Project ENGAGE: A Summer Immersion Experience in Engineering for Middle School Girls

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Introduction

Project ENGAGE (Empowering the Next Generation: Advancing Girls in Engineering) is Syracuse University's (SU) summer residential engineering program for high-ability middle school girls. The mission of this program is to increase talented rising 8th and 9th grade girls' knowledge of, and interest in, engineering as a means to contribute to positive societal change. The vision of the program is that young women who have participated in Project ENGAGE will be more likely to pursue careers in engineering, science and technology fields, thus increasing the number of women in these fields where they are presently under-represented.

Engineering is a prime contributor to solving some of the most difficult challenges facing the world today. Women's participation in engineering is crucial to stimulate diversity of thought in scientific discovery, the development of new technologies, and to promote innovation that addresses challenges throughout the full spectrum of society including healthcare, environmental issues, energy, infrastructure and transportation. The National Science Foundation reports that women were awarded 57% of all bachelor degrees in 2012, but earned only 19% of the total engineering degrees[1]. This disparity continues for graduate degrees[2] and women hold less than 25% of all STEM positions in the workplace[3] and only 14% of the engineering positions[4]. Women are clearly missing from engineering-related fields in both higher education and the workforce.

In order to increase the gender diversity of these fields, we must make engineering attractive to girls from a young age. Too few girls who are bright, ambitious, and motivated to contribute to the betterment of the world are aware of how rewarding Science, Technology, Engineering and Math (STEM) careers can be[5]. A recent report by the Girl Scout Research Institute (GSRI) found that over 88% of the girls surveyed said that they wanted to make a difference in the world and 90% wanted to help people, yet few recognized that STEM careers are a pathway to these ambitions. The GSRI recommends that showing girls that they can change the world and help people through STEM careers will make traditional scientific and engineering fields more attractive to girls as they think of future careers and college majors[6]. A recent opinion article in the New York Times by Lina Nilsson reaffirms the GSRI study and suggests that women "seem to be drawn to engineering projects that attempt to achieve societal good". Ms. Nilsson suggests that to attract more females to engineering, the goals of engineering research and curriculums should be reframed "to be more relevant to societal needs".[7] In addition, Halpern et al found in order to cultivate girls' interest in STEM they should be exposed to women in STEM role models and come to understand and appreciate their achievements in math, science and engineering[8].

Making Engineering Attractive to Middle School Girls through Project ENGAGE

Project ENGAGE aims to foster girls' understanding of engineering as an avenue through which they can contribute to societal change and have a positive impact on people and the environment. By introducing engineering to girls at the middle school level, a pivotal time when so many girls lose interest in STEM[9], and when they are beginning to think about college and their future careers, we hope to demystify engineering as a viable career choice for women.

The objectives of Project ENGAGE are to help young women become engaged in engineering by providing a deeper understanding of women's achievements and potential for success, as well as connecting their skills, interests and altruistic motives to these important fields. Specifically Project ENGAGE:

- Creates an understanding amongst bright, well-rounded young women that engineering careers are an avenue to contribute to positive societal change.
- Gives participants the opportunity to interact with female engineers as role models through SU's College of Engineering and Computer Science's female faculty and professional female engineers in the field, and thus realize that women play a critical role in technical innovation, creative design and solving societal problems.
- Raises their awareness of the full spectrum of skills engineers rely on for success in their careers, beyond strong math and science skills including: creativity, teamwork and communication, in order to help participants increase their identity with the profession.
- Provides fun, hands-on, inquiry based projects and investigations, which allow the girls to approach projects in their own learning styles while learning to use the engineering design process.
- Explore learning opportunities that participants are not able to experience at home or in the traditional classroom.

Another Project ENGAGE objective is to increase the number of women in the engineering talent pool with ties to Central New York, while showcasing local corporations and engineering firms.

- Project ENGAGE ensures that at least 50% of its participants live in Central New York.
- The program includes offsite experiential learning experiences at local engineering companies that enhance the program.

Program History

Project ENGAGE is based on a successful pilot program developed by the Syracuse University College of Engineering and Computer Science (ECS) in 2012. The program was the brainchild of the former Dean of Syracuse University's College of Engineering and Computer Science, Laura J. Steinberg "to not only encourage girls to excel in math, sciences and engineering, but also to showcase their skills and talents. Her idea was based on two beliefs: In the future, engineering is going to need women to enter the field in much larger numbers than they do now, and the field will need practitioners who aren't only good in math and science, but are talented enough to undertake almost any career"[10]. As a woman and an environmental engineer, former Dean Steinberg was well aware of the challenges faced by young women who are exploring

science and engineering careers, and she was personally committed to helping them navigate these difficult waters.

This highly competitive pilot program, funded by the Siemens Foundation at no cost to participants, served 21 rising 8th graders the first week and 20 rising 9th graders in the second. These 41 students were selected from an impressive group of 120 applicants from New York, New Jersey, and Pennsylvania. The girls lived on campus from Sunday afternoon through the following Saturday morning while participating in themed, engineering-focused activities, field trips and lessons, which culminated in final team projects. Our themes for 2012 were *"Sustainability and Alternative Energy"* for our rising 8th graders and *"Engineering and the Human Body"* for our rising 9th graders. Our programs included field trips that were designed to give the girls the opportunity to see professional engineers in action tackling real world challenges.

Through the 2012 pilot program evaluations, pre- and post-program assessment surveys and discussions with student participants and their parents, we found that the program accomplished many of our original goals. The girls indicated that the program had influenced their attitudes about potential career choice, self-awareness and confidence levels. The girls' comments showed that they gained a great deal from the interaction with their peers and that the program provided them with an opportunity to develop the teamwork skills so necessary for school and the workplace. We used our experience with the 2012 program and the feedback we received from participants to inform our programming and planning for Project ENGAGE programming in 2014 and 2015.

The Current Program

Project ENGAGE is now preparing for its third summer on Syracuse University's campus. The program, which is largely funded through grants and corporations, allows qualified students to attend for little or no family financial contribution. The program presently serves 64 talented middle school girls during two one-week residential programs, 50% of which live in Central New York.

Recruitment & Selection

Applications to attend Project ENGAGE are made available through our website (http://projectengage.syr.edu/) by January 1, school counselors are notified and encouraged to nominated two academically successful 7th grade and two academically successful 8th grade girls. Nominations and applications are due in early March. We generally receive over twice the number of students we can accept. We expect the number of applicants to increase as more schools become aware of the program. The program is extremely selective and a committee of the program administrator and teachers thoroughly review each applicant's grades, recommendations and short essay answers to select 32 girls for each program week. We have found that the selection process has enabled us to gather a group of exceptional and like-minded girls who enjoy working together on creative and open-ended activities.

Preparing for the Girls Arrival

Program participation forms are sent to parents and guardians to be completed prior to the girls' arrival on campus. An on-line survey is used to assess the girl's attitude about engineers, and engineering.

Social Media, including the Project ENGAGE Facebook page (https://www.facebook.com/SUProjectEngage), is used to get the girls excited and prepared for the program. Beginning in June we use the page to highlight staff and faculty that will be working with the girls during their stay on campus.

Program Staffing

The Project ENGAGE staff team consists of:

- **A Program Coordinator:** The Program Coordinator provides all aspects of program administration, including hiring all program staff. She assists Foundation Relations and Advancement to help procure outside corporate and foundation funding to help reduce the family contribution for attending the program. The Coordinator works for the College of Engineering and Computer Science in a part-time capacity during the year and full time from early June through the program delivery.
- **Middle School Teachers (2):** Two middle school teachers are hired each summer to help with participant selection, curriculum and activity development, and to provide continuity for each week's programming. The teachers are with the girls during all daytime programming, chaperone field trips and provide the "glue" and context for the activities, lessons and the weeklong project. They lead activities and lessons and assist faculty during faculty led activities. When we increased the number of participants from 20 to 32 girls each week, we also decided to split the group in half many times during the week for better activity experiences. Having two teachers allows two activities to be going on simultaneously. In addition they help faculty engage our target audience, an audience University professors might not have experience with.
- **Resident Hall Assistants (RAs):** Three RAs are hired to provide supervision, the appropriate staff to minor ratio, and fun team building activities for the girls in the evening and in the resident hall. The RAs undergo background checks and are trained on working with "Minors on Campus" through Syracuse University College. We try to ensure at least one of our RAs each year is an engineering student or has a degree in engineering to help serve as a STEM mentor.
- **Assistant to the Coordinator:** We also hire one assistant to the Coordinator each year from early June through the last day of the program to help with program details such as registration, photography, Facebook administration (loading program photos during the week(s), etc.
- **Faculty:** Over 10 University faculty members and two graduate students volunteer their time and talents to provide lessons, laboratory and other activities to our Project ENGAGE participants.

Project ENGAGE Curriculum

Each program week focuses on a specific theme, which the girls can relate to and can be easily linked to societal benefits. The curriculum elements throughout the week, including lessons, activities and laboratories, feed into the students' final group project, a creative depiction of their learning experience, which is presented to their parents, as well as SU faculty, at the conclusion of the program. The final project experience incorporates crucial 21st century STEM skills including critical thinking, problem solving, innovation, creativity, collaboration and teamwork. Numerous activities throughout the week are led by female faculty, thus providing a direct role model of women in STEM for girls who might associate science and engineering with men.

Week 1 for rising 8th grade participants focuses on "Sustainability and Alternative Energy". The final team project is to build a model of a green or sustainable home. The girls build the model in the wood and metal shops after introductions to power tool use and safety. This component was specifically added after engineering faculty expressed concern that incoming college freshmen engineering students often have no experience working with hand tools. The week's activities and lessons include: introduction and use of the engineering design process; teambuilding exercises; building and testing wind turbines and micro-hydro units; learning about the solar decathlon; size and scale exercises; how energy is stored; green buildings and infrastructure; rainwater harvesting; green roofs and permeable sidewalks; insulation properties; passive solar and building and testing raspberry solar cells using nanotechnology.

Week 2 for our rising 9th grade participants focuses on "Biomedical Engineering: Bridging the Technology-Medicine Gap". During the week the girls are exposed to a variety of biomedical engineering principles. Activities and lessons for this week include: measuring material strength including chicken bones using a MTS system; joint replacement through virtual surgery; introduction to nanotechnology; synthesizing nanoparticles and group discussions on how nanotechnology may be used to benefit human health and fight disease; prosthetics and medical diagnostics, designing, building and measuring the stress and tension of tissue scaffolds. The final project is for the girls to identify a medical problem that is important to them and to design a product for solving this problem; create a pitch for selling their potential solution to a Venture Capitalist or Medical Device Company so that you have the money to theoretically create a prototype of their design and test the proposed solution.

Activities during the week are made up of both lessons found through on-line resources, tweaked to meet the program's needs, and lessons created by faculty or our middle school teachers. On-line resources we have used and/or modified include:

- Try Engineering (http://tryengineering.org),
- Teach Engineering (https://www.teachengineering.org),
- SciGirls (http://pbskids.org/scigirls/home),
- eGFI (http://www.egfi-k12.org/),
- University of Wisconsin Madison-Materials Research Science and Engineering Center Education Group (http://education.mrsec.wisc.edu/index.htm),
- Greenlearning.ca (http://www.re-energy.ca)
- US Environmental Protection Agency (http://www.epa.gov) and
- NASA (http://www.nasa.gov/audience/foreducators).

Each program week includes at least one off-site experiential learning opportunity with a local corporation or not-for-profit organization, which demonstrates the relevance of STEM careers by connecting to real-world problems and real-world work and gives the girls the opportunity to see women engineers in the field as role models. In the past we have visited the Women's Rights National Historic Park, the Women's National Hall of Fame, Seneca Meadows Landfill, the Onondaga Lake Superfund Clean-up Project and the Rosamond Gifford Zoo's green infrastructure in Week 1. In Week 2 we have visited Corning Museum of Glass; Welch Allyn, a local medical diagnostic company; and the Institute for Human Performance.

Each week we take advantage of the Syracuse Center of Excellence, a LEED ™ Platinum certified building with meeting and laboratory space, to hold activities and give the girls exposure to not only the green aspects of the building but also the opportunity to tour faculty laboratories there.

Project ENGAGE hosts an evening at The Museum of Science and Technology (MOST) in downtown Syracuse for participants during both program weeks. We invite SU faculty members and professional engineers to a reception to speak in a more informal setting with the Project ENGAGE participants, helping to broaden their exposure to different engineering fields. The girls are each given an engineering "passport", which encourages the participants to talk to different adults during the evening so that they can have their passport signed by engineers representing different engineering fields. We have an inspirational keynote speaker from the field of engineering speak about their career choice and path during a catered dinner. This corporate sponsored evening provides company recognition and allows for the company to provide the inspirational speaker and has been found through program evaluations to be a very special evening for the girls.

A "Typical" Project ENGAGE Day

While there is no typical day at Project ENGAGE, this immersion course allows participants to experience first-hand what engineers do, how they approach, design and solve problems, and the creativity needed to accomplish these goals.

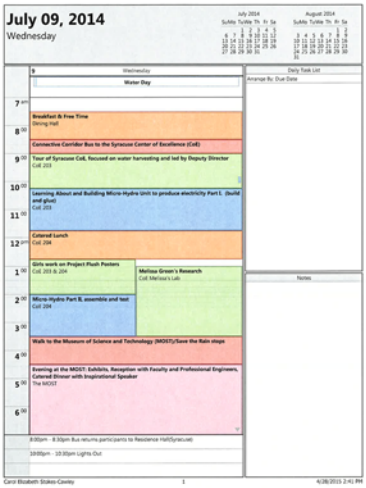

Figure 1: Block Curriculum for Project ENGAGE Week 1, Day 4

Above is a block curriculum for "Day 4" of Project ENGAGE Week 1 "Sustainability and Alternative Energy." The girls wake up at 7 am and after showers they walk over to the dining hall for breakfast. After breakfast the girls take the Connective Corridor bus to the Syracuse Center of Excellence, (CoE) where we spend the day studying water and water sustainability.

- Our first activity of the day is the **"Water Tower Challenge"** led by our middle school teachers and adapted from a Try Engineering lesson (http://tryengineering.org/lesson-plans/water-tower-challenge). In teams of four, the girls develop a water tower that can deliver water to a paper cup that is 90 cm away from the source in a controlled manner (they must be able to stop and start the water flow). This activity allows the girls to think creatively, while working in small teams.
- Our second activity is a lesson developed by the Deputy Director of the CoE and one of our middle school teachers titled **"Project Flush"** and takes advantage of the rainwater harvesting that is used to flush the toilets in the building. The Deputy Director leads a tour of the building focusing on the water harvesting aspects of the building, as well as its other green features. The girls are asked to compare where the toilet water comes from in the residence hall to the CoE. The participants, again in teams of four, are tasked with designing a system, based on a natural-system, that can be harnessed for human needs and illustrate their idea in a poster format, which they share with the rest of the participants.
- Our third water activity consists of building a **"Micro-hydro Electric Generator"** adapted from http://www.re-energy.ca/hydro-generator. Using magnets, plastic spoons, cork, a gallon jug, plastic tubing, dowel, electric tape, wire etc. the girls follow directions in this two part project to build and test their micro-hydro unit. This activity encourages the girls to use the engineering design process, as the generator rarely works without some tweaking.
- During a break in the activities and lessons, a catered lunch is served, and in small groups the girls tour a "water channel" laboratory with a female research faculty member.
- Our last water activity of the day is a walking tour of examples of the County of Onondaga's **"Save the Rain"** projects (http://savetherain.us). In order to avoid building a new Sewage Treatment Plant, the County embarked on projects such as porous pavement, green roofs, and vegetative swales throughout the city of Syracuse that would reduce the stormwater entering the sewer systems and Onondaga Lake and its tributaries. This walk has the dual purpose of leading the girls to the Museum of Science and Technology for our "**Night at the MOST."**

Housing and Meals

The students live in SU residence halls and participate in the summer dining plan for the week they are on campus. While this residential component adds to the cost of the program, it ensures that we can reach exceptional students from a much wider geographic range. Program feedback indicates that the residential component is a significant incentive for the students to attend and that they greatly enjoyed spending both academic and social time with other high-achieving girls.

Project ENGAGE: Assessment

The success of reaching many of Project ENGAGE's objectives is determined through pre- and post-participation assessments as well as through program evaluations completed by the students. Evaluation data is used to address shortcomings, make adjustments and improve performance. SU continues to explore ways to follow up with Project ENGAGE participants as they continue on in their schooling and hope to track what majors they choose in college and evaluate whether the girls stay in the pipeline of STEM education.

The evaluations have been very positive in general and the students also provide detailed suggestions for improving individual activities. Anecdotal evidence from participants and parents which attest to our success in reaching our overall mission, to help participants learn and get excited about careers in engineering, include:

Participant Quotes

"*My experience at Project ENGAGE has been so positive. I learned that I do have a creative side and I enjoy thinking 'outside the box'. I love to make designs of devices that could have a huge positive impact on others and working in groups to do so.*"

"During the past week I have learned many things about myself. I have learned that once I have an idea I know how to explain it. I also tend to take over if I know exactly what to do. This program has taught me how to listen to other's ideas and incorporate it with others to make everyone happy."

"The project really helped me understand engineering more and got me interested in the field. The program actually exceeded my expectation for learning about engineering."

"Coming into this program I only wanted to be a physical therapist, no one could change my mind. However, through the week I have had so much fun and learned the many opportunities in engineering and I have been so inspired. ENGAGE has changed my mindset completely!"

" ..not only did I acquire knowledge about engineering and different sciences, but this program helped me learn that I can be by myself and meet as well as grow close to people in short times. I learned that when I stick with things, they turn out to be worthwhile. Opportunities should always be considered. And also, I can't take things for granted. I say all these because I was hesitant to leave home for a week because I've never really done that for that long. Also, at first I wasn't sure if I would enjoy the week of the program. However, I did and am so glad I did it!"

"It has influenced my decision to become an engineer later in life- before that week I had no clue what an engineer actually did!"

"Project ENGAGE made me realize that there are many problems in the world and the world needs people to be able to work together to solve these problems."

" Through Project ENGAGE I learned about what engineers do and jobs they work on."

" Project ENGAGE showed me that I could really be an engineer and that I could enjoy it"

Parent Quotes

"I have already recommended the program to every parent I know who has a middle school daughter! My daughter came home a different person – she seemed more mature and self-confident. She wasn't exactly a wallflower when she left but she seemed a lot surer of herself when she returned home. I wish she could go back every summer!"

"I absolutely would recommend this program! It was just fantastic, and I hope that it can continue, or even grow!"

" The program allowed my daughter to see that is OK for girls to be a little on intelligent side and there are other girls just like her, it was an excellent confidence builder. It exposed her to opportunities that as parents we could not provide or would not have the same effect."

"I would not add or remove anything – I only wish there more programs like this giving students with "potential" the opportunity to discover "what they can do" "

Program Uniqueness and Challenges

There are currently efforts throughout the Country and New York State to provide STEM opportunities for middle and high school age girls to encourage them to pursue careers in these fields. We believe the strength of the Project ENGAGE model comes from the following factors:

- We focus the week's programming on themes, which are both meaningful and personally relevant, rather than a broad-brush approach to engineering disciplines.
- The activities, lessons, and weeklong project feed into the week's theme.
- We include "real world" and theme based experiential field trips.
- We limit the number of participants through a highly selective process, which provides for a community of motivated and energized peers.
- The program is residential with a fairly low or no family financial contribution.
- The selected engineering lessons take advantage of the strengths of the University's faculty expertise.
- Middle school teachers provide continuity during the week.
- Professional and faculty role models are included in a number of ways and inspire participants to pursue engineering and other STEM fields.

The most significant challenge facing the future of Project ENGAGE will be ensuring its sustainability and even growth at Syracuse University. We have prided ourselves on selecting and accepting a fairly small number (32/week) of high achieving young women without considering their ability to pay. We presently charge only about 40% of the actual program cost to participants and offer full scholarships to those in need. In order to continue to offer these scholarships and a subsidized tuition, the program must continue to receive monies from foundations and corporate sponsorships. Over the last few years, fundraising, in itself, has

required resource time and effort by the project staff, as well as staff from Foundation Relations and Advancement. In the long run, the program would best be served through multi-year large grant or sponsorship which might provide corporate naming opportunities. We continue to search for the best corporate or foundation fit for subsidizing Project ENGAGE.

Project ENGAGE presently is the only residential STEM outreach program for middle school girls at Syracuse University. We foresee opportunities for additional weeks in other engineering disciplines, as well as other STEM fields. From the number of applications we receive we believe there is both the desire and need for growth within Project ENGAGE umbrella or by using Project ENGAGE as an outreach model.

Conclusion

Project ENGAGE continues to introduce young women to the power and opportunities presented by engineering disciplines to affect positive societal change. Participants identify with female engineers in both academia and in the field as role models and realize the vital role they play in technical innovation and creative design. At the program's conclusion the girls realize through the structure of the program that math and science skills are only part of the STEM career equation and that creativity, working well in teams, communicating ideas effectively, and understanding other cultures and stakeholders are equally as important.

We believe that by exposing highly motivated, bright, middle school girls to the exciting and innovative fields of engineering through engaging, hands-on experiences with experts in their fields, we can continue to increase the number of these students who consider engineering majors and careers. In the long run we foresee expanded Project ENGAGE to other Engineering and STEM disciplines within Syracuse University and to serve as a model for other Universities, throughout the Country.

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