Badges, Brownies, Building; applied constructionism to promote confidence in STEM topics in girls

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The Asheville Museum of Science, in partnership with the Asheville area Peaks to Piedmont Girls Scouts council, designed and tested a series of two to three-hour Science, Technology, Engineering, and Math (STEM) workshops for girls ages five to ten. The workshops were a response to the Girl Scouts of the United States of America (GSUSA) releasing new badges, the first in a decade, that focused specifically on STEM skills. The workshops were held on Saturday mornings at the museum, most girls were accompanied by their mothers whom worked in collaboration with girls on projects. The curriculum for these workshops was based on three influences; the guidelines published for facilitators by the GSUSA, the tenants of meaningful making set forth by the FabLearn organization, and the historic under representation of females in STEM. Exit surveys were shared with the parents who accompanied their daughter during the workshop, in hopes of assessing any changes in their daughter's confidence in the topic they studied during the workshops (either robotics or mechanical engineering).

Constructionism Concepts: **Maker Mindsets • Peer to peer Mentoring • Artifact Construction • Democratization of Powerful Tools and Ideas •**

KEYWORDS

Skill badges, STEM badges, Girl Scouts of the United States, Diversity, Engineering Education, Constructionism, 3D printing, Laser Cutting

1 INTRODUCTION

According to the United States department of Commerce, Economics and Statistics Administration, American women occupied 47 percent of all U.S. jobs in 2015 yet held only 24 percent of all positions related to STEM (science, technology, engineering and maths) fields [1]. Also termed the gender gap [2], explanations for the gap have ranged from sexual or emotional harassment in the workplace, lack of female role models in research positions and in the media, the challenge of work life balance, [3,4] and the pervasive perception that boys are smarter or better adapted for the hard work of STEM careers [5].

Out of school efforts to attract more girls in STEM are not a new phenomenon. Several startups have begun to tackle this issue from the product development side, while other groups that already serve an all female population, such as the Girl Scouts of the United States of America (GSUSA), have ramped up their efforts to change the statistics through research and programming [7, 8]. Traditionally seen as a leadership and friendship focused organization, in the summer of 2017, the GSUSA announced the release of several new STEM "Badges," along with new STEM "Journeys," as opportunities to engage all female populations in engineering and constructivist learning environments.

The release of the STEM badges corresponded with the GSUSA's acquisition of a new CEO, Sylvia Acevedo, one of the first Hispanics to earn a Master of Science in systems engineering from Stanford University. To develop the curriculum and construction kits for girls and their troop leaders for the earning of STEM badges, the GSUSA partnered with organizations like Code.org, SciStarter, GoldieBlox and the Society of Women Engineers. Curriculum materials and kits are proprietary materials that scouts, and their families purchase at http://www.girlscoutshop.com. [9]

This paper describes the design and implementation of a series of workshops offered to girl scouts to earn these new STEM badges. The workshops modeled the criteria of the GSUSA guides for troop facilitators, while also

attempting to create the conditions for transformative learning, also termed by the Fablearn community as Constructionism or "Meaningful Making" [10]. Meaningful making is defined as a learning experience focused on self-directed learning (agency), access to tools and technologies for creation (skill development), and the construction of an artifact that can be used to showcase and demonstrate learning (assessment).

In 2016, the Girl Scout Research Institute released a report entitled *How Girl Scout STEM Programs Benefit Girls.* A key finding of this report was that "a majority of girls are more confident in their science and math abilities after participating in Girl Scouts STEM programs" and this increased confidence was attributed to the hands-on, supportive nature of GSUSA programming [11]. Due to the newness of the STEM badges, there is no currently published data on the effects of GSUSA supported, skills-based learning experiences to earn badges, on girls' interest or confidence in the STEM. This paper reflects the process of trying to answer the question, can meaningful making experiences, in effort to authentically earn STEM badges, cause positive change in identity and confidence in STEM topics in girls ages five to thirteen?

2 EXPERIMENTAL DETAILS

2.1 Workshop details

All workshops were held on Saturday mornings inside the Asheville Museum of Science beginning at nine in the morning and ending at either eleven or noon. Registration for workshops was coordinated by Carol Covington, Girl Experience Manager for the Peaks to Piedmont Girl Scouts Council in Asheville, North Carolina. The STEM workshop topics that girls could choose from were robotics or mechanical engineering. Mechanical engineering was further broken down by age and a focus on making flying machines or miniature roller coaster cars.

Workshops were tailored for three age groups. The youngest group of girls (Daisies) range in age from 5-7. Brownies are the next level of scout and these girls range in age of 8-10. The next level of scout is the Jr, ages 11-13. The following table shows what badge workshops were offered between January 2018 and June 2018.

STEM Badge	**Age of Girls**	**Workshop Length**	**No. of Participants**
Robotics: Daisy	5-7	3 hours	32
Robotics: Brownie	7-10	3 hours	20
Robotics: Jr	10-13	3 hours	15
Mechanical Engineering: Roller Coaster Design	5-7	2 hours	10
Mechanical Engineering: Fling Flyer Challenge	7-10	2 hours	15
Total badges earned			92

Table. 1. STEM badge workshop title, age of participant, length of workshop and number of girl participants. Total number of badges earned with AMOS, 92. The total number of girls who participated is less than 92, as some girls earned up to five of those badges individually.

2.1.1 Post workshop surveys

Carol Covington helped to deliver post STEM workshop surveys to the parents who registered their daughters, through email. These surveys asked about their daughter's previous experience doing STEM activities, whether their daughter engaged differently with STEM activities after their time in the workshop, whether their daughter continued to engage with the project she began in her workshop, and finally, whether their daughter was more confident in the STEM topic that was the focus of the workshop taken.

Most parent participants did not respond to the post survey, leaving lots of questions regarding the overall efficacy of the program. This form of assessment failed to fully answer our questions regarding post workshop attitudes on STEM. Sample data from survey sent to parents to assess shifts in attitude around STEM topics post workshop experience. Parents that elected to reply to the call for feedback, agreed (out of a scale of strongly disagree to strongly agree) with the statement "My daughter feels more confident in the STEM subject she learned about at AMOS (Asheville Museum of Science)." Ideally some form of follow up engagement would be planned for gaining reliable assessment of these workshops. Read more in results and discussion.

2.2 Robotics Badge Workshops

The robotics workshops were an intense three-hour course, with each hour focusing on a different question; What is a robot? What do robots do? And how do we make and control robots? The workshops for each badge (What Robots Do, How Robots Move, Design a Robot) for Daisy scouts and (Programming Robots, Designing Robots, Showcasing Robots) for Brownies/Jrs, lasted one hour each. Except for one participant, all other participants elected to stay for all three hours to earn all three badges at once. Snacks and time to play in the museum were budgeted into the workshop series.

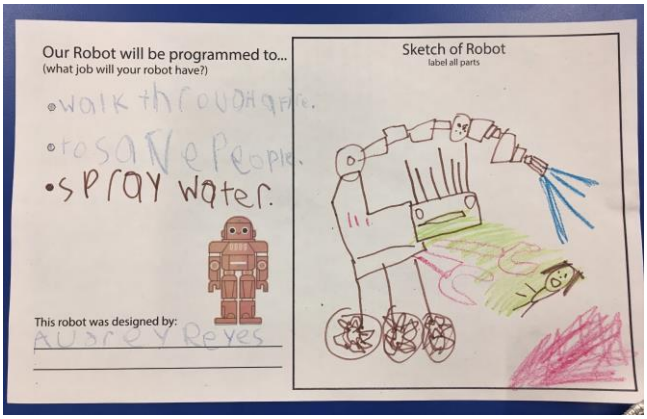


Fig. 1. (above) Each girl was paired with another to brainstorm tasks for their robot. Worksheets were given out to give time for planning, ideating, sketching and 2D modeling. See video on showcasing robots for peer critique.

2.2.1 Robotics for Daisy's

The curriculum used for the younger girls included unplugged games like "program a girl scout" using block programing (paper with move commands printed on them), as well as a robot design activity. In the design activity girls were asked to make of list of tasks their robot would perform, then sketch the body, brain and sensors the robot would need to perform the tasks they chose. Low cost recycled materials were then given to the girls for them to make a 3D model of the prototype they sketched. While not required, girls each took time to share the function of their robot, as well as its parts and purposes. Girls took home their robot prototypes (2D and 3D) after the workshop.

2.2.2 Robotics for Brownies and Jrs

The curriculum used for Brownies included the museum's LEGO EV3 robotics kits. Hour one of the workshop began as it did with the Daisy groups using unplugged activities to introduce terms of algorithms and the parts of a robot, including its use of sensors for autonomous work. The second half of the series was devoted to learning the block program language LEGO EV3.

Each girl paired up with another and was introduced to file naming and saving, how to move a motor and how to use a touch sensor to move a motor. Then girls were given time to explore and play for the remainder of the hour until it was time to showcase their final inventions. Girls were not allowed to take home the LEGO robots they built, therefore they did not leave with an artifact of their workshop like the Daisy participants.

Fig. 2. (left) Two scouts work together to build a body with no building plans, to support their moving parts.

2.3 Mechanical Engineering Badge Workshops

Once the Robotics Badge series was over, the museum was asked to design and facilitate another round of workshops in the mechanical engineering category. These workshops kept their named for the badge, "Fling Flyer" and "Roller Coaster Design" Challenge. These badges and their accompanying curriculum guide was originally produced for the GSUSA by Goldieblox, an American toy company that targets its products to girls.

Due to reasons unpublished on the subject, the kits produced by Goldieblox that were originally recommended for the earning of the mechanical engineering badges became unavailable for purchase. As a response, the GSUSA opened the potential to earn the badge without a kit, using "unplugged" activities [12]. Using the basic plans of the Goldieblox kits, AMOS staff 3D printed, and laser cut similar parts for construction kits for each participant at a fraction of the cost of buying the commercial kits. See details below.

2.3.1 Roller Coaster Design Challenge 1

From the curriculum guide for Daisy Roller Coaster Design Challenge One: "In the Roller Coaster Design Challenge, Daisies learn about engineering and motion by building and testing a roller coaster. Daisies explore how roller coasters work and how to design, build, and test a new product." After making a simple roller coaster car using an inexpensive kit designed by AMOS staff, scouts tested their builds by dropping their cars down a steep ramp. Cars that did not fall apart during the drop test were then tested with a load. See Fig. 5, a scout uses a steel marble as a passenger (load).

Fig. 3. (right) Badge that scouts earn after completing the workshop.

Fig. 4. (below) Basic parts list for the car build that scouts complete after completing a deconstruction of a model thinking routine.

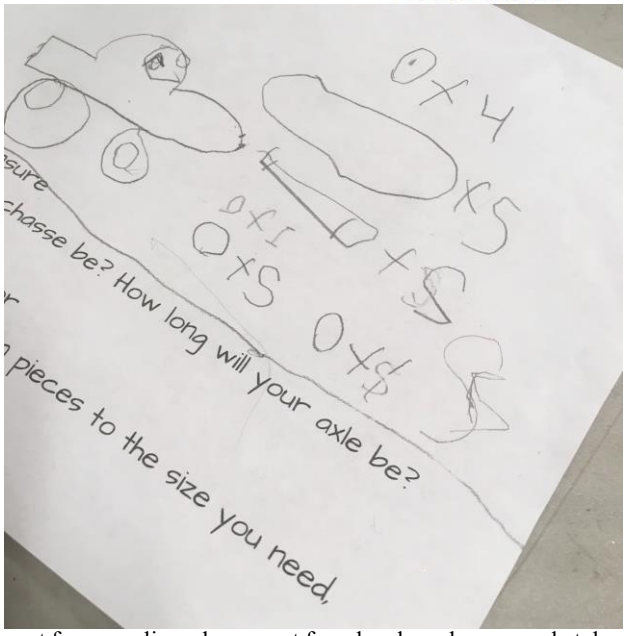


Fig. 5. (above) The basic roller coaster chasse consists of two 3D printed ends and two popsicle sticks. Wheels are laser cut from acrylic, axles are cut from bamboo skewers, axle tubes from straws, rubber bands hold it all together.

2.3.2 Fling Flyer Design Challenge 1 and 2

From the curriculum guide for Brownie Fling Flyer Design Challenge 1: "In the Fling Flyer Design Challenge, Brownies learn about the forces that affect flight as they design, build, and test a Fling Flyer. Brownies learn how to design an investigation—and fine-tune their designs after testing it." The fling flyer kits that each scout received consisted of three 3Dprinted connecting pieces, one dowel and access to colorful, heavy-duty paper.

Fig. 6. (right). Girls line up near at the door of the lab with new flying machines in hand, ready to go to the launch/testing zone.

Fig. 7 (below). Demonstrating proper launch technique to distinguish between practiced use of tool and efficacy of design.

Fig. 8 (left) Mechanical Engineering badge that scouts receive when they complete their workshop.

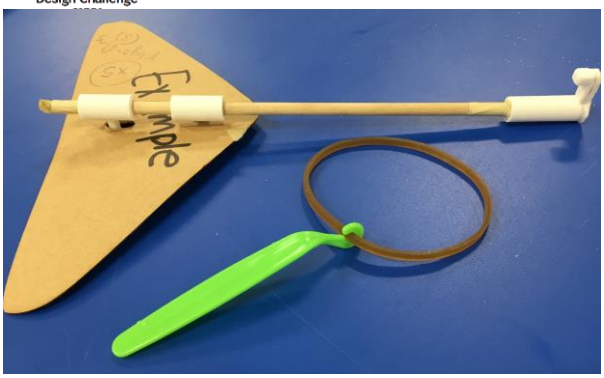


Fig. 9 (right) The flyer basic design consists of three 3D printed connectors, one 0.125 inch dowel, and cardstock. The launching stick (bottom of image) can be 3D printed or made from a rubber band and popsicle stick. We shared different prototypes of the final 3D printed design parts to role model the maker mindset and the time it takes to be an engineer.

3 RESULTS AND DISCUSSION

3.1 Role Models Matter

At the museum, we regularly set out self-directed engineering challenges in our learning space, called the STEMlab. While facilitating these challenges in the STEMlab, a few gender stereotypes have come to light. During engineering challenges, lab facilitators never hear a dad or male guardian say, “Go, get mommy, I’m no good at this stuff (engineering).“ The comment , “Go, get daddy, I’m no good at this stuff (engineering).“ has been made by mothers, however, especially if their husband is present in the museum. Self-identity role modeled by adult female chaperones in front of young girls, not only a gender-based lack of confidence in STEM, but a potentially damaging deference to the intellectual strengths of males [5].

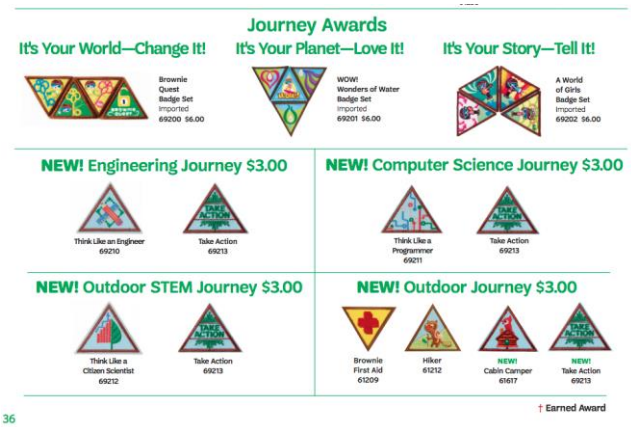
Due to the dynamics of who supports girl scouting, these workshops turned out to be 100% female, most of the time. This model of mother as collaborator and co-learner replicates one established by youth services librarian Nancy Andrus, founder of the Make-HER program at the Sunnyvale Public Library in Sunnyvale California. The Make-HER program model requires two factors. First, the workshops are for girls ages 7-12, and girls are accompanied by one guardian and that guardian is female. The second factor requires facilitators of all the workshops to be practicing female STE(A)M experts. Now in its fourth year, the Make-HER program is a free to the public, informal education opportunity that has shown promise in building confidence in young girls in STEM. The Make-HER model can be easily re-created using the girl scouts and their troop leaders as a preexisting, mostly female environment. [13,14]

3.2 How do boys fit in?

Once word got out that the museum was offering STEM badges for Girl Scouts, we began to get inquires for similar programs for the boy scouts. Despite past struggles the Boy Scouts of America has faced on issues of inclusivity [15], world

scouting groups are the largest youth organizations in America and beyond, with some of the most diverse populations of young learners, working as a community to develop their personal potential, as well as their role in society [16,17]. Regardless of gender, confidence in STEM topics and the possession of STEM skills is a value, not only to the individual who possesses the skills, but to society at large. Workshops that offer STEM skills and confidence building should be gender neutral and effective. A focus on girls should be based solely on the need to close the gender gap within this generation.

3.3 Potential next steps: Journeys and Citizen Science



How can we design systems and experiences that support lifelong engagement in STEM topics for these girls? Beyond the basic badge, girls can earn "Journey Awards" where they get to think and work like an engineer or scientist. These badges require long term projects and connections to citizen science projects available in a local area. The GSUSA is continuing to develop new STEM badges. The newest badges to be released this year will focus on astronomy.

Table 2. Table of New STEM Journeys currently available to girls ages 7-10, from girlscouts.org

4 CONCLUSIONS

Too few post workshop surveys were collected to assess the average perceived value of these workshops by parents, or their efficacy at changing attitudes around STEM topics in girls ages five to ten. Preliminary post workshop survey results did show that girls continued to engage in similar STEM activities related to their workshop at home, or in their community. For example, one girl continued to build on her robotics knowledge through mentoring other girls earning their STEM robotics badge. Another girl went home and used available materials to build a new robot model.

Further pathways need to be laid down for STEM opportunities for scouts after their experience at the museum, or other informal learning environment. It is not enough to just introduce scouts to topics, they need real problems and real time to practice STEM skills and mindsets in a transformative manner. There is potential for this built into the structure of "Journeys." Deeper partnerships with area robotics teams, university engineering programs that provide outreach, and in-school "STEM clubs" could provide this kind of post experience support. Lastly, scouting groups are effective partners for informal educational centers like libraries and the Asheville Museum of Science [18]. Informal STEM experiences that girls are getting in libraries, at home, and in museums, have the potential to be transformative, not only for the girl participants, but for their mothers and fathers too.

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