miniGEMS 2018: A Mixed Methods Study Exploring the Impact of a STEAM and Programming Camp on Middle School Girls' STEM Attitudes

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Abstract

miniGEMS (Girls in Engineering, Mathematics, and Science) is a free two-week summer STEAM and programming camp for middle school girls launched in 2015. The goal of miniGEMS is to address the female gender gap and introduce more female students into STEM fields through project-based learning experiences. This study utilized mixed methods to identify the effectiveness of a STEM enrichment summer camp and explore how middle school girls' STEM attitudes changed after participating in miniGEMS. A pre- and post- survey was conducted with 92 students in grades six through eight to measure their self-reported attitudes in mathematics, science, engineering and technology. The results showed a significant increase in campers' self-perceived attitude in mathematics. In addition, semi-structured interviews were conducted with 22 campers to explore how the camp experiences altered attitudes toward STEM study and impacted their career interest. Interview findings indicated (1) campers had opportunities to develop STEM, robotics, and programming knowledge through various hands-on activities which made the camp fun and interesting, (2) teamwork and single-gender learning environment helped campers become more open to STEM subjects, and (3) coding and programming were two major themes in miniGEMS that affect campers' career choices and interests in advanced studies in STEM.

Study Background

Science, Technology, Engineering, and Mathematics (STEM) play important roles in the United States educational reforms and global economy [1]. The U.S. considers STEM education as a national priority to strengthen the political, social, and economic positions [2]. However, gender discrepancies have been found in many STEM fields [3]. Studies have shown that adolescent girls express less interest in STEM subjects and STEM-related careers than adolescent boys during the middle school and high school years [4]. When it comes to career choices, women are underrepresented in many STEM-related careers, such as engineering, manufacturing, construction technology, aviation technology, and automotive technology [5]. Moreover, Latinos, as the largest ethnic or racial minority group in the United States, suffer from a greater gender gap in STEM careers (more men than women) compared with Asians and African Americans [6], [7]. These gender gaps in STEM interest and STEM-related careers signal the need for broadening the participation of women and students of color in STEM fields [8].

There is mounting evidence of the impact of STEM enrichment programs on changing students' attitudes toward STEM subjects, stimulating the interests of K-12 students, influencing students' self-efficacy, improving retention for STEM in schools, and expanding students' sense of STEM career options [9]- [14]. In recent years, a growing number of educators have added Art to STEM to turn it into STEAM. Many STEAM interventions have also effectively increased students' interest and access to STEM in the United States [15]. The informal learning experiences from STEM and STEAM programs are often great ways for students to connect meanings with scientific experiments and concepts for which there is not enough time during the school year. Additionally, project-based and problem-based learning approaches are creating new learning environments to actively engage students in the STEAM learning process [48].

Targeting Underrepresented Students for STEM

The middle grades are essential, formative, and transactional years to developing interests in STEM fields, preparing a fast-changing future, and learning foundation skills for future successful STEM-related careers [2], [16]. However, formal school STEM education in middle grades faced several challenges to engage students in STEM-related fields. On the one hand, the prevalence of standardized testing and imbalanced curricula may cause the disengagement of middle school students in STEM study. The emphasis that schools place on standardized testing may cause the reduction of hands-on laboratory time in formal middle schools' curricula [20]. As Kager [21] described, students are often the passive learners in a school classroom, where they learn on their own rather than learning through conversations among peers. Most of the time, students are given made-up problems and forced to solve the problems instead of learning through practicing real-world knowledge. On the other hand, middle school education highly emphasizes mathematics and science (e.g., geoscience, physics, chemistry, biology) which lack the integration and connection with other subjects [22], [23], [24]. Engineering and technology education do not get enough attention in many middle schools. This situation is especially worse in the Title I schools that have high percentages of students from low-income families and a high ratio of at risk students [25].

Compared to boys, the attitudes toward STEM subjects for middle-school aged girls become more negative between seventh and ninth grades, and decline at a more rapid pace [17]. The existing gender gap in the attitudes and interests of girls may affect their performance in STEM study and their lifestyle choices associated with important life phases [18]. When it comes to career interest, females are less interested in STEM subjects and careers overall than males. While, male present more interest and confidence in scientific abilities and ultimate decision to pursue scientific careers (Dare et al., 2015; Levine, 2015; Sadler, Sonnert, Hazari, & Tai, 2012). The gender gap remains for female's career choices in many STEM fields, such as engineering, manufacturing, construction technology, aviation technology, and automotive technology (Hagedorn & Purnamasari, 2012). Hence, researchers believe middle school years are an appropriate time to intervene for girls to pursue advanced studies and careers in STEM-related fields [17], [18], [19]. It is also important to inspire students of color, females, and students from low socioeconomic backgrounds to learn STEM [26]. Broadening the participation of underrepresented student populations is a major concern that relates to STEM as a whole (Wade-Shepherd, 2016).

Providing Informal and Student-Centered Learning Experiences

In STEM education, it is essential for students to connect the "school" science to practical science and understand the importance of science to their lives, which in turn may raise their attitudes toward and interests in STEM subjects. Informal STEM learning experiences have the benefits of heightening students' curiosities, connecting school science to the real world, and encouraging students to gain a sense of ownership over their learning [27]. Compared to formal learning, informal learning shifts the learning from the teacher to the student and provides students more learning choices [28], [29]. Furthermore, educators are attempting to change students' attitudes by engaging them in student-centered learning approaches to STEM learning [48]. For example, project-based learning has a strong hands-on component that students have more opportunities to build, design, and create products with their hands. Problem-based learning focus on having students to work together to figure out the solutions.

In recent years, many STEM enrichment programs have been designed in an informal learning environment and utilized student-centered learning approaches to supplement education and STEM academies [30]. Such STEM learning experiences provide more learning opportunities and connect meanings with scientific experiments and concepts, which are viewed as great ways to address the limitations of the formal school experience [26]. Usually, the traditional approaches to science learning stress the learning of facts, concepts, and theories. In contrast to traditional approaches, the informal learning from STEM intervention programs provide enrichment activities and opportunities for students [2]. Many students who struggle in the classroom have their first moment of success in STEM subjects in an out-of-school activity [30]. Denson [31] states that engineering-focused informal learning environments promote students' awareness of engineering, provide academic enrichment with competent instructors, and engage students' participation. Student-centered learning also encourages students to become motivated self-directed learners [48].

Factors that Influence Middle School Girls' Attitudes toward STEM

Studies have shown that girls' attitudes and perceptions toward STEM are affected by their feeling of fit in science, experience, role models, and self-efficacy [17], [26]. O'Brien et al. [17] found that a sense of fit is an important factor in female intentions to continue in the mathematics fields and achieve success in STEM fields. Students can increase interests in pursuing STEM careers by developing positive or enthusiastic feelings of fitting and belonging in science. Furthermore, students' academic and social experiences are also important. During the middle school years, students are especially impacted by peers, but many of them are embarrassed and shy to expose their thinking to others [26]. The learning experience from formal education is taught in a solitary form, while the informal learning experience from various programs are often great ways to increase students' self-efficacy and excitement about STEM subjects [32], [33]. Moreover, in the learning process, observing others is useful for people to gain knowledge, rules, skills, attitudes, and beliefs [34]. Having female role models plays an important role in keeping middle school girls' interests in STEM fields. By providing tangible information, female role models represent women succeeding in science [35].

From a social cognitive perspective, students' attitudes and intrinsic interests are related to students' perceived self-efficacy rather than actual ability [36]. This finding explains the reasons why many girls lose interest in STEM even though they do not lack STEM abilities. Girls lack the belief that they are capable of attaining STEM goals, which leads to decreased interest in pursuing STEM subjects and lower perceived self-efficacy in STEM careers [37], [38]. Thus, developing students' positive self-efficacy beliefs is a significant factor to facilitate students' success in STEM [39].

Situated Learning Theory as Theoretical Framework

In this study, situated learning theory was used as the theoretical framework to examine the influences of participating in an informal learning experience on students' attitudes toward STEM learning. Situated learning theory as a part of experiential learning emphasizes the roles of the environment on people's ways of knowing and learning [40]. In this view, learning is anchored in the situation in which the experience is occurring and not in the individual [41]. Knowledge is obtained through social processes situated in specific contexts [2].

From the situated perspective, authentic activity is important for learners, because "it is the only way they gain access to the standpoint that enables practitioners to act meaningfully and purposefully (p.36)" [42]. As result of participating in authentic activity, learners have opportunities to acquire and apply knowledge, gain experiences, and practice skills [26], [42]. Understanding the application of knowledge and skills is as important as learning the knowledge and skills itself [43]. When learning occurs from meaningful participation in the community, learners are able to develop a deeper understanding of content [25], reconstruct their experiences, transform obtained knowledge, and connect real-world application [2].

Researchers have applied situated learning theory into the design of STEM interventions. The results of a study by Kwon [44] indicated that hands-on experiences are important to encourage interests and enthusiasm toward STEM learning. Students express higher enthusiasm to explore mathematical concepts with real-world solutions. Similarly, Ogle et al. [45] recruited middle school girls from underserved districts and integrated fashion into the STEM program to ignite students' curiosity about STEM fields. The results showed positive influences on girls' self-efficacy in math and science, while the learning experience may foster future educational interest and achievement in the STEM fields. By applying situated learning theory, students in these programs worked in groups, engaged with peers and instructors, and worked through real-life challenges [2]. In this study, situated learning is used to explore the connections between the informal learning environment and STEM study, especially to study the influences of hands-on activities on middle school girls' attitudes toward STEM.

Methods

The purpose of this research was to explore the influence of a two-week STEAM summer camp on middle school girls' STEM learning, attitudes toward STEM, and career interests. The study used a mixed explanatory sequential design to address the following research questions:

RQ1: Are there any statistical differences between pre- and post- survey scores on attitudes toward mathematics, science, and engineering and technology?

RQ2: How does the learning experience of participating in a STEAM summer camp impact middle school girls' attitudes toward STEM learning and STEM-related career interests?

Description of miniGEMS STEAM Summer Camp

The miniGEMS STEAM camp has been launched at UIW since 2015 [49], [50]. The camp targeted middle school girls from Title I public schools who spent two-weeks in a summer-camp setting. The camp focused on attracting underrepresented populations and providing robotics and programming learning experiences. The mission of the camp is to introduce more females into STEM fields, especially into the engineering field.

In summer 2018, four two-week miniGEMS STEAM camps were hosted at the University of the Incarnate Word for a total of eight weeks. Students learned STEAM concepts through well-rounded hands-on activities and team projects. Robotics provided an engaging platform for students to learn, build, explore, and communicate with peers to develop their programming and problem-solving skills [26]. The camp also gave the students an opportunity to explore the different careers in the STEAM fields and to be creative with engineering and structural design.

In the first week, the students started off the camp with team building activities. Then, they had an introduction to structural principles by designing and building a structure using K'nex kits to withstand a shaker table simulating an earthquake. On the fourth day, students were introduced to EV3 robots, learning how to program and code. They programed the robots to go through a maze using the EV3 software and MATLAB. To close the first week, the students learned to create a 3D image on the computer using gaming software with the Geek Bus and practiced their skills by designing their own video game.

The second week of the camp involved meteorology, nutrition, music record, computer programming, and working with the EV3s. The students began the week by visiting a meteorology weather lab. Then, they studied the importance of healthy eating while making whole wheat dough for their chicken and vegetable pizzas. The students continued learning how to program and code using MATLAB and worked with their EV3s. They were put into teams and had a sumo wrestling EV3 competition where the goal was to push the opponents EV3 out of the boundary or flip it over. Music activities, such as learning how to record and produce the music were connected with other STEM activities.

Participants and Demographic Information

There were a total of 108 middle school girls participating in the miniGEMS STEAM summer camp. Of them, 100 students who completed both pre- and post- surveys, but 92 survey responses were used in the final analysis. These 92 participants consisted of camp 1 (23.9%), camp 2 (21.7%), camp 3 (23.9%), and camp 4 (30.4%). According to students' self-identified data, students' ethnic backgrounds consisted of White (4.8%), Hispanic/Latino (85.6%), African-American (6%), Native American (1.2%), and Asian (2.4%). The mean of their age was 11.80 years old. Students were going to 6^{th} grade (40.2%), 7^{th} grade (31.5%), 8^{th} grade (28.3%) during the summer. Additionally, the researchers randomly selected one or two students from each group/table in camp 1 to 4. A total of 22 students presented their groups/tables to conduct in-depth interviews with us on the last day of each camp. Of the 22 interviewees, six were from camp 1, seven were from camp 2, five were from camp 3, and four were from camp 4. All students and their guardians were required to sign consent letters.

Instruments

The instrument used in this study was the Middle/High School Student Attitudes toward STEM (S-STEM) survey. This instrument was a useful tool in the evaluations of the university's outreach projects and K-12 STEM initiative [46]. The researchers adapted the S-STEM into a 26-item assessment, covering three subscales: attitudes toward mathematics (8 items), attitudes toward science (9 items), and attitudes toward engineering and technology (9 items). All three subscales used a five-point Likert scale (5=Strongly Agree, 4=Agree, 3=neutral, 2=Disagree, 1=Strongly Disagree). The details of the design and validation of the S-STEM are reported by the Friday Institute [45]. A permission to use the survey was obtained from the Friday Institute.

The internal consistency of the three survey subscales was evaluated using a Cronbach alpha coefficient. Table 1 presents the calculated coefficient alpha for the three subscales in pre- and post- test. As can be seen, there are high internal consistency for all three scales.

Table 1 Reliability of Survey Instrument

		Cronbach's alpha	
Scales	# of Items	Pre-test	Post-test
Attitudes toward Mathematics	8	.872	.876
Attitudes toward Science	9	.803	.855
Attitudes toward Engineering and Technology	9	.836	.833

Data Collection Procedure

Quantitative. On the first day of each camp, prior to participating in any activities, students voluntarily completed the pretest and included their name or nickname on the survey. On the last day of each camp, after participating in all activities, students completed a posttest. Students were pre- and post-tested to measure their attitudes toward mathematics, science, and engineering and technology.

Qualitative. On the last day of each camp, student participants, for which we had IRB approval, participated in a semi-structured interview lasting approximately 10 minutes. All interviews were audio-taped. The purpose of the interview was to explore students' learning experiences in the summer camp, and how those experiences influenced their attitudes toward STEM study and career choices. The interview protocol was designed by the researchers and reviewed by two professors from the University of the Incarnate Word, who helped to validate the interview questions (see Table 2 for the interview protocol).

Data Analysis

Quantitative. Survey data were analyzed using the SPSS software. To answer RQ1, we used a paired sample t-test to compare the significant differences between pre- and posttest scores. The researchers used individual's mean to replace the 12 missing data in total.

Qualitative. The transcripts of interviews were imported into the Dedoose software. In order to increase the reliability of the interview data, two graduate students from the University of the Incarnate Word worked together to transfer the audio recordings into transcripts. For the purposes of decreasing bias, two graduate students independently coded all transcripts, compared the themes, and made coding consensus. The grounded theory coding approach was used to analyze interview transcripts [47]. Open coding assigned any possible codes and themes related to the camp experiences. Then, axial coding categorized themes from transcripts into subcategories. Finally, selective codes focused on reporting critical characteristics of attitudes towards STEM learning and careers development, especially toward STEM fields. To protect all participants, the study used pseudonym to present the results.

Table 2 Student Interview Protocol

Number	Questions
1	What does STEM mean to you?
2	What do you think about your STEM abilities?
3	Why did you decide to attend this summer camp?
4	What do you want to be when you grow up? Why?
5	How did this camp differ from formal school learning? What do you think about the girl-only learning environment in this camp?
6	What have you enjoyed about this camp? Why?
7	In what ways was this camp preparing you for your classes and future study, especially for STEM subjects?
8	In what ways was this camp preparing you for your future careers, especially for STEM-related careers?
9	In what ways was this camp changing your attitudes toward STEM study and STEM-related careers?
10	Would you like to attend this camp again next year? Why? Do you have any suggestions?

Results and Discussion

The researchers used a mixed explanatory sequential design to collect and integrate quantitative and qualitative data. In this study, the quantitative data was built first, while the qualitative data was followed by the quantitative and explained the results of the quantitative data. By utilizing this research design, the researchers had a more comprehensive understanding of the influences of participating in miniGEMS on middle school girls' attitudes toward STEM learning and STEM-related career interests.

Quantitative Findings

To answer the RQ1, paired sample t-tests were used to compare pre- and post- test scores, including three scales: attitudes toward mathematics (8 items), attitudes toward science (9 items), and attitudes toward engineering and technology (9 items). Table 3 displays the mean scores of pre- and post- test scores, along with results from pair-t tests comparing the pre- and posttest scores. Students' pre- and posttest scores revealed a statistically significant increase in students' attitudes toward mathematics (t (7) =-6.37, *p*<.001). However, attitudes toward science (t (8) =-.822, *p*>0.05), attitudes toward engineering and technology (t (8) = 0.97, *p*>0.05) were not statistically significant. Even though there were no statistical differences in attitudes toward science and engineering and technology, the mean differences in these two scales were slight.

Table 3 Camp 1-4 Pre- and Posttest Scores

Pre and Posttest pairs (scales)	N	Pretest M	Posttest M	Mean Difference	St. D Difference	t	df	Sig (2-tailed)
Mathematics	92	3.66	3.78	-.12	.05	-6.37	7	*.000
Science	92	3.74	3.78	-.04	.12	-.822	8	.435
Engineering and Technology	92	3.78	3.78	.001	.09	.04	8	.972

* Significant at *p*<0.05

Furthermore, the researchers utilized a paired t-test to explore the statistical differences in each question. As can be seen in Table 4, the statistically difference was found in the scale of mathematics attitudes. The pre- and posttest scores revealed a statistically significant increase on the question 2 "I would consider choosing a career that uses math" (t (91) =-2.103, *p*=0.038). There was no statistical significance on any questions from the scales of attitudes toward science and attitudes toward engineering and technology.

A mixed between-within ANOVA was conducted to assess the differences between four camps on participants' scores on question 2 "I would consider choosing a career that uses math" between two time periods (pretest and posttest). As showed in Figure 1, there was a significantly interaction between pre- and posttest scores on camp 1 to 4, Wilks' Lambda = .86, F (3, 88) =4.912, *p*=.003. By splitting two time periods (pre and posttest), one-way ANOVA was conducted to compare the differences between four camps on two times periods. The results showed there is significant differences between four camps on pretest scores (F (3,88) = 3.839, *p*=.012). However, there was not a significant effect of four camps on posttest scores (F (3, 88) = .917, *p*>0.05). By splitting four camps, a paired t-test was conducted to compare camp 1-4 in two times periods. There was a significant difference in the scores for pretest (M=2.91, SD=.921) and posttest (M=3.45, SD=.858) in camp 3 (t (21) =-2.53, *p*=.019). There was also a significant difference in the scores for pretest (M=2.86, SD=1.05) and posttest (M=3.32, SD=.863) in camp 4 (t (21) =-3.10, *p*=.004).

Table 4 Camp 1-4 Attitudes toward Mathematics

Questions	Pretest M	Posttest M	St. D	t	df	P
Math has been my worst subject in school	3.78	3.89	.063	-1.734	91	.086
I would consider choosing a career that uses math	3.18	3.38	.093	-2.103	91	*.038
Math is hard for me	3.51	3.65	.095	-1.491	91	.139
I am the type of student to do well in math	3.67	3.80	.108	-1.203	91	.232
I can handle most subjects well, but I cannot do a good job with math.	3.71	3.79	.099	-.882	91	.380
I am sure I could do advanced work in math	3.46	3.62	.096	-1.705	91	.092
I am get good grades in math	4.23	4.25	.093	-.234	91	.815
I am good at math	3.74	3.87	.092	-1.422	91	.158

* Significant at $p<0.05$

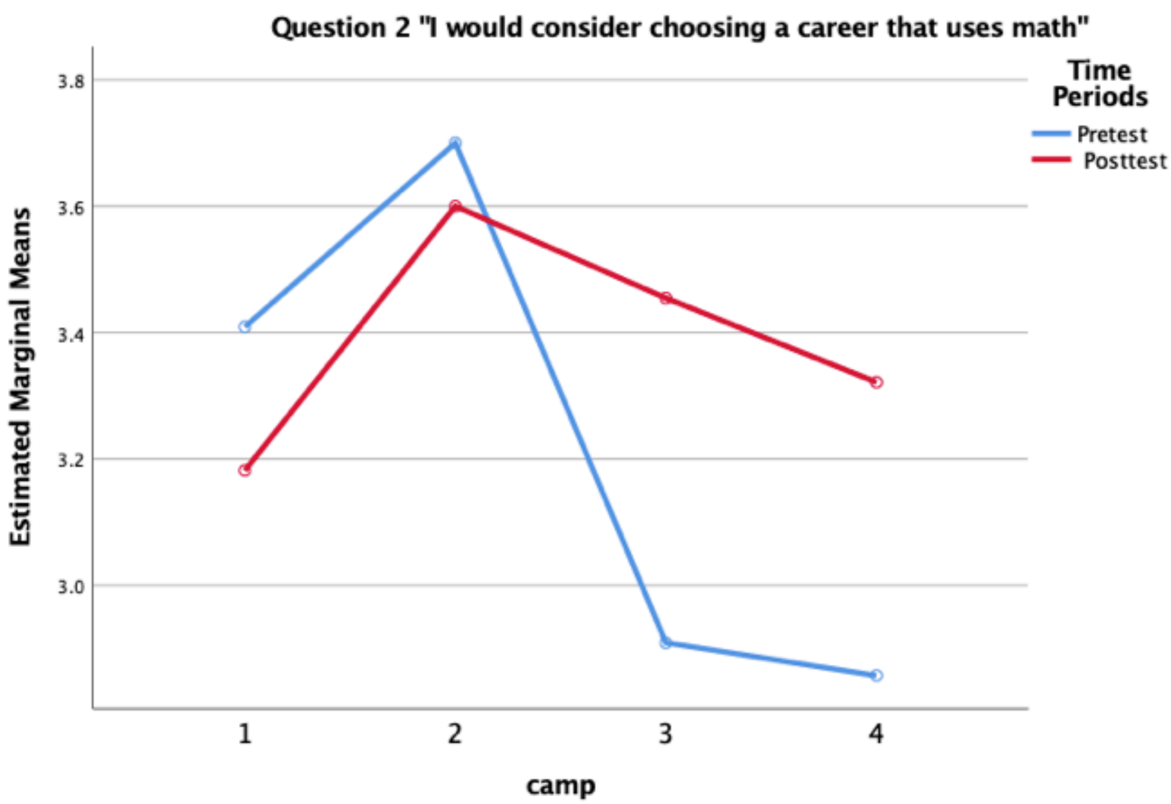

Figure 1 Estimated Marginal Means of Question 2 in Math Scale

Qualitative Findings

In the qualitative part, we focused on exploring the influences of participating in miniGEMS summer camp on participants' attitudes toward STEM study and career interests. The qualitative findings presented participants' purposes to participate in the camp, understandings of STEM, attitudes toward STEM after the two-week intervention, and career interests. Interview findings indicated three key concepts: (1) campers had opportunities to develop STEM, robotics, and programming knowledge through various hands-on activities which made the camp fun and interesting; (2) the cooperative and single-gender learning environments helped campers become more open to STEM subjects; and (3) coding and programming were two major themes in miniGEMS that affect campers' career choices and future studies.

Purposes and Learning in miniGEMS. Students decided to participate in the camp, because they were interested in engineering and programming. They had the purposes of learning more things during the summer. Nola explained, "because I want to learn something new. I want to try it because I have never been to one [STEM camp]. It is pretty nice and I was interested about engineering, science, and math." Monica also stated, "I didn't know what STEM or STEAM was before I came here. That is what I am looking for in learning." Students were also motivated by the interesting learning environment and the opportunities to work with projects and other girls. Cabell explained, "I want to be a scientist. I found this camp would help my future. It will help me to learn more about science. It is a big opportunity that most of girls don't get this chance."

During the two weeks, students were able to learn many STEM contents, such as STEM-related careers, nutrition, programming, and game design. Lucy stated, "I learned how to program. I learned how to build, be more creative, how to eat healthy, how to be healthy." They also practiced and improved their coding and programming skills through working with EV3 robots. For example, Kacie and Vida participated in the miniGEMS summer camp last year. They realized that they continued learning new things and were getting better with coding than last year. Furthermore, facilitators in the camp provided students more access to learn, encouraged students to participate in activities, and boosted students' confidences. As expressed by Lucy, "I like the teachers a lot. Because they told us you could do this, you could do that, you could do it again. Really boost my confidence."

Informal and Experiential Learning Experiences. Students realized that the learning experience in the miniGEMS camp was different from formal school learning. The camp was more fun than the schools. As indicated by students, they usually stayed in one classroom, repeated similar things, and did independent works in schools. But in the miniGEMS summer camp, they felt less stresses, received extra help from facilitators, met new friends, and completed work in groups. More importantly, the camp included more hands-on experience which the schools usually did not provide. Students expressed that they were able to connect the concepts to the application through doing various authentic activities. For example, Anna stated, "I like miniGEMS a lot more than schools. Because you can come to see the garden, do a lot of fun activities, and play games. While, at school, we only do work and do PE and Lab something." Additionally, there were some examples to show students' perspectives of hands-on activities. Monica explained, "I think that one [earthquake stimulate tables] helped a lot with STEM concepts, because knowing what is the structure, what you need for your base is how to make the top." Juliet descripted an experiment which helped her understand healthy choices, "they [facilitators] showed us a soda thing. We [students] thought it is healthy, but actually there are some unhealthy things there. But we do not know. It really made me think about healthy food."

Robotics was a platform that gave students opportunities to communicate and solve problems together. Juliet believed the EV3 brought the team members together and made the group start working together. Then, she described the teamwork in her group, "I finished the task by working as team. They build, then I programed. So it is kind of easy for us." In this process, students' communication skills had been improved that they became more open to talk with others. For example, after participating in the camp, Kacie realized she talked to more people and felt more comfortable to talk with group members than before.

Students were not only able to apply the concepts to problem-solving, but also would be able to use the knowledge they gained from the camp in their school classes, the development of STEM competencies, and future careers. For example, Mia realized she could apply the programming and coding in her math class, because the programming is the math stuff. Lily also stated, "It [miniGEMS] helped me study a lot. It can help if I want to be any of these engineers."

Influences on Attitudes towards STEM. It is important to understand students' perspectives of learning STEM subjects. As they expressed, math was a big challenge for them, because it was related to science, engineering, and other STEM subjects. The concepts and problems in math (e.g. algebra and fractions) were difficult to understand and were less interesting than other subjects. While, in science learning, students had troubles to comprehend the concepts, integrate the knowledge, and solve complicated problems. However, students believed their capabilities to get good grades and push forward in math and science learning.

After participating in two-weeks STEAM camp, students indicated the cooperative learning environment was an important factor which impacted their attitudes toward STEM study. Monica explained, "meeting new people, learning about them, working with them as a group, I am more open to the things I learned in the camp." Similarly, Ella indicated how her attitudes changed:

> "At the beginning, everything I was kind of nervous in my shell. I did not want get out of my shell. Then, I got to learn about other people and meet other people. So I opened up more and more each day. There is an attitude change. We got more competitors throughout the day which was really fun but still really stressful. Because it is like I want to get it done, get it done. Especially when we are doing mazes, that is really stressful. All of the teammates want to get it done. But not everyone knows how to do it. So you have to slow down and explain to them."

In cooperative learning, students had different teamwork experiences. Students expressed teamwork is a good way to learn from each other, meet new friends, and correct themselves. In an effective team, students leaned their weaknesses and strengths and put efforts together which made them finish work more quickly and efficiently. In this situation, students believed the camp was very interesting and engaging. They could also be able to work the way engineers do. One example from Cabell explained, "I love how in every project we do it together. We are taught that being an engineer you cannot be doing things alone. You need everybody's idea to help you do it." However, a team did not work well when girls had negative attitudes, strong independent personalities, and felt stressed. In these situations, when students gained more experience, they preferred to work independently. Students who did a better job in EV3s guided other members and had authorities to assign tasks to others. For example, Kacie argued, “sometimes guiding them [group members], sometimes they won’t do anything. Sometimes we do things. It depends. But most of time, I want to do it by myself.”

Furthermore, students realized that gender differences exist in school STEM education that boys tend to perform better than girls and have a high interest in engineering, programming, and coding. So, girls often have limited access and opportunities to learn engineering in schools. However, participants in the miniGEMS camp were all girls. Students stated all-girls learning is less distracting and less tense, so they could be able to focus on the learning itself and communicate more with other girls. The single-gender learning allowed girls to ignore the gender differences (i.e. boys’ negative behaviors), behave more relaxed (i.e. speak louder), and build a sense of “fitting in” in STEM subjects (i.e. express more on robotics and engineering topics). For example, Vida stated, “because there are not many girls in the engineering. Guys already know a lot about coding. In classes, they are already on the girls. They do not have many things for girls.” Similarly, Mary also indicated her perspectives of single-gender learning on STEM learning.

> “Usually people think robotics is only for guys. I like all girls here. Nobody can stop me from putting me in hands-on programming. In my school, usually the guys do it. Sometimes I am the only girl who does the robotics. It is good for girls in robotics and engineering.”

Influences on Career Interests. Among 22 interviewees, 16 girls had an idea of their career interest. The majority of these career aspirations were related to STEM fields, such as cyber engineer, scientist, technician who deal with data, video designer, and doctor. Students’ career aspirations were influenced by their personal interests, family, social status, and school and camp learning experiences. For instance, Monica expressed “my mom worked in the medical field. I usually played with her. It was interesting to me, like the human body, all of the cells, muscles, bones.”

Participating in the camp helped students develop career competences. The learning in the camp provided science knowledge, information about careers (i.e. occupational categories; income of STEM-related careers), and chances to practice skills related to careers in STEM fields. Furthermore, the camp experience also helped students identify a career path. For instance, Lucy stated, “the learning here really helped me with data. I learned some technology stuffs. I know STEM and data are different. I want to go to data, because I feel like working on data is more advanced.” Moreover, coding and programming were two major themes that affected campers’ career choices and future studies. An example from Kacie, “I think they mentioned something that these [STEM-related] jobs pay well. I am also interested in. So I may choose a career that involves the coding and programming.” Mary described as, “I want to do programming when I grow up. So this [camp] applies a lot.”

In addition, some non-STEM career aspirations occurred after participating in the miniGEMS. These non-STEM ideas mainly came from kitchen, music, graphic design and other non-STEM activities. For example, Diana expressed her preference to teach in the future by saying, “I can apply the teaching here, like how to teach miniGEMS. Because I think this is really fun. I can challenge others.” Cabell showed her interest in being a YouTuber and she said, “coming here could help me find my place. I want to be a YouTuber when I grow up. I think if I become a YouTuber, it [camp learning] could help to edit videos.”

Conclusion

The miniGEMS STEAM summer camp created an informal learning environment and provided students, particularly underrepresented middle school girls, opportunities to learn STEM contents and music, work with group projects, and connect knowledge to problem-solving through various authentic hands-on activities. By integrating the qualitative and quantitative data, the researchers found the STEM summer camp learning experience had positive influences on students' attitudes toward STEM learning, increased students' interests in STEM-related careers, and the benefits of participating in this camp also extended to students' advanced studies in STEM fields. Specifically, the camp learning experience had an impact on changing students' attitudes toward math and increasing students' interests in engineering, math, and programming careers. The use of project-based learning in the camp allowed students to connect knowledge to real-world problems and understand the needs of STEM in real life. As a result, students had a more comprehensive understanding of how math, science, engineering, and technology were applied in the calculations that students used in MATLAB and the programming, in engineering design and related careers, in robotics competitions, in video and game design, and in gardening and nutrition.

Students revealed that the access to authentic activities, the cooperative learning, and the opportunities of interacting with all-girls were three important components of their informal learning experience in the miniGEMS summer camp. These components were essential to make the camp more fun and engaging than formal schools. Because of the prevalence of standardized testing and budget cuts in Title I public schools, students often have limited accesses to STEM activities in authentic settings and learn through practicing real-world knowledge [21]. Kager [21] indicated the result of lacking hands-on experiences was a disconnection between the school learning and real-world application. In the miniGEMS camp, the curriculum addressed the limitations of formal school learning and included more hands-on experiences which the schools usually did not provide. As students expressed, they were able to connect the concepts to the application through doing various authentic activities. Furthermore, girls realized the existence of gender differences in STEM studies; that boys tend to perform better and have a higher interest in STEM-related subjects. This perspective affects girls' motivation and self-efficacy to participate in STEM-related activities in schools. The miniGEMS camp was designed for girls only and provided opportunities to cooperate with other girls. This all-girls learning environment helped campers become more open to STEM subjects. As the students' own comments showed, they could be able to focus on the learning itself and communicate more with other girls in the camp. Thus, miniGEMS camp offers a great chance for middle school girls to become more involved in STEM activities and concepts.

Suggestions for Future Research

This study showed middle school girls' perspectives of how participating in a two-week STEAM summer camp influenced their attitudes toward STEM, career interests, and advanced studies in STEM. The findings of this research can be useful for designing authentic activities and providing informal learning experiences for middle school girls. However, this study had a limited number of interviewees which was limited to the students who were present on the last day of the camp. Both survey and interview collected participants' self-reporting data which relied on respondents' own report of their beliefs and attitudes. Hence, a further study of this research will be necessary to include a broader selection of data sources and include perspectives from teachers, facilitators, and parents to confirm students' attitudes toward STEM and beliefs of choosing STEM-related careers.

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