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# Learning in Informal Environments through Engineering Activities through the Partnership with the Girl Scouts

More affordable and portable robots have enabled easier access for outreach activities to happen in different environments. However, exposure to robotics often relies on seeing robots in action, such as industrial robotics and robots that are used for research purposes. Old Dominion University's College of Engineering and Technology in Norfolk, Virginia recently signed a partnership agreement with the Girl Scouts of Colonial Coast as one of the focused outreach strategies that target the female population. Various events are held on campus in the Hampton Roads residential area located in the southeastern United States, which has a population around 2 million people. Through this method, elementary age girls can be exposed to engineering content by attending events that are held on the university campus and lead by faculty along with graduate and undergraduate students. This paper showcases one such learning activity through an informal setting activity designed for the K-5 elementary grade levels. In this case, Girl Scouts in the following groups: Daisies, Brownies, and Juniors. Similar activities can be delivered on any other college campus that offers majors related to the area of mechanical engineering / mechanical engineering technology; civil engineering / civil engineering technology; and electrical engineering / electrical engineering technology. .

## Introduction

Girl Scouts is girls only, non-profit organization focused on character development through wholesome reading, charitable works, and social activities under the guidance of role model women [1]. Girl Scouts has been in existence since the organization was founded in the United States by Juliette "Daisy" Gordon Low in 1912 [2]. This girl-centered organization offered activities traditionally inaccessible to young women at that time, such as outdoor recreation and leadership events [2]. Many of these activities are related to identity development and discussion about gender specific standpoints, while some involve striving for excellence and independence, and others are more related to helping or supporting roles [3]. Almost three million American children and 800,000 adult members currently participate in the Girl Scouts of the USA [4]. The organization annually runs the cookie program, which is focused on the development of five key business and leadership skills: 1) goal-setting; 2) decision-making; 3) money management; 4) people skills; and 5) business ethics [5]. However, some recent studies compared the gender messages in Girl Scout and Boy Scout handbooks and noted that boys were exposed to more activities that are based on scientific content [2], although engineering badges have been implemented in the Girl Guides of Canada, ages 9-12, in 2003 by Ryerson University's Women in Engineering Committee [6]. As well, the Girls Scouts of USA councils have also been integrating various activities focused on STEM and, more specifically, on engineering concepts [7].

**Broadening Participation of Female Students in Engineering and Technology**

Some research studies confirm that ethnicity, along with the parental level of education, play a significant role in female students' perceptions and experiences related to engineering, as well as their selection of engineering majors [8]. This is very significant in urban, diverse populations that surround many of the engineering undergraduate programs across the country, and where diversity in engineering does not match diversity among the engineering student body. Once enrolled, the populations found the most vulnerable to leave programs are African American, Hispanic, and Native American students for which retention rates are lower than their white peers [8-11]. Breaking these barriers is also significantly harder for first generation students [8]. This gap is even more pronounced for female, undergraduate engineering students, for whom the percentages of enrollment are far from the population distribution in most engineering majors. The domestic available pool of talented women still remains significantly underutilized in order to fill the national gap in the STEM workforce, and many of them choose non-engineering based majors for their career [11]. One of the important factors needed for choosing engineering pathways is interactions with engineers from the same general population group, which is often lacking in the general K-12 traditional education setting, and is missing for many disadvantaged and underrepresented students [11]. One of the factors that hinder or discourage women from entering the engineering field is the lack of role models and networks [12]. Hence, having them participate in activities led by female engineers, or engineers from their own ethnic group, can expose them to the role models they would otherwise not have had the chance to meet. For this purpose, engineering colleges host various events throughout the year to make sure they reach a wider range of K-12 students.

At Old Dominion University, First Fridays are one of the outreach events developed by Batten College of Engineering at Technology. It is an opportunity for students and families to learn more about different engineering programs. The event includes laboratory tours, as well as meetings with current students, faculty, and the Office of Admissions. Faculty from various departments open their labs and showcase their research. Other events are focused on hosting a specific group of students, such as the Girl Scouts or the Verizon STEM Academy. Additionally, other groups are hosted specifically for laboratory tours, such as various high and middle schools from the area. The college also hosts an Open House, Scholar Day, Discover Engineers Week, Admitted Students Day, and Engineering Student Senior Design Expo. The open house is an event in which teachers, counselors, prospective students, and parents are invited to tour the college. There are also events that are specially targeted to the groups underrepresented in engineering. One of them are female engineering students. The following description is related to some of these specially designed events to provide outreach to a female population.

## Barriers and Resource Constraints Related to the Participation in STEM Outreach

The lack of time and a one-size fits all approach have been identified as important barriers when it comes to teaching STEM practices to undergraduate students [13]. Moreover, due to the restrictions related to the normal K-12 school operations, the outreach events frequently happen outside the regular work hours and during the weekends. Adequate access to resources is one of the barriers [13] to hands-on activities with limited availability of age appropriate outreach kits and modules for elementary, middle, and high school students. The lack of adequate resources is also a very significant problem in urban public schools, which often have a high percentage of underrepresented student groups [11]. Due to this fact, many schools still do not have adequate venues for typical exposure to engineering, such as robotic clubs, after-school STEM programs, or even Internet access in instructional computer labs on all of the computers.

Engineering colleges have advanced research equipment and use their available funds to support ongoing research activities. Generating research funds to support laboratories and graduate students are in high demand but not always easy to acquire. When funding is scarce, making any provision for the equipment necessary for STEM outreach activities is not very often a priority. Resources for K-12 outreach and through hands-on activities also requires financial resources and dedicated space. Outreach activities are often expected as part of funded engineering research efforts from funding agencies, so faculty have a chance to purchase this equipment and have them in their laboratories for such service activities. However, having sufficient and age-appropriate equipment and activities for any sized group, or ones available in the stores with updated technology is still challenging. Another issue is that hands-on activities and the educational kits would have to cover different aspects of engineering disciplines represented in a specific college to include civil, mechanical, and electrical engineering disciplines.

## Partnership Between the College of Engineering and Technology and Girl Scouts of Colonial Coast

The partnership between the Batten College of Engineering and Technology (BCET) and the Girl Scouts of Colonial Coast was an initiated by Dean Stephanie Adams when she arrived at Old Dominion University in the summer of 2017. Dean Adams was looking for opportunities to increase outreach for the college and the local Girl Scout council was looking for engineering expertise to develop activities to meet their new engineering badge requirements. A formal agreement between the parties was signed in the fall of 2017. Several out-of-school events were held, on weeknights and weekends, with activities that engaged the Girl Scouts in engineering activities with options to earn robotics badges. Some of the faculty at ODU had personal experience with either Girl or Boy Scouts organizations, with the Dean of the college being a former Girl Scout herself. These experiences motivated the interest in establishing a strong relationship between the college and the girls' organization.

Figure 1: The Assistant Dean for Outreach and Diversity and Girl Scouts participants at the Engineering Badges Workshop at the Batten College of Engineering and Technology, Old Dominion University

**Civil Engineering and Civil Engineering Technology Activities**

K'Nex [14] is a construction toy system invented by Joel Glickman in 1992 [15, 16]. This toy set has multiple parts that can be assembled together to form various three dimensional structures by combining rods, connectors, and other components [17]. These sets can be sold as kits that include construction steps, bills of materials, and step-by-step instructions that guide students to create a specific construction model, or they can be used for open play and engaging students to create their own designs [17]. K'Nex is designed for 5- to 12-year-old children. The K'Nex Intro to Structures: Bridges kits have been used multiple times during outreach events including with the Girl Scouts and with the Verizon STEM Academy students. These kits allow students to create bridge structures (Figure 2) and then test the bridge structures to see how much weight they will hold (Figure 3).

Figure 2: Girl Scouts building different bridge designs during the Engineering Badges workshop

Figure 3: Testing of the bridge structures for how much weight they hold

**Electrical Engineering and Electrical Engineering Technology Activities**

Snap circuits have been a very popular choice recently for introducing students of various ages to electrical circuits and electronics, which nowadays are part of everyday life. The study and practice of electronics and electricity relies heavily on mathematics and used to be accessible only to trained specialists, but the Snap Circuits idea is to "Learn by Doing" and allows students to easily build circuits as they learn about them. With the soldering part eliminated, building and testing circuits becomes very easy and fun to do, and has the advantage of stimulating a student's interest in the field. A large variety of snap circuit kits are currently available on the market. The Elenco SC-750 Hobby (Figure 4) is the set that was chosen by the ODU faculty to use for STEM related activities. This kit is an excellent choice for schools and clubs because it can be used with different group ages, elementary, middle and high school students. The kit includes a wide variety of projects and circuits to build, and can be used to introduce the students to basic electricity laws, electronics components, such as diodes, transistors or integrated circuits. The circuits vary in complexity from very basic ones that simply introduce a concept or a specific component to more complex circuits, such as AM and FM radios. For younger students the set can just be used to put together circuits to illustrate electrical concepts, while students in middle and high school can use the kit to build hands-on projects to teach and reinforce the theoretical concepts learned in school. The set offers flexibility for various STEM programs, since the selection of projects can be easily adjusted to the age of the participating students and to the time frame available for the activities.

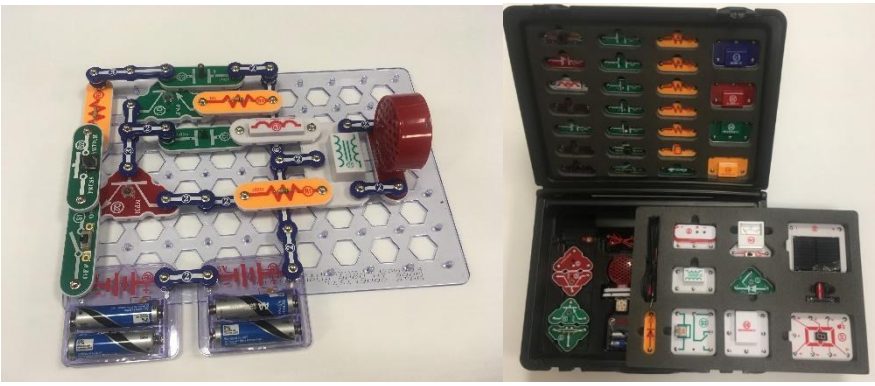

Figure 4: Elenco SC-750 Hobby kits [18]

**Mechanical Engineering and Mechanical Engineering Technology Activities**

LEGO Mindstorms have been used in K-12 settings, and as a tool for teaching computer engineering and programming at the college level [19-23]. These robots are purchased with educational modules and have plans for different age populations and respective activities, so it is easy to customize the activities based on the time available, the number of students, and their age group.

**Robotic Badges Workshop Developed for the Girl Scouts**

The Robotic Badges workshop was held for the first time on January 2018 for a group of 20 Girl Scouts from a local Girl Scout troop, which includes mostly girls from a local elementary school that is in the neighborhood nearby Old Dominion University, Norfolk, Virginia. The workshop was held out-of-school during their regular biweekly meeting. An engineering technology professor, a robotics expert, who developed this workshop is a mother of one of the girl scouts in this troop. She is a registered Adult Girl Scout who is sometimes helps with the activities in the troop. Four other female professors and three graduate students helped during the workshop, as well. Girl scouts' leaders and a few parent helpers were chaperones and led the craft robots' activity.

Robotic badges were introduced during one of the regular week time meetings of the local troop. Most of the children in the troop are from a local elementary school, which is 1 mile away from the ODU campus. Demographics of the local school are (according to the Great Schools database) approximately 62 % White; 17 % Black; 7 % Two or more races; 7 % Asian; 7% Hispanic; less than 1 % American Indian / Alaska Native; and less than 1 % Hawaiian Native / Pacific Islander. Low income students are 19 % of the total student body [24].

One example of an engineering intervention, designed for an underrepresented group of female students, was an event that focused on the Robotic Badges for a local Girl Scouts troop. The Girl

Scouts visited the Batten College of Engineering and Technology on January 31, 2018. They engaged in various engineering related activities for two hours. There were four main stations with different activities and the participants rotated around all stations to complete all four activities in order to earn a robotics badge specific for their age group.

The event started with a video and talk about bio-inspired robotics, which is the core topic of a 400-level senior elective course offered by the Department of Mechanical and Aerospace Engineering. Students in this course learn about the kinematics and mathematical fundamentals of popular robotic configurations, while using biological inspiration to engineer quadrupedal crawling robots over the course of the semester [25]. After the video and the short lecture, the girls were presented with multiple robots designed by the research group from the Collaborative Robotics and Adaptive Machines Laboratory. They also interacted with robots that were designed and built by undergraduate students, as well as with a NAO robot from SoftBank Robotics, as shown in Figure 5 [26].

Figure 5: Bio-inspired robotics and humanoid robotics activity

After the introduction, students toured the robotics lab and reviewed industrial grade Mitsubishi robots [27]. They learned about robots in industry in a short lecture by a professor from the Mechanical Engineering Technology Program. The follow-on session was led by the Assistant Dean for Outreach and the girls were introduced to different kinds of engineering, such as civil engineering and civil engineering technology, electrical engineering and electrical engineering technology, and mechanical engineering and mechanical engineering technology. Each one of the majors was introduced by a female faculty member from respective engineering programs. The four stations had various hands-on activities related to engineering and robotics. The girls were divided into groups based on their age level (Daisy Girl Scouts - kindergarten and first grade, Brownie Girl Scouts - second and third grades, and Junior Girl Scouts - fourth and fifth grade).

***Station 1: Robot Prototypes Craft***: All groups of Girls Scouts participated in this station. The station was managed by Girl Scout leaders. The girls created their own robot prototype using recycled materials, such as toilet paper rolls, cups, tin foil, pipe cleaners, and plastic caps. The girls were guided to think about the following questions: How does the robot move? How will it interact with the world? How will it pick up things? How will it sense what is around it? This way, the girls' perceptions about the robot were used to create fun, inspired robotic lookalike creations.

***Station 2: Programming Insect Robots***: Two Girl Scout groups, Daisies and Brownies, learned how to program a Kamigami robot [28], [29], shown in Figure 6, and a Cozmo robot [30], shown in Figure 7. The girls were introduced to several pre-made insect robots. They had a chance to learn simple coding techniques to make the robots move through wireless controls of the electronic tablet. The girls also learned about bio-inspired design and the difference between a simple machine and a robot.

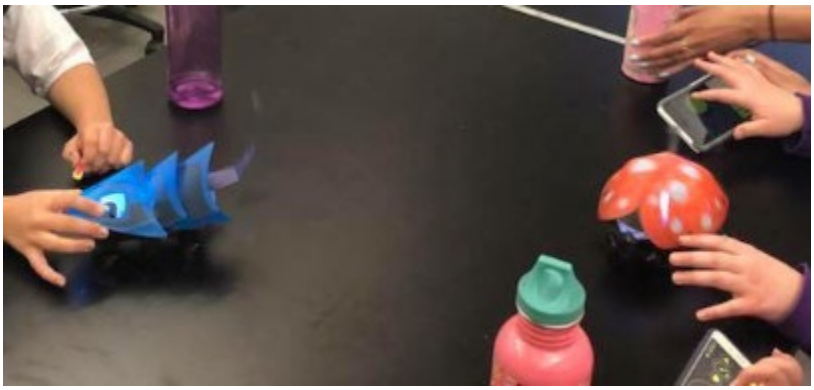

Figure 6: Girl Scouts learning how to control autonomous robots Kamigami [28], [29]

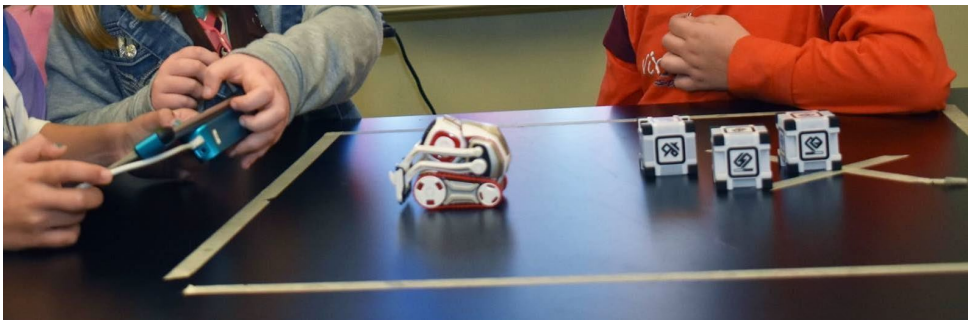

Figure 7: Girl Scouts learning how to control autonomous robot Cozmo [30]

***Station 3: Building Robots***: Two Girl Scout groups, Brownies and Juniors, used several robotic kits to assemble a robot, whereby the girls explored the different parts of the robot and how all of the parts help a robot perform its job. When complete, they learned how Robotics engineers use programming to make them function.

***Station 4: 3D Printers and the Robotics Lab***: This station was attended by all groups. The Girl Scout participants were introduced to the 3D printers where they watched how a toy was scanned and printed. During this activity, the Girl Scouts received 3D printed badges, as shown in Figure 8.

Figure 8: Robotic badges were made on the additive manufacturing system

The robotic badges event in October 2018 included a larger population of girls from the Girls Scouts of Colonial Coast, which serves more than 11,000 girls in southeastern Virginia and northeastern North Carolina [31]. This event was an out-of-school weekend event with most of the girls participating from the Hampton Roads region, located in southeastern Virginia. The parents did not participate in the event; however, several took on the role of chaperone. Data about participants' demographics was not collected. However, the Hampton Roads area has 1,706,878 residents with the following demographics: 60.1 % are White; 30.8 % are African American; 3.7 % are Asian; 3.7 % are two or more races [32]. The main city in the area, Norfolk, where Old Dominion University is located, has over 59.6 % of its residents who are White, over 31.3 % are African American, and 3.5% Asian [33].

## Conclusion

A well-organized outreach plan is one of the most important factors for future, continuous enrollment of high quality undergraduate students and a pathway to enabling a diverse future engineering workforce. Efforts related to reaching out to population subsets not frequently exposed to engineering careers and engineering majors, and who do not see themselves necessarily in that career track, are of the utmost importance. The engineering field and some of its areas, such as manufacturing, are not perceived as easy and doable by many of the K-12 students, and are regarded as less rewarding than some other fields that are more frequently chosen by high performing female students. Hence, outreach programs tailored for specific groups, such as those that are presented in this paper aligned with the Girl Scout partnership, can lead to planting the idea and the "can do" attitude from an early age, and in the long run has a possibility of increased enrollment and retention in this population subset. Based on the highly successful Girl Scout Partnership described in this paper, other universities desiring to enhance the number of female engineering majors may wish to consider a similar Girl Scout Partnership. The Batten College of College of Engineering and Technology plans to continue the newly formed partnership with the local Girl Scout Council throughout the following years. It will be interesting to explore the possibility of tracking the participants and quantify the program's success in producing future engineering majors and graduates. The activities presented in this paper were the pilot workshops and have not been assessed at this time.

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## References:

[1] J. J. Brumberg, The body project: An intimate history of American girls. Vintage, 1998.

[2] K. E. Denny, "Gender in context, content, and approach: Comparing gender messages in girl scout and boy scout handbooks," Gender & Society, vol. 25, no. 1, pp. 27-47, 2011.

[3] T. M. Proctor, Scouting for girls: a century of girl guides and girl scouts. ABC-CLIO, 2009.
[4] GirlScouts. (2018). Facts About Girl Scouts. Available: https://www.girlscouts.org/en/about-girl-scouts/who-we-are/facts.html
[5] D. M. Goerisch, "Smart cookies: The gendered spaces of labor, citizenship, and nationalism in the Girl Scout cookie sale," San Diego State University, 2013.
[6] L. S. Anderson and K. A. Gilbride, "Discover engineering girl guides conference: Helping girl guides achieve their 'engineer'badge," in Proc. 2003 National Conference Society of Women Engineers, SWE 2003, 2003.
[7] K. E. Schmahl, "Introducing engineering to girl scouts," age, vol. 1, p. 1, 1996.
[8] J. M. Trenor, S. L. Yu, C. L. Waight, K. S. Zerda, and T. L. Sha, "The relations of ethnicity to female engineering students' educational experiences and college and career plans in an ethnically diverse learning environment," Journal of engineering education, vol. 97, no. 4, pp. 449-465, 2008.
[9] A. R. Brown, C. Morning, and C. Watkins, "Influence of African American engineering student perceptions of campus climate on graduation rates," Journal of Engineering Education, vol. 94, no. 2, pp. 263-271, 2005.
[10] G. Huang, N. Taddese, and E. Walter, "Entry and Persistence of Women and Minorities in College Science and Engineering Education," Education Statistics Quarterly, vol. 2, no. 3, pp. 59-60, 2000.
[11] G. S. May and D. E. Chubin, "A retrospective on undergraduate engineering success for underrepresented minority students," Journal of Engineering Education, vol. 92, no. 1, pp. 27-39, 2003.
[12] G. Siann and M. Callaghan, "Choices and Barriers: Factors influencing women's choice of higher education in science, engineering and technology," Journal of Further and Higher Education, vol. 25, no. 1, pp. 85-95, 2001/02/01 2001.
[13] S. E. Shadle, A. Marker, and B. Earl, "Faculty drivers and barriers: laying the groundwork for undergraduate STEM education reform in academic departments," International Journal of STEM Education, journal article vol. 4, no. 1, p. 8, April 13 2017.
[14] K'Nex. (2018). Available: https://www.knex.com/
[15] J. I. Glickman and M. F. Doepner, "Offset matrix adapter for toy construction sets," ed: Google Patents, 2010.
[16] J. Glickman and M. F. Doepner, "Construction toy component," ed: Google Patents, 2007.
[17] K. P. Hussa-Lietz, "Method of constructing a three-dimensional structure with a multi-part construction toy set," ed: Google Patents, 2009.
[18] ELENCO. (2018). Snap Circuits Extreme 750 Experiments. Available: https://www.elenco.com/product/snap-circuits-extreme-750-experiments/

[19] D. J. Barnes, "Teaching introductory Java through LEGO MINDSTORMS models," in ACM SIGCSE Bulletin, 2002, vol. 34, no. 1, pp. 147-151: ACM.
[20] A. Behrens et al., "MATLAB meets LEGO Mindstorms—A freshman introduction course into practical engineering," IEEE Transactions on Education, vol. 53, no. 2, pp. 306-317, 2010.
[21] S. H. Kim and J. W. Jeon, "Introduction for freshmen to embedded systems using LEGO Mindstorms," IEEE Transactions on Education, vol. 52, no. 1, pp. 99-108, 2009.
[22] F. Klassner, "A case study of LEGO Mindstorms'™ suitability for artificial intelligence and robotics courses at the college level," in ACM SIGCSE Bulletin, 2002, vol. 34, no. 1, pp. 8-12: ACM.
[23] F. Klassner and S. D. Anderson, "Lego MindStorms: Not just for K-12 anymore," IEEE Robotics & Automation Magazine, vol. 10, no. 2, pp. 12-18, 2003.
[24] greatSchools (2019) Larchmont Elementary Demographics, Retrieved on March 18, 2019 from: https://www.greatschools.org/virginia/norfolk/1186-Larchmont-Elementary-School/#Race_ethnicity
[25] K. Kaipa, ed. Norfolk, VA: Batten College of Engineering and Technology YouTube Channel, 2017.
[26] SoftbBankRobotics. (2018). NAO Robot. Available: https://www.softbankrobotics.com/emea/en/robots/nao
[27] MitsubishiElectric. (2018). Industrial Robots - MELFA. Available: https://us.mitsubishielectric.com/fa/en/products/industrial-robots-melfa
[28] KamigamiRobots. (2018). Kamigami™ - The Robot that Moves Like a Real Animal. Available: http://kamigamirobots.com/
[29] E. Morris, D. A. McAdams, and R. Malak, "The State of the Art of Origami-Inspired Products: A Review," in ASME 2016 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, 2016, pp. V05BT07A014-V05BT07A014: American Society of Mechanical Engineers.
[30] ANKI. (2018). COZMO. Available: https://www.anki.com/en-us/cozmo
[31] Girl Scouts of the Colonial Coast, About Our Council, Retrieved on March 18, 2019 from:https://www.gsccc.org/en/our-council/about-our-council.html
[32] HRPDCVA.gov (2019). Census information for Hampton Roads, Hampton Roads, Virginia, Hampton Roads Planning District Commission, Retrieved on 3/18/2019 from https://www.hrpdcva.gov/uploads/docs/HR%20Demographic%20Characteristics.pdf
[33] City of Norfolk (2019). Demographic Profile for Population Estimates, Projections, And Change Norfolk and The Hampton Roads Region, Retrieved on 3/18/2019 from https://www.norfolk.gov/DocumentCenter/View/874