# AC 2008-1834: A DAY CAMP FOR MIDDLE SCHOOL GIRLS TO CREATE A STEM PIPELINE

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# A Day Camp for Middle School Girls to Create a STEM Pipeline


## Abstract

The College of Engineering at the University of Arkansas hosted an Engineering & Science Summer Day Camp for girls, July 30-Aug 3, 2007. This camp was initiated by two teachers involved in pre-engineering programs at Springdale High School. The teachers are involved in Project Lead the Way initiatives and approached the University about forming a potential pipeline that begins at the middle school level with the students proceeding to the pre-engineering program in their local high school and eventually pursuing degrees at the university. The unique aspect of this program is the ability for the teachers to plant the "seed" regarding pre-engineering as a possible avenue for the students to consider in their future. These very girls will be their students of the future. Faculty and staff at the university were involved in coordinating this program and hosted it on campus to gain exposure to this select group of girls. The Springdale area is in close proximity to the university and was targeted due to the recent growth in that area of the Hispanic population. School counselors and teachers were asked to help identify students and encourage them to apply. An overview of the camp was given to parents and students in both English and Spanish. Twenty-four girls were selected from forty-one applicants. Daily activities and assignments were modeled after activities in the pre-engineering high school program. The girls gained experience and confidence while building and programming an elevator, racing remote controlled cars, designing a product using a 3D modeling program, programming small robots and participating in a field trip to a local company. The participants enjoyed the camp, formed friendships with their peers, expressed interest in science/engineering, and look forward to follow-up Saturday activities to be held throughout the year in Springdale.


## Introduction

The "Engineering and Math Summer Day Camp for Girls" is an engineering recruitment and diversity initiative focused on creating an interest in science and engineering in the female population, a group severely underrepresented in engineering fields. Women account for approximately 17 percent of students enrolled in undergraduate engineering programs, compared to 57 percent of the total undergraduate population.[1]

Many investigators using outreach methods consider increasing K-12 students' interest in math and science as the primary avenue.[2] However, a study by Gilley and Begolly revealed that the primary reason for female underrepresentation is lack of familiarity with the nature and possibilities of engineering careers.[3] The UA-SHS day camp targets 7$^{th}$ grade (rising 8$^{th}$ grade) girls in Springdale to increase the number entering the Springdale High School pre-engineering program and ultimately the engineering profession. Support for single gender programs and specifically reaching this age group is supported by research. Studies have shown significant attitudinal differences between girls attending single-gender programs compared to mixed-gender programs,[7] and that targeting underrepresented rising 8$^{th}$ graders in this critical period of educational development and growth was very effective.[8,9] Students began forming career choice opinions and were generally receptive to engineering as a realistic career choice. The UA-SHS camp provided a means to interact with students and parents, opened their minds on

females' opportunities when pursuing challenging STEM fields, instilled confidence in the girls and provided a continuing information resource to them.

The problem addressed by this project is the critical need for a more diverse work force in science and engineering fields and a declining number of students entering the technical work force, an aim that many are striving for today.[10] The UA-SHS day camp goal was to provide awareness and generate enthusiasm for technical fields in northwest Arkansas, a diverse region geographically close to the university. Springdale has a school system with much diversity, and this diversity was reflected in the day camp program participation. The demographic breakdown of the 24 students participating in the inaugural camp was 50% Caucasian, 42% Hispanic and 8% African American.

The camp was staffed for a student-mentor ratio over 4:1, ensuring an enjoyable and safe experience plus the ability to provide a challenging curriculum. The mentoring team consisted of two certified Project Lead the Way (PLTW) instructors, two female SHS Pre-engineering students, one UA faculty member, and two female UA undergraduate engineering students. All mentors were in the classroom every day. Women undergraduate engineering students who participate in outreach activities show tremendous interest in helping younger students, and they experience enhanced confidence in their discipline.[4] Society of Women Engineering (SWE) participants often have a positive impact with their outreach activities.[5, 6]

The UA-SHS camp program is actually a two part program. The primary component was the day camp held during the summer which provided hands-on engineering and math educational activities, a field trip, and mentoring. The second component consists of follow-up activities and mentoring sessions held on selected Saturdays at SHS, where the students are engaged in fun hands-on engineering and math activities. These Saturday activities provide a direct connection for the students to the SHS Pre-engineering program and their facilities.

The PLTW instructors worked with the University of Arkansas faculty/staff to: design the promotional flyer and camp application; recruit participants by talking to middle school counselors, teachers, girls, and parents; recruit through informational mailings in English and Spanish; review the camp applications; write acceptance letters; and train assistants.

The participation by high school teachers that are actively teaching PLTW curriculum in Springdale is a unique aspect of this program. PLTW has a rich history as a national program forming partnerships among public schools, academic institutions and industry to increase the quantity and quality of engineers.[11] Schools employing PLTW curriculum were evaluated in Indiana and found that 37% of students participating in PLTW are female with the most equitable distribution being in middle school where 47% of the students are female.[12] The SHS PLTW instructors were able to adapt lessons from their curriculum to fit into the day camp format (8:00 am – noon) and for the follow-up Saturday.

Funding from the Women's Giving Circle at the University of Arkansas allowed full scholarships to each participant, removing traditional financial barriers, thereby attracting a more diverse pool of students, many of which had limited previous experience in working with technology and/or limited experience with educational camps of any kind. For example, during camp introductions when asked what fun things the students had done that summer, one girl

responded, “This camp!” It was a true highlight for her and her primary focus for the summer. To remove transportation barriers, the Springdale School District provided daily bus transportation. Exposing the students to the University of Arkansas campus was important, especially for students who may become first-generation college students.

**Camp Preparation**

After receiving funds for Girl Camp 2007 the team developed a brochure geared towards middle school girls for the camp. The brochure contained information regarding “who, what, when;” costs and the full scholarships; application materials; and some exciting language to get the girls interested. A bilingual letter was also created to be mailed in conjunction with the brochure, so that parents without good English skills could understand the opportunity for their daughters. Brochures were also sent to participating schools’ teachers and distributed to interested girls. An evening information session was held at _HS for parents and students to gather additional information, ask questions, and meet the camp coordinators. The team received forty-one applications and randomly selected 24 students to participate.

The team held several pre-event meetings to discuss and select the camp activities. The students’ age, skill level, interest, attention span and fun level were taken into account. Chosen events were inventive, entertaining, and applied the concept of team work.

The girls were divided into teams of 5-6 and team leaders were selected. Students were provided laptops for use during the camp, personal jump-drives to store their work, t-shirts to wear on the field trip, and a water bottle they could personalize.

**Camp and Follow-up Activities**

The primary objective of the camp was to expose the girls to the science and engineering fields through fun and exciting activities. During the camp, there were two types of activities – fun academic related activities and fun relational activities. The main academic activities are described below in a day-by-day format, followed by the fun relational activities. The Saturday follow-up activities to-date will conclude this section. With all activities, the students were guided by the instructors, professor and other mentors, providing personalized attention and role models. Key to all activities is the high school and university student mentors. They serve as role models, and it is anticipated that some current day camp girls will become future camp mentors.

*Fun Academic Activities*

The daily academic activities are described below.

Day 1 – Thinking Outside the Box

Each girl used Autodesk Inventor software’s 3D modeling and design software to design a simple box of given dimensions which they personalized. 3D modeling was used from the design concept through finished project. The students personalized the lid with their name or initials. This project allowed the students to become familiar with 3D modeling software; design

a project using the basic commands and applications in the software; and see the relevance of dimensioning, fits and mating parts. A follow-up Saturday activity will involve milling the boxes on a CNC milling machine.

Day 2 – Moving On Up

After finishing the project that was started on day 1, the students were introduced to their next project -using Fischertechniks and programmable logic controllers (PLCs) to design and build several mechanisms, such as conveyor belts and rotating platforms, programmed to perform specific operations. (Fischertechniks are Lego-like building blocks.) In teams of two or three members, the students became familiar with the building blocks, motors, sensor controls and logic software needed for the introductory projects to design, build and program an elevator. From this project, the students learned to design and build mechanical systems that perform specific operations found in manufacturing operations; use sensors such as photocells and thermocouples as switching mechanisms to control the operations of motors, lights, etc.; and program PLC's to control the designed operation of the mechanical system using logic.

Day 3 – Mmm mmm. Good

At this camp midpoint, a change of pace was warranted. The students toured McKee Foods, a local high-tech company manufacturing Little Debbie and Sunbelt snack cakes and granola bars. Several engineers talked about their engineering careers and how rewarding it has been. The students toured the facility and saw the cakes being made and packaged, a highly automated process. Students saw real world applications of science, math, technology and engineering used in product production. The students also saw women in challenging engineering roles which is important to help visualize themselves in those roles.

Day 4 – Keep Moving On Up

The teams finished their projects from day 2 which was to design, construct and program an elevator system. Teams who finished early were challenged with adding another floor to their elevator project. This twist increased the problem solving challenge and provided an additional programming challenge relative to the operation of the elevator for multiple floors.

After the elevator project was completed, the students were introduced to the next day's project.

Day 5 – "Boe-Bot" the Robot

In this final project, the girls wired and programmed a mobile robot called "Boe-Bot" to follow a track on the floor. The teams then competed to see which robot completed the operations and course in the shortest amount of time. Each team was provided a Boe-Bot kit and was guided through its basic wiring and programming. They learned the robots' programmable logic sequence; forward, reverse and turning programming; and how to program the robot to move in the most efficient and effective manner.

*Fun Relational Activities*

Throughout the week, the girls participated in activities for icebreaking, teambuilding, and to keep them physically and mentally active. Two examples of these activities are illustrated below.

Activity Example 1 – Stick-em Up

In this activity, each team sticks a girl to the wall using duct tape, with the goal to keep her attached to the wall for the longest period of time. Each team was given a roll of duct tape and a chair and the teams were spaced along a concrete block wall. With the girl standing on the chair, the other team members tape her to the wall. After a specified amount of time, the chairs were removed and the team with the girl remaining on the wall the longest time won a prize. This activity served as an ice-breaker on the first day, and introduced the concept of working together to solve a problem. The girls also got to know each other while having fun.

Activity Example 2 – Radio Car Relay

In this mid-week activity, teams relay-raced radio controlled cars on a given path. Each team was given a radio controlled car. The race was relay style where each member controlled the car on a given course and then passed the controller to the next team member. Team mates can help each other, but only one member at a time can operate the radio controller. This activity provides a mid-week or mid-activity break from the projects, fosters team cooperation, and lets the girls relax, laugh and have a good time.

*Saturday Activities*

Three Saturday events were scheduled during the subsequent school term to enhance the summer activities and continue engaging the girls in mentored STEM activities during their eighth grade year. Saturday activities were typically held at SHS's Engineering and Architecture Academy facilities and in conjunction with the SHS students' STEM projects.

Saturday Activity 1 – BEST Competition

The fall weekend activity introduced the girls to the BEST (Boosting Engineering, Science and Technology) robotics competition for junior and high school students. BEST students work with university and industry mentors to help student teams problem solve while designing, developing, and building a robot. BEST students learn technical skills in fabrication and electronics while developing teamwork and fair play skills.

The first Saturday activity was held in Fort Smith, Arkansas where the girls attend the BEST robotics competition with SHS. During this competition, the girls helped the high school students staffing the S HS team booth; help out with the robot with repairs, and even driving and spotting the robot during the competition itself. The girls enjoyed the activities tremendously.

Saturday Activity 2 – Box it Up

The second activity has not occurred at the time of this writing (February 2008). The second activity will introduce prototyping using CNC (computer numerical control) and 3D rapid prototyping - technologies used in design and development, manufacturing processes and fabrication. The girls will use the 3D modeling software they used to design their box in summer camp, but will now actually produce the physical box. Through this project, the students use industry standard software and hardware to learn about the use of material removal and rapid prototyping applications; tolerances in mating parts; and the importance of process design in product fabrication.

Saturday Activity 3 – Becoming an Expert

The third activity will extend their knowledge of Fischertechnik parts and PLC design and programming for different applications. The students will 1) use a small motor, fan and thermistor to create a thermostat; 2) use motors and gears to design a garage door which opens when a car approaches; 3) design a mechanical system that will separate marbles into three different bins as their color is detected; and 4) write a program for the PLC's that will operate all of the above devices.

**Evaluation of the Participants**

The expected outcomes for the student participants at the end of the project included the ability to: 1) identify specific exercises that were particularly helpful in understanding a concept; 2) identify specific exercises or events that were particularly helpful in increasing their interest in science and engineering; and 3) identify the obstacles that students perceive in pursuing a career in science/engineering. Data was accumulated from participant surveys and reviewed by the project management team as a method to report results, improve future project activities, and determine a "best practices" model for this type of outreach activity.

The students completed a written survey every day except the field trip day. The last day's evaluation was about the overall program; the other surveys were about the day's activities. The students were also asked about their most and least favorite aspect of the daily activities and to make any suggestions for improvement. Overall, the girls worked very well together in small groups, they concentrated on the more difficult tasks and enjoyed the games and meals together. There were enough students to create a meaningful cohort (~5 students/group) that help to decrease any feelings of isolation. Most participants liked all the activities, with very few negative comments. For those who did not like an activity, they expressed that it was due to their lack of familiarity with the computer or with building things. This was a typical observation by the management team regarding female students and their lack of confidence or perception in their abilities, and was identified as being the primary reason for a lack of interest.

The girls were so complimentary about the camp that it is somewhat difficult to assess how to make changes for a future camp. They were very much looking forward to the follow-up Saturday activities that take place in Springdale throughout the year. For assessment purposes, the evaluations were reviewed each day and two questions were highlighted: "What will you tell your friends about?" and "Which part took the most concentration?" They were also asked

for suggestions on improvement and the most helpful thing they did for their group. The results are shown below.

***Table 1: Response to survey question, "What will you tell your friends about?"***

| Responses | Day 1 | Day 2 | Day 4 |
|---|---|---|---|
| **Duct Tape Activity** | 80% | | |
| **Designing the small box** | 20% | | |
| **Fischertechniks/motors/switches** | | 100% | |
| **Elevator project** | | | 52% |
| **Remote car relay racing** | | | 48% |

***Table 2: Response to survey question, "Which part took the most concentration?"***

| Responses | Day 1 | Day 2 | Day 4 |
|---|---|---|---|
| **Making the box using the computer** | 65% | | |
| **Sketching the box by hand** | 20% | | |
| **Computer instruction** | 15% | | |
| **Motors/switches** | | 66% | |
| **Making lid for CAD box** | | 22% | |
| **Programming the elevator** | | 12% | |
| **Two-story elevator** | | | 86% |
| **Three-story elevator** | | | 14% |

*Table 3: Response to survey question, "What could be improved?"*

| Responses | Day 1 | Day 2 | Day 4 |
|---|---|---|---|
| **Nothing** | 60% | | |
| **Computer instruction** | 30% | | |
| **Pace of instruction** | 10% | | |
| **Nothing** | | 58% | |
| **Pace of instruction** | | 42% | |
| **Nothing** | | | 57% |
| **Wire reliability, troubleshooting elevator** | | | 43% |

For the survey question, "What is the most helpful thing you did for your group," responses included: Day 1: finding angles for the box; locating where to place duct tape and cutting the duct tape; volunteering for things, lifting spirits (entertainment); Day 2: asking group members to explain in their own words, motors; designing box lids; computer basics; Day 4: troubleshooting elevator, fix broken wires, computer controls, keeping a positive outlook.

On Day 5, the students were asked about their overall thoughts of the camp using the scale 1 = Excellent, 2 = Very good, 3 = Good, 4 = Fair, and 5 = Poor. The overall average rating was 1.4. Additional questions shown below were asked and the responses provided.

**Favorite thing:** Field trip, 3D boxes, elevator project, robots, remote car racing, duct tape activity
**Least favorite thing:** Being confused, wearing hair nets at the company, waking up early, nothing, bus ride to the company, leaving the camp at the end of the week
**What one thing would you like to see stay the same:** robots, elevator, field trip, group leaders, games, all girls, computer activities
**Did the camp help you become more interested in science/engineering:** Yes (88%), No or not really (12%)
**What lessons will you take with you:** Never give up, skills in troubleshooting, computer basics, how to ask for help, how to understand what engineers do, team work helps you figure things out, and that engineering is a great career

The project management team was excited to see all activities being liked by participants with a clear indication that most activities helped in confidence building and enthusiasm for science/engineering. The participants gained confidence on using a computer, programming movable parts, and thinking through things to get to a solution. It is also clear that they enjoyed the atmosphere created in the single gender camp and some girls indicated they felt sorry for the male coordinators because there were so few!

In the long-term, our goal is to track these students and retain at least 50-60% of these students through a degree program at UA. This plan is very likely to create a steady flowing pipeline of underrepresented students from the surrounding region.

## Summary

In summary, the project objective was to raise awareness and create enthusiasm for the science and engineering disciplines in middle school female students as a way to address the lack of diversity in these fields. This project consisted of a 5-day summer non-residence camp and follow-up events to be held on Saturdays throughout the year as well as faculty and peer mentoring. The project was considered to be successful and will address long-term diversity issues by providing an engineering and math experience early enough in the girls' educational experience that they can start taking the courses necessary to be engineering-ready. Another important aspect of the camp is the instruction by Pre-Engineering instructors intimately familiar with the skills necessary for being successful in these disciplines. Assessment indicated an overall positive experience with the activities, the leadership, and the atmosphere.

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