

Engagement in Practice: A Process for Creating a New "Council's Own" Junior Girl Scout Badge in Mechanical Engineering

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Abstract

Over the past two years, a team of female faculty and industry innovators have collaborated to develop a new Junior (4th and 5th graders) Girl Scout badge in Mechanical Engineering. The activities required to earn the badge cover engineering careers, kinematics, thermal energy, the design process, and learning about new technologies. The Girl Scout Council of Greater Atlanta is sponsoring our engineering badge as a “Council’s Own” badge. The badge is also sponsored by the ASME Design Engineering Division and Lockheed Martin. This paper serves as a structured guide to the process of creating a Girl Scout badge from scratch, to encourage and support the development of additional new badges. The process includes the following components: team assembly, curriculum research and development, piloting the badge, refinement, secondary badge piloting, and embodiment/deployment. Two workshops were delivered to Girl Scouts in parallel with the ASME IDETC 2015 and 2016 conferences, allowing the team to test and refine the badge activities. The first set of thirty-six Girl Scouts earned the badge during the workshop in August of 2016. In addition to a physical badge, the team has developed a badge guide and badge support website. The badge harmonizes with many activities in the Girl Scouts’ “Get Moving” Journey, helping to support troops pursuing those experiences in addition to earning the badge. By disseminating this experience and process through ASEE, the team hopes to encourage others to develop new badges and patches to enrich the Junior Girl Scout experience, especially in (but not limited to) STEM areas. Next steps include launching the badge to a national audience.

1. Introduction and Background

According to the analysis of US Census Data over the past 50 years performed by the American Association of University Women, there has been a steady increase in the number of females entering the workforce in STEM fields. In the life sciences, female representation in the US workforce has increased 25-31% since 1960; but there has only been an 11% increase in females in engineering fields in the same period [1]. In 2014, only 7% of all mechanical engineers in the US workforce were females [2]. It is evident that the representation of females in engineering is low, and that the gender gap is persistent.

What are the strategies for closing this gender gap? Research has shown that young adolescents who expected to have a career in science are more likely to complete a college degree in science [3]. These results indicate that developing interest early to enable young adolescents to develop these self-expectations could be a mechanism for closing the gender gap in STEM. In high school students, it was found that connecting course content back to students’ lives increased course grades and interest in science [4]. Through an after-school STEM program called Techbridge, researchers found over the course of 6 years that young girls who participated in the STEM program had significantly higher GPAs, higher scores on math and science standardized tests, and a higher likelihood of taking advanced placement courses in high school [5]. Stout et al. found that by exposing girls to female experts in STEM, they were able to foster stronger identification with STEM, more self-efficacy, and increased effort on STEM tests. They found that even if negative stereotypes remained in girls’ minds with respect to gender and STEM, that

their own self perception benefited from contact with female experts in STEM [6]. Interventions to increase interest, expectations, performance and self-esteem in STEM in young girls have been shown to be effective.

How can Girl Scouts help close the gender gap? Royse found that the Girl Scouts curriculum has a significantly positive impact on the self-esteem of adolescents [7]. From a report entitled “How Girl Scout STEM Programs Benefit Girls” published in 2016 by the Girls Scouts of the USA [8], data shows the following trends:

- “Girls become more positive about STEM.” [8]
- “Girls become more interested in engaging in additional STEM activities and taking more STEM-related classes in school.” [8]
- “Girls want to learn more about STEM careers, and older girls become interested in college-level STEM majors and pursuing STEM careers.” [8]
- “Girls develop a more equitable perception of the relative abilities of men and women in STEM.” [8]

In a report published in 2016, Girl Scouts of the USA partnered with Techbridge and the Noyce Foundation to make recommendations to engage and empower both volunteers and girls in STEM. Recommendations included connecting students to female STEM role models, incorporating a multitude of hands-on activities and training, and allowing for ample time to execute the intervention [9]. As of 2016, there were no nationally-sponsored engineering badges, mechanical or other, at any age offered by Girl Scouts of the USA [10]. There was a clear opportunity for our team to fill this gap with a new mechanical engineering (ME) Junior Girl Scout badge, with the goal of increasing engagement and excitement about STEM and ME in girls early on, so they might begin to imagine themselves becoming mechanical engineers in the future.

2. Partner Development

A team of experts comprised of professors, engineers, Girl Scouts, troop leaders, and Girl Scout Council leaders was formed to address this gap in the Girl Scout badge curriculum. The team was chosen to address the mix of industry, educational, and scouting experiences needed to create a meaningful badge. Local university and industry resources provided critical support towards the execution of the badge. Professors from the Georgia Institute of Technology lent their expertise and facilitated the mechanical engineering badge workshop in Atlanta, Georgia. Lockheed Martin leveraged lessons learned from their history of STEM badge workshops to lead the Mechanical Engineering Girl Scout badge workshop during Engineers Week in February 2017. A set of local options was tailored to work in the Lockheed Martin factory setting. We also partnered with the Chattahoochee Nature Center to give the badge workshop at their nature preserve in Roswell, providing an emphasis on the interactions of nature and engineering, as well as the role of engineering in environmental stewardship. Future opportunities for expansion include local science festivals and STEM events. The members of the badge development team are not centrally located, thus increasing the ability of the group to reach other councils to teach the badge and partner with local resources nationwide.

3. Benchmarking

In the development of the badge, it was important that the activities were of similar difficulty and structure as existing Girl Scout badges. Existing badges, such as “Product Designer” and “Entertainment Technology,” were reviewed when designing activities for the badge. Other

engineering-themed badges local to specific councils were reviewed. Additionally, Girl Scout Journeys were also evaluated. Journeys, structured by a guidebook, facilitate a long term, cohesive experience to help girls focus on a particular area of passion or interest. A guide was created explaining how the completion of the mechanical engineering badge could fulfill some of the requirements for the “Get Moving” Journey, which focuses on all types of energy. It was also important that the badge was of appropriate age level and complexity, and covers the core principles of mechanical engineering. We also compared the requirements of our badge with the Boy Scout Webelos elective engineering adventure (which can be used to earn the Webelos and Arrow of Light badges) and determined that successful completion of our badge would also meet the requirements of the Webelos engineering badge [11].

4. Project Design Process and Execution

Overall, approximately 300 person-hours were devoted to the creation of this new badge. To begin the badge development process, we formed a team of engineers and scouting experts and researched the needs for a Girl Scout badge about engineering. We researched how to make a Girl Scout badge and the differences between a national badge and a Council’s Own badge. To develop a badge that represented the breadth and opportunities in mechanical engineering, many discussions were held about which topics to include. The final topics represent the foundational building blocks of Mechanical Engineering, and thus are used as an introduction to engineering for the badge [13]. Foundational topics were identified by examining core undergraduate curricula in Mechanical Engineering and adapting these concepts to a level that was age appropriate. The activities in each topic were chosen to let the girls explore this aspect of engineering in an engaging, real life challenge at an appropriate skill level. The badge was tied to core values of Girl Scouts such as “Make the world a better place,” “Use resources wisely,” and personal and team responsibility. This grounded the badge in familiar concepts that opened up an exploration of sustainability and the potential impact a girl can make on her community through engineering.



Figure 1. GSGATL
Mechanical Engineering
Badge Design

It was also important that the badge sparked curiosity and discussion around “Changing the Conversation” in engineering, as formulated by the National Academy of Engineering in 2008 [14]. The activities reinforce the message that girls are successful at technical challenges. They also emphasize the team and leadership skills that are important to engineers, project managers, and technical leaders today. Girls are asked to explain their ideas, find ways to communicate abstract concepts, and collaborate on a design. Using funding obtained from an ASME Design Engineering Division grant, we drafted a set of requirements and activities that led to the “prototype” badge workshop at MIT in Boston, MA during the ASME IDETC 2015 conference [12]. We taught different activities to see what worked for the target age group (grades 4-5).

Based on our experience from the first badge workshop, we updated our requirements and the structure of the topics based on lessons learned. For example, we learned that activities that may seem to communicate a concept clearly to adults are not always practical for a large group of young girls. We asked girls to try different types of insulating materials to retain heat in a hot

water bottle and monitor temperature with thermometers. Based on the insulative properties of the materials chosen, the results should have been clear and predictable. However, the experiment was hard to supervise with a large group of students. Another lesson centered on the mechanical functionality of an activity. The “Kinetic Art butterfly” featured a wireframe butterfly that used energy stored in a twisted rubber band to flap its wings. The first iteration of the butterfly had inconsistent performance related to the structure of the bent wire. The design was changed to a 3D printed plastic frame, improving the success of the activity. Further notes were taken and used to refine the design.

After the first badge workshop, we talked to the Girl Scouts of Greater Atlanta (GSGATL) Council and obtained permission to create a Council’s Own badge. A Council’s Own badge requires activities with local content. The activities were written following the required Girl Scout badge format of five steps with at least 3 activity options for each step. Girls complete at least one activity from each step to earn the badge. Each step can be completed in 30 to 120 minutes. Atlanta based activities, for example touring Lockheed Martin, were added to fulfill the Council’s Own badge requirements. Alternative activities were included in the topics so that the badge could be completed nationally, supporting the nationalization goal of the team and enabling girls nationwide to earn the badge.

The refined set of activities was used for the next workshop, which serviced 36 girls in Charlotte NC during ASME IDETC 2016. The workshop was followed with a debrief session in which additional lessons learned were captured and integrated during the final writing, editing, and council submission processes for the badge. The final badge steps are shown in the Table 1 below:

Table 1. Mechanical Engineering GSGATL Girl Scout Badge Steps

Goal	Girls leave the workshop thinking Engineering would be a fun, interesting career where they could make a positive impact in the world.
Step 1: Explore Engineering	Learn about Engineers and what they do. Provide an introduction to the breadth of engineering careers plus learning about newer fields in engineering such as biomimicry.
Step 2: Let's Get Energized	Teach girls physics and motion fundamentals used in mechanical engineering
Step 3: Go Green	Heat Transfer and Thermodynamic are core areas of mechanical engineering. These plus alternative/green energy sources are explored.
Step 4: Dream It! Sketch It! Model It!	Designing is a key part of mechanical engineering. Girls learn the fundamental design approach including brainstorming, sketching and modeling.
Step 5: Building for Tomorrow	Manufacturing and Sustainability are key to getting a product to market. Visiting a factory provides opportunities for the girls to see the reality of how the products they use are made. Advanced manufacturing technologies such as 3-D printing are introduced.

More detailed descriptions of the activities and instructions can be found in the badge guide [15].

5. Strategic Path to National Badge

With the ultimate goal of establishing a national badge, we started with the local development of a Council's Own badge. A Council's Own badge follows the standard badge formatting and is required to have locally themed content. A Council's Own badge can be earned by scouts outside of the council, provided they complete the required number of steps/activities. Within the aforementioned five required steps, the three options for activities are varied so that the step can be completed without access to specific technology or local resources. Our local content was developed around unique capabilities at the Lockheed Martin Aeronautical plant in Marietta Georgia, the Chattahoochee Nature Center in Roswell Georgia, and using innovation and prototyping resources through Mechanical Engineering at Georgia Tech.

We developed the activities such that at least 1 or more of the options in each step could be earned at locations outside of Atlanta so girls in other parts of the country or world could earn the badge. This allows us to leverage the extensive Girl Scout network to advertise the badge nationally and internationally and encourage troops and independent scouts to complete the requirements and earn the badge themselves. The physical badge can then be ordered from the Atlanta Girl Scout Council store and worn on the front of the vest/sash of the official Girl Scout uniforms. We have demonstrated the flexible nature of this local badge by leading badge workshops in Massachusetts and North Carolina, and plan to continue leading workshops across the country. Our hope is that by disseminating this badge across the country, we will reinforce the importance of a Mechanical Engineering badge and show that there is sufficient demand to invest in the roll out of the badge at the national level.

6. Funding

Badge development efforts were funded by a grant from the ASME Design Engineering Division in the amount of US \$13,000. This grant was made to fund the purchase of supplies related to the badge and workshops. It also was made to partially fund travel for the development team, enabling in-person meetings and implementation of the badge workshop at several engineering conferences. To extend the reach of the funds, in-person meetings were held at conferences that team members would already be attending. The badge workshops were held on Saturdays with team members volunteering their time. Pre-workshop coordination was facilitated by the use of online tools such as WebEx, Skype, and Google Docs. A portion of the grant funds will be used for upcoming expansion of online resources to support the badge.

7. Conclusions and Next Steps

Moving forward, the team plans to extend the reach of the badge through the development of a suite of online resources to allow leaders and girls anywhere to complete the badge requirements independently. A web site was created to explain the badge requirements and activities to remote troops. The badge guide has also been posted to the stem.girlscoutsatl.org site, which troops can access freely at any time [15]. Other resources will include short videos of team members describing ways to teach the lessons or find local activities. Also, links to existing engineering content and resources will be included. An example of an external website that will be referenced is the Stanford University site "How Everyday Things are Made," created by Design4X.Inc [16]. Girls will be able to take virtual factory tours as extensions to their learning in the Step 5 badge requirement, "Building for Tomorrow." Currently, this badge has the potential to reach 8734 active girls at the Junior Girl Scout level in the Greater Atlanta Area.

Additionally, the Mechanical Engineering badge will serve as the foundation to develop additional engineering related badges for the Girl Scouts of Greater Atlanta Council. The next badge planned is a Mechanical Engineering badge for middle school girls (Cadette Girl Scouts). Maintaining the same core principles of mechanical engineering, the higher-level Girl Scout badges will include more in-depth activities that explore these principles in a more technical manner. The National Girl Scout Council is looking into developing badges around STEM curriculum. To avoid duplicating effort, continued communication with the national council will be necessary. This raises a potential area for future exploration, namely, determining the density of engineering badges that might reasonably be supported by the Girl Scout council, given the diversity of badges available to a troop, troop interests, and the limited time that troops have to meet each month. A final area for study in the future would be a longitudinal study of badge earners and their interest in STEM fields as they go to higher education and choose majors, relative to the population of Girl Scouts and students in their graduating classes.

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