Middle School Girls as "Experts" to Elementary Students: A Coding Trial (Work in Progress)

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The objective of this "work is progress" is to allow middle school girls to become the "experts", rather than the students, in computer science and engineering outreach. The hypothesis is that leading outreach will cause middle school girls to self-identify in STEM while acting as role models for the younger students. Although the number of women in STEM fields has been steadily growing, this has not been true in computer science. Over the past 20 years, the percentage of women earning computer science degrees has decreased from 28% to 18%.[i] This is a problem not only because these women are missing out on a lucrative career, but also because society is losing the diversity required to solve complex problems in the world.[ii]

Previous work on both the recruitment and retention of females in STEM fields has focused on two main themes: the desire to make a difference and the stereotypes held about STEM professionals. The National academy reported that words like "Making a difference" and "engineering is essential to our health, happiness and safety" are more appealing to women and minorities.[i] Similarly, Cheryan *et al.* report that "The work in computer science and engineering is seen as isolating and relatively dissociated from communal goals such as helping society and working with others"[ii] In addition when asked how to describe an engineer or computer scientist, children will mention males, nerds, glasses, and a lack of interest in outdoor activities.[ii] Some young girls do not identify with these role models and therefore decide early in life not to pursue a STEM field.[iii]

One of our authors noticed that this was starting to occur for her daughter in middle school. Although her daughter loved learning computer coding in 7th grade, there was no way for her to use this to help others. In the meantime her friends were enjoying getting involved in local community events that helped other people. While programs like Girls who Code [iv] can mitigate these impacts by having the girls work on socially relevant projects, these programs put the girls into a role of *receiving*, not of *teaching*.

The hypothesis of this work in progress paper is that if middle school girls take on the role of teacher to elementary school children, they will feel more like experts. This in turn will allow them to more strongly identify in STEM fields while providing role models to younger children. An additional benefit of these activities is that the elementary teacher can learn from the middle school students and see new ways to bring engineering into the classroom. Here we will discuss the first attempt to accomplish this with two 8th grade female students going to a 4th grade classroom to teach code.org, Java Script from Khan academy and coding with a coding mouse. We will discuss how these activities were designed and implemented and make suggestions about further assessment and expansion of the program.

Materials and Methods
We used readily available materials for this outreach program. This includes buying a coding mouse and using free websites to learn coding language.

Coding Mouse: We used the Learning Resources STEM Code & Go Robot Mouse Activity Set. This set is sold for $50 - $60 and is shown in Figure 1. [v]

Figure 1: Learning Resources STEM Code & Go Robot Mouse Activity Set. This set includes a battery operated mouse that can be programmed to turn in four directions. The kit also include plastic maze grids and barriers for creating you own maze, suggested activity cards and double sided coding cards (see arrows in top left). This kit costs about $50 and the mouse alone costs about $20.

Code.org: The 4th grade students did the first three Puzzles on Classic Maze to introduce them to basic coding.[vi]

JavaScript on Khan Academy: The 4th grade teacher set up a free account for each student in Khan Academy and used the New JavaScript Program found under Computer Programming.[vii] This program introduces them to JavaScript and allows them to create an image.

Information about students and sessions.
The leaders of the outreach activities were one 4th grade teacher and two 8th grade female students, Lauren and Jessica. The 4th grade class contained 25 students with 11 female students and 14 male students. There were 5 sessions that lasted for 45 minutes each and the sessions took place during the last period of the school day. Each student already had a chromebook to use for these sessions. The teacher uses Google classroom. The middle school students were bused from the middle school and had to make up the work they missed.

Connecting middle school students with teachers.
The two middle school girls were interested in reaching out to the elementary school to share what they were learning in coding in the middle school. After reaching out to the elementary school principal, they put together a one page proposal about their ideas. The principal then connected them with the elementary enrichment teacher who then connect them with a 4th grade teacher. They scheduled two planning meetings and together they put a plan together about the activities that would work best with the students and the time that would best fit in the school day. They planned for five sessions of 45 minutes each. During sessions 2 -5, the students were divided into two groups. One group worked with the teacher and one middle school student on Khan Academy. The other group worked with the other middle school student on the coding mouse. Halfway through the session the groups switched. These sessions are detailed below.

Description of Sessions:
Session 1: Introduction to Coding and Code.org
Goal: To assess stereotypes of coders held by the 4th graders, to introduce the students to what coders do and to teach them basic coding with Code.org.

1. The teacher asked the elementary students to draw what they think a "coder" looks like on a white index card. The students then spoke with their neighbor about their drawing and reasoning behind it. With teacher assistance, students taped their index card onto one half of a large poster board. The teacher asked some students to share.
2. The middle school students explained what coders do through a slideshow presentation.
3. The elementary students logged into www.code.org[vi] and complete the first three puzzles on Classic mode with middle school students assisting (10 – 15 minutes).
4. The middle school students introduced the two projects they will be working on during the next four sessions: 1) Java Script on Khan Academy and 2) Go Robot Mouse.

Session 2 – 5 for Khan Academy: Introduction to JavaScript including Color Background and making rectangles, circles and coloring and outlining their shapes.
Goal: To show students how a coding language can be used to create a picture in Java Script. Below we describe the commands that they were taught to create a picture like Figure 2.

1. The students opened their chromebooks and logged into Khan Academy. Then they selected computer programming and scrolled down and selected New JavaScript Program.[vii]
2. The middle school students showed them how to make a color background using *background(red,green,blue).* Then they showed them how to change the color while explaining that the three numbers represent (red, green, blue). For example if they use the numbers *background(148,218,235*); they will get a blue color as shown in Figure 2.
3. Next they showed them how to code a rectangle and circle with *rect(x,y,width,height); and ellipse(x,y,width,height);* Most students made the circle into a sun.
4. Students were shown the fill code: *fill(red,green,blue);* and it was explained that the fill command needs to go before the shapes commands.
5. In this session the students learned about outlining shapes with the stroke command (*stroke(red,green,blue);)* to color the outline of the shape.
6. The students were then taught the command *strokeWeight(thickness);* This command determines the thickness of the outline.
7. At the end of each session the students were given time to experiment on their own.


```
1  background(148, 218, 235);
2  strokeWeight(6);
3  stroke(120, 49, 148);
4  fill(170, 0, 255);
5  rect(125,250,150,150);
6  fill(211, 237, 12);
7  ellipse(300,50,60,60);
8  rect(150,200,95,50);
9  strokeWeight(5);
10 stroke(0, 0, 255);
11 rect(215,300,30,40);
12 rect(155,300,30,40);
13 fill(12, 12, 13);
14 rect(50,100,20,300);
15 fill(0, 196, 255);
16 rect(50,100,100,70);
17
```
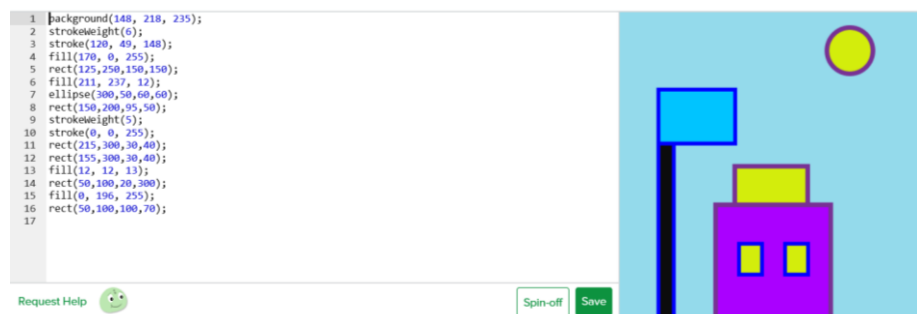
Request Help   Spin-off Save

Figure 2: Example house drawn with JavaScript on Khan Academy. After these 5 session the students should be able to code a similar house on their own.

Sessions 2 – 5 for Go Robot Mouse
Goals: Students will learn how to program the mouse, set up coding cards and practice with set mazes. Students will then create their own maze to be used by 1st grade students.

1. One mouse was given to the entire group of students. The middle school student showed them how pressing the arrow would allow the mouse to move in four directions.
2. The students were given time to experiment with the mouse.
3. The students were asked to set up challenges based on the cards given in the Go Robot Mouse kit (see Figure 1 for examples).
4. The students set up the coding cards and one student programmed the mouse. Then they took turns programming the mouse. This continued with more mazes.
5. Students were encouraged to make their own mazes with the plastic pieces and were told that 1st graders would code the mouse to follow their maze.

Session 5: Wrap-up
The last session was shorter to allow for some wrap-up. The middle school students presented videos from code.org.

The 2 minute first video is "The hour of code is here" **https://www.youtube.com/watch?v=FC5FbmsH4fw** the second 5 minute video is "What most schools don't teach". **https://www.youtube.com/watch?v=nKIu9yen5nc.** The videos included many famous people (as role models) talking about coding. The goal of these videos was to inspire the students to see and hear about the power of coding.

After the presentations the students were asked to write down what they think a coder looks like on a white index card. They glued them onto the other side of the poster paper. The students were asked to discuss what they think changed in their mind.

Observations and Recommendations
We did administer the STARS Outreach Computer Attitude Survey for Secondary Students[viii] but since this was the first time trying this, we did not obtain permissions to share the experiences of the elementary students. Part of the purpose of this work in progress was to try various activities to gain anecdotal evidence before beginning a more formal and precise study. We can, however, comment on general observations from both the middle school students and the teacher.

Observations from the middle school students.
The middle school students observed that the elementary students enjoyed both code.org, Khan Academy and the Robot Mouse. The middle school girls also mentioned that they felt more "like coders". They felt good doing something extra volunteer work. Although the plan was for the college students to also come to the class, the middle school students enjoyed being the "experts" in the room. Having a college student might have diminished this impact.

Observations from the 4th grade teacher. After these five session, the teacher found that she could now connect with some of her students who had already had some experience in coding in various forms. Also she gained more confidence in this type of activity. She found herself coding on her own after school and plans to purchase more coding mice to use in her classroom.

Recommendations and Future plans

The next step is for the 4th grade students to share their mazes with the 1st grade students and teach them how to use the coding mouse to go through the maze. In this case the 1st grade teachers will chose less than 10 students to participate instead of using the whole class. This will allow the 4th grade students to feel like experts. In addition the middle schools students would like to expand their work to include another elementary school and to recruit more middle school "experts". In the future they would make the following changes:

1. The sessions should not be split in half but instead the students should be split in half and have the whole session to work on one activity. Half of the students would work on the mouse and half would work on Khan Academy for the whole session.
2. Some of the 4th grade students struggled a little with understanding grids, width and height, especially with Khan Academy. One suggestion is to work with the mouse first to aid in understanding of grids. Either the middle school students could review this first or the teacher could incorporate this into a math lesson before the outreach event.
3. We should buy more mice so that a group of 3 students could have a mouse instead of 12 students sharing a mouse.
4. We should obtain IRB permission to collect data on self-efficacy and stereotypes for both 1st, 4th and 8th graders to assess self-efficacy and changes in stereotype views of all the students.
5. We should expand the program to include more middle school girls and various elementary schools.
6. We will coordinate for the 4th graders to teach the coding mouse to the 1st graders. (This is currently in progress.)

Conclusions

The hypothesis was that making middle school girls "experts" in STEM (instead of just receivers of outreach), will help them more strongly self-identify as members of the STEM community. Here we discussed a first approach using middle school girls to teach coding to 4th graders and then having the 4th graders teach what they have learned to 1st graders. We are excited to continue this work.

[i] Committee on Public Understanding of Engineering Messages, 2008. Changing the Conversations: Messages for Improving the Public Understanding of Engineering. National Academy of Engineering. The National Academy Press. Washington, DC.

[ii] Master, A., Cheryan, S., & Meltzoff, A. N. (2016). Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science. *Journal of Educational Psychology*, *108*(3), 424.

[iii] Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural stereotypes as gatekeepers: increasing girls' interest in computer science and engineering by diversifying stereotypes. *Frontiers in psychology*, *6*, 49.

[iv] https://girlswhocode.com/ assessed on 02/04/2017

[v] (https://www.learningresources.com/product/learning+essentials--8482-+stem+robot+mouse+coding+activity+set.do) accessed on 02/04/2017.

[vi] https://studio.code.org/hoc/1 accessed on 02/04/2017.

[vii] (https://www.khanacademy.org/computer-programming/new/pjs) accessed on 02/04/2017.

[viii] http://starscomputingcorps.org/program-evaluation-toolkit-how-assess-outreach-programs accessed on 02/04/2017.