2015

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Final Report

Engineers Change the World: A Hands-on Workshop for 13- to 18-Year-Old Girls

(2012-009S)

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January 2015

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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 fifteen workshops which reached a total of 246 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 246 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 145 participants. UF conducted eight workshops that they developed and reached a total of 101 participants. A total of 246 girls attended the fifteen 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 14, 2013 which hosted 30 girls; one in Winston-Salem, NC on February 19, 2013 which hosted 44 girls; and one in Greenville, NC on March 13, 2013 which hosted 27 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
2/14/2013	Introduce a Girl to Engineering Workshop	Raleigh	30
2/19/2013	Introduce a Girl to Engineering Workshop	Winston-Salem	44
3/13/2013	Introduce a Girl to Engineering Workshop	Greenville	27
		TOTAL	101

"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, a panel discussion featured female engineers from the NCDOT. Panel members discussed how they became interested in studying engineering, shared stories about their work experiences, and gave advice on how to prepare for a career in engineering. The discussion was followed by a question and answer session.

The hands-on activity consisted of creating a safety restraint system for an egg that occupied a toy truck during a staged crash. Participants were given time to design and build their project with guidance from the engineers. The toy trucks were "crashed" at the bottom of a ramp and the eggs were checked to see how well the safety restraint worked. Participants were very involved in the activity – they used markers to draw faces on their eggs, gave their eggs names, and spent time discussing and sketching out their designs. As each team prepared to send their truck down the ramp, they described how their restraint design was supposed to work. After each crash, there was discussion as to why the restraint system worked or failed.

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 construct a safety restraint for an egg.

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
12/13/2012	Transportation YOU Workshop	Raleigh	19
2/23/2013	Transportation YOU Workshop	Raleigh	7
4/25/2013	Transportation YOU Workshop	Raleigh	5
11/14/2013	Transportation YOU Workshop	Raleigh	13
		TOTAL	44

The first event was held on December 13, 2012 and was attended by 19 girls. The theme for the evening was surveying. The speaker described the work involved in surveying and explained why surveying is important in civil engineering. She described how surveyors use elements of mathematics, physics, engineering, and law in their work. A question and answer period followed.

After the presentation, participants were given pencils, rulers, paper, and a cardboard box. They were asked to measure a point on the box, estimate the coordinates, exchange their boxes with other groups and find the marked point on other boxes based on the coordinates.

A second event was held on February 23, 2013. This event had seven girls in attendance and focused on the role of archaeology in transportation engineering. The speaker talked about how archaeologists investigate the location of highway projects and look for historical locations around the site. A question and answer period followed the presentation.

The participants divided up into teams participated in an activity where they profiled layers of cranberries, raisins, and grapes in a container of jelly and mapped the layers on paper.

The third event held on April 25, 2013 focused on innovations in aviation, specifically, unmanned aircraft systems. The speaker discussed the different uses of unmanned aircraft systems, such as agriculture and law enforcement, and talked about the role of engineers. A question and answer period followed.

The five girls in attendance worked with the engineers on an activity to design, build, and fly small paper airplanes in a prototype fan-driven wind tunnel. Participants discussed why some airplane designs worked better than others.

On November 14, 2013, the focus of the fourth event was on the role of women in transportation engineering. The speaker was the first female highway division engineer for the NCDOT. She shared how she became interested in engineering, talked about her college experiences, and described her work experience with the NCDOT.

After a question and answer session, the 13 girls in attendance worked with engineers to learn about highway design in an activity that used paper towel rolls and file folders to construct a curvy roadway on a hilly base. Starting at the top, a gumball had to make the trip down the roadway in no less than 10 seconds.

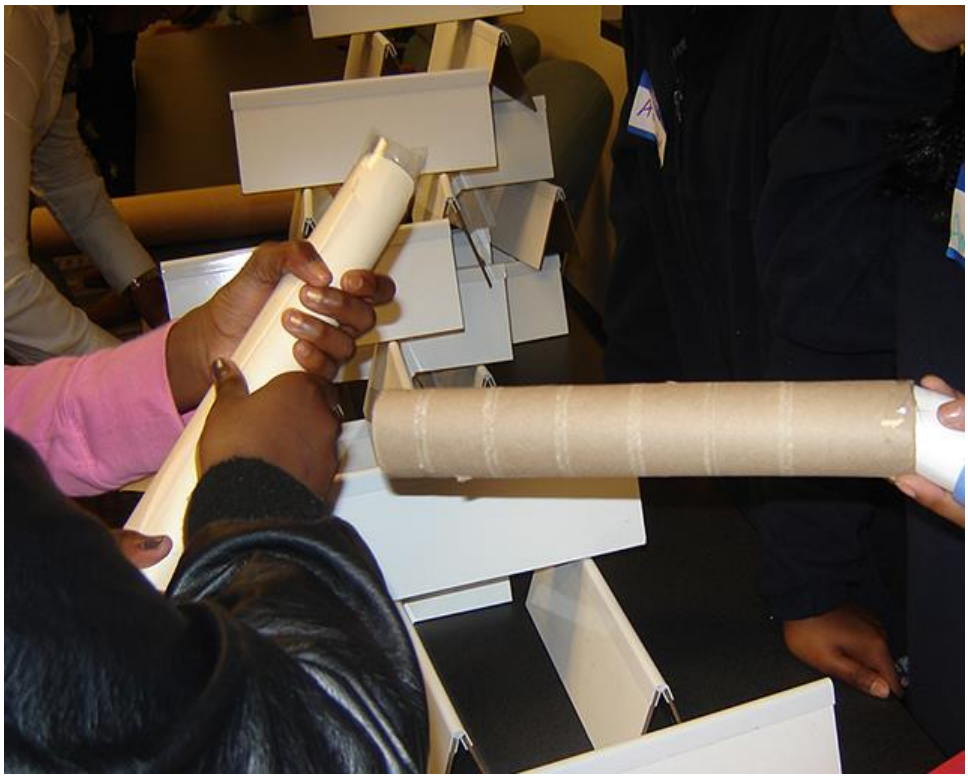

Figure 2-2. Transportation YOU participants build a curvy roadway in a highway design activity

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. Panel members were female and offered their unique perspectives. Workshops reached a total of 101 participants as indicated in Table 2-3.

Table 2-3. Participant Summary for Florida Workshops

Date	Event	Location	Participants
1/26/2013	Engineers Change the World Workshop	UF Campus	8
3/7/2013	Engineers Change the World Workshop	Boone High/Orlando	15
4/10/2013	Engineers Change the World Workshop	Lincoln Middle	20
4/13/2013	Engineers Change the World Workshop	Jacksonville	19
5/14/2013	Engineers Change the World Workshop	Mebane Middle School	12
7/22/2013	Engineers Change the World Workshop	Bishop Middle	7
7/24/2013	Engineers Change the World Workshop	Lincoln Middle	9
10/19/2013	Engineers Change the World Workshop	Arlington Middle School	11
		TOTAL	101

UF conducted their first workshop in conjunction with a statewide science fair on January 26, 2013. Eight high school girls participated in the workshop. The WTS student chapter provided a panel discussion and answered questions prior to starting the activities.

A second workshop was held at Boone High School in Orlando on March 7 with the assistance of the Central Florida WTS Chapter. Fifteen high school girls participated as well as two volunteers from the Central Florida WTS Chapter and two University of Florida Transportation graduate students.

UF teamed with the Alachua County 21st Century Community Learning Center for two workshops. This program supports programs that provide academic enrichment opportunities during non-school hours for children, particularly students who attend high-poverty and low-performing schools. Workshops were held for middle school girls at Lincoln Middle School April 10, 2013 and at Mebane Middle School May 14, 2013. A total of 32 students participated in hands-on activities while learning about career opportunities in engineering.

On April 13, 2013 UF teamed with the North Florida WTS Chapter and the University of North Florida (UNF) to host a five hour workshop on the UNF campus for 19 high school girls. The North Florida WTS Chapter provided a panel of speakers from various transportation engineering and planning backgrounds. Students also participated in team building projects, designing and building hot chocolate machines and mining for chocolate.

Figure 2-3. Workshop participants test the output of their hot chocolate machine.

UF continued their partnership with the Alachua County 21st Century Community Learning Center for two additional workshops. Workshops were held for middle school girls at Bishop Middle School July 22, 2013 and at Lincoln Middle School July 24, 2013. A total of 16 students participated in hands-on activities while learning about career opportunities in engineering.

Arlington Middle School in Jacksonville, FL contacted UF for help encouraging middle school girls to join a robotics team. Leslie Washburn and Morgan Witter provided a workshop on October 19, 2013 for eleven girls to learn more about careers in transportation engineering and

LEGO® robotic programing. The girls watched videos, presentations, worked on programing tutorials and developed their own programs for following a bus route and detecting pedestrians.

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

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.

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.

Ten members are needed in order to form the student chapter of WTS in the triangle region of North Carolina. Seven people have expressed interest in joining; however, the $30 membership fee is cost prohibitive. If WTS International could lower the membership fee or provide a special rate for first year members, it would help get this chapter started.

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Appendix

Anticipated Budget for Outreach Activities

- Can range from $20-$250 depending on the numbers of participants and costs of supplies and if refreshments are provided.

Suggested Strategic Partners

- Local University or College
- State Department of Transportation
- WTS International
- ASCE
- ITE

Ideas for Experiential Learning Activities

- http://www.discovere.org/our-activities
- https://www.wtsinternational.org/