Impact of "Imagineer Day", an Outreach Program, on K-8 girls and Women in Engineering

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Dr. Mustafa received a Ph.D. in Electrical and Computer Engineering from the University of California at Irvine in 2012. In 2005, she received M.S. in Electrical and Computer Engineering from California State University, Los Angeles. She is currently an Assistant Professor at California State University, Chico specializing in embedded systems design, cyber-physical systems, Computer architecture design, FPGA-based systems design, and Engineering educational innovation and research. Currently, she is a member of the McLeod Institution of Simulation Sciences at Chico state working on evaluating multi-FPGA communication protocols in high-speed real-time simulations and teaches courses in Embedded Systems Design, High-Performance Computing, and Digital Systems Design. She has been actively involved in implementing and evaluating new pedagogical approaches in her classes to promote students' success and improve retention rates. She has been serving as the Society of Women's Engineers advisor since 2015.

Shelby Ann Freese

Shelby Freese is a fourth-year Sustainable Manufacturing Engineering student at California State University, Chico. Shelby currently owns two roles in SWE, as she is the Section President of Chico State, and the Region A Collegiate Senator. She has been involved with Society of Women Engineers for almost 4 years, accounting for her entire Undergraduate Collegiate Career. Some of Shelby's passions include hosting Outreach Events, such as Imagineer Day, giving back to her community through various volunteering activities, and teaching middle school girls in her A Local Outreach Program alongside Hadil Mustafa. She has won various awards, including the Region A Future Collegiate Leader Award (2017), Region A Outstanding Collegiate Leader Award (2018), and the Chico State Mac Martin Excellence in Leadership Award (2018). She has career aspirations to be in the Automotive/Racing Industry. As she has plans to remain and be an active member in SWE as a Professional Member, upon graduation in May of 2019.

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Abstract

The Society of Women Engineers at California State University, Chico developed an educational outreach program to promote Science, Technology, Engineering and Math (STEM) to K-8 girls in 2012. Since then, every year over 200 local K-8th grade students are invited to participate in multiple hands-on labs that demonstrate basic science and Engineering concepts. The goal of the outreach program is to get young girls interested in STEM fields, particularly, Engineering. For the past six years, not only had the program managed to introduce Engineering to young girls, but it has also provided a unique opportunity for undergraduate female Engineering students to develop communications and leadership skills. Also, the program has allowed students from several Engineering organizations (Latinos in Technical careers LTC, National Society of Black Engineers NSBE, American Society of Civil Engineers, Women in Science and Engineering WiSE, and Mathematics Engineering Science Achievement MESA) to work together as teams and organize activities and labs. This collaboration between SWE and other clubs and organizations in the college helped in promoting diversity and inclusiveness in respect to gender, ethnicity, age, and discipline.

Introduction and Motivation

While the number of women in certain STEM fields, such as biology, chemistry, and math, has increased in the last decade, it had declined in Computer Science and Engineering [1]. The US Department of Commerce has published an updated study of Women in STEM in 2017 as part of a series of reports examining the STEM workforce and its gender dynamics. The study showed that the distribution of women and men in STEM majors has persisted to differ significantly in the workforce since 2009. As shown in figure 1, 59% of women who chose STEM field majored in physical life science while only 31% of men majored in the same field. On the other hand, women's representation in Engineering and Computer Science was less than half those of men's. [2] [3].

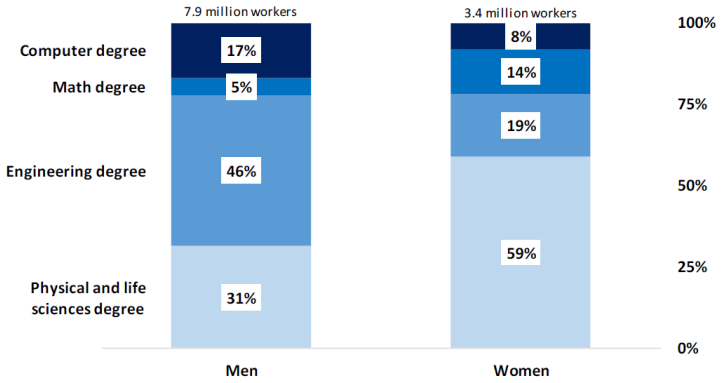


Figure 1: College-educated workers by STEM degree, 2015 [2]

Similarly, the number of women earning degrees in Engineering and Computer Science has ranged from 18-19% in a recent study conducted by the National Center for Science and Engineering Statistics (NCSES) in 2017 [4]. Although these numbers have increased in the past 20 years, women's participation remains well below that of men in all fields of Engineering. Additionally, a decline in the number of women enrolled in these programs has been recorded in the years between 2004 and 2014, as shown in figure 2. In fact, the number of female students in the College of Engineering at Chico State has been at a record low of less than 10% for many years.

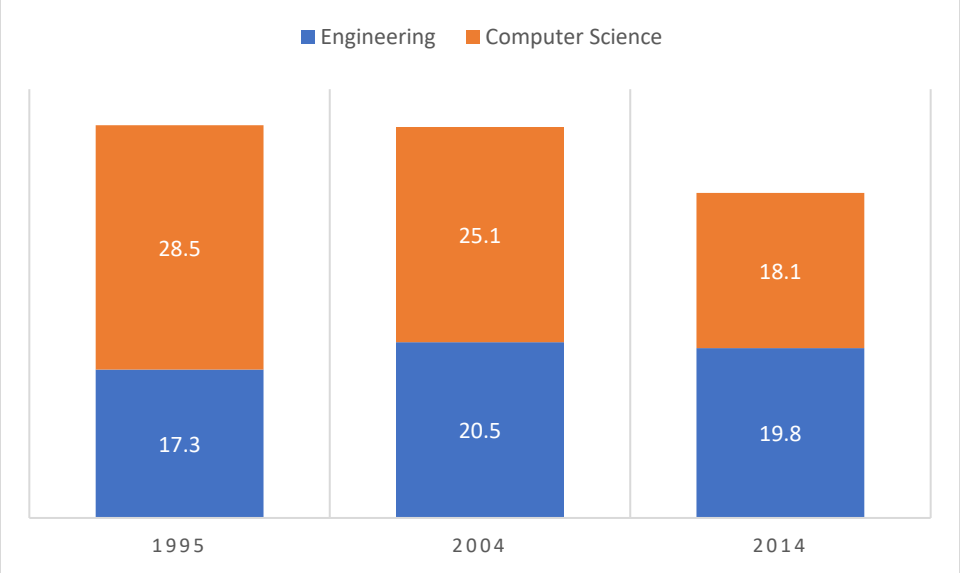


Figure 2: Women earning Engineering and Computer Science degrees by year, 1995-2014

One of the main reasons, as explained by several female students in our Engineering program, was "not having been exposed to STEM growing up." Many research studies support this statement when outlining the factors that influence young girls' interest in Engineering and Computer Science [5] [6] [7] [8]. Studies show that the low representation of women in STEM fields is a result of several factors including, but not limited to, lack of role models, insufficient exposure to STEM subjects, and gender stereotypes [7]. Studies also show that the retention rate in Engineering and Computer Science programs is higher in male student population than that of females [3].

Addressing the underrepresentation of women in STEM fields has been the focus of many researchers for the past 20 years [9]. Studies suggest that approaches to promote STEM to young generations should not focus only on the development of knowledge and skills during school hours, but should also incorporate talent development through after-school programs and outreach events starting at an early age [5]. However, majority of STEM outreach programs in the United States target middle and high school students, with little-to-no emphasis on elementary school students [10]. Based on a literature survey, Barnes in [10] suggested that there

is a national need to establish outreach programs that target girls at an early age, particularly elementary school before they distance themselves from STEM [11][12].

In 2012, a group of female Engineering students at Chico State founded the first K-6 grade outreach program "Imagineer Day" in the "institution region." The program's goal was to get young girls interested in Engineering through engaging them in “hands-on” activities pertained to different Engineering disciplines. Since it started, the program has grown and received national recognition. The study in this paper focuses on evaluating the effectiveness of our outreach program, taking into consideration the following aspects:

1. The influence the outreach program has on young girls’ perception of Engineering as a career for women
2. It’s effectiveness in promoting STEM to young female students
3. The impact it has on female Engineering students

Imagineer Day Overview

Imagineer Day is an annual one-day outreach event founded by the SWE section at Chico State in 2012. This one-day event creates an opportunity for the participants to engage in hands-on lab experiments that demonstrate basic Engineering concepts in its multiple disciplines. Each participant joins in four different lab experiments based on grade level, Kindergarten through 8th grade. The participation in the event is open to both genders with a metered 90% attendance of girls. The solemn purpose of this event is to not only advocate and introduce STEM-related activities to the attendees but to capture the interest of girls at an early age to seek a route in STEM as they progress through their lives. Imagineer Day will be holding its sixth annual event in the year 2018.

The event takes 7 hours to complete, during which all groups, except 7th-8th, spend the day rotating between labs with 29-30 kids per lab. Each lab activity lasts for 50 minutes and introduces the participants to a different field of Engineering. As an alternative, the 7th-8th groups participate in all-day robotics activity. Table 1 outlines a typical schedule for the lab activities throughout the day.

Table 1: Imagineer Day activity schedule 4th-6th

Time	Activity
8:00 - 8:50	Registration
8:50 - 9:05	Welcome Ceremony
9:10 - 10:00	Lab 1: Civil Engineering “Earthquake in Classroom”
10:10 - 11:00	Lab 2: Electrical Engineering “Sound and Frequency”
11:10 - 12:00	Lab 3: Mechanical Engineering “Fluid Mechanics”
12:10 - 12:50	Lunch
01:10 - 01:50	Lab 4: Mechanical Engineering “Rubber Band Car”
02:10 - 02:50	Closing Ceremony

Each lab introduces different Engineering discipline and is taught by SWE officers, SWE members, or students from other Engineering clubs. SWE provides lunch, snacks, a theme-oriented t-shirt and a goodie-bag filled with school supplies to all participants, including volunteers. All students participate in a closing ceremony to conclude the event. Additionally, the 7^{th}-8^{th} group displays their completed robotic projects in a showcase. Figure 3 shows a sample lab from all age groups, Kinder-3^{rd}, 4^{th}-6^{th}, and 7^{th}-8^{th}. A sample lab activity is provided in the Appendix A.

Figure 3: Imagineer Day 2017

Results and Analysis

The purpose of this study is to evaluate the impact the outreach event has on K-8 graders, particularly girls, as well as undergraduate female Engineering students. In this section, we represent the data collection method, data analysis and results from each group segment.

Part A: Undergraduate Female Students

A survey was administered to students who have been involved in organizing and running the outreach event for a year or more. The students cover most disciplines of Engineering, including Electrical, Computer, Mechanical, Mechatronics, Civil and Computer Science. The first part of the survey consisted of 6 questions and was constructed to evaluate the event's effectiveness in developing the following skills [7]:

(A) leadership skills
(B) understanding of Engineering concepts
(C) self-confidence
(D) communication skills

(E) presentation skills
(F) time management skills

Students were asked to rate the level of impact that the outreach event had on their lives using a scale from 0-5, where 0 represents (no impact), and 5 represents (significant positive impact). A total of 20 students participated in the survey some of which have already graduated from the program.

As shown in figure 3, the quantitative part of the survey results indicates that outreach has a significant impact on most of the respondents (77%-93%) in all areas. Time management skills were the most influenced area followed by communication skills. 7% of the students felt the event had no impact on their understanding of engineering concepts.

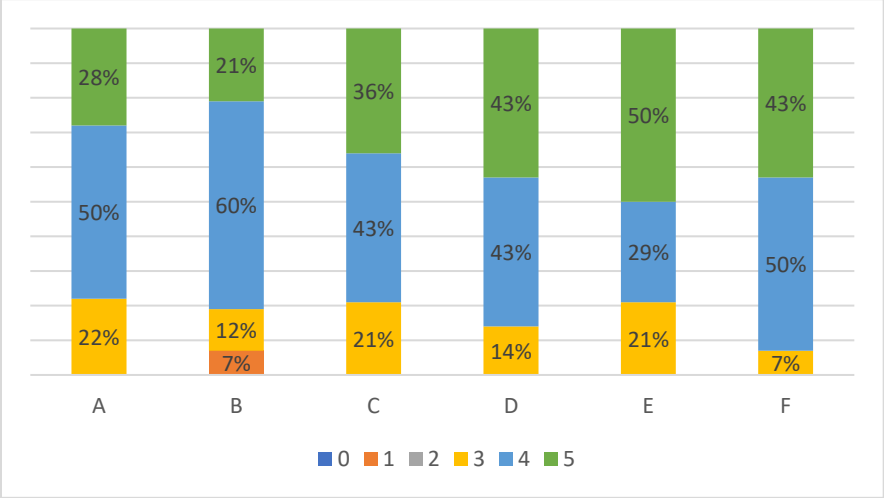


Figure 4: Outreach impact on areas A-F in scale 0-5 ("0" no impact, "5" significant positive impact)

In addition to the personal assessment portion, the survey contained a free response section. In this section, students were asked to reflect on their view of the importance of the outreach event, in correlation to self-development, society, and education.

I: Outreach and Personal Skills

Students indicated that outreach helped them develop and enhance their communication skills, public speaking skills, self-confidence, teamwork and leadership skills. The majority of the respondents mentioned communication as one of the most developed skills.

> *"Public speaking and communication skills. I'm a communication minor and communication isn't so important in everything in life...and unfortunately, most engineers aren't noted for their communication skills. So outreach helps build these skills and show employers that you are a responsible human and not a robot doing work."*

Another significant benefit was the development of time management skills. The planning for the events starts immediately following the preceding event. Officers and members spend most of

the school year fundraising and preparing for the event. All expenses are covered through fundraising and ticket sales, which require an extensive year-round planning and involvement. Several students stated that planning for the event forced them to manage their time better to meet deadlines.

> *“practicing being clear and concise while meeting time goals/constraints."*

II: Outreach and Engineering Skills and Knowledge

Aside from its influence on social skills, students indicated that outreach helped them polish their understanding of Engineering concepts and forced them to enhance their presentation skills.

> *"Outreach not only helps cement what I already know but also builds soft skills that can also be applied to classes and life. Outreach helped me get my foot in the door for my internship."*

> *"Outreach broaden my horizons and helped me to better understand some tough topics."*

III: Outreach and STEM

Upon establishing the outreach event, one of the primary goals was to get young girls interested in the Engineering field. Several responses reinforced this objective and expressed a growing interest in promoting STEM to young generations.

> *“Helping spread the STEM fields to the younger generation and show (especially those who don't feel they can) that Engineering is possible for them."*

> *“Just getting kids to think outside the box and get excited about STEM. I think we have a huge role in education. They are the future, and we should open them up to make what we couldn't possible."*

Additionally, students reported that being involved in outreach increased awareness of their responsibility in promoting Engineering as a possible field of study to young girls.

> *"I love getting these young girls interested in the STEM field and impacting an aspect of their lives helpfully and beneficially."*

> *“I enjoy helping others gain an interest in what I do. I want to inspire others, show them that they too can do what I do."*

Finally, the majority of the responses suggested that seeing the impact on young generations was the most rewarding outcome from the event.

"The most rewarding thing about outreach was seeing the faces of those we helped. The smiles that came across their faces."

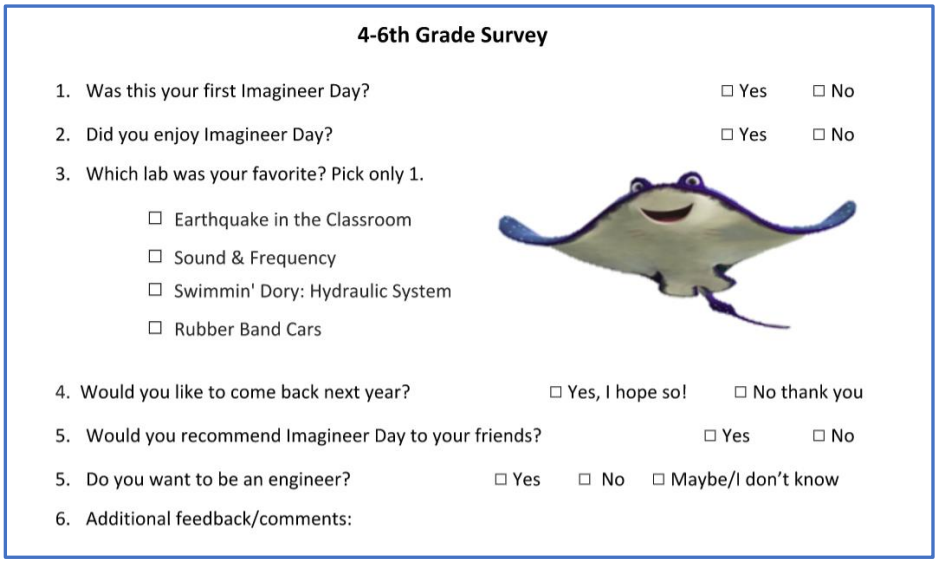
"Inspiring the next generation of engineers."

"I find it rewarding making a difference and to come away with inspiring people and knowing they've learned something."

"Inspiring the younger generation. Watching their eyes light up as they come to have a basic understanding of Engineering concepts."

Part B: K-8 graders

During their final lab rotation, the attendees were handed a brief feedback survey to fill out. The survey addressed questions in regard to their overall experience with Imagineer Day (figure 5 shows the 4th-6th grade survey template).



4-6th Grade Survey

1. Was this your first Imagineer Day? ☐ Yes ☐ No
2. Did you enjoy Imagineer Day? ☐ Yes ☐ No
3. Which lab was your favorite? Pick only 1.
   - ☐ Earthquake in the Classroom
   - ☐ Sound & Frequency
   - ☐ Swimmin' Dory: Hydraulic System
   - ☐ Rubber Band Cars

Figure 5: Imagineer Day 4th-6th Survey, 2017

The final question was constructed to evaluate the events' impact on the attendees' perception of Engineering. It asked the participants if they "would like to be an engineer?" As shown in Table 2, a majority of the students expressed uncertainty in their future choice. For example, in the 2017 event, 49% indicated they "maybe" want to be engineers, 22% answered "No," while 29% answered "Yes" to the same question. It should be noted that 2016 was the first year an attempt was made to collect feedback from the participating students. In the 2016's survey, the question "do you want to be an engineer?" had only two possible answers, "yes or no." We have received several suggestions to add a third choice of "maybe/I do not know" to the answers. The attendees were hesitant to give an explicit answer of "Yes" or "No" to this question. Almost half of the

students (47%) expressed interest in Engineering compared to 29% in 2017. While this result does not conclude that the students' interest declined in 2017, it certainly implies that students preferred to answer "No" than "Yes" when asked to express their interest in the Engineering discipline.

Table 2: K-8 end-of-day survey results

Question	2016			2017		
	Yes	No	Maybe	Yes	No	Maybe
Will you come back next year?	74%	11%	18%	95%	3%	2%
Do you want to be an engineer?	47%	53%	Was not included	29%	22%	49%

Not only the survey allowed event organizers to analyze how the kids felt about the day but also sought out ways to improve the event for years to come. For example, answers to the question "what was your favorite lab" were taken into consideration when planning future events. Furthermore, the recorded responses indicated the event's retention rate. Data shows that the number of returning students increased by 18% between the years 2016 and 2017. Only 30% of the attendees in 2016 were returning students from previous years compared to 48% in 2017.

Conclusion

Our overall data analysis indicates that Imagineer Day outreach event has been successful in promoting Engineering and Computer Science to young generations. We have seen a grown interest in the program over the past six years, as the number of participants increased from 100 students in 2012 to 250 students in 2018. Additionally, the increasing number of returning students suggests that the program has managed to retain young girls' interest in STEM over the years. To be able to study the impact of this event, in the long run, the School of Engineering is monitoring the progress of female students who had participated in Imagineer Day for two years or more.

On the other hand, the event has allowed our collegiate girls to exemplify and teach the skills they acquired throughout their college career to younger generations. It also helped them improve their public speaking and time management skills, of which both contributed to an increase in overall self-confidence.

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Appendix A

Lab Experimental Proposal
Chico State SWE Imagineer Day
March 10th, 2018

Lab Leaders: Michael Doris (Electrical Engineering Student), Carissa Leveille (Society of Physics Students), Joseph Levine (Society of Physics Students), Jason Mickel (Society of Physics Students)

Age Group: 4 – 6

Discipline: Electrical Engineering / Renewable Energy

Experiment Title: *Exploring Circuits and Renewable Power*

Description:
Lecture:

- The electron and electricity **(5 Minutes)**
- Renewable Energy and Demonstration **(5 Minutes)**
- How to Connect Snap Circuits **(5 Minutes)**
- Snap Circuits Activities **(25 Minutes)**
- Student Show and Tell and Reflections **(10 Minutes)**

Materials:
Participants will be working in groups. Assuming 30 children: 5 Groups of 6 children.
Every group gets:

- Snap Circuit Jr. Base and Components (20.99 ea x 5 = 104.95)
- Project Outlines
- One Form of Snap Circuit "Green" Energy
- AA Batteries (10 * 1.32 ea = 13.20)

All materials, shown in figure 1, will be in a plastic bin for each group. All materials will be shared between sessions. After
each session every built project must be disassembled and re-prepared for the next session. Lab Leaders and TA's must ensure pieces are not lost or damaged.

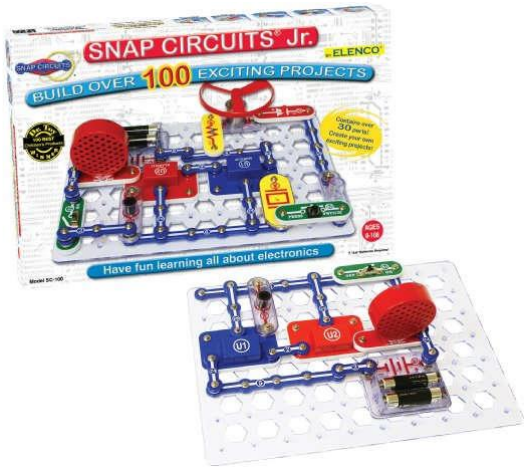

Figure 1

Special Requests: Computer + Projector for lecture component.

Preparation:
Five bins must have enough Snap Circuit Components for the available projects. Each bin will have multiple projects to choose from. A power source for each bin must be available, either batteries or a form of "green" energy. This must be repeated between sessions. Each Lab Leader or TA must be present to help with questions, guide concepts, and ensure circuits are connected safely/properly.

Pre-Lab Discussion:

The Atom: Protons, Neutrons, and the ELECTRON! (2 Minutes)
https://drive.google.com/file/d/1LyryvIFUCWGQ1_zInHOC1btnxw2tjFup/view?usp=sharing
Now, these electrons that are a part of atoms are used to create Electricity! I'll let Bill Nye describe that for you though.

What is Electricity? (2.5 Minutes)
https://drive.google.com/file/d/1ErwGBq6kByK88jnghnrffszu1W8x_TPF/view?usp=sharing

Forms of Renewable Energy. Solar Panel/EV Demonstration. (5 Minutes MAX)
There are now many forms of renewable energy. The most common you'll see are: Solar, Wind, Hydroelectric, and Geothermal.Regardless of what you use, these energy methods all create a potential, or *VOLTAGE.* This voltage pushes the electrons and makes them want to move. As you saw in the videos, this creates a *CURRENT* in a circuit. But, we also learned that everything is made of atoms, and these atoms want to hold onto electrons. This tries to slow down the flow of electrons and this creates *RESISTANCE.*
NOTE: At this point an actual photovoltaic circuit will be demonstrated.
But you know what else you can do with electricity, and renewable energy in general? Well, Imagineer Day is themed around Cars, right? Well who here knows what a Tesla is? Tesla uses electricity to power their cars instead of gas. Many of their car chargers use solar or wind power. By using the same concepts about voltage, current, and resistance you'll learn today

with these circuits, they built super-fast cars like this!
https://www.youtube.com/watch?v=tw4jkyfY4HE (**30 seconds)**

How To Connect Snap Circuits (5 Minutes MAX)
Now, *CURRENT* in circuits flows from the positive end to the negative end. When you connect your pieces, make sure you snap them together so everything flows one way. Connect the Positive (+) to the negative (-). But REMEMBER! You need a potential, a VOLTAGE, so make sure you connect a power supply in the form of batteries or renewable energy. The lab assistants will help you with this.
Every kit has several projects to choose from. Split into five groups and work together to accomplish the project. If you finish one fast, you can do the others too!

Post-Lab Discussion:
Circuit Demonstrations
What Concepts were learned?
How did the "Green" Power Sources Work?