JOURNAL of STEM OUTREACH

Vol. 6, Issue 1, May 2023

# Empowering High School Girls in a University-Led STEM Summer Camp

**Molly Nation[1*] and Joanne Muller[2]**

*[1]Department of Ecology and Environmental Studies and [2]Department of Marine and Earth Sciences, Florida Gulf Coast University, Fort Myers, FL;*

**Corresponding author*

Keywords: STEM Education, Girls, High School, Experiential Learning, Engaged University, Education Programme Evaluation

Publication Date: May 11, 2023

DOI: https://doi.org/10.15695/jstem/v6i1.09

**ABSTRACT:** Women are less likely to choose STEM educational programs, hold STEM degrees, or enter the STEM labor force. Several factors contribute to this including intrinsic psychological factors, external environmental variables, academic mindsets, and STEM attitudes. This paper discusses a 10-day long STEM camp aimed at engaging high school girls in authentic field-based environmental research. The goal of the camp is to foster and encourage interest in STEM fields through hands-on laboratory experiences, discussions with female scientists, field trips, and a broad range of research-focused authentic scientific activities. The descriptive research study used observational qualitative and quantitative data to better understand and improve the future of informal STEM experiences for high school-aged girls. Results of the study found that girls were more likely to see themselves in STEM fields; exposure to authentic scientific research, hands-on fieldwork, and final research presentations promoted self-efficacy and confidence in their ability to undertake university-level research. Finally, the camp provided a place to engage with other females through academic and social collaboration.

## INTRODUCTION

Preparing students for careers in science, technology, engineering, and mathematics (STEM) is of significant importance to future workforce demands within the United States (Sadler et al., 2012). Both the National Research Council (NRC) and the President's Committee of Advisors on Science and Technology (PCAST) highlight this issue and offer guidance on how future STEM workforce demand might be accommodated (NRC, 2010). In order to tackle the "grand challenges" that face us in the future, such as clean energy, stewardship of natural resources, and advances in medicine, there must be an increase in the number of students pursuing careers in STEM (Obama, 2009).

Women remain an underrepresented minority in STEM fields (Beede et al., 2011). In 2015, women constituted only 28% of workers in STEM occupations, although they accounted for 50% of the college-educated workforce overall (National Science Foundation, 2018). The greatest disparities are seen in engineering, computer science, and the physical sciences. For example, examination of the National Survey College Graduates (NSCG) data reveals that since 2010, the percentage of women working as geoscientists has remained relatively steady near 25%. Less than 20% of women with terminal geoscience degrees work in the geosciences and since 2010, the percentage of women with geoscience degrees working as geoscientists declined from 17% to 11% in 2017 (Gonzales, 2019).

Pursuit of STEM careers is often decided prior to high school (Tai et al., 2006). That said, high school remains an important time in which students become aware of and interested in STEM careers, and begin to seriously consider pursuing certain career choices (Hall et al., 2011; Kitchen et al., 2018; Sadler et al., 2012). Research suggests a need for increased university/college partnerships with local K–12 counterparts, as these partnerships serve as highly effective tools to strengthen and diversify STEM pathways (Constan and Spicer, 2015; Eeds et al., 2014; President's Council of Advisors on Science and Technology [PCAST], 2012). The University-led 10-day program was designed to help increase interest in STEM disciplines among underrepresented groups, increase exposure to a variety of STEM fields, and increase high school aged females' interest in STEM fields and their perceived self-efficacy about their ability to participate in authentic scientific research.

**What Drives Gender Disparities in STEM?** Theories focusing on the development of gender roles suggest at different stages of life, people perceive certain roles to be more or less appropriate for their gender (Martin and Halverson, 1981). A review of over 400 studies on the possible causes of women's underrepresentation in STEM points to issues such as exposure to research opportunities, gatekeeping tests, and stereotype threat (Ceci et al., 2009). A lack of females in STEM positions may signal to women that they lack the skills necessary to be successful in those domains, leading women or girls to avoid certain academic or high-status fields due to psychological barriers created by these stereotypes (Eagly et al., 2000).

Reasons for gender disparities in childhood and adolescence differ from those in emerging adulthood or early-to-middle adulthood. Three decades of research on gender disparities in STEM have produced the "leaky pipeline" metaphor, in which girls and women leave STEM at every key joint (Diekman et al., 2015). The "joints" represent childhood, high school, college, graduate school, STEM professions, and STEM leadership positions. Research finds that boys receive more encouragement than girls to get involved in STEM as children and are more likely to be active in STEM activities in high school, pursue STEM degrees in college, enter a STEM profession, stay in a STEM profession, and are more likely to advance to leadership positions within STEM (Diekman, et al., 2015; Preston, 2004).

The leaky pipeline starts early. From middle school through college, female students perform worse on science and mathematics tests compared with male peers and report less confidence and aspiration (Else-Quest et al., 2010). Gender gaps in science and math performance have been closing, but gaps in STEM aspirations remain large. Even when girls and women perform as well, or better than their male peers on STEM tests, many lose interest and do not pursue advanced courses, majors, and careers in STEM. This leads to an exodus of girls and women from STEM (Dasgupta, 2011). Thus, interventions aimed at closing the gender gap need to target multiple time points in the developmental trajectory.

One key part of this pipeline occurs during high school years where boys consistently demonstrate more interest in STEM than girls. High school is a crucial time in the STEM pipeline as it is the first-time students have the choice of opting into, or out of, STEM classes and extracurricular activities (Riegle-Crumb et al., 2012). During this time significant differences emerge between teen boys and girls with respect to interest in, and engagement with, STEM courses and activities (Sadler et al., 2012). For example, interest in STEM careers remains stable for boys throughout high school (39.5% for first- year students compared to 39.7% for seniors), but for girls it starts at a much lower level and declines during high school (15.7% for first-year students compared to 12.7% for seniors) (Sadler et al., 2012). These formative years are crucial for providing opportunities and engagement in STEM experiences particularly for girls.

Decreased funding of STEM programs has led to a lack of formal field-based science experiences within the public schools (Executive Office of the President, 2010; Gonzalez, 2012). Formal science curriculum is increasingly focused on standardized testing, which can decrease opportunities for students to explore all aspects of the STEM fields (Hammack and High, 2014; Strauss, 2012). Hall et al. (2011) found the greatest influence on high school and college students' career choice was information provided by teachers, school counselors, and their parents. Therefore, information regarding STEM college majors and career choices is limited to those sources. Outreach activities are needed to give girls access to more information regarding their choices in college and the STEM career field and universities are in a unique position to be able to do so. Promoting girls' interest in STEM through valuable field-based experiences can utilize the resources and expertise found on college campuses to leverage these experiences (Heise et al., 2020).

**Self-Efficacy of Girls in STEM.** Negative stereotypes, lower self-assessments of STEM-related abilities and performance in STEM tasks are found among females and other underrepresented students (Hill, 2010). However, STEM self-efficacy among women and underrepresented groups increased through positive interactions and learning experiences (Leslie et al., 1998; Stout et al., 2011). Differences in self-efficacy beliefs, particularly among adolescent girls and other underrepresented students suggest development needs in this area and can potentially benefit from carefully designed programs to improve STEM self-efficacy (Bell et al., 2009; Falco and Summers, 2019).

Informal STEM education provides optional STEM experiences that occur outside of normal school hours. These experiences do not focus on formal learning outcomes, rather emphasize hands-on learning with scientific process skills, involve science and laboratory practices, learning how to apply science content, and building an identity as STEM learners (Bell et al., 2009). In order for informal STEM experiences to positively impact girls' self-efficacy they must be optional and cumulative (Bell et al., 2009). Studies found that girls who participate in these types of STEM experiences benefit in terms of self-efficacy and competence (George et al., 2020; Pajares, 2002).

This study highlights the development of a university-led STEM camp for high school girls and presents the data collected over three consecutive years of the camp. The camp was developed using proven methodologies for engaging girls in STEM and targets the formative time period of high school. It also targets the field of environmental geosciences, a STEM area that currently sees significant disparities between men and women in the workforce (25% females) (Gonzalez et al., 2018).

**The STEM Summer Camp for High School Girls.** Valla and Williams (2012) have previously evaluated effectiveness of K-12 STEM interventions to maintain increases in STEM representations of women and ethnic minorities and found varying results among the wide variety of K-12 STEM interventions that exist. The following outlines the characteristics of effective programs and models of which students and families have reported opened both eyes and doors to postsecondary possibilities: (1) include individuals who monitor and guide students, as a group and individually, over an extended period of time; (2) offer high-quality instruction, more specifically through access to the most challenging courses; (3) make long-term investments in students rather than short-term interventions; (4) have sensitivity to the cultural back-grounds of students; (5) provide a peer group that supports students' academic aspirations as well as giving them social and emotional support; and (6) provide financial assistance (Gándara and Bial, 2001).

Per these guidelines, we developed a 10-day long STEM camp for high school girls in Southwest Florida aimed at engaging girls in authentic field-based environmental research. Key novel elements of our program were the inclusion of multiple field trips, hands-on laboratory experiences, discussions with female scientist role models, and a broader range of research-focused hands-on scientific activities, including investigation of environmental challenges of climate change on coastal communities and ecosystems.

The STEM Camp for High School Girls provides girls in grades 9-12 with an opportunity to conduct authentic field-based research with university researchers in a college laboratory setting at Florida Gulf Coast University in Southwest Florida. The program ran for 10 days over the summers of 2018 and 2019, and for five days over the Spring of 2021 (due to COVID-19 restrictions). The program focused on local climate change issues in particular those related to sea level rise and hurricanes. The first day focused on background project theory and some in-class laboratory activities that provided participants with background information to understand the research they would be undertaking. The following three days provided field research opportunities at Vester Marine and Environmental Science Research Field Station. The students were taken out on research vessels to collect data and samples for their laboratory work. The following six days were spent on campus undertaking laboratory analyses, compiling results and interpreting data within small groups. Each group was led by a faculty, undergraduate, or graduate student within the area of expertise (see Table 1). During this time, campers also got the opportunity to meet with female STEM faculty, learn about their on-going research, and understand the experience of a female in STEM through formal and informal lectures and discussions. The expertise of these faculty members represented a wide range of fields including engineering, mathematics, anthropology, and biology. On the final day students presented their projects in poster format to undergraduate and graduate students, faculty, and family and friends.

**Table 1.** *Day-to-day activities during the STEM Camp for High School Girls.*

| Monday (8:00-3:00) | Tuesday (8:00-3:00) | Wednesday (8:00-3:00) | Thursday (8:00-3:00) | Friday (8:00-3:00) |
|---|---|---|---|---|
| Background theory on science | Field day (Sediment coring; beach profiling) | Field day (Water collection & sampling) | Field day (Seagrass/ sand dollar monitoring; Shorebird monitoring) | On-campus Laboratory Analysis Female STEM Lecture |
| **Monday (8:00-3:00)** | **Tuesday (8:00-3:00)** | **Wednesday (8:00-3:00)** | **Thursday (8:00-3:00)** | **Friday (8:00-3:00)** |
| On-campus Laboratory Analysis Female STEM Lecture | On-campus Laboratory Analysis Female STEM Lecture | On-campus Laboratory Analysis Female STEM Lecture | Presentation Preparation with Research Group | Student Presentations |

The camp was funded by a local charitable organization, The Collaboratory, where education, especially for minority groups, is at the forefront of their cause. In an effort to reduce barriers to participation from underrepresented groups the camp was free to participants and bus transportation was provided to and from the camp, in addition lunch was provided to participants each day.

**The Goal of the Camp**. The primary goal of the camp was to foster and encourage the interests of high school girls in the STEM fields. We used the following action items to accomplish this goal:

1. **Community-Based Problems**: Informal STEM activities attract girls when the activities are communally oriented—that is, organized around real-world problems and helping people (Diekman et al., 2010). Placed-based education, grounded in student learn-

**Table 2.** *Climate and environmental change themes used during the camp. Girls were asked to pick from the below topics for their final projects.*

| | Geomorphology | Paleoclimatology | Water Quality | Biodiversity and Populations |
|---|---|---|---|---|
| Research, fieldwork, and laboratory skills used throughout the camp related to the topic. | Beach profiling, coastal erosion monitoring, GIS mapping, satellite imagery | Sediment coring, sedimentary analysis, microfossils | Water sampling, microplastics analysis, eutrophication | Shorebird nesting monitoring, seagrass monitoring, sand dollar monitoring |

ing of specific regional locations where the learning takes place, allows students to feel connected to their community (Smith, 2002). Our program focused on local climate change issues, in particular sea level rise and the impact of hurricanes on coastal ecosystems using environmental science research methods. Studies show that girls are more engaged in STEM if there are community-based problems at the forefront. In this context the participating girls learned content on an extremely important and timely topic for their coastal region.

2. **Teamwork**: Although the root of underrepresentation of women in STEM is still debated, most agree that early socialization and achievement experiences of women and girls have a positive impact on students' decisions to pursue and persist in careers in science and math throughout the STEM fields (Ceci and Williams, 2011). When extracurricular projects in STEM involve teamwork, girls are most eager and participatory in teams that have gender parity (50% girls) or a female majority and far less engaged in teams with female minorities (25% or less) (Dasgupta et al., 2015). The girls were divided into research teams, typically 2-4 girls per project. Each team had a scientific research question they were working to answer throughout the camp.

3. **Female Mentorship and Role Models**: Interventions that target the underrepresentation of women in certain occupations and academic fields often involve exposure to counterstereotypic role models (Olsson and Martiny, 2018). Gender-stereotypical beliefs, which are widespread beliefs about the attributes of men and women, are one of many factors that determine female achievement-related aspirations and choices (Heilman, 2001; Wigfield and Eccles, 2000). Other studies have found female students are also positively influenced by female role models in STEM (Dasgupta, 2011; Dasgupta et al., 2015; Stout et al., 2011). Extracurricular activities, such as the above-mentioned STEM camp, should involve female techs, engineers, and scientists, as their presence can illustrate to girls who they could become in the future (Dasgupta et al., 2015). All of the mentors taking leadership roles in the camp were female scientists, engineers, and undergraduate and graduate students from STEM programs. Most importantly, several layers of female mentorship were provided throughout this program. The lead research scientists were female and provided leadership and mentorship to the girls for the entirety of the camp. Furthermore, female STEM majors served as secondary leaders and mentors. This model also allowed the university students to gain skills and confidence in leadership. Finally, we invited female guest speakers from the university that represented other underrepresented STEM fields such as professors from engineering, math, chemistry, geology, and biology.

4. **University-led research partnership**: It has been shown that university-run high school summer programs have a positive impact on the STEM career aspirations of students (Kitchen et al., 2018). The participating girls were provided an opportunity to engage in authentic scientific field work and research. They were taken out on research vessels, mentored in field methodologies, and collected their own samples. Subsequently, they worked on analyzing these samples in a university laboratory setting while being mentored in laboratory practices. They used state-of-the-art laboratory instruments in their analyses with the help of undergraduate and graduate mentors. Finally, they presented their findings in a conference style setting to their family, friends, university undergraduate and graduate students, faculty, and staff. The themes addressed throughout the camp are outlined in Table 2.

## METHODS

**Recruitment.** The application for the camp was distributed via the local school district portal and sent directly to science teachers via email. In addition, advertisements via the local radio station, local news outlets, and the university website served as a mode by which to attract girls to the program. The applicants were asked to answer various demographic questions including their current grade level, GPA, household income, and whether or not they had decided to attend college upon graduation. They were also asked to respond to open-ended questions such as their anticipated career field, favorite high school science course, and why they were interested in the camp (See Appendix A). The application questions were used to recruit interested applicants, and if necessary, serve as a way to evaluate applicants in the event there was not enough space for all applicants. The camp grew over the three-year period from 10 campers in 2018, to 20 campers in the summer of 2019, and to 15 for the 2021 spring break camp, which was rescheduled from summer 2020 due to the COVID-19 pandemic. However, there was never a case in which the applications were competitive, as each year we were able to sponsor all students who applied for the program.

**Participants.** The STEM summer camp consisted of incoming 9th–12th graders N=10 in 2018, 20 in 2019 and 15 in 2021. According to students' self-identified data, participants over the three-year period were 100% female, 6% Asian, 12% Black, 12% Hispanic/Latinx, 58% White, 12% other (e.g., mixed race). Around 25% of campers reported a household income less than $40,000 a year.

**Instrument**. The observational descriptive research study aimed at directing future research in participatory STEM experiences of girls employed the use of a mixed methods design. A strength of descriptive studies is that participants are questioned or observed in a natural setting and can serve as a way to identify the prevalence of particular problems and the need for new or additional research. Data collection included both qualitative and quantitative data. Qualitative data collection including the use of observational and video recorded data, student work, and field notes were analyzed using thematic coding. Quantitative data were collected using a previously validated survey that was modified (Feldman et al., 2013; Kardash, 2000). The 35-39 question pre and post-surveys were administered before and after the STEM summer research program, respectively (See Appendix B). Participants were asked to what extent they were able to engage in a variety of science practices using the following choices: Not at all; Somewhat; Very Much; and Always. The survey was a modified Likert-type instrument that was developed and validated that describes the science practices needed to engage in authentic scientific research (Feldman et al., 2013). In addition to the science practices, the survey asked a variety of questions about the students' abilities and expectations of themselves as researchers, their overall attitudes towards the program and research project, and their likelihood of pursuing a career in STEM. This online survey was distributed via email to the students by our community partner, and identifiable data were removed. Therefore, the study did not meet the Department of Health and Human Services definition of human subject research and was classified as exempt.

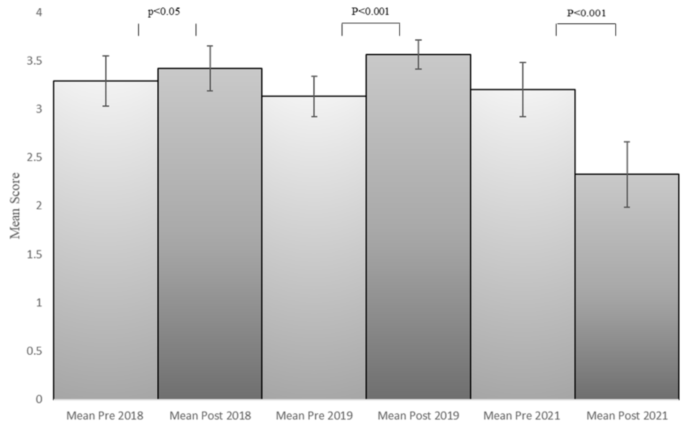
In 2018 and 2019 participants were asked to complete the survey during the camp on the first (pre-survey) day. In 2018 and 2019, the students were asked to complete the same post-survey during the camp on the last day. In 2021 students were asked to complete the pre- and post-survey online at home, before (pre-survey) and after the camp (post-survey). Ratings were analyzed by using a paired t-test. Rating scales and rubrics are commonly used measurement tools in educational contexts, however, there is a great deal of controversy surrounding how data derived from these tools can and should be analyzed (Harpe, 2015; Norman, 2010). A paired sample t-test was conducted to assess the difference in mean scores of participants' ability to perform research and scientific investigations, interest in future research, and participants' perception of the role of women in STEM before and after their participation in the camp. A paired t-test, also known as a dependent or correlated t-test, is a statistical test that compares the means and standard deviations of two related groups to determine if there is a significant difference between the two groups. The groups in this study are the campers prior to participating in the camp, and after their participation. The error bars represent the difference between means in each sample.

## RESULTS

The study was built based on the strength of both quantitative and qualitative research methods and provided more insightful findings that can help describe the characteristics of the population. There is limited research, or data, regarding the impact of girls' participation in a university-led STEM camp, particularly on the students' willingness to pursue a STEM field after such an experience (Cappelli et al., 2019). Thus, this descriptive study was used to examine the relationships between participation in a 10-day camp and the experiences of those participants. Here we present the results from three consecutive years of the STEM Camp for High School Girls (Summer 2018, Summer 2019, Spring 2021). In 2018 we had 10 girls participate in the camp and survey, in 2019 we had 20 girls participate in the camp and survey and in 2021 we have 15 girls participate in the camp, but only six participated in the pre-survey and only two completed the post-survey. In 2019 four questions were added to the 35-question survey. We grouped the questions from the survey into the following themes: 1) Ability to Perform Research and Scientific Investigations 2) Future Interest in Research 3) Perception of Research and 4) The Role of Women in STEM.

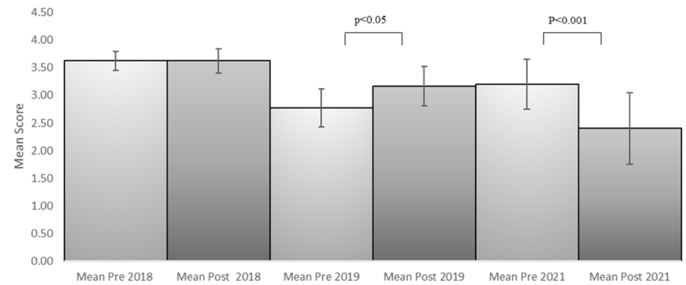
**Ability to Perform Research and Scientific Investigations.** Figure 1 includes the mean pre- and post-self-assessment scores to the following questions. Students were asked to rank to what extent they: 1) Understand science and engineering concepts related to research; 2) Make use of the primary research literature in the research; 3) Identify a specific question for investigation in the research focus of this summer program; 4) Design an experiment or theoretical test to

**Figure 1.** Ability to perform research and scientific investigations. Average pre- and post-self-assessment scores from Theme 1.




*Note: this figure represents participants' responses to the themed questions "Ability to Perform Research and Scientific Investigations": 2018 N=10, 2019 N=20, 2021 N=6 pre and N=2 post.*

**Figure 2.** Future interest in research. Average pre- and post-self-assessment scores from Theme 2.




*Note: this figure represents participants' responses to the themed questions "Future Interest in Research" 2018 N=10, 2019 N=20, 2021 N=6 pre and N=2 post.*

answer the question; 5) Understand the importance of control in research; 6) Make observations and collect data; 7) Analyze numerical data; 8) Interpret data by relating results to the original question; 9) Orally communicate the results of your research; 10) Write a scientific or engineering report of your research; 11) Think independently about your research focus; 12) Ask questions related to scientific research; 13) Develop and use scientific models; 14) Plan and carry out scientific investigations; 15) Analyze and interpret data; 16) Use mathematics and computational thinking; 17) Construct explanations of scientific phenomena; 18) Engage in argument from evidence [in your research]; 19) Obtain scientific information; and 20) Evaluate scientific information.

There was a significant difference in the 2018 theme 1 scores for the IV level 1 (M= 3.29, SD= 0.26) and the IV level 2 (M= 3.42, SD= 0.23) conditions; $p<0.05$. There was a significant difference in the 2019 theme 1 scores for the IV level 1 (M= 3.13, SD= 0.21) and the IV level 2 (M= 3.56, SD= 0.15) conditions; $p<0.001$. There was a significant difference in the 2021 theme 1 scores for the IV level 1 (M= 3.20, SD= 0.28) and the IV level 2 (M= 2.33, SD= 0.34) conditions; $p<0.001$.

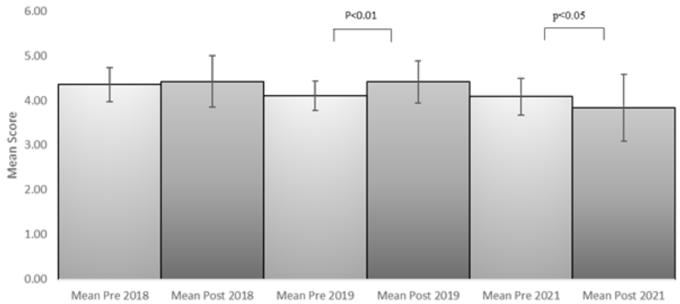
Data displayed in Figure 1 shows relatively higher scores between the pre- and post-camp survey in both 2018 (N=10) and 2019 (N=20). The differences between pre- and post-surveys in 2019 are higher than in 2018. In 2021 we see lower scores between the pre- and post-camp survey in 2021. Individual questions that saw the greatest differences between pre- and post-surveys were: Make use of the primary research literature in the research (0.5 point increase in both 2018 and 2019); Design an experiment or theoretical test to answer the question (0.35 in 2018 and 0.74 in 2019); Develop and use scientific models (0.5 in 2018 and 0.83 in 2019); and, Plan and carry out scientific investigations (0 in 2018 and 0.71 in 2019). Observational data, and data collected from student presentations indicated that students were more comfortable performing research, and more confident in their ability to perform research. This includes their ability to perform research tasks on their own with little to no guidance and related to their data collected via their presentations. One group stated, "Some observations to note were the fact that Causeway B was significantly busier than Causeway A, so our hypothesis that it would lack species quantity was correct. With Causeway A having a higher seagrass coverage, we assumed that it would also have a higher biodiversity, but the opposite was shown." Students also mentioned the research and field experiences as the most highly favored, one stated, "My favorite part of [the camp] was going underwater to count how many sand dollars were in the square."

**Future Interest in Research**. Figure 2 includes the mean pre- and post-self-assessment scores to the following questions related to STEM research. Students were asked to rank to what extent they are: 1) a skilled researcher; 2) an independent researcher; 3) able to make a contribution to your research; 4) interested in pursuing science, engineering (a STEM field) in college or university; 5) interested in pursuing a career in science of engineering; 6) perceive yourself as a capable STEM researcher; and 7) interested in pursuing a graduate degree.

There was no significant difference in the 2018 theme 2 pre and post scores. There was a significant difference in the 2019 theme 2 scores for the IV level 1 (M= 2.77, SD= 0.35) and the IV level 2 (M= 3.17, SD= 0.36) conditions; $p<0.05$. There was a significant difference in the 2021 theme 1 scores for the IV level 1 (M= 3.20, SD= 0.45) and the IV level 2 (M= 2.40, SD= 0.65) conditions; $p<0.001$.

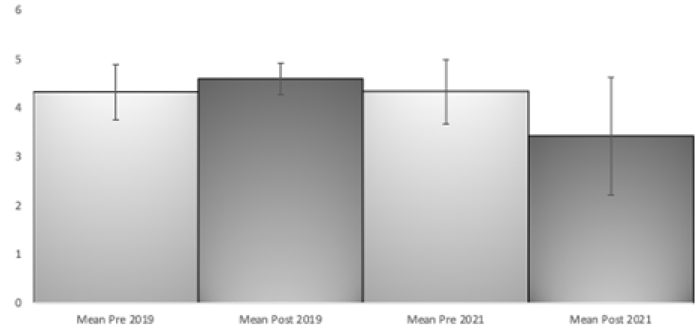
Data displayed in Figure 2 show no difference between the pre- and post-camp survey in 2018 (N=10) while in 2019 an increase is noted between the pre- and post-camp survey (N=20). Again, the differences between pre- and post-surveys in 2019 are higher than in 2018. In 2021 we see lower scores between the pre- and post-camp survey. Individual questions that saw the greatest differences between pre- and post-surveys were: a skilled researcher (0 in 2018 and 0.64 in 2019); and, an independent researcher (0 in 2018 and 0.76

**Figure 3.** Perception of Research. Average pre- and post-self-assessment scores from Theme 3.




*Note: this figure represents participants' responses to the themed questions "Perception of Research" 2018 N=10, 2019 N=20, 2021 N=6 pre and N=2 post.*

**Figure 4.** The Role of Women in STEM. Average pre- and post-self-assessment scores from Theme 4.




*Note: this figure represents participants' responses to the themed questions "The Role of Women in STEM" 2019 N=20, 2021 N=6 pre and N=2 post.*

in 2019). Students' attitudes towards research also increased as a result of their participation in the camp, often expressing increased interest in the STEM fields, and increased interest in attendance at the university where the camp took place. One camper stated, "For the career path that I want to go into it deals with a lot of computer software. I feel like this camp allowed me to see what the STEM world is really like. I think this camp can prepare you for the real world too because you will get to experience things that you wouldn't normally do on a daily basis."

**Perception of Research**. Figure 3 includes the mean pre- and post-self-assessment scores to the following questions related to STEM research. Students were asked to rank to what extent: 1) The project or research I am working on was challenging 2) The project I was working on can be carried out in the amount of time planned 3) The project I was working on is interesting 4) My mentor has made his or her expectations for me clear 5) My mentor has given me sufficient support to complete my work 6) I am helping complete valuable research work 7) I feel confident in presenting my research to my peers 8) I feel confident in presenting research to experts in the science field.

There was no significant difference in the 2018 theme 3 pre and post scores. There was a significant difference in the 2019 theme 2 scores for the IV level 1 (M= 4.11, SD= 0.33) and the IV level 2 (M= 4.41, SD= 0.47) conditions; $p<0.01$. There was a significant difference in the 2021 theme 1 scores for the IV level 1 (M= 4.08, SD= 0.41) and the IV level 2 (M= 3.83, SD= 0.75) conditions; $p<0.05$.

Figure 3 shows small, but not significant increases between the pre- and post-camp survey in 2018 (N=10) and in 2019 (N=20). Again, the differences between pre- and post-surveys in 2019 are higher than in 2018. In 2021 we see lower scores between the pre- and post-camp survey (N=2). Individual questions that saw the greatest differences between pre- and post-surveys were: "I feel confident in presenting my research to my peers" (0.67 in 2019). "I feel confident in presenting research to experts in the science field" (0.84 in 2019). Observations of reservations to presenting in a conference-type setting were apparent among many of the campers prior to presenting. However, qualitative data indicated after the presentation was over, campers found the experience exciting and fun to describe their projects to friends, family, and university folks.

**The Role of Women in STEM.** Figure 4 includes the mean pre- and post-self-assessment scores to the following questions (that were not included in the 2018 survey). Students were asked to rank to what extent: 1) Female research scientists belong in STEM fields 2) There is a need for more female research scientists in the STEM field 3) Female researchers are as capable as male researchers in the STEM field 4) My science and math courses in school have adequately prepared me to participate in the research for this camp.

There was no significant difference in the 2019 or 2021 in theme 4 pre- and post-scores. Data displayed in Figure 4 shows an increase between the pre- and post-camp survey in 2019 (N=20) and lower scores between the pre- and post-camp survey in 2021 (N=2). All of the questions included in this theme saw little pre- and post-camp survey change (scores range between -0.1 and 0.15 in 2019). Overall, in comparison to other themes, this theme saw the highest pre- and post-survey scores. Qualitative data collected from the student response indicated exposure to women in STEM was important to the experience. One camper stated what they enjoyed most was, "This week working with other passionate women in expanding our knowledge of data collection and interpretation, and getting out into nature together to see what our own futures may hold!"

## DISCUSSION

**Analysis of the General Survey Findings.** The data from the pre- and post-camp surveys generally show that post-camp scores are higher than pre-camp scores, however these differences are not statistically significant (indicated by error bars in Figures 1-4). A major factor that affects the statistical significance of the data is the number of girls participating in the survey tool (2018 N=10, 2019 N=20 and 2021 N=2). In terms of statistical significance, the greatest increases were observed in 2019 when all 20 participants completed the pre- and post-camp surveys. We also saw greater differences between pre- and post-camp surveys in 2019, which may be due to the larger cohort and greater diversity within the cohort. In 2021 we instituted strict protocols in order to run the camp during the COVID-19 pandemic. One of these protocols included surveying the participants outside of camp hours. For this reason, we saw low participation. Only six participated in the pre-camp survey, and only two participated in the post-camp survey. Furthermore, we are unsure if the same girls that took the pre-camp survey took the post-camp survey. Results could be skewed if the girls that took the pre-camp survey differed from the girls that took the post-camp survey. In addition, the 2021 data shows large error bars, due to the low participation (Pre: N=6 and Post: N=2). We have included the 2021 data in Figures 1-4, however, for the above reasons we are not including the 2021 data in the analysis of the camp outcomes. In fact, in 2021 post-camp survey results are lower than the pre-camp survey results which is not in line with 2018 and 2019 results. The below discussion is therefore focused on 2018 and 2019 results.

**Increased Positive Perception of the University and STEM fields.** As previously mentioned, research suggests that students who pursue STEM careers often decide to do so prior to high school, in their childhood years (Tai et al., 2006). However, studies also show that high school is the time period in which students become more aware of STEM careers, begin to seriously consider career choices, and make important decisions about their STEM field interests (Hall et al., 2011; Kitchen et al., 2018; Sadler et al., 2012). We found that all the girls who engaged in the camp became more interested in pursuing science in college or university. This is shown in Figure 1 (Ability to perform research and scientific investigations); Figure 2 (Future interest in research); and, Figure 3 (Perception of research) where post-scores are higher than pre-scores.

However, it is important to point out that most applicants already had a preexisting interest in the STEM field, or pursuing a career in STEM. One student mentioned in the application

> *The experience would truly help me in reaching my goals, and on top of that, it would be super fun. In college I plan to study Environmental Science/Engineering, and I think it's coincidental that this opportunity came up because water quality (like in oceans, rivers, and their connection systems) and climate change are the two topics I would really like to focus on....*

Another mentioned

> *I think this camp will give me a great opportunity to get hands-on with some research in this field. Water quality, the environment, and climate change are issues that I am passionate about. I hope that this opportunity reinforces my eagerness to explore this area of study as a career goal.*

Lastly, another stated

> *[...]with this experience, I can use the tools I learn for any future experiments I might do in the future. I can also teach others what I've learned, and maybe get them passionate about the health of the environment, too. I believe it will also serve me in college when I participate in future research. I hope to learn about issues about the environment I might not have known before, and how I can do my part to solve the problem.*

Even though many of our applicants already had preexisting interests in STEM, we contend that our camp occurred at a crucial part of the "leaky pipeline" for high school girls, helping to encourage the girls' interest in STEM. Because interest in STEM careers remains stable for boys throughout high school, but declines for girls, it is crucial to promote activities in high school that increase retention rates of girls in STEM.

Our camp offered an opportunity for high school girls to explore STEM degrees and careers while on a university campus. Previous research has identified the importance of university/college partnerships with local K–12 counterparts as a highly effective tool to strengthen and diversify STEM pathways (Constan & Spicer, 2015; Eeds et al., 2014; President's Council of Advisors on Science and Technology [PCAST], 2012). Hall et al. (2011) found that while parents and teachers represented strong influences on consideration of potential careers, their knowledge of STEM occupations is limited. For these reasons, we included a 1-hour timeslot during laboratory days on campus, where women from different STEM disciplines would present guest lectures on their STEM fields, research, and personal experience. We found the girls grew confidence in their ability to undertake university level research through the following questions: Make use of the primary research literature in the research (0.5 point increase in both 2018 and 2019), Design an experiment or theoretical test to answer the question (0.35 in 2018 and 0.74 in 2019), Develop and use scientific models (0.5 in 2018 and 0.83 in 2019), Plan and carry out scientific investigations (0 in 2018 and 0.71 in 2019). These three questions saw the greatest positive changes in our survey, indicating positive affirmation with the students' perception of themselves as researchers.

**Access to Hands-On Fieldwork and Research Experience.** We found that regardless of grade level, the participants lacked actual hands-on fieldwork experience the camp provided. Many of the campers had never been on a boat, and none of them had participated in the type of fieldwork opportunities provided through the camp, which may be a reflection of the limited funding for these types of experiences in the formal education sector.

Participants had overwhelmingly positive responses to the field-based work. As mentioned above, the results from the survey indicate nearly all participants agreed the program helped them become more independent and skilled researchers. The results of the survey also suggest the girls found the project they were working on to be interesting, and felt as though they were helping to complete valuable research. The girls reported being able to make better use of primary literature and research in the field after they had completed the 2-week program. Lastly, they reported their laboratory skills were improved as a result of the program, including their ability to make observations, collect and analyze data, and orally communicate the results of their research through the poster presentation session at the university on the final day of the program (Theme 1: Ability to perform research and scientific investigations). The above outcomes are supported by TechBridge Girls https://www.techbridgegirls.org/. TechBridge Girls advises that the most successful activities in their programs are those that are hands-on and relevant to girls' lives. They also find that activities that are least popular are those that feel too "school-like" or are not interactive enough (Mosatche et al., 2013).

A variety of barriers to these types of opportunities, such as fieldwork, exist including time, funding, access to transportation and qualified experts and their equipment. However, our study and other research suggests exposure to field related experiences are crucial to developing girls' STEM skills and abilities to participate in authentic science research and their likelihood of pursuing STEM careers (Heise et al., 2020). Providing access to these types of learning opportunities is increasingly important for girls to see themselves in the STEM field.

**Ability to Communicate and Present Scientific Data.** Participants presented their research results and analysis at a public presentation on the final day of the camp. In 2018 and 2019 this was done via poster presentation on the university's main campus. In order to simulate a conference-like setting we invited students from undergraduate classes, graduate students, faculty, parents, and friends. The camp participants presented their research to the undergraduate students in a 1-hour session, in which the undergraduate students judged the camp participants using oral presentation rubrics. The students then presented more informally to graduate students, faculty, parents, and friends for the subsequent hour. Generally, the camp participants were very nervous leading into the presentations, however their attitudes during and after the presentation were very positive. We saw significant change between pre- and post-results for the following questions centered on communication and presentation 1) I feel confident in presenting my research to my peers (0.67 in 2019) and 2) I feel confident in presenting research to experts in the science field (0.84 in 2019).

Research shows the ability for students to communicate is strongly correlated with self-efficacy. Self-efficacy is someone's judgment on their capability to organize and execute courses of action to achieve designated types of educational performance (Bandura, 1997). When they deliver the speech successfully, their self-efficacy is likely to increase. In addition, Schunk (1987) observes that peers can be role models to other students, and if peers successfully perform a task, it may raise self-efficacy in others. Students who observe their classmates delivering speeches successfully may experience increased public speaking self-efficacy. We found this to be the case, where the girls felt a sense of comradery after the presentations.

Other studies have shown that public speaking self-efficacy predicts public speaking achievement (Dwyer and Fus, 1999). In a subsequent study, Dwyer and Fus (2002) also investigated the relationship between communication apprehension, public speaking self-efficacy, self-perceived public speaking competence, and course grade. The results show that self-efficacy influenced students' final grades. In short, positive public speaking experiences can have positive effects on communication apprehension, public speaking self-efficacy, self-perceived public speaking competence, and course grade. For this reason, we believe the final presentation day is critical to the primary goal of the STEM camp, to foster and encourage the interests of high school girls in STEM fields.

**Connection to Valuable Female Mentorship and Peers.** Role models can be inspirational and can reduce the self-stereotyping of stigmatized groups, research shows this may be the case for women in male-dominated STEM fields. This is particularly true if girls are the first in their families to pursue higher education and professional careers and do not have role models at home who work in STEM fields to encourage them to follow in their footsteps (Mosatche et al. 2013). Dasgupta (2011) used the theoretical lens of the stereotype inoculation model to explain how contact with successful female STEM role models can serve as "social vaccines" that protect the self-concept of women in STEM against stereotypes.

Same-gender role models are an effective option for attracting young women into STEM (González-Pérez et al., 2020; Stout et al., 2011). Stout et al. (2011) discovered that women exposed to female calculus professors showed enhanced self-efficacy, greater self-concept, as well as a higher identification with and commitment to STEM, even among students who still maintained gender stereotypes Similarly, Plant et al. (2009) exposed middle school girls to computer-based female role models and found that the role model was effective at promoting academic interest and motivation among girls.

Thus, the promotion of girls in STEM requires role models (sometimes mentors) who not only work in a STEM field, but who are also female. Because the participation rates of women in these fields are low, finding a sufficient number of professional women in STEM fields such as engineering, math and physical science presents challenges (González-Pérez et al., 2020). One of the actions we used during the camp was exposure of women from multiple STEM fields. We also provided several layers of female mentorship throughout the camp. The lead research scientists were female (Professors of Environmental Studies and Geoscience) and provided leadership and mentorship to the girls for the entirety of the camp. Furthermore, female STEM majors at both the undergraduate and graduate level served as secondary leaders and mentors. This model also allowed the university students to gain skills and confidence in leadership.
The camp provided a place for girls to engage with other females in an academic and social way in a safe environment. Results from the post-survey indicate nearly all campers over the three years agreed or strongly agreed with the following statements: 1) Female researchers are as capable as male researchers in the STEM field 2) There is a need for more female research scientists in the STEM field 3) Female research scientists belong in STEM fields. A small increase was noted between pre- and post-scores in 2019, however the scores were high regardless, in comparison to the other themes discussed above such as "Ability to Perform Research and Scientific Investigations" and "Future Interest in Research."

## LIMITATIONS

**Recruitment.** In addition to gender we considered other demographic identities, such as socioeconomic status (SES), race and ethnicity when developing our program. Issues of gender, SES, race and ethnicity in STEM achievement do not exist in isolation from each other. The intersection of these identities have been shown to impact students' overall sense of competence and confidence with respect to STEM achievement (Byars-Winston et.al. 2010). For example, youth from low SES communities face a variety of structural challenges to STEM success, including a higher likelihood of attending schools with lower funding levels, resulting in lack of basic educational materials, including science learning materials, and training for teachers (Nasir et al., 2011); and families have fewer financial resources and/or time to provide overall academic support (Orr, 2003). In addition to these structural challenges, youth from low SES communities who self-identify or feel they are associated with a lower SES class identity are more likely to feel stereotype threat around academic achievement in general – and STEM achievement in particular (Harrison, et al, 2006) – as well as feeling stress due to family financial constraints (Mistry et al., 2009).

In our funding proposal we pledged that we would endeavor to recruit girls from lower SES backgrounds, and target girls from underrepresented ethnicity and race groups. As reported above participants over the three-year period were 100% female, 6% Asian, 12% Black, 12% Hispanic/Latinx, 58% White, 12% other (e.g., mixed race). Around 25% of campers reported a household income less than $40,000 a year. Unfortunately, these numbers were lower than we anticipated, as our goal targets were 50% non-white students and 50% students with household income less than $40,000. We proactively addressed this in 2021, when we partnered with the local school district in recruitment efforts. Unfortunately, due to the COVID-19 pandemic and our generally low enrollment in the Spring of 2021, it is difficult to determine if this partnership helped with recruitment in these important demographics. However, we are continuing to work with the districts to better target these underrepresented groups in future programs. In particular, we are targeting specific schools with high populations in these target demographics and the STEM teachers in these schools. Increased recruitment efforts are needed to ensure we are reaching a wider range of high school girls, including those who may not have prior experiences or preexisting interest in the STEM fields.

**Program Evaluation and Survey Instrument**. Ensuring quality STEM program evaluation is crucial for successfully determining program impact. We learned from the last three years of program assessment and evaluation that our survey tool needs improvement. Research shows there are effective practices for designing evaluations (Reisner, 2005; Wilkerson & Haden, 2014; Wimer et al., 2008). In future programming we plan on incorporating the following changes:

1. *The use of an external evaluator*: External evaluation in education is important because it leads to self-awareness since it provides the program managers with opportunities to see themselves as they really are. Self-awareness in turn leads to reform of activities and thereby quality improvement (Hajifathali et al., 2006; Kristoferson, 1998). Experts bring new views of opportunities and assets, which may not have been thought of and adding an external aspect

increases validity of results of internal evaluation (Kristoferson, 1998). In addition, stakeholders are interested in the quality of educational programs being approved through external evaluation.

2. *Surveying students during the camp itself.* In 2021 we learned that if the surveying process is not completed during camp hours, participation will likely be low. In 2018 and 2019 we had 100% participation in the camp survey instrument when students were given time to do it during camp hours. In 2021, due to the COVID-19 Pandemic, students took the survey from home before and after the camp. We had 40% participation in the pre-camp survey and 13% participation in the post-camp survey. As a result, the 2021 data were largely unreliable.

3. *Shorten our survey instrument.* Due to the relatively short duration of our camp we will keep future survey instruments brief. For example, we found that our theme "Ability to perform research and scientific investigations" contained too many questions (20 total). Our future survey tool will significantly cut down on these questions (5-10). Studies show that shorter surveys cut down on data analysis and reporting, thus decreasing the budget (Wilkerson & Haden, 2014).

4. *Identifying program outcomes that are most appropriate and important to evaluate based on what we have learned from the previous surveys.* In 2019 we assessed the "Role of Women in STEM" with the following questions: 1) Female research scientists belong in STEM fields; 2) There is a need for more female research scientists in the STEM field; and, 3) Female researchers are as capable as male researchers in the STEM field. All of these questions saw high scores both pre- and post-survey. In the future we will ask questions that provide feedback on our goal to improve STEM perceptions through female mentorship and their female peers. For example, potential open-ended or short answer questions could be included to better understand how the participants view the role of women in STEM.

5. *Identify stakeholders (individuals, groups, or organizations who are served by or have an interest in the survey outcomes) and what information stakeholders are interested in*. By identifying key stakeholders, evaluations can be designed and implemented to collect more meaningful data while increasing the likelihood that the evaluation results will be used to guide future program activities. Thereby increasing the likelihood of future funding from the same stakeholders (American Evaluation Association, 2018; Stecher and Davis, 1987).

6. *Learn from evaluations of similar programs*. We will work with our external evaluator to identify existing instruments that align closely with our program outcomes—for example Evaluation Database (Geiger and Britsch, 2003).

7. *Recruit more participants*. As the program matures, we will incorporate more participants, which will lead to additional evaluation data and therefore the likelihood for statistically significant results. In future years we hope to have at least 20-30 participants take part in the camp.

## CONCLUSIONS

We found that by engaging in the STEM Camp for High School Girls, participants became more interested in pursuing science in college, or university, even though most participants already had a preexisting interest in STEM. We found that the girls grew confident in their ability to undertake university level research during our program, reinforcing a positive affirmation with the girls' perception of themselves as researchers. During the camp we exposed the girls to hands-on fieldwork, which is crucial in the development of girls' STEM skills. The exposure to authentic scientific research further increases the likelihood that girls will pursue STEM careers. Providing access to these types of learning opportunities is increasingly important for girls to see themselves in STEM fields. We also found that the girls' final research presentations had a positive effect on their self-efficacy in STEM. Finally, the camp provided several layers of female mentorship as well as a place for girls to engage with other females in a safe environment.

We learned that greater recruitment efforts are needed in order to ensure we are reaching a wider range of high school girls, including those who may not have prior experiences or preexisting interest in the STEM fields, those within minority racial and ethnic groups, and those from lower socioeconomic groups. We have also learned that our instrument requires improvement, should be developed with the assistance of an external evaluator, and should take into account our stakeholders. With an improved instrument and increase in camp participants, we should see more reliable and statistically significant data that will in-turn allow for improved camp evaluation and generalized findings. Our 2021 camp was implemented during a time when K-12 students across the country were experiencing a disconnect from social and physical interaction due to COVID-19 protocols. Even though the data from 2021 was unreliable, due to low participation, the camp provided a much-needed social outlet for the girls to explore science during a global pandemic.

## ASSOCIATED CONTENT

Supplemental material mentioned in this manuscript can be found uploaded to the same webpage as this the manuscript.

## AUTHOR INFORMATION

### Corresponding Author

Molly Nation. Department of Ecology and Environmental Studies, Florida Gulf Coast University. 10501 FGCU Blvd S, Fort Myers, FL, 33965, USA. mnation@fgcu.edu

### Author Contributions

The manuscript was written through contributions of all authors. All authors have given approval to the final version of the manuscript.



## ACKNOWLEDGMENTS

We would like to thank The Collaboratory for providing funding to facilitate this camp over three years. We would also like to thank The Sanibel Sea School for providing space and access to classrooms, laboratories, and research boats. We thank our media relations team, WGCU public radio, for assisting us with advertising and recruitment efforts. We also thank our local school districts with assistance in our recruiting efforts.

## ABBREVIATIONS

NSCG: National Survey College Graduates; NRC: National Research Council; PCAST: President's Committee of Advisors on Science and Technology; SES: Socioeconomic Status; STEM: Science, Technology, Engineering, and Mathematics

## REFERENCES

Bandura, A. (1997). Self-efficacy: the exercise of control. New York: Freeman.

Beede, D.N., Julian, T.A., Langdon, D., McKittrick, G., Khan, B. and Doms, M. E., (2011). Women in STEM: A gender gap to innovation. Economics and Statistics Administration Issue Brief No. 04-11, Available at SSRN: https://ssrn.com/abstract=1964782 or http://dx.doi.org/10.2139/ssrn.1964782

Bell, P., Lewenstein, B., Shouse, A. W., and Feder, M. A. (2009). Learning science in informal environments. Washington, D.C.: The National Academies Press.

Byars-Winston, A., Estrada, Y., Howard, C., Davis, D., and Zalapa, J. (2010). Influence of social cognitive and ethnic variables on academic goals of underrepresented students in science and engineering: A multiple-groups analysis. Journal of Counseling Psychology, 57(2), 205-218.

Cappelli C. J., Boice K.L., and Alemdar, M. (2019). Evaluating university-based summer STEM programs: Challenges, successes, and lessons learned, Journal of STEM Outreach. 2(1). https://doi.org/10.15695/jstem/v2i1.13

Ceci, S.J., and Williams, W.M. (2011). Understanding current causes of women's under-representation in science. Proceedings of the National Academies of Science USA. 108(21), 3157–3162.

Ceci, S. J., Williams, W. M., and Barnett, S. M. (2009). Women's underrepresentation in science: sociocultural and biological considerations. Psychological bulletin, 135(2), 218.

Constan, Z., and Spicer, J.J., (2015) Maximizing future potential in physics and stem: evaluating a summer program through a partnership between science outreach and education research, Journal of Higher Education Outreach and Engagement, 19(2), 117.

Diekman, A.B., Brown, E.R., Johnston A.M. and Clark, E.K. (2010). Seeking congruity between goals and roles: A new look at why women opt out of Science, Technology, Engineering, and Mathematics Careers. Psychological Science, 21(8), 1051-1057.

Diekman, A.B., Weisgram, E.S., and Belanger, L. (2015). New Routes to recruiting and retaining women in STEM: Policy implications of a communal goal congruity perspective. Social Issues and Policy Review, 9(1), 52–88.

Dasgupta, N. (2011). Ingroup experts and peers as social vaccines who inoculate the self-concept: The stereotype inoculation model. Psychological Inquiry, 22, 231-246.

Dasgupta N., McManus Scircle, M., and Hunsinger, M. (2015). Female peers in small work groups enhance women's motivation, verbal participation, and career aspirations in engineering, Proceedings of the National Academy of Sciences, 112(16), 4988-4993.

Dwyer, K. K., and Fus, D. A. (1999). Communication apprehension, self-efficacy, and grades in the basic course: Correlations and implications. Basic Communication Course Annual, 11, 108–132.

Dwyer, K. K., and Fus, D. A. (2002). Perceptions of communication competence, self-efficacy, and trait communication apprehension: Is there an impact on basic course success? Communication Research Reports, 19, 29–37. doi:10.1080/08824090209384829

Eeds, A., Vanags, C., Creamer, J., Loveless, M., Dixon, A., Sperling, H., and Shepherd, V. L. (2014). The School for Science and Math at Vanderbilt: An innovative research-based program for high school students. CBE Life Sciences Education, 13(2), 297–310. doi.org/10.1187/cbe.13-05-0103

Eagly, A. H., Wood, W., and Diekman, A. B. (2000). Social role theory of sex differences and similarities: A current appraisal. In The Developmental Social Psychology of Gender, T. Eckes and H. M. Trautner, Eds. (Mahwah, NJ: Erlbaum), 123–174.

Else-Quest, N. M., Hyde, J. S., and Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: A meta-analysis. Psychological Bulletin, 136(1), 103–127. https://doi.org/10.1037/a0018053

Executive Office of the President, President's Council of Advisors on Science and Technology (2010). Prepare and inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's future. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-stem-ed-final.pdf

Falco, L. D., and Summers, J. J. (2019). Improving career decision self-efficacy and STEM self-efficacy in high school girls: Evaluation of an intervention. Journal of Career Development, 46(1), 62-76.

Feldman, A., Divoll, K., and Rogan-Klyve, A. (2013). Becoming researchers: The participation of undergraduate and graduate students in scientific research groups. Science Education, 97, 218-243.

Feldman, A., Ozalp, D., Alshehri, F., Chapman, A., and Vernaza-Hernández, V. (2013). The Impact of an REU and RET Program on Participants' Scientific Research Skills. Paper presented at the Annual meeting of NARST, April 16. Rio Grande, Puerto Rico.

Gándara, P., and Bial, D. (2001) Paving the way to postsecondary education: K-12 intervention programs for underrepresented youth (NCES no 2001205). National Center for Education Statistics; Washington, DC. (ERIC Document Reproduction number ED 458 340)

Geiger, E., and Britsch, B. (2003). Out-of-school time program evaluation: Tools for action. Portland, OR: Northwest Regional Educational Laboratory.

George, B.T., Watson, S.W., and Peters, L. P. (2020). The impact of participating in a STEM academy on girls' STEM attitudes and self-efficacy. Electronic Journal for Research in Science and Mathematics Education, 24(4)

Gonzales, L., (2019). Participation of women in the geoscience profession. American Geosciences Institute, Data Brief 2019-015; November 15, 2019

Gonzalez, H. B., and Kuenzi, J. (2012). Science, technology, engineering, and mathematics (STEM): A primer. Washington: Congressional Research Service. https://www.ccc.edu/departments/Documents/STEM_labor.pdf.

González-González, C. S., García-Holgado, A., de los Angeles Martínez-Estévez, M., Gil, M., Martín-Fernandez, A., Marcos, A., ... and Gershon, T. S. (2018). Gender and engineering: Developing actions to encourage women in tech. In 2018 IEEE global engineering education conference (EDUCON), April (pp. 2082-2087). IEEE.

González-Pérez, S., Mateos de Cabo1, R., and Sáinz, M. (2020). Girls in STEM: Is it a female role-model thing? Frontiers in Psychology, 11, 2204. doi: 10.3389/fpsyg.2020.02204

Hajifathali, A., Avarzamani, M., Noori, A., Niaie A.M.., Negahban, E. (2006). External evaluation: A requirement for accountability and responsiveness. Journal of Medical Education, 8 (2), 83-88.

Hall, C., Dickerson, J., Batts, D., Kauffman, P., and Bosse, M. (2011). Are we missing opportunities to encourage interest in STEM fields? Journal of Technology Education, 23(1), 32–46.

Hammack, R., and High, K. (2014). Effects of an after-school engineering mentoring program on middle school girls' perceptions of engineers. Journal of Women Minorities in Science and Engineering. 20, 11–20. 10.1615/JWomenMinorScienEng.2014006726

Harpe, S. E. (2015). How to analyze Likert and other rating scale data. Currents in Pharmacy Teaching and Learning, 7(6), 836-850.

Harrison, L. A., Stevens, C. M., Monty, A. N., and Coakley, C. A. (2006). The consequences of stereotype threat on the academic performance of white and non-white lower income college students. Social Psychology of Education, 9, 341-357

Heilman, M.E. (2001). Description and prescription: How gender stereotypes prevent women's ascent up the organizational ladder. Journal of Social Issues, 57, 657–674. doi:10.1111/0022-4537. 00234

Heise, N., Hall, H. A., Ivie, K. R., Meyer, C. A., and Clapp, T. R. (2020). Engaging high school students in a university-led summer anatomy camp to promote STEM majors and careers. Journal of STEM Outreach, 3(1), 1-7.

Hill, C., (2010). Why so few? Women in science, technology, engineering, and mathematics. American Association of University Women, Washington, DC, https://ww3.aauw.org/resource/why-so-few-women-in-science-technology-engineering-and-mathematics-executive-summary/

Kardash, C. (2000). Evaluation of an undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors. Journal of Educational Psychology, 92(1), 191–201.

Kitchen, J. A., Sonnert, G., and Sadler, P., (2018) The impact of college- and university-run high school summer programs on students' end of high school STEM career aspirations. Science Education, 102, 529–547.

Kristoferson, D. (1998) Quality assurance guidance: Procedures and operational aspects of European higher education organization. Orlangton: Ashgete.

Leslie, L. L., McClure, G. T., and Oaxaca, R. L. (1998). Women and minorities in science and engineering: A life sequence analysis. The Journal of Higher Education, 69, 239–276.

Martin, C. L., and Halverson, C. F. Jr. (1981). A schematic processing model of sex typing and stereotyping in children. Child Development. 52, 1119–1134. doi: 10.2307/ 1129498

Mistry, R. S., Benner, A. D., Tan, C. S., and Kim, S. Y. (2009). Family economic stress and academic well-being among Chinese-American youth: The influence of adolescents' perceptions of economic strain. Journal of Family Psychology, 279-290.

Mosatche, H. S., Matloff-Nieves, S., Kekelis, L., and Lawner, E.K. (2013) Effective STEM programs for adolescent girls: Three approaches and many lessons learned. Institute of Education Sciences, 17, 17-25.

Nasir, N. S., Shah, N., Gutierrez, J., Seashore, K., Louis, N., and Baldinger, E. (2011). Mathematics learning and diverse students. In National Research Council's Workshop on Successful STEM Education in K–12 Schools (pp. 10-11).

National Science Foundation, (2018) Science and Engineering Indicators 2018, National Science Board

National Research Council (NRC) (2010). Rising above the gathering storm, revisited: Rapidly rising to category 5. Washington, D.C.

Norman, G. (2010). Likert scales, levels of measurement and the "laws" of statistics. Advances in Health Sciences Education, 15(5), 625-632.

Obama, B. (2009). Remarks by the President at the National Academy of Sciences Annual Meeting, National Academy of Sciences, The White House, Office of the Press Secretary Washington, D.C.

Olsson, M., and Martiny, S. E. (2018). Does exposure to counterstereotypical role models influence girls' and women's gender stereotypes and career choices? A review of social psychological research. Frontiers in Psychology, 9, 2264.

Orr, A. J. (2003). Black-White differences in achievement: The importance of wealth. Sociology of Education, 76, 281-304.

Pajares, F. (2002). Gender and perceived self-efficacy in self-regulated learning. Theory into Practice, 41(2), 116-125. https://doi.org/10.1207/s15430421tip4102_8

Plant, E., Ashby, Baylor, A. L., Doerr, C. E., and Rosenberg-Kima, R. B. (2009). Changing middle-school students' attitudes and performance regarding engineering with computer-based social models. Computers and Education. 53, 209–215. doi: 10.1016/j.compedu.2009.01.013

President's Council of Advisors on Science and Technology; Executive Office of the President. (2012). Report to the President, engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics. Executive Office of the President, President's Council of Advisors on Science and Technology.

Preston, A. (2004). Plugging leaks in the scientific workforce. Issues in Science and Technology, 4, 69–74.

Reisner, E. R. (2005). Using evaluation methods to promote continuous improvement and accountability in after-school programs: A guide. Washington, DC: Policy Studies Associates.

Riegle-Crumb, C., King, B., Grodsky, E., and Muller, C. (2012). The more things change, the more they stay the same? Prior achievement fails to explain gender inequality in entry into Stem college majors over time. American Educational Research Journal, 49(6), 1048–1073.

Sadler, P., Sonnert, G., Hazari, Z., and Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. Science Education, 96(3), 411–427.

Schunk, D. H. (1987). Peer models and children's behavioral change. Review of Educational Research, 57, 149-174.

Smith, J.L., and White P.H. (2002) An examination of implicitly activated, explicitly activated, and nullified stereotypes on mathematical performance: It's not just a woman's issue, Sex roles, 47(3), 179-191

Stecher, B. M., and Davis, W. A. (1987). How to focus an evaluation. Newbury Park, CA: Sage.

Strauss, V. (2012) How to integrate literacy with STEM, Washington Post

Stout, J. G., Dasgupta, N., Hunsinger, M., and McManus, M. A. (2011). STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). Journal of Personality and Social Psychology, 100, 255–270. doi: 10.1037/a0021385

Tai, R., Liu, C., Maltese, A., and Fan, X. (2006). Planning early for careers in science. Science, 312, 1143–1144.

Valla, J. M., and Williams, W. (2012). Increasing achievement and higher-education representation of under-represented groups in science, technology, engineering, and mathematics fields: A review of current K-12 intervention programs. Journal of Women and Minorities in Science and Engineering, 18(1).

Wigfield, A., and Eccles, J.S. (2000). Expectancy-value theory of achievement motivation. Contemporary Educational Psychology, 25(1), 68–81. https://doi.org/10.1006/ceps.1999.1015.

Wilkerson, S. B., and Haden, C. M. (2014). Effective practices for evaluating STEM out-of-school time programs. Afterschool Matters, 19, 10-19

Wimer, C., Bouffard, S., and Little, P. (2008). Measurement tools for evaluating out-of-school programs: An evaluation resource. Cambridge, MA: Harvard Family Research Project