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The Effect of Creative Computer Science Workshops on the Interest Levels of Female Middle School Students

Ella Hilton

Literature suggests that the lack of female involvement in computer science (CS) is detrimental to the field. The disconnect between females and CS is not due to their ability to succeed in the subject, but rather the perceptions and stigmas surrounding it. This paper will focus on female interest in CS at a medium sized suburban middle school in Western Pennsylvania. The two guiding points for the paper include 1) the idea that female role models are thought to be crucial in the advancement of closing the gender division and 2) Harvey Mudd College's approach to female CS learning. The measure of each subject's CS interest was collected through pre and post-surveys during workshops led by the researcher. The paper ultimately argues that yes, the girls at the specified middle school are more interested in computer science after engaging in creative problem solving led by a female role model.

Keywords: Computer science, middle school interest, creative problem solving, female role model

I. Introduction and Literature Review

Computer science is a rapidly developing field of study that impacts every other discipline; however, it is also one in which women are largely underrepresented (NCWIT, 2014). This issue is so imperative that hundreds of today's "leaders and trend-setters" believe that computer science and/or computer programming is essential in shaping today's world ("Leaders and trend setters…", 2019). Therefore, beneficial research has been conducted and must be conducted further in order to reach conclusions as to what could encourage more women to engage with computer science. If not, the voices of women around the world will be continuously disregarded in the conversations and opportunities that computer science presents. Throughout this literature review, prior studies regarding women in computer science will be compiled to explore the issue that can be seen in a medium sized suburban district in Western Pennsylvania and ultimately answer the following question:

Compared to their initial perceptions, do girls at a medium sized suburban middle school in Western Pennsylvania demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model?

Key Terms

… found in literature review

Computer Science

While coding/programming is included in computer science, it certainly does not represent the entire discipline. Computer science "develops students' computational and critical thinking skills and shows them how to create, not simply use, new technologies" ("Computer science develops…") The study of computer science entails algorithmic problem solving, computing and data analysis, human computer interaction, graphic design, security, programming, etc. ("Computer science develops…").

Perception

Many of the historical issues surrounding the gender imbalances of computer science are perception-related. A perception is "a thought, belief, or opinion, often held by many people" (Meaning of perception…).

Social Cognitive Theory

Within a cornerstone work of this literature review, researchers use social cognitive theory "to identify and understand reasons why students choose to study computer science" (Alshahrani, 2018). Their definition for social cognitive theory has four components: "prior experience, social support, self-efficacy and outcome expectation" (Alshahrani, 2018). This keyword relates to the perceptions and biases presented throughout the literature.

… found in research question

Creative Problem Solving

When the research question is justified, the notion of creativity will be stressed. Creativity is "the ability to perceive the world in new ways, to find hidden patterns, to make connections between seemingly unrelated phenomena, and to generate solutions" (Naiman, 2019).

When the researcher presents the concept of "creative problem solving", they are using Maria Klawe's idea of real world application capturing "interest and enthusiasm", an idea that is returned to in the "Current Solutions" section of the paper (Nickelsburg, 2019).

Female Role Model

A female role model can be any female that others look up to in some fashion, but "local examples provide more easily imaginable visions of success" (The Power of Role Models).

Attitudes and Perceptions / History of Problem

Boys tend to create an environment surrounding computer science that proves difficult to penetrate by outsiders (Margolis & Fisher, 2003). This thesis was explored through the collection of data regarding attraction of programming and other like factors to reach the conclusion that slight differences in computer upbringing between the sexes leads to an experience gap in the future (Margolis & Fisher, 2003). According to their study, something as slight as 5 and 6-year-old boys crowding the classroom computers during free time can play a role in the decision to move forward with computer science (Margolis & Fisher, 2003). Exposure differences such as this has led to differing perceptions of abilities, as seen in a 2015-2016 Google Gallup survey, where, when asked the question "How confident are you that you could learn CS if you wanted to?", 65% of twelfth grade boys surveyed reported to feel "very confident" in their abilities, while a mere 48% of twelfth grade girls surveyed felt "very confident" in theirs ("Students who have been told…").

The idea of it being a "boy thing" is not the only developing attitude around computer science. In an "interview with 17 mixed gender subjects currently studying CS at three Scottish universities", the students shed light on the perceptions concerning computer science (Alshahrani, 2018). Of these 17, a total of 9 perceived characteristics coinciding with people in the field being nonsocial, 6 used the words "nerd" or "shy", and 3 used "geek" (Alshahrani, 2018).

Contradicting the students from the interviews, a vast majority of Pennsylvanians have a positive perception of the field ("To inform the public on progress…"). Despite these positive perceptions in Pennsylvania, action is not being taken to give children ample opportunities for computer science learning, which prolongs the issue of those within the coding environment (mostly boys) to have a consistent leg up on those who have yet to enter the discipline at all (mostly girls) ("To inform the public on progress…").

Women in Computer Science

"When computer technology first emerged during World War II and continuing into the 1960s, women made up most of the computing workforce" ("The Bureau of Labor Statistics…", 2013). Today, "the percentage of women working in computer science-related professions has declined… , dropping from 35% to 26% between 1990 and 2013" ("The Bureau of Labor Statistics…", 2019). However, according to the American Association of University Women, we can reverse this trend by removing negative connotations around women in computer science" ("The Bureau of Labor Statistics…", 2019).

Creativity

The cornerstone work that is *A Report on the Status of Women in Information Technology* goes into detail on how gender diversity in computing is important on the basis of enhancing innovation (NCWIT, 2014). The discipline requires creativity because "computing is a field created by innovative thinkers whose products and systems have become critical to our daily lives" (NCWIT, 2014) "Research shows that under the right circumstances, diverse teams improve creativity, problem-solving, and productivity. A large study spanning 21 different companies showed that teams with 50:50 gender membership were more experimental and more efficient" (NCWIT, 2014).

Current Solutions

Role Models

From the same literature that studied the perceptions of computer science from boys and girls, the importance of female leadership is stressed in the journey towards a solution ("Students who have been told…"). Luckily, interest surrounding the need for these female role models has been generated with research into understanding why students do or do not choose to study computer science (Alshahrani, 2018). Pulling again from the study surrounding social cognitive theory, the subjects believed that having female role models might sway more girls into joining suit (Alsharhrani, 2018). When these role models are weaved into out of school programs they become some of the greatest opportunities for growth in reasoning as well as social interaction while learning (Deschenes et al, 2010).

Harvey Mudd College

A prime example of an institution that was able to pose a solution to the gender gap is Harvey Mudd College in Claremont, California (Klawe, 2017). As stated by Maria Klawe, president of Havery Mudd, "five years after Harvey Mudd redesigned its introductory computer-science course, women went from being 10 percent of computer-science graduates to 40 percent" (Klawe 2017). Klawe reported that when teaching students computer science, it is important to express that the concepts have real world application because that "can capture the interest and enthusiasm of more students — including women" (Nickelsburg, 2019; Klawe, 2017).

Assumptions

In setting up their work, the researcher assumes that computer science skills and knowledge could be retained by middle school girls with the use of "problem-solving groups in class" as NCWIT Senior Research Scientists Barker and Cohoon proved could be done with undergraduates (Barker & Cohoon, 2009).

Additionally, the researcher assumes that using the same techniques as carried out by Harvey Mudd College (teaching that stresses creative problem solving) would produce similar results in the district being studied (Klawe 2017). They also assume that they themselves could fill the role of a leader, as inconsistent female leadership has led to imbalances in field engagement and is a large factor in the disparity seen in the field (Blaney, 2018). Also, the researcher is both local and relatable, which is important according to the definition of female role models presented earlier (The Power of Role Models).

Justification of Research

Justification of researching female interest in computer science

When comparing the number of male and female students taking AP exams in mathematics and science during 2009, most STEM subjects can be closely compared, while the girls significantly dropped off for the two computer science tests (Dawson, 2014). Yet interestingly enough, the small number of girls who did take the AP Computer Science A test scored relatively similar to the boys, showing that they can succeed at the same rate (Dawson, 2014). These statistics narrow the need for attention from STEM as a whole to the problem that spurs with computer science. Once within the computer science field, research can be further justified because negative perceptions of computer science have led to mass decline of women engagement (Women in Computer Science, 2019).

Justification of using creative problem solving and a female role model

The method in which the researcher chooses to measure interest is justified for the following three reasons: 1) female role models are thought to be crucial in the advancement of closing the gender division (Alshahrani, 2018). 2) Harvey Mudd as well as the NCWIT found real world applications, or problem solving, to be useful in generating interest (Klawe, 2017; Barker & Cohoon, 2009). 3) The computing field needs more girls for the creativity they bring to the table (NCWIT, 2014). Therefore, the researcher has the ability to use this literature to fuel their research question.

Research Question

Compared to their initial perceptions, do girls at a medium sized suburban middle school in Western Pennsylvania demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model?

II. Methodology

Throughout the literature review, the researcher was able to draw the conclusion that a widespread issue with computer science is the lack of female involvement (NCWIT, 2014). On a more personal level, the researcher is interested in solving this problem within the specific school district due to her involvement with the computer science curriculum, which includes being the only female enrolled in AP Computer Science A during the 2018-2019 school year.

When considering methods, the researcher first contemplated interview techniques as seen in a cornerstone study from the literature review. However, because the interviews were conducted with adult subjects majoring in computer science, the researcher decided that the middle school girls (with little to no exposure) would have more difficulty in an interview setting (Alshahrani, 2018). Secondly, the researcher considered descriptive research; however, because *Practical Research* describes this method as not involving modifying the situation but simply collecting a judgment sample, this method was also dispelled (Leedy, 2019). Instead, a mixed-method study implementing pre and post-surveys was the best choice. With this method, the researcher is able to integrate findings from qualitative and quantitative data through a convergent design of structured and open-ended questions (Leedy, 2019). Although the interviews from Alshahrani's study were dismissed, the researcher included his style of content analysis within the mixed-method study by categorizing the open-ended responses into "clusters of similar entities" and using these clusters to identify "consistent patterns and relationships between variables or themes" (Alshahrani, 2018).

The researcher drafted the following study of which all parts were approved by the IRB:

Study Design

In order to assess their research question, the researcher created and implemented three "creative computer science" workshops for the middle school girls in sixth and seventh grade. They consisted of three parts:

The girls completed a pre-survey concerning their current perceptions and interest levels surrounding computer science. They were only able to complete the survey if their parent/guardian had returned a signed consent form. See the consent form in Appendix A.

For each workshop, the researcher created three programmed scenes using Carnegie Mellon University Computer Science Academy that centered around the shape that was to be learned during that particular workshop. Each of the girls received an anonymous login to the course and the researcher's starter code was copied into each of their "sandboxes". The first workshop was built around circles, the second rectangles, and the third three-sided polygons. The researcher chose these shapes because they are building blocks for all of the scenes that the researcher coded using CMU CS Academy. There is not enough time in a forty minute workshop to learn all of these shapes, which is why they were split up in that manner. The learning of a single shape does not expand upon the last; therefore, if a participant attended the second workshop but not the first her progress was not hindered. The researcher was cognizant of standardization throughout their workshops, making sure that they administered each lesson with the same format and similar content.

The researcher passed out a worksheet that explained how to create and color the shape that the workshop focused on that day. See the workshop handouts in Appendices B-D.

The researcher chose to work with Carnegie Mellon University Computer Science Academy (a free, browser-based Python course) in the first place because it is user-friendly and analyzes mistakes. This way, when the researcher was unable to come around and answer their questions immediately, the girls could either problem solve together or receive feedback from the computer itself.

The girls completed a post-survey concerning their new (possibly changed) perceptions and interest levels surrounding computer science. A debriefing form was sent home for their parent/guardian. See debriefing form in Appendix E.

Pre and Post-Surveys

The pre and post-surveys were administered through google forms, with all personal-information collecting features turned off to ensure anonymity; however, the girls were assigned to a number at the beginning of the workshop and asked to state that number in both surveys. This is how the researcher linked their pre and post- surveys together without collecting personal information.

See both full surveys in Appendix F.

Study Setting

The workshops took place in the middle school on January 7, January 28, and February 18 of 2020. Although there were three different workshops, the researcher performed each twice: once 7th period and once 8th period on each of the designated days. The workshops were offered both periods because half of the students that participated have their study hall during 7th and the other half during 8th. The workshops took place in the robotics lab because this is the usual setting of the STEAM Girls Workshops (workshops offered at the middle school every few weeks where female students can participate in planned activities related to STEAM, not connected to the researcher), and computer science falls into the STEAM category. The lab has extra computers if any of the participants forgot their personal device.

Study Population

Participants were "recruited" through emails sent home to all parents of the students as well as announcements made during the students' lunches. The middle school age group seemed appropriate because after interacting with the researcher's experiment the students have the information and experience needed to make an informed decision as to their future involvement with computer science as they move into high school and beyond. The girls all have their own district devices, meaning every participant had access to her own editable code that the researcher provided. Although they could edit the program individually, they sat at tables to spark conversation and solutions.

In the end, a total of 15 sixth and seventh grade girls attended the workshops, three of which came to one workshop, five who came to two, and seven who came to all three.

Presentation of Findings

As shown in Table 1, the researcher dissected the research question into three parts and presented the findings in that manner.

Table 1: Breakdown of Research Question in Relation to Findings

"Compared to their initial perceptions, do girls at a medium sized suburban middle school in Western Pennsylvania demonstrate a heightened interest in computer science…"	The researcher gathered the perceptions of interest from the following questions both in the pre and post- surveys: How interested are you in computer science? Would you continue with computer science in the future? For the comparison of interest, the researcher conducted a Paired T-test for the true mean difference in interest levels (post - pre). They also recorded the difference in the participants' reported likelihood of continuing with computer science in the future before and after the workshops. (see Tables 2-4)
"... after engaging in creative problem solving…"	To address the creative problem solving point, the researcher asked the following questions in the final post survey: Which workshop was your favorite? During which workshop were you able to be the most creative? The researcher recorded how often participants favorite workshops were also the one in which they felt the most creative. (see Table 5)
"...led by a female role model?"	To address the female role model point, the researcher asked the following survey question in the final post survey:

Findings & Data Analysis

Introduction

The findings demonstrate that girls at a medium sized suburban middle school in Western Pennsylvania do demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model. As the breakdown in Table 1 suggests, this overarching claim is made based on data drawn from each subsection of the research question: 1) a paired t-test assessing the true mean difference in their interest levels from pre to post as well as their thoughts on continuing with computer science from pre to post, 2) a comparison between their favorite workshop and the one during which they were able to be the most creative, and 3) categorized answers to the question of if they enjoyed working with the female role model. Although this claim does not seem evident after the first step of analyzation, parts two and three suggest a "yes" to the research question. With this in mind, the researcher's findings paired with those from the literature review solidify the understanding of how young girls in the specified township respond to such exposure to computer science in ways that could be expected based off of Alshahrani's interviews and trends seen at Harvey Mudd College.

Interest Levels

Table 2 presents each participant's reported interest levels from the first pre-workshop survey they completed to the last post workshop survey they completed. In the last column, the difference in this quantitative measure of interest is calculated and is used as the data in the paired t-test seen in Table 3.

Table 2: Interest Levels in Pre and Post-Tests

Participant's Assigned Number	Pre-Test Interest (1)	Post-Test Interest (2)	Difference (2-1)
1	4	5	1
10	4	5	1
11	5	4	-1
12	4	4	0
13	2	4	2
14	3	3	0
15	5	4	-1
16	2	2	0
17	3	5	2
18	5	5	0
19	4	3	-1
2	4	4	0
20	3	3	0
21	3	3	0
22	5	5	0

Table 3: Paired t-Test for the True Mean Difference in Interest Levels (Post - Pre)

Null Hypothesis (H_0)	Alternative Hypothesis (H_a)	Sample Mean	Sample Standard Deviation	Sample Size	Degrees of Freedom	t-value	alpha	p-value
μ2-μ1=0	μ2-u1>0	0.2	0.95	15	14	0.823	0.05	0.212

The null hypothesis for this scenario is the pre and post-interest levels being the same, showing that the participants' interest levels did not change before and after engaging in the workshop(s). The alternative hypothesis for this scenario is the post interest levels being greater than the pre-interest levels, showing that the participants' interest levels increased. When the p-value is greater than the alpha, the null hypothesis is unable to be rejected. However, when the p-value is less than the alpha, the null hypothesis can be rejected.

Because the p-value of 0.212 is greater than the alpha of 0.05, the researcher failed to reject the null hypothesis.

There is not enough evidence to convince that the sample's mean interest level after participating in the workshop(s) increased from the mean interest level before.

Table 4 presents each participant's reported interest in continuing with computer science from the first pre- workshop survey they completed to the last post workshop survey they completed. The yellow rows show that 5/15 participant's interest in continuing with computer science increased (maybe to yes), the red row shows that 1/15 participant's interest in continuing with computer science decreased (yes to maybe), and the white rows show that the remaining 9/15 participant's interest in continuing with computer science stayed the same (maybe to maybe or yes to yes). At no point did a participant answer "no" to the question: Would you continue with computer science in the future?

Table 4: Thoughts on Continuing with Computer Science in Pre and Post-Tests

Participant's Assigned Number	Pre-Test Interest	Post-Test Interest
1	Maybe	Yes
10	Maybe	Yes
11	Yes	Yes
12	Maybe	Yes
13	Maybe	Yes
14	Maybe	Maybe
15	Yes	Yes
16	Maybe	Maybe
17	Yes	Yes
18	Yes	Yes
19	Maybe	Maybe
2	Yes	Maybe
20	Maybe	Yes
21	Maybe	Maybe
22	Yes	Yes

From the quantitative data in Tables 2 and 3 alone, it is not evident that the middle school girls demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model. The calculated p-value from the t-test in Table 3 is far too high to reject the null hypothesis of the mean interest level before and after being equal, and therefore there is a very good chance that the null hypothesis is true, meaning that the girls' interest levels did not increase after participation with the researcher's workshop(s). In Table 4, the claim of their interest levels remaining stagnant is further strengthened by 60% of participants having the same thoughts on continuing with computer science after the workshop(s) as they had before partaking in the workshop(s).

The Bureau of Labor Statistics' estimation of the decline of "women working in computer science-related professions" becomes further validated as an issue because the researcher did not find evidence to prove their methods worked to reverse the trend. Additionally, the researcher's initial assumption that "using the same techniques as carried out by Harvey Mudd College would produce similar results in the district being studied" is dismantled at this point, and the importance of gender diversity within the computer science field remains a goal unmet (NCWIT, 2014). Therefore, one can be reasonably certain that based off of the quantitative data alone it appears a "no" would answer the research question and refute the general tendency seen in the body of knowledge.

Creative Problem Solving

Contrary to the results stemming from the general interest rates, the findings convey that the participants responded favorably to the creative problem solving aspects of the workshop(s) in which they attended. Table 5 proves that more often than not the participants' favorite workshop aligned with the one in which they felt most creative. So while the researcher failed to conclude that the general interest levels increased from pre to post-workshop, the second portion of the research question regarding creative prob-

Table 5: Creativity's Alignment with Favorite Workshop

Participant's Assigned Number	Favorite Workshop	Workshop During Which They Felt the Most Creative
2	Creating Rectangles	Creating Three-Sided Polygons
10	Creating Rectangles	Creating Rectangles
12	Creating Three-Sided Polygons	Creating Three-Sided Polygons
13	Creating Three-Sided Polygons	Creating Three-Sided Polygons
15	Creating Three-Sided Polygons	Creating Three-Sided Polygons
17	Creating Three-Sided Polygons	Creating Three-Sided Polygons
19	Creating Three-Sided Polygons	Creating Rectangles
22	Creating Three-Sided Polygons	Creating Circles

Table 6: Participant Feelings Towards the Female Role Model

	Nice/Kind	Explanatory	Fun/Funny
Number of responses in which specified theme was mentioned	5	3	2
Full quote example of theme	"yes she is a very nice girl and she worked with us and i think its amazing that she did this with us."	"Yes, because she explained the instructions good and is nice."	"yes, she was really nice and funny"

lem solving can be seen as being a convincing factor for girls at a medium sized suburban middle school in Western Pennsylvania to partake in computer science.

Table 5 conveys that 5/8 responding participant's favorite workshop was the same as the workshop during which they felt the most creative (depicted by yellow rows), while only 3/8 responding participant's favorite workshop was not (depicted by red rows). This shows that a majority of respondents preferred a workshop in which they felt the most creative.

Therefore, the researcher can draw similarities after all between their research and the work at Harvey Mudd College - both groups responded well to creative problem solving / application (Klawe, 2017). Ultimately, these findings support the idea that Hampton Middle School girls enjoy computer science more when creativity is involved.

Female Role Model

Shown in Table 1: Breakdown of Research Question in Relation to Findings, the third portion of the research question's purpose was to determine if the participants responded well to a female role model. Depicted in Table 6, the participants very much enjoyed having a female role model to walk them through the workshop(s) that they attended. All 8 respondents provided a favorable response to the question: Did you like working with the leader of the workshops? Explain why or why not. While there were only 8 responses, some responses contain more than one theme. See Table 6 for theme breakdown and examples of each theme in a direct quote from a participant.

The unanimous positive perception of computer science as taught by a female role model is in line with the interviews from Alsharhrani's social cognitive study, where subjects believed that having a female role model would have a positive impact on how young girls viewed computer science (Alshahrani, 2018). Additionally, the researcher's assumption of them being able to embody such a role was obviously brought to fruition. With that, it is evident that the participants were interested in computer science when an older, seasoned female was involved.

Limitations

The major limitations of this study are issues with the sample regarding size and randomization. First of all, the sample size of n=15 is small. For a paired t-test as used by the researcher, it is preferred that the sample size be at least n=30 in order to generalize the findings to the population. Despite efforts made to gain as many participants as possible through emails sent home to all parents/guardians of the middle school girls and announcements made during all lunches (as mentioned in the study setting section of the methodology), the limitation of a small sample size could not be overcome. Additionally, the sample was not randomly selected: the participants signed up for each of the workshop(s) they wanted to attend. However, this sign up method was necessary in recruiting participants because the workshops were held during study halls due to the alignment of the researcher's schedule with that of the middle school, and students cannot be forced to partake in an activity during their free period. With this non-random selection, bias occurs because the sample is made up of students that chose to partake in this study, many of whom already had an interest in science, technology, engineering, and/or math.

Finally, again due to the researcher's availability and the study hall schedule at the middle school, only sixth and seventh graders were able to participate in the workshops. This limitation is addressed by Bowling Green State University professors Booth and Gerard's findings of uniform school climates with "shared perceptions of the academic environment" (Booth and Gerard, 2014). Due to these shared perceptions throughout a school, the researcher assumes that the eighth grade students would have similar feelings towards the workshops as the sixth and seventh graders.

In future studies, these limitations could be avoided if the workshops could be taught to each of the three grade levels within a random selection of mandatory classes rather than study halls. This way, the sample would be larger, more inclusive, and more representative of the population. However, this solution assumes that 1) neither the researcher nor the school had scheduling conflicts and 2) all guardians would be willing to sign a consent and debriefing form for their minor, as they had in the original study.

Conclusions

A significant imbalance in the ratio of girls to boys in computer science was found through the literature. The researcher saw this imbalance firsthand in a medium sized suburban township in Western Pennsylvania specifically and framed their research to address the following question: Compared to their initial perceptions, do girls at a medium sized suburban middle school in Western Pennsylvania demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model? After three workshops addressing all three aspects of the research question through appropriate methods, the sweeping conclusion that *yes*, girls at a medium sized suburban middle school in Western Pennsylvania do demonstrate a heightened interest in computer science after engaging in creative problem solving led by a female role model was reached after assessing each part of the research question separately. The implication of such a conclusion is that if this middle school implements a computer science curriculum that allows girls to be creative and engage with females that they look up to, the imbalance could be rectified.

Further research could be conducted using similar methods applied to the larger county and beyond. With a wider variety of schools, a conclusion could be further generalized in a way that applies to many more middle schools. For now, this research applies to the medium sized suburban middle school in Western Pennsylvania in allowing its computer science program be better equipped in serving its young women.

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Appendix A

Dear Parents/Guardians,

Hello, my name is [redacted], and I am a senior at [redacted]. During my junior year, I was the only girl enrolled in AP Computer Science A at [redacted]. This is an issue for the district and community because of the gender difference it creates when girls are not continuing into higher level computer courses. This year I have chosen to take AP Research, a class where students have the ability to research a topic that interests them for the duration of the year. With this opportunity, I am exploring a possible avenue through which to remedy the situation: creative problem solving as led by a female role model. My goal is to ultimately give girls at [redacted] information and experience that they can use to make an informed decision on whether or not to continue with computer science, rather than making that decision based off of the "it's a boy thing" attitudes seen far too often.

Your daughter has the opportunity to take part in a research study that measures her interest in computer science before and after engaging in creative problem solving led by a female role model. I am inviting your daughter because of her prior interest in the [redacted] STEAM Girls workshops at [redacted]. Please read this form carefully and ask any questions you may have before agreeing to your daughter's participation in the study.

What the study is about: The purpose of this study is to explore if [redacted] girls demonstrate a heightened interest (compared to their initial perceptions) in computer science after engaging in creative problem solving led by a female role model.

What I will ask of your daughter: If you agree to this study, your daughter will engage in the creative problem solving tasks I have created using Carnegie Mellon University Computer Science Academy. They will also complete pre and post-surveys. The surveys will include a multiple choice question about their interest level, as well as open ended questions asking to explain their answer.

Risks and benefits: This study has been approved by [redacted]'s Institutional Review Board and they do not anticipate any risks to your daughter participating in this study. There is also no benefit in terms of compensation, although they do get to explore computer science in a safe and fun environment.

Your daughter's answers will be confidential. The records of this study will be kept private. The completed consent forms will be kept in a locked safe. The survey results will be stored in a digital spreadsheet only accessible to myself and my advisor, [redacted]. In any sort of report I will not include any information that will make it possible to identify your daughter. While each student will be given a login for CMU CS Academy, this login will be anonymous and not connected to any personal contact information (ex: [redacted]User1). The surveys will be administered through Google forms, and all personal information collecting features will be turned off.

Taking part is voluntary: Taking part in this study is completely voluntary. In the surveys, your daughter may skip any questions that she does not wish to answer. If you choose not to consent to the surveys, your daughter is still welcome to participate in the workshop while being excluded from the data set.

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If you have questions: Please feel free to contact me at [redacted] if you have questions about the study. You may also contact [redacted] or my supervisors, [redacted]).

Statement of Consent: I have read the above information, and have received answers to any questions I asked. I consent for my daughter take part in both the workshop and the survey.

Parent/Guardian Signature ________________________________ Date ______________________

Parent/Guardian Name (printed) ____

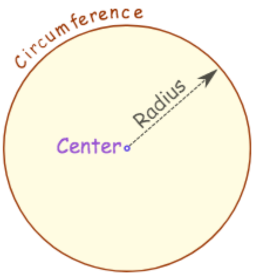
Student Participant Signature ________________________________ Date ______________________

Student Participant Name (printed) ____

Appendix B

Creating Circles

Radius: the distance from the center of a circle to any point on the circumference (outside of circle)



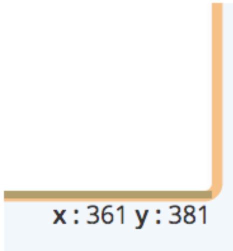
Plan your circle:

1. Decide what point (x,y) to call the center
2. Decide what size you want for your radius
3. Decide what color you want your circle to be

Create your circle:

Circle(centerX, centerY, radius, fill='color')

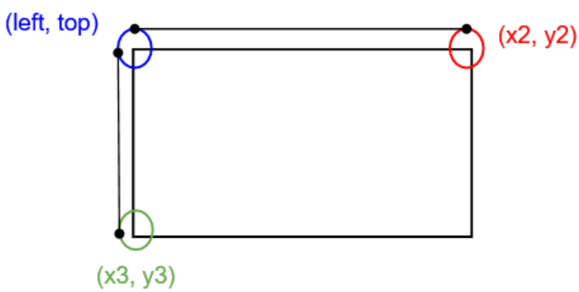
There is an arrow tool that displays your location in the sandbox.



Move the arrow tool around until you find a point to put your circle and use that point as your circle's center.
Remember that the sandbox only goes to 400 in each direction!
Please let me know if you have any questions!

Appendix C

Creating Rectangles



Plan your rectangle:

1. Decide what point (x,y) to call the left-top corner
2. Decide the width you want for your rectangle
3. Decide the height you want for your rectangle
4. Decide the color you want your rectangle to be

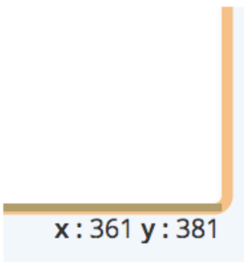
How do I find width?
Find the change in the x-values. In the rectangle above, that would be **x2 - left** (or just use trial and error to find wich dimensions result in the rectangle that you wanted)

How do I find height?
Find the change in the y-values. In the rectangle above, that would be **y3 - top** (or just use trial and error to find wich dimensions result in the rectangle that you wanted)

Create your rectangle:

Rect(left, top, width, height, fill='color')

How do I know where to put the left-top corner of my rectangle?
There is an arrow tool that displays your location in the sandbox.



Move the arrow tool around until you find a point to start your rectangle and use that point as your rectangle's left-top corner.
For the width and height, you can use the subtraction strategy demonstrated above or just use trial and error to find which dimensions result in the rectangle you wanted.

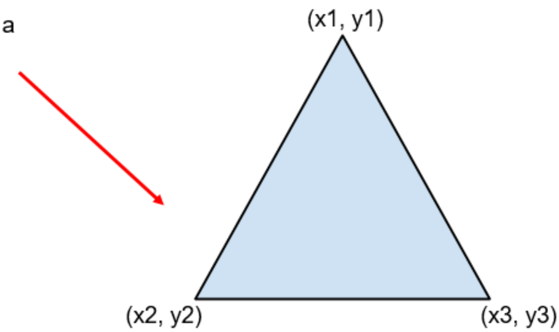
Remember that the sandbox only goes to 400 in both directions!
Please let me know if you have any questions!

Appendix D

Creating Three-Sided Polygons

A polygon is a shape formed with straight lines.

So a three-sided polygon is a triangle!



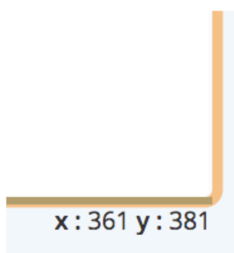
Plan your polygon:

1. Choose three points to be the three corners of your triangle. You will be connecting these points with straight lines.
2. Decide what color you want your triangle to be

Create your polygon:

Polygon(x1, y1, x2, y2, x3, y3, fill='color')

How do I know where to put my three-sided polygon?
There is an arrow tool that displays your location in the sandbox.



Move the arrow tool around until you find a point to put a corner of your three-sided polygon / triangle and start with that point. From this point, find two others that would appear to make the triangle you were hoping for.

Remember that the sandbox only goes to 400 in each direction!
Please let me know if you have any questions!

Appendix E

Project Title: Creative Computer Science for Girls
Principal Investigator: [redacted]
Department/Course: Social Sciences / AP Research
Contact Information: [redacted]

Taking part is voluntary
Although your daughter has already completed the survey, your daughter's involvement is still voluntary, and you may choose to withdraw the data she provided prior to debriefing, without penalty. Withdrawing your submission will not adversely affect your relationship with [redacted], the researcher, or any of our affiliates.

Privacy/Confidentiality
If you agree to allow us to use your daughter's data, here is how we will maintain confidentiality of the information:
The records of this study will be kept private. The completed consent forms will be kept in a locked safe. The survey results will be stored in a digital spreadsheet only accessible to myself and my advisor, [redacted]. In any sort of report I will not include any information that will make it possible to identify your daughter. While each student will be given a login for CMU CS Academy, this login will be anonymous and not connected to any personal contact information (ex: Steamgirl1). The surveys will be administered through Google forms, and all personal information collecting features will be turned off.

The main researcher conducting this study is [redacted], a student at [redacted].

If you have questions later, or would like to know about the results of the study, you may contact [redacted] at [redacted]. You may also contact her faculty advisors [redacted] and [redacted]).

If you have any questions or concerns regarding your daughter's rights as a subject in this study, you may contact the Institutional Review Board (IRB) for Human Participants at [redacted]. Please sign below (or in the case of phone, online or other media where signed debriefing is waived, use another method to get participant preference) if you do, or do not, give permission to have your data included in the study:

I have been debriefed by the Research team, and I understand the true intent of and the purpose of my daughter's participation in the Creative Computer Science Workshop. I agree that the data collected during the study may be included for the purpose of the study. ________________________________

I have been debriefed by the Research team, and I understand the true intent of and the purpose of my daughter's participation in the Creative Computer Science Workshop. I **DO NOT** give permission for the data collected during the study to be included for the purposes of the study. ________________________________

*adapted from Cornell University Office of Research Integrity and Assurance
https://www.irb.cornell.edu/forms/

Appendix F

Creative Computer Science Pre-Survey

Please answer these questions honestly before we begin the workshop.

1. Have you turned in a signed parental consent form?

   Mark only one oval.

   - Yes
   - No

2. Enter the number that was assigned to you.

   ____

3. What grade are you in?

   Mark only one oval.

   - 6
   - 7
   - 8

4. How many of the other Creative Computer Science workshops have you been to before this?

   Mark only one oval.

   - This is my first time
   - I've been to one before
   - I've been to two before

5. Which Creative Computer Science workshop are you attending today?

   Mark only one oval.

   - Creating Circles
   - Creating Rectangles
   - Creating Three-Sided Polygons

6. How interested are you in computer science? (0- I do not know what computer science is ; 1- I am not interested ; 2- I have no opinion ; 3- I am interested ; 4- I am very interested ; 5- Computer science is my favorite thing to do)

Mark only one oval.

	0	1	2	3	4	5	
I do not know what computer science is	⬭	⬭	⬭	⬭	⬭	⬭	Computer science is my favorite thing to do

7. Explain why you rated your interest level in that way.

8. Would you continue with computer science in the future?

Mark only one oval.

⬭ Yes
⬭ No
⬭ Maybe

Thank you!

You have completed the pre-survey. Thank you for your time.

Creative Computer Science Post-Survey

Please answer these questions honestly to end the workshop.

1. Enter the number that was assigned to you.

____

2. How interested are you in computer science? (0- I do not know what computer science is ; 1- I am not interested ; 2- I have no opinion ; 3- I am interested ; 4- I am very interested ; 5- Computer science is my favorite thing to do)

Mark only one oval.

	0	1	2	3	4	5	
I do not know what computer science is	◯	◯	◯	◯	◯	◯	Computer science is my favorite thing to do

3. Explain why you rated your interest level in that way.

4. What was your favorite part of the workshop today?

5. Would you continue with computer science in the future?

Mark only one oval.

◯ Yes
◯ No
◯ Maybe

Final Workshop Survey

6. Which workshops have you attended? (choose all that apply)

Check all that apply.

☐ Creating Circles
☐ Creating Rectangles
☐ Creating Three-Sided Polygons

7. Which workshop was your favorite?

Mark only one oval.

- Creating Circles
- Creating Rectangles
- Creating Three-Sided Polygons

8. How creative were you able to be in the workshop(s)? (0- Not creative at all. I was told exactly what to do. ; 1- Barely able to do my own thing ; 2- Creative, but not as much as I'd like to be ; 3- Creative ; 4- Very creative ; 5- I was able to be super creative and explore my own solutions to problems.

Mark only one oval.

	0	1	2	3	4	5	
Not creative at all. I was told exactly what to do.							I was able to be super creative and explore my own solutions to pro

9. During which workshop were you able to be the most creative?

Mark only one oval.

- Creating Circles
- Creating Rectangles
- Creating Three-Sided Polygons

10. During which part of the workshop(s) were you able to be the most creative?

Mark only one oval.

- Changing the colors of shapes
- Creating my own shapes
- Making pictures out of the shapes

11. What was your SINGLE favorite part out of all of the workshops you attended?

12. Did you like working with the leader of the workshops? Explain why or why not.

Thank you!

You have completed the post-survey. Thank you for your time.