Greenville	41
		TOTAL	134

“Introduce a Girl to Engineering” is a national movement to help girls understand the creative and collaborative nature of engineering and how engineers are changing our world. Workshops were held in February and March to coordinate with Introduce a Girl to Engineering Day designated by the Engineers Week Foundation in February.

At each of the three events, there was a panel discussion featuring female engineers from the NCDOT, followed by a question and answer session. The hands-on activity consisted of building a two-wheeled car powered by a rubber band. Participants were given time to design and build their cars with guidance from an engineer. The cars were tested to see if they could travel for at least four feet. If unsuccessful, they were given an opportunity to discuss what went wrong and why and then make adjustments to their car. Pizza was served at each event and the girls ate lunch while participating in small group conversation with the engineers.



**Figure 2-1. Participants at the Introduce a Girl to Engineering workshop assemble a rubber band car.**

### *Transportation YOU*

Transportation YOU is a hands-on, interactive, mentoring program that offers young girls an introduction to a wide variety of transportation careers. The U.S. Department of Transportation and WTS International created the Transportation YOU joint initiative as part of the workforce development effort to greater ensure outreach and recognition to women in the transportation field.

CTE teamed with WTS NC Triangle to co-sponsor Transportation YOU events held in Raleigh. This is a series of workshops for girls ages 13-18 that address a variety of transportation-related engineering topics.

- Each workshop focuses on a different topic related to transportation engineering. Speakers, who work in the field, give a presentation on the topic.
- Each workshop provides an opportunity to participate in an experiment that demonstrates the highlighted engineering principle.

Four events were held in Raleigh from 6-8pm at the Institute for Transportation Research and Education at NCSU and reached a total of 44 participants as shown in Table 2-2.

**Table 2-2. Participant Summary for Transportation YOU**

Date	Event	Location	Participants
2/20/2014	Transportation YOU Workshop	Raleigh	13
4/24/2014	Transportation YOU Workshop	Raleigh	11
9/18/2014	Transportation YOU Workshop	Raleigh	8
11/20/2014	Transportation YOU Workshop	Raleigh	8
		TOTAL	40

The first event was held on February 20, 2014 and was attended by 13 girls. The speaker, a pavement design engineer with the North Carolina Department of Transportation, talked about her day-to-day work. She showed the participants core samples so they could see the aggregate and fabric within the samples. The hands-on activity was to make asphalt cookies. The process of making these cookies paralleled the procedures used to produce asphalt pavements. The participants gained an understanding of paving, the physical properties of asphalt, and its

importance in road construction. Chopped walnuts, flaked/shredded coconut, old fashion oats, and quick cooking oats symbolized the various aggregates used in asphalt paving. Melted chocolate represented the binder and soda cans were used as rollers. Mentors assisted the participants in the activity.

A second event was held on April 24, 2014. Eleven girls heard the speaker talk about her work as a geotechnical engineer with a private engineering firm. She explained the difference in structural engineers, who design what you see, and geotechnical engineers, who design what you don't see. She described how a split spoon sampler can be used to take soil samples.

The hands-on activity involved creating a sample profile of a cake. The soil was represented by three different colors of cake mix. Hollow cylinders were used to represent drills for boring in the soil. A ruler was used to measure the depth of each layer which represented sand, silt, and clay. Participants created the sample profiles and drew these on graph paper. They presented their sample profiles to the group and the presenter asked them questions related to their activity. Mentors assisted the participants in the activity.

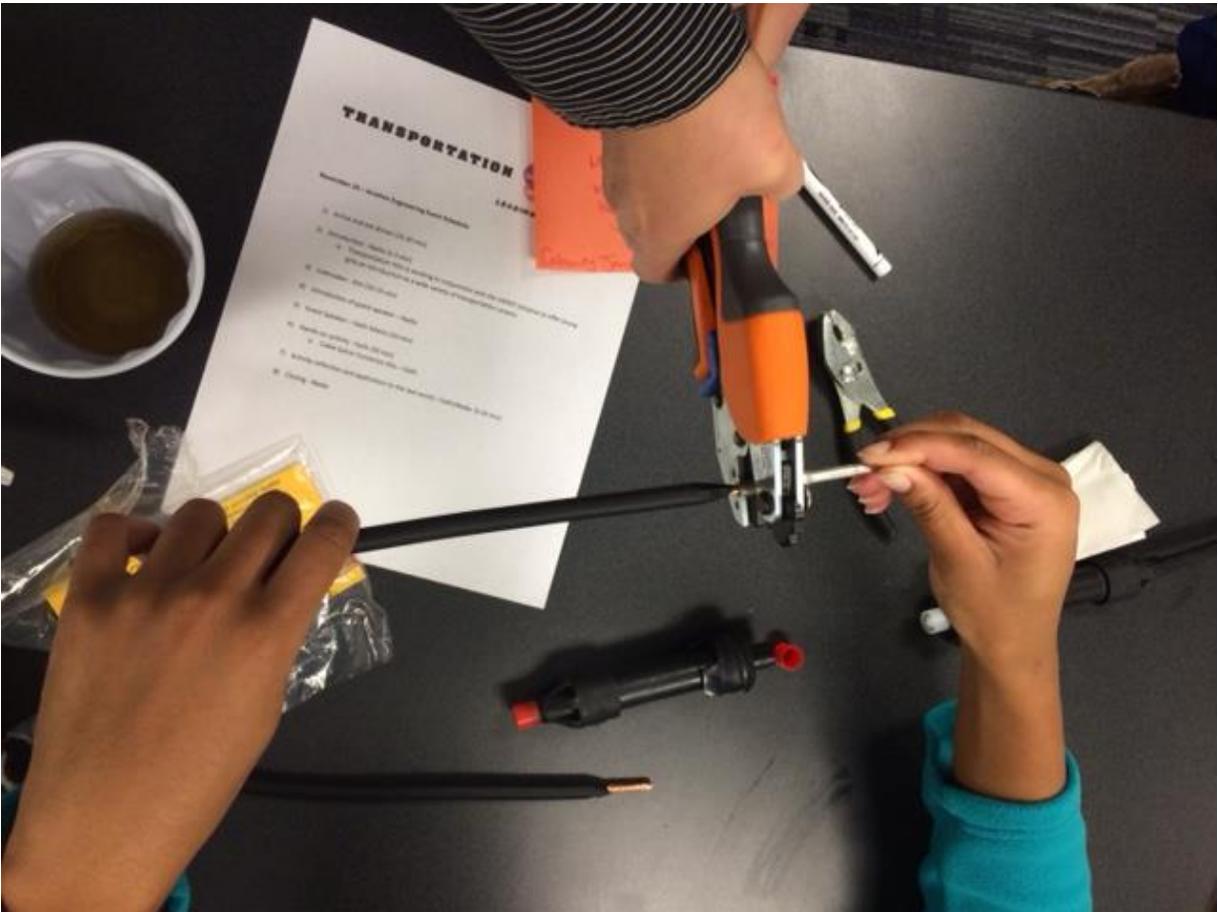
The third event held September 18, 2014 in Raleigh had eight girls in attendance. They heard a marketing/proposal manager for one of the largest transportation companies in the US talk about how she works with engineers, graphic artists, photographers, and other to produce appealing proposals. She also talked about how she travels around the U.S. working at trade shows to advertise her company and find potential clients. A traffic safety project engineer with the North Carolina Department of Transportation also talked to the participants about different materials that are used for construction and explained the basic concepts of tension and compression when a load is applied to a member.

The hands-on activity was based on the story of the three little pigs and the big, bad wolf who tries to blow their houses down. The activity consisted of three timed rounds where participants used different materials to build “houses.” The participants were divided up into teams of two and were given drinking straws as building material for the first round. A hairdryer, which substituted for the wolf, easily blew away the straw structures. Wooden pencils were used as building material in the second round. Like the straws, the pencil structures were no match for the hair dryer. In the final round, participants used Legos to build their houses. The hair dryer was unsuccessful in destroying the Lego houses. Mentors gave the participants advice as they built their houses in each of the three rounds.

On November 20, 2014, the focus of the fourth event was on the role of women in transportation engineering and it was attended by eight girls. The guest speaker was Faith Adams, a group manager in aviation services at Atkins. She discussed the use of different lights and signs on airfields. These lights and signs provide information and guidance to the pilots landing or taking off on the airfield. Maintenance is very important to keep the lights functioning properly. She explained that the older technology was wired light old Christmas tree lights. If one bulb was broken, the whole strand of lights became useless. This is not the case today. If a light fails, it does not affect the other lights. Participants asked many questions about airports in general such as how traveling by planes work and what happens when planes flip over on the runway.

The activity consisted of creating links of wire that would potentially be inserted into the light structure. The main part was building the connect piece which connects two pieces of electrical wire. The length of wire is dependent on the size of the airfield and the quantity of lights. Connectors are used to customize the length of wire and attach the lights to a power

source. Two engineers who work for Ms. Adams, helped the girls build the connection. The engineers assisted the girls by crimping the ends of the wire so the wire could fit in the connector. The girls had a great time working with the wire and connector pieces and learning about the lighting system on airfields.



**Figure 2-2. Transportation YOU participants crimp connections in runway light design activity.**

### *Student Chapter of WTS*

In 2010, the UF student chapter of WTS was the first recognized student chapter of WTS International. The chapter adopted the Transportation YOU initiative as part of their efforts and has conducted several K-12 outreach programs in recent months reaching over 250 children.

UF and the WTS student chapter at the University of Florida are currently working with WTS International to establish guidelines and policies for student chapters of the organization. CTE is collaborating with UF to foster the establishment of a student chapter of WTS in the Research Triangle region of North Carolina. This chapter will consist of students from North Carolina State University, Duke University, and the University of North Carolina at Chapel Hill and will serve to help “Expand opportunities for women in the transportation industry through professional development, mentoring, and strategic positioning of women (5).

### **Florida**

UF conducted workshops, working with the WTS UF student chapter, the Central Florida WTS chapter and other WTS chapters while inviting Department of Transportation employees and consultants as speakers. Workshops reached a total of 79 participants as indicated in Table 2-3.

**Table 2-3. Participant Summary for Florida Workshops**

Date	Event	Location	Participants
2/17/2014	Engineers Change the World Workshop	UF Campus	9
5/6/2014	Engineers Change the World Workshop	Lincoln Middle	22
5/25/2014	Engineers Change the World Workshop	Bishop Middle	20
6/24/2014	Engineers Change the World Workshop	Camp Kateri, Orange Springs	14
6/25/2014	Engineers Change the World Workshop	Camp Kateri, Orange Springs	14
		TOTAL	101

UFTI hosted a workshop February 17th on the UF east campus for nine middle school girls. The girls participated in a panel discussion with three engineers, learned about many career opportunities in engineering as well as learned to program a LEGO robot to simulate a vehicle of the future.

UFTI conducted four additional Engineers Change the World workshops. The first two workshops were held during after school programs in Gainesville middle schools on May 6th at Lincoln Middle School for 22 girls and May 25th at Howard Bishop Middle School for 20 girls. Leslie Washburn provided a PowerPoint presentation on careers in engineering and transportation with an interactive discussion. Morgan Witter then lead teams of two students in a hands-on activity building bridges out of straws, paper clips and tape. The students competed to build the strongest bridge and tested their bridges by loading them with pennies.

On June 24th and 25th, UFTI partnered with the Girl Scouts of Gateway Council to host two consecutive workshops at Camp Kateri in Orange Springs, FL. Each workshop began with a presentation on careers in engineering with an interactive discussion on transportation. This

discussion lead into the LEGO robotic vehicle lesson plans. Fourteen girls participated in each of the single day workshops.



**Figure 2-3. Workshop participants discuss transportation engineering with UFTI leaders.**



**Figure 2-4. Workshop participants display the LEGO® robots they programmed and tested.**

In addition to the workshops for girls, UFTI and the WTS student chapter at the University of Florida have been working with WTS International to establish guidelines and policies for student chapters of the organization. Through contact with WTS International's current President, Masha Ferranto, and Tiffany Jackson (WTS International), discussions began on creating a more organized and structured student chapter presence for WTS International. Under Ines Aviles-Spadoni's guidance, the UF WTS chapter students created a report with recommendations and sent them to Ms. Ferranto.

The UF WTS chapter met with representatives from several chapters during the UTC Conference for the Southeastern Region, March 24-25 2014. UF organized this session and facilitated dialogue between Ms. Jackson and those who wanted to create new chapters. Both FIU and UF student WTS chapters have been ratified by WTS International in the past year. Ms. Jackson then included the UF WTS chapter in a student chapter creation task force that collected input from students and advisers. In September 2014 the UF WTS chapter formulated questions and provided input to assist Ms. Jackson in creating a survey which will go out to students regarding their student chapters' initiative.

## CHAPTER 3 FINDINGS AND APPLICATIONS

Findings for these workshops were derived from qualitative analysis of open-ended questions asked during the workshops, questions asked by workshop participants, and comments by resource teachers, parents, and engineers from the DOTs and WTS.

Participants left the workshops with an introduction to the field of engineering, specifically transportation engineering. Some indicated that they were interested in pursuing engineering as a career. Participants expressed their appreciation for being able to participate in the event and a mother of one of the participants said the following, “I wanted to say thank you for having my daughter on Saturday. She is usually very shy but whatever you all did she was talking all the way home. I hope you are going to continue to have other activities in the area. I really think it made an impression on her as she has not really decided what she wants to study in college.”

The female engineers painted a realistic picture of the field and the workplace. Participants took advantage of the opportunity to ask questions about preparing for college and how to find jobs in the field. Questions asked by the participants indicated that they were engaged in the presentations as they mentioned points the engineers had made when they asked their questions.

During the experiential activities, participants learned how to apply knowledge learned in STEM disciplines to creative problem solving. Through working in teams, they discovered how good communication skills can impact the success of a project. Participants were engaged in the activities and were able to explain why some things that they did in the activity worked well and how they made adjustments. The engineers who assisted with the activities expressed that many

of the participants demonstrated that they showed that they already possess many of the skills needed to be a successful engineer.

## **CHAPTER 4 CONCLUSIONS, RECOMMENDATIONS, AND SUGGESTED RESEARCH**

### **CONCLUSIONS**

Qualitative analysis of open-ended questions during the workshops as well as observation by others indicated that the activities in the workshop had a positive impact on the girls in attendance. Several parents were also positively influenced by the workshops.

Opportunities to talk with the engineers and work with them on the activities provided the participants with insights on the field that they may not have obtained otherwise.

Working in teams allowed girls with similar interests to be able to meet and discover commonalities while discovering the importance of teamwork and effective communication.

### **RECOMMENDATIONS**

Small group discussions with the female engineers were especially positive as it provided more one-on-one interaction and some of the girls were more engaged than they were during the panel discussion.

The experiential activities were very popular and proved to be a good way for the girls to learn while having fun. Continuation of such activities is a great way to heighten girls' interest in STEM subject matter.

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