

A Summer STEM Camp for Girls

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(Research-to-Practice, Strand: Other)

Introduction

From July 24, 2016 to July 29, 2016, a STEM Summer Academy for Girls was organized at West Virginia University Institute of Technology with Toyota Motor Manufacturing Virginia University as the primary sponsor, following the success of STEM Summer Academy for Girls held last year (2015). As last year, the main objective of the STEM Summer Academy for Girls is to inspire female high school students' interest in STEM (science, technology, engineering, and mathematics) disciplines and encourage them to choose STEM as their college major. Thirty-two female high school students participated in the 2016 STEM Summer Academy for Girls, which constitutes 45% increase with respect to the number of participants in 2015. As another tremendous improvement compared with 2015, 25% of the participants are African American students in 2016. During the academy, the participating female students learned about fundamental knowledge of science and engineering, were exposed to cutting-edge technologies, and conducted multiple mini-projects. The photo in Figure 1 was taken at the academy with all the academy participants.



Figure 1: Participants of the STEM Summer Academy for Girls held in July 2016.

As last year, we embraced femininity while using hands-on activities to explore STEM. Some contents of the 2016 STEM Summer Academy was particularly tailored for girl participants. For example, the participating girls applied biomechanics of the human foot to design shoes, and

in the Chemistry Lab they made their own lipsticks and lotions. Also, in the 2016 STEM Summer Academy for Girls employed a large number of female faculty members as instructors and female university students as the participating girls' counselors. A new element of the 2016 academy was a special session in which female university students shared their own experience from elementary school to an engineering university. They specifically talked about the roles of their parents and school teachers in their career choice, involvement of after school science club and participations in STEM summer camps like ours inspired them to pursue STEM. A range of information related to STEM majors (such as job opportunities and availability of scholarships) was provided to the participants and their parents at the end of the academy.

Previous Work

A report analyzing data from the U.S. Census Bureau's 2011 American Community Survey¹ found that while women's representation in all STEM fields has increased since the 1970s, they remain "significantly underrepresented" in the two areas that comprise 80% STEM jobs: engineering and computer occupations. The female students' interest in STEM fields has been low due to issues encountered in K-12 education system¹²⁻¹⁴. In order to address this deficiency, enormous endeavors have been devoted to increasing female K-12 students' interest in STEM across the nation²⁻¹¹. Several universities had successfully initiated annual STEM camp series for middle school and high school female students, Women's Technology Program (WTP) of MIT², Girls Only (GO) STEM! Camp of United State Naval Academy³, and Girls Robot Camp of University of North Texas⁴, to name a few examples. There are also some examples of annual STEM camp series concentrating with racial minorities⁵⁻⁶.

In 2015 we launched our pilot STEM Summer Academy for Girls¹⁵. However in 2014 we offered a "girl only track" for our yearly co-ed Camp STEM. In 2014, our main goal was collecting initial data which will help us to design our STEM Summer Academy for Girls.

The program design of the 2016 Academy was grounded in the literature and our previous experience in last two years. We agree with literature that "just as women are under-represented in technology and other areas of STEM, so too, girls tend to be under-represented at STEM camps⁸". Stephanie Fletcher, one of our 2015 Girls Academy participant, said she had originally applied to attend our co-ed Camp STEM, but changed her mind when she heard about the all-girls Academy. "In engineering and science fields you're always going to be outnumbered by guys, so I liked how it focused more on the impact that women can have and the job opportunities women have," she said.

Following literature²⁻¹¹ the we designed our Girls Academy to increase interest of young women in STEM by combating stereotypes, creating connections through interaction with both female professional engineers and college females pursuing degrees in engineering and demonstrating

the real-world social impact of engineering. While designing our Academy we decided to embrace femininity while using hands-on activities to explore STEM. One of the biggest misconception about STEM among young girls is that the field is masculine⁸. Through our shoe design content and fashion show we demonstrated to these young women how they can incorporate math and engineering into their own lifestyle. At the same time we incorporated neutral hands on activities (designing gear or robotics) to make sure that the Academy does not become stereotypical. According to one of our participants in 2015, “I was worried the camp was going to be too girly”. She says at home, she mainly hangs out with guys because they’re the people at school who share her interests. When she decided to go to an all-girls summer camp she was worried she wouldn’t get along with the other campers. She was worried she wouldn’t like the stuff they had to do, because she doesn’t like the stuff most girls like. “But it’s not like that,” she says. “You can take the assignments any way you want.” She pulls out a sketch she’s made for the high-heel competition. The shoe looks like a cat—a whole new play on the term “kitten heels”—proving a feat of engineering doesn’t have to be masculine to be impressive.

Unfortunately in literature we could not find much distinction among the girls in the target group, the girls new to STEM and the girls already interested in STEM. After our experience in 2015 Girls academy where we worked mostly with the latter group (girls who are already interested in STEM) we changed our target group and worked with the former group. Our success story resulted through this change in directions is described in our result section.

Implementations

The Summer STEM Camp includes the following nine technical sessions. The technical sessions are divided in two major categories, Science and Engineering. In the Engineering sessions we have covered five different fields of Engineering as provided below.

- (1) Computer Engineering: Playing with Robots
- (2) Civil Engineering: Traffic Signals
- (3) Mechanical Engineering: Gears
- (4) Chemical Engineering: Battery and Fuel Cell Technologies
- (5) Electrical Engineering: Basic Electrical Circuit Operation

On the other hand our Science categories included four different fields:

- (1) Computer Science: Scratch Programming
- (2) Biology: Exploring the Microscopic World
- (3) Nursing: Future of Nursing in West Virginia
- (4) Chemistry Session: The Chemistry of Cosmetics

In order to give them the opportunity to learn about each technical session, each girls took each of these sessions. As a result we can see a large number of students considered new options for

their careers which they did not consider before. In order to accommodate our larger group of students, most of the technical sessions were divided into two sections and ran those in parallel. Each technical session provides the participating female students with plenty hands-on experiences. Along with these technical sessions we also offered Industry sessions. During two days of the Academy employees of Toyota and Dow industries offered three hour long Industry sessions. We also offered Speaker sessions in which women successful in STEM fields shared their stories with our participants. The agenda of the 2016 STEM Summer Academy for Girls is shown in Table I. It includes various types of sessions, as elaborated in the following.

Table I: Agenda of the 2016 STEM Summer Academy for Girls.

	8 AM - 9 AM	9 AM - 10 AM	10 AM - 11 AM	11 AM - 12 PM	12 PM - 1 PM	1 PM - 2 PM	2 PM - 3 PM	3 PM - 4 PM	4 PM - 5 PM	5 PM - 6 PM	6 PM - 7 PM	7 PM - 8 PM
Sunday 7/24									Check in	Dinner	Orientation, shoe design	
Monday 7/25	Robotics, Biology			Lunch	Nursing		Group projects		Dinner	Shoe design		
Tuesday 7/26	Civil Engineering, Mechanical Engineering			Lunch	Chemical Engineering, Electrical Engineering				Dinner	Shoe design, fashion show		
Wednesday 7/27	Group projects	Industry session		Lunch	Computer Science		Group projects	Meet president	Dinner	Guest speaker	Water balloon	
Thursday 7/28	Charleston trip								Dinner	Movie		
Friday 7/29	Group projects	Chemistry	Group projects	Lunch	Industry session	Presentations, family picnic			Check out			

1. Engineering Sessions

In the followings we described our engineering sessions.

Subject: Computer Engineering

Topic: Playing with Robots

In this computer engineering session, the Girls Academy participants used a graphical user interface to program real-life robotic solutions and learn to use touch, sound and light sensors to program a robot to react to its environment.

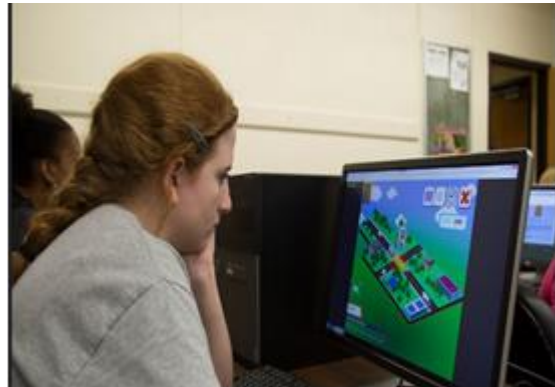
Subject: Civil Engineering

Topic: Traffic Signals

In the civil engineering session, participants learned about some transportation and traffic issues we all face. They used a computer software that aims to design the different time allocations of a traffic signal, and used the traffic signal inputs of traffic volumes, intersection layout and pedestrian volume inputs to design a functional traffic signal.



(a) Computer engineering session.



(b) Civil engineering session.



(c) Mechanical engineering session.



(d) Electrical engineering session.

Figure 2: Photos taken in different Engineering sessions.

Subject: Mechanical Engineering

Topic: Gears

The gear is one of the most commonly-used mechanical components in the world. Gears transmit motion between rotating shafts by meshing with one another. In this mechanical engineering session, students learned the fundamental operations and parameters of realistic gears.

Subject: Chemical Engineering

Topic: Battery and Fuel Cell Technologies

There is a major need for alternative sources of fuel to power our homes, cars and everything in between. Batteries and fuel cells use electrochemical reactions to generate electricity. For these cells to work, they need fuels such as hydrogen and oxygen. In this session, the girls were introduced to the reactions involved in generating electricity in these cells and built a simple battery.

Subject: Electrical Engineering

Topic: Basic Electrical Circuit Operation

This session covered basic electrical circuit operation to measure the current and power flow of a system and simulate the basic wave form. After attending this session, they have a rough idea how a complicated circuit system works.

2. Science Sessions

In the followings we described our Science sessions.

Subject: Biology

Topic: Exploring the Microscopic World

In this session the girls explored the microscopic world by looking at some of the inhabitants of ponds such as protozoans, algae, water bears, and rotifers as well as inhabitants of the human mouth. They also learned how to use the standard clinical-style bright-field compound microscope with magnification up to 1000X. Microscopy techniques in this session include oil immersion, slide preparations, and a simple staining technique for bacteria.



(a) Biology session.



(b) Chemistry session.

Figure 3: Photos taken in Science sessions.

Subject: Chemistry

Topic: The Chemistry of Cosmetics

Cosmetics are an excellent example of how discoveries in chemistry are part of our day-to-day lives. In fact, just reading the composition of any common cosmetic can become a chemistry class: water, emulsifiers, preservatives, thickeners, pH stabilizers, dyes and fragrances, combined in different ratios, for different purposes. The manufacturing of skin, nail and hair care and other beauty products will be the highlight of this session. Participants will explore the chemistry involved in the manufacturing of a few of these products and will gain firsthand experience to apply chemistry to make their own homemade cosmetics.

Subject: Computer Science

Topic: Scratch Programming

Student learned the interactive Scratch programming. In this hands-on session the girls wrote their first Scratch programs.

Subject: Nursing

Topic: Future of Nursing in West Virginia

The instructors shared the wide variety of career options in health care and specifically in nursing. They discussed what is important to do in high school to prepare to go into health care professions. They shared the difference health care professionals and nurses make in the health of individuals and communities.

3. Industry Sessions

As a new addition, this year we included two exclusive three hours industry sessions. On the



Figure 4: Pictures of Industry sessions.

third day of Academy DOW brings a group of five young engineers. They conducted a three hour session which included multiple hands on experiments. On the final day of the summer camp, Toyota sent a team of three engineers. They also brought a robot with them along with four

members of their Robotics team. Both industries paid special attention to include diversity among their team members.

4. Speaker Sessions

Several successful female professionals were invited to speak at the Summer STEM Camp, including Ms. Robin Sizemore, Science Coordinator, Middle/Secondary Learning of West Virginia Department of Education. Also the female members of West Virginia Manufacturers Association Educational Fund members provided an overview of the industry and examples of some of the many flourishing manufacturing companies in the state of West Virginia. The presentation also offers information about educational paths students can pursue for a career in manufacturing.



Figure 5: Photos taken in Speaker sessions.

Shoe Design Contest

Due to the popularity on our last 2015 Girls academy, we brought back the shoe design contest. After the participating girls learned the biomechanics of human foot and where pressure points lie, they were asked to design a shoe that would be comfortable, practical, as well as fashionable. Afterwards, they purchased materials and built the shoes. Finally, a contest was held: the shoes were judged by a group of female engineers according to a variety of criteria including appearance, fit, cost, and structural integrity. Figure 6 shows four photos taken during the show design contest. In the top left photo, there is a catwalk for the fashion show made by our female camp counselors. In the bottom left photo, girls were working on their design; in the top right, a girl was walking on a 20-foot runway to test her shoe; and the winner team with the pair of shoes they designed and constructed was displayed in the bottom right photo.



(a) The catwalk for fashion show.



(b) The fashion show.



(c) Girls working on the shoes.



(d) The winner team.

Figure 6: Photos taken in shoe design contest.

Girl's Day Out

On the fourth day of the camp, the participants embarked on a day-long field trip to the state's capital city of Charleston. In the morning, the group visited the city's iconic Clay Center for the Arts & Sciences of West Virginia. The Science Co-coordinator of West Virginia Department of Education Ms. Robin Sizemore gave an inspirational speech on STEM. Later the girls enjoyed a delicious lunch at a Japanese hibachi-style steak house. In the afternoon the girls enjoyed ice skating at the Memorial Ice Arena at Charleston.



Figure 7: Photos taken during “Girls day out”.

Results

A series of surveys and interviews were conducted to assess the outcomes of our Girls Academy. Surveys collected after the Academy reveal that the Academy was well received by the participating girls. For instance when the participating girls were asked to comment on “attending this Academy increased my interest in STEM,” 19 answered “strongly agree,” 7 answered “agree,” 5 answered “neutral,” and none answered “disagree” or “strongly disagree.” In another survey question, “I liked learning about engineering in STEM Summer Academy for Girls”, 17 answered “strongly agree,” 8 answered “agree,” 6 answered “neutral,” and none answered “disagree” or “strongly disagree.” Finally according to our survey, 48% of the participating girls indicated that they changed their career preferences to STEM after attending the Academy.

When we compare our results with the results from our pilot Academy held in 2015, we found that 2016 STEM Summer Academy for Girls was more successful in different ways. First of all comparing to our 2015 STEM Summer Academy for Girls, we have a 45% increase in the total number of participants. We needed to make changes in our program design by running parallel sessions to accommodate more participants.

Compared with summer camps we organized in the past (including our co-ed CAMP STEM), one of the primary successes of this Academy was in bringing diversity. During the planning phase, increasing diversity of the participants had been one of our major goals. Throughout the recruiting effort, we worked closely with the local organization, African American Collaborative (AAC). As an exciting outcome, about 25% of the participants of our 2016 Academy were African American students. The two photos in Figure 8 were taken when AAC staffs and we met some African American students and their parents.



Figure 8: Meeting with participants from minority groups and their parents.

Another successful effort of our 2016 Academy is the inclusion of Industry sessions. Specifically, two three-hour industry sessions were offered for the participating girls to interact with industry professionals from Toyota and Dow Chemical respectively. Both Toyota and Dow selected their young female engineers to attend our Academy and introduce STEM careers to the girls. After the Industry sessions, several participating girls said that STEM careers are no longer distant /mysterious to them and they would seriously consider STEM careers in the future.

Finally our biggest success was a huge increase in STEM career preferences. According to the surveys collected during our 2015 Girls Academy, the percentage increase in the participating girls' interest in STEM career was not high (it was only 8%). As we were very surprised with this low number, after thorough analysis we identified a possible reason. As the participants were selected through advertisements we ended up with girls who were already interested in STEM field even before they attended the Academy. For our 2016 Girls Academy we did not recruit the participants through advertisement. Instead we worked with school teachers, counselors and local community organizations to recruit the participants. As our 2016 Girls Academy was entirely free it also allowed us to recruit participants from low income families. By analyzing the survey data collected from our 2016 Girls Academy, we found that about 48% of the girls changed their career preferences to STEM after attending the Academy.

Our 2016 STEM Summer Academy for Girls was reported by several news media, including Register-Herald and WVNS (which is affiliated with both CBS and FOX). Below are some of the comments the news reporters collected from the participants.

Martinsburg student 11th-grader Kimberly Gray said "The projects have been so fun," Gray said. "I've been learning new topics and what we can become in STEM fields. It's been a really good

experience. I have been to three camps this summer and this is by far my favorite. The girls here are amazing and I've got to meet new people."

According to Raleigh County resident and incoming High School freshman Sierra Beaulieu, the opportunity to attend the Academy and participate in hands-on projects greatly appealed to her. "That's kind of like knowing how things work inside," Beaulieu said. "It's more experimenting in what you're doing. It seems like it might be one of my fortes." The experience at the Academy has helped Beaulieu experience new STEM fields and she strongly endorsed it.

"I highly recommend it to anyone who is interested in STEM. This is a great opportunity to meet people with similar interests," Beaulieu said.

Toyota production engineer Ya-Haddy Salla said an event like the STEM Academy for Girls is very important to companies like Toyota. "We need STEM education for technological advancement," Salla said. "It's great seeing all these young women interested in STEM." Salla stated that she would like to see STEM reach students before high school and that its role in education is important to for future growth. "It would generate and foster interest in STEM at an earlier age and help students determine sooner what fields they want to pursue in the future," Salla said.

By making the Academy girls only, Academy director Afrin Naz said, Academy officials and speakers can tailor some of the programming highlighting challenges the young female students will face pursuing education in STEM fields. She stated that it's also important for parents to be more aware of STEM opportunities. The Academy also works to highlight to the female students jobs that are available in the state and beyond in STEM related fields. "We're bringing all these pieces together, working together to show these girls they can do it and how they can be successful," Naz said. "I want to see our industries and school districts working together to touch the lives of these young girls."

Conclusion

In this paper we describe our experience in launching the 2016 STEM Summer Academy for Girls in West Virginia University Institute of Technology. As the previous year, the main objective of the STEM Summer Academy for Girls is to inspire female high school students' interests in STEM disciplines and encourage them to choose STEM as their college major. Compared with summer camps we organized in the past, we demonstrated significant improvement in multiple areas. This year we achieved 45% increase in the number of participants with respect to the number of participants in 2015. This year the Academy was entirely free of charge. As another tremendous improvement compared with 2015, 25% of the participants are African American students in 2016. Surveys collected after the Academy reveal that 48% of the participating girls indicated that they changed their career preferences to STEM

after attending the Academy.

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