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# Investigating the Influences of Summer Experiences on Students' Self-Efficacy in STEM

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**Investigating the Influences of Summer Research Experiences on Students' Self-Efficacy in STEM**

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## Abstract

Improving high school students' interest and confidence in STEM is a national priority. Educators and stakeholders in educational policy have pressed for increasing opportunities to engage students in authentic science experiences and focus on teaching 21st century skills. The purpose of this case study was to investigate how a summer research experience may have influenced high school students' self-efficacy and career interests in STEM subjects and practices as well as identifying what students learned from their experience in the program. Pre/post program surveys were analyzed to measure change in student attitudes towards STEM and to capture students learning outcomes from the program. Even with a small group of students in the program, analysis of Likert scale survey items and open-ended responses provided practical insights in two ways: 1) Participation in a STEM summer enrichment program influenced student attitude toward STEM, and 2) Students learned about essential 21st century skills and were provided with opportunities for authentic science experiences. This study adds support that summer enrichment programs that emphasize teaching of 21st century skills and offering authentic science experiences can provide positive learning outcomes and increase student attitudes towards STEM areas.

## Introduction

Science, technology, engineering, and math (STEM) education has become an increasingly important area of study in recent years. Increasing participation in STEM of students from underrepresented populations is a national priority in the U.S. (National Academies of Sciences, Engineering, and Medicine, 2019). Expanding access to opportunities for all students to engage in STEM practices in authentic ways can help with addressing present national challenges. In the United States, pressure to compete globally in these areas is the highest it has ever been, with estimates that the U.S. will be outcompeted by other countries who are investing more funds into research and development (R&D) in areas of science and engineering (S&E) (Burke, Okrent and Hale, 2022). Foreign-born individuals account for about one-fifth of the entire STEM workforce, with over 50% of workers with a degree in S&E being from Asia (Burke, Okrent, and Hale, 2022). Higher education is necessary to prepare future generations for careers in STEM, but a lack of interest, confidence, and knowledge of careers in STEM could result in fewer individuals pursuing these careers (Blotnicky et al., 2018). Stakeholders in STEM education such as the National Science Board have called for policy changes and program implementation that supports transforming STEM education and creating a positive community that accepts responsibility in the promotion of STEM education in high school (National Science Board, 2010). Allowing adolescent students to develop their own confidence and interests in STEM through authentic science experiences in and out of schools is crucial to addressing the lack of confidence and interest in STEM careers in the United States.

In addition to a general lack of confidence or interest in STEM, the recent COVID-19 pandemic has limited the extent of enriching science experiences students could participate in and out of the classroom during the past few years. With online school in 2020 and 2021, many resources that would usually be available to students at school were essentially cut off. For students who rely on access to these resources at school, engaging and authentic learning experiences became limited.

Both of these issues magnify the importance of expanding access to experiences that expose students to STEM fields. In previous instances, some communities have addressed this issue by developing summer enrichment programs as a means of intervention for students who may have been deprived of an opportunity to practice meaningful science in and out of the classroom. Many of these programs are collaborative between public schools and local universities. They are usually a few weeks long and focus on authentic science and engineering experiences such as research (Mastronardi, Boklage, Hartman and Yanez, 2020). This case study discusses the influence of one pilot program that focused on offering high school students research opportunities and exposure to a positive and collaborative STEM environment. This case study serves the purpose of investigating how the program may have influenced students' self-efficacy and career interests in STEM subjects and practices as well as identifying what students learned from their experience in the program.

## Background

In academic contexts, student motivation is often referred to as *self-efficacy.* Self-efficacy can be described as an individual's own perception of their capabilities in performing a task successfully (Bandura, 1977). Albert Bandura is a prominent figure in motivation and self-efficacy research that proposed that a student's self-efficacy affects how an individual will choose activities, the amount of effort a student will put into a task, and how much a student will persist in a difficult task. Bandura was able to categorize sources of self-efficacy into four different categories: mastery experiences, observational experiences, verbal persuasion, and physiological and affective states (Bandura, 1977).

Previous research has been done on ways to increase motivation in STEM as well as developing strategies for encouraging high school students to pursue STEM majors or careers after high school. Many outreach programs have been developed for underrepresented youth to allow additional access to authentic science experiences outside of the classroom. Pender et al. (2010) reported that implementing experiences such as research opportunities into the college curriculum is an important factor in improving the retention of students into STEM disciplines. Allowing students to practice science themselves through mastery and observational experiences has been explored through numerous programs (Pender et al., 2010). By extension, interventional summer research programs can be utilized to provide experiences to high school students to increase students' perception of their capabilities in STEM practices.

Furthermore, The Next Generation Science Standards (NGSS) emphasize the importance of building student knowledge alongside supporting students' social-emotional and career development capacities. "Authentic Science Experiences: *Designing High School Science Learning to Reach all Students*" present an approach to the promotion of authentic science experiences in a high school science classroom, which includes five main features that are crucial to creating enriching and authentic science experiences (Sarna, Wolbrink, & Soltanzadeh, 2021). Three of these five features heavily correlate to supporting research from Bandura (1977). These three features emphasize integrating a student-centered approach to learning that values the student's identity, experiences, and confidence in STEM. Engaging with peers, adults, and professionals in the science community is promoted through these approaches as well to support science practices and the types of experiences that have been shown to contribute positively to a student's self-efficacy.

In addition to the benefits of adopting a student-centered approach, there is a broad range of important skills, habits, and traits that have been identified by educators and employers as critically important in the 21$^{st}$ century workplace. These ideas have been congregated into a single term: 21st century skills. While there is no centralized curriculum for 21st century skills, the Partnership for 21st Century Skills (P21) developed the Framework for 21st Century Learning, which identifies specific skillsets needed for success in work and everyday life in the 21st century. Notable components of this framework include life and career skills, the 4C's (critical thinking, collaboration, communication and creativity), and information, media, and technology skills ("Framework for 21st Century Learning", 2019).

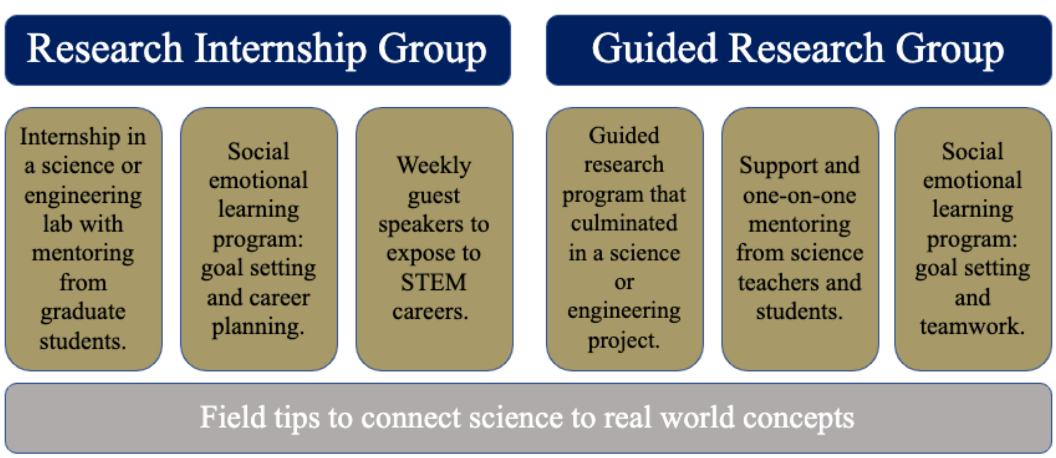
Prior research has implicated positive effects of summer intervention programs, which provides rationale for policy makers or universities to fund them. Research from Kitchen, Sonnert, and Sadler (2017) shows that college and high school collaboration within these programs can provide high school students close to graduating opportunities to explore elements of a STEM career they would practice in the field and as part of their degree. Findings from Kitchen et al. (2017) significantly supported increased student interest in pursuing a STEM career. Evidence shows that students who participated in programs that incorporated real world relevance were 1.6 times more likely to indicate STEM career aspirations than those who did not participate (Kitchen et al., 2017). Other studies such as that done by Aschbacher, Li, and Roth (2009) investigated how providing additional support to students who are interested in STEM positively affects their retention in STEM careers and goals after high school. When high school students were given support and opportunities to perform science and engineering practices, they were able to acknowledge their own interests in STEM as part of their identity (Aschbacher, Li, and Roth, 2009). Additional programs have been funded for students who are already pursuing a STEM career in college. For example, The Ohio State University started a summer bridge program called Ohio's Science and Engineering Talent Expansion Program (OSTEP) for incoming freshman in the colleges of engineering, physical sciences, or biological sciences (Tomasko, Ridgeway, Waller, and Olesik, 2016). Five cohorts of students were selected for the program and surveyed about their experiences. Data from this program showed significant increases in retention in STEM fields in participants from year to year of their undergraduate education. Similar to the program of this case study, the OSTEP program highlights their focus on the "whole student" rather than just content alone (Tomasko, et al., 2016). Data showed that this focus on students was supported in the OSTEP program. In addition to STEM focused programs, programs that emphasize teachings of employability skills such as 21st century skills or social-emotional skills have shown to be especially useful for disadvantaged students who have limited access to career readiness and authentic STEM experiences in school or at home (Cohen et al., 2019). These studies provide empirical evidence that supporting students with STEM experiences at this stage of their life is effective and essential in increasing student interest and confidence in STEM fields.

## Intervention

The program under study was developed in collaboration between university faculty and a school district to address the loss of learning opportunities during the pandemic, especially in relation to science research and engineering design, which would have occurred as part of science fair competitions. The program focused on juniors and seniors in high school, as they were making decisions about career and college plans. The author was an undergraduate member of the program who mentored the students in both groups in one-on-one and group settings when the students were on campus.

There were several goals for this program. One was to provide authentic science experiences to students to promote interest in STEM fields and careers to newer generations. Another focus of the program was on making up for lost learning opportunities during COVID-19. The participants were in their freshman and sophomore years of high school when schooling was fully online or in a hybrid format, which was a huge shift in routine for students and teachers. Participants attended a school district with a high percentage of students considered economically disadvantaged. Consistent with national and state recommendations to consider the whole child in educational programming, part of the program focused on the incorporation of Social Emotional Learning within the STEM learning experiences. Participants learned strategies that allowed them to be more cognizant of their emotions and involved these strategies in their day-to-day activities in the program. Summer 2022 was the pilot year for this program. Data was collected prior to the study for program improvement. Figure 1 compares aspects of the program between the guided research group and the research internship group.

**Figure 1.** Comparison of Activities in the Two Program Groups



**Program 1: Guided Research**

This program was four weeks long and provided a guided research experience with the support of university staff and teacher mentors, while integrating a social emotional learning curriculum that emphasized mindfulness, goal setting, teamwork, and self-reflection. The participants had the opportunity to conduct their own independent research in a topic that interested them. Students had the option of either conducting an experiment or designing their own solution to a problem through engineering. The research process was guided to help the students learn about the design process and to engage them in science that is similar to what they could be doing in a STEM field. Participants had opportunities to listen to speakers from their community talk about career opportunities in STEM. Students also took field trips throughout the four weeks to places like the local zoo, a hydroponic farm, and the local nature preserve; all places where there are career opportunities for people in STEM. The guided research program mainly emphasized exploring STEM careers and developing skills through authentic science experiences. Selected participants often collaborated with one another in labs and design challenges to meet a goal or solve a real-world problem. Students were given the chance to explore different areas of STEM through these labs and challenges. For example, in the first week of the program, students collaborated as teams and competed to build a wind turbine with limited instruction and materials. Through this one activity, students learned about the usefulness of critical thinking in science and engineering. They also noted in weekly feedback questionnaires that they learned how improving designs is part of the process of engineering. Participants also reflected on science and engineering content they learned through the activity. For the wind turbine activity, students reflected on their knowledge of basic aerodynamics and different kinds of windmills that are used to generate power. In addition to design challenges and group labs and activities, students also used the four weeks to independently research their own design solution or carry out an experiment to test a hypothesis. Students were given the freedom to define their own problem or scientific question they wanted to investigate. Some students used Tinkercad to design solutions to their defined problem, and others gathered materials and planned for an experiment to support their hypothesis. In feedback questionnaires, students expressed their enjoyment of the opportunity to do independent research overall. Some students expressed surprise or annoyance in the experimental design process and called it more "repetitive" or "tedious" than they expected it would be. During the last week of the program, students had a chance to compile all of their research and findings into a presentation. Participants would present their findings to each other as well as members of the science and engineering community. These guests were professionals in their field of science or engineering and provided the group with feedback and questions about their projects. In weekly feedback, participants stated that at first, they were anxious about presenting, but most were proud of their hard work and had a positive outlook on the opportunity overall.

**Program II: Research Internship**

This research internship program focused on college and career opportunities in research. Students selected a topic that was being researched in a lab at the local university that was interesting to them and were then mentored in that lab by a graduate student for eight weeks. These students assisted with day-to-day lab practices with the guidance of the graduate mentor and learned about related college and career opportunities with the help of the program's education faculty. Each week, students were given a feedback form that asked them what kinds of things they were experiencing in the lab. Students often responded with specific lab techniques they were learning how to do. While some students were learning how to use CAD software or make prototypes in an engineering lab, students in a science lab learned how to collect data from their samples and analyze the results. Students also reflected on other activities, such as reading related literature and cleaning lab equipment. During the last week of the program, students summarized their learning by developing a research poster that showcased their findings and experiences over the seven weeks of being in the science or engineering lab. On the last day, students showcased their posters to members of the science community such as university professors and graduate student mentors. Their families and the participants of the guided research program were also invited to the research showcase. In the weekly feedback responses, there was an overwhelmingly positive response to how students thought their experience in the lab and presentation went.

## Methods

This case study used existing data that were collected during summer 2022 for the purposes of program evaluation. Pre and post surveys were given to both groups during the span of the program to assess students' own perceptions of their abilities in STEM practices and 21$^{st}$ century skills. Specific questions about student attitudes in science, engineering, and 21$^{st}$ century skills from the pre and post surveys of each group were used to examine students' attitudes towards these subjects before and after participation in the program. These questions were adapted from a valid and reliable instrument, S-STEM, developed for use with middle school and high school students (Unfried et al., 2015). The S-STEM survey includes sections for science, engineering, mathematics, and 21$^{st}$ century skills, where participants could choose if they agreed or disagreed with a statement about their interest and motivation for these subjects. The possible responses for the questions that were analyzed in this way were Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, and Strongly Disagree. Results were analyzed using Likert analysis by quantifying each response as a number, with Strongly Agree being the highest score (5), and Strongly Disagree being the lowest score (1). Each participant's pre and post responses for questions about science confidence, engineering confidence, and twenty first century skills were averaged with this code, giving an average score for each prompt's response before the program and after the program. For analysis the guided research program and the research internship program data were analyzed separately, as these were relatively different programs. Descriptive statistics were used for the pre and post surveys to calculate frequencies for each choice selected, and mean scores for each scale were calculated. A two-tailed t-test was used for the scale scores calculated to identify any significant changes in the pre and post data. Students who only filled out one survey, either pre or post, were removed from the data pool. In addition to the Likert questions, the post survey included prompts for participants to list three things they learned from the summer program. These were formatted as free response questions and students could write about any part of the program. Responses to the open-ended questions were analyzed qualitatively and through two cycles of coding to identify key learning outcomes as reported by participants.

A separate feedback form was also given to participants at the end of each week as a "Weekly Check-In" that recorded what students liked and disliked about specific activities they did during the week. These forms were analyzed to generate a rich description of the program. The questions asked about effectiveness, usefulness, and enjoyment of each activity. These feedback forms also included open-ended response questions about learning from weekly activities. The guided research program feedback forms asked what students learned from lab activities, speakers, group challenges, and independent research. The feedback forms for the research internship group asked about what students' tasks were in their graduate lab that week and their feelings towards what they have accomplished. Open ended responses for pre/post surveys and weekly feedback forms were coded and prominent themes for the responses were identified. Open ended responses from the guided research program weekly check-in answered the following prompts: “What did you learn from the Windmill Design Challenge?”, “Please share any comments and feelings about you actually doing your experiment.”, “Please share any comments and feelings about preparing your slide presentation.”, and “Please share any comments and feelings about actually presenting in front of judges who are scientists and engineers.”.

## Findings

Pre and post means from the pre and post survey on each of the subscales of the STEM attitude scales (Science, Engineering, and 21$^{st}$ Century Skills) are presented in Tables 1 and 2. An alpha value of 0.05 was adopted as customary in educational research, with a p-value less than or equal to 0.05 indicating a statistically significant change between the pre and post data. In the guided research program, results indicate a statistically significant change from pre to post survey responses for the 21$^{st}$ century skills ($p=0.05$). In the research internship group, responses on the student attitudes towards science scale showed a statistically significant increase ($p=0.001$). The means of the pre and post data from other sections of the survey were not significantly different (p-values greater than 0.05).

**Table 1**
Program I - Guided Research Pre/Post Comparison of Means on STEM self-efficacy

| Program I | 21st Century Skills | | Science | | Engineering | |
|---|---|---|---|---|---|---|
| | PRE | POST | PRE | POST | PRE | POST |
| Mean | 4.32 | 4.66 | 3.32 | 3.66 | 3.98 | 4.17 |
| N | 10 | 10 | 10 | 10 | 10 | 10 |
| t Stat | 2.21 | | -1.47 | | -0.89 | |
| P(T<=t) | 0.05 | | 0.17 | | 0.51 | |

**Table 2**
Program II – Research Internship Pre/Post Comparison of Means on STEM self-efficacy

| Program II | 21st Century Skills | | Science | | Engineering | |
|---|---|---|---|---|---|---|
| | PRE | POST | PRE | POST | PRE | POST |
| Mean | 4.5 | 4.39 | 3.86 | 4.35 | 3.91 | 3.94 |
| N | 9 | 9 | 9 | 9 | 9 | 9 |
| t Stat | 0.69 | | -4.91 | | -0.13 | |
| P(T<=t) | 0.51 | | 0.001 | | 0.9 | |

Results in Table 3 and Table 4 correlate with the findings presented in Tables 1 and 2**.** Table 3 shows the student response frequencies from the guided research group's pre and post survey items for 21$^{st}$ century skills. Similarly, Table 4 shows the student response frequencies from the research internship group regarding the science survey items. These frequencies were averaged and used to analyze data calculated in Table 1 and 2.

**Table 3**

Guided Research Group's Survey Item Frequencies for 21st Century Skills

| Survey Item | Frequency | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SD | | D | | N | | A | | SA | |
| | PRE | POST | PRE | POST | PRE | POST | PRE | POST | PRE | POST |
| I am confident I can lead others to accomplish a goal. | 0 | 0 | 1 | 0 | 0 | 0 | 6 | 2 | 3 | 7 |
| I am confident I can encourage others to do their best. | 0 | 0 | 2 | 0 | 0 | 0 | 7 | 5 | 2 | 5 |
| I am confident I can produce high quality work. | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 4 | 3 | 6 |
| I am confident I can respect the differences of my peers. | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 7 | 6 |
| I am confident I can help my peers. | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 6 | 7 |
| I am confident I can include others' perspectives when making decisions. | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 7 | 6 |
| I am confident I can make changes when things do not go as planned. | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 2 | 5 | 7 |
| I am confident I can set my own learning goals. | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 6 | 6 |
| I am confident I can manage my time wisely when working on my own. | 0 | 0 | 1 | 0 | 0 | 0 | 7 | 4 | 2 | 5 |
| When I have many assignments, I can choose which ones need to be done first. | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 2 | 4 | 8 |
| I am confident I can work well with students from different backgrounds. | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 6 | 9 |

SD= Strongly Disagree, D= Disagree, N=Neither Agree nor Disagree, A= Agree, and SA=Strongly Agree

**Table 4.**

Research Internship Group's Survey Item Frequencies for Science Confidence

| Survey Item | Frequency | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SD | | D | | N | | A | | SA | |
| | PRE | POST | PRE | POST | PRE | POST | PRE | POST | PRE | POST |
| I am sure of myself when I do science. | 0 | 0 | 0 | 1 | 2 | 1 | 5 | 6 | 2 | 3 |
| I would consider a career in science. | 0 | 0 | 1 | 0 | 1 | 2 | 4 | 1 | 3 | 8 |
| I expect to use science when I get out of school. | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 1 | 3 | 7 |
| Knowing science will help me earn a living. | 0 | 0 | 0 | 1 | 1 | 0 | 5 | 2 | 2 | 8 |
| I will need science for my future work. | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 1 | 3 | 7 |
| I know I can do well in science. | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 5 | 2 | 6 |
| Science will be important to me in my life's work. | 0 | 0 | 2 | 0 | 3 | 3 | 4 | 2 | 2 | 6 |
| can handle most subjects well, but I cannot do a good job with science. | 1 | 1 | 2 | 0 | 2 | 0 | 3 | 6 | 2 | 4 |
| I am sure I can do advanced work in science. | 0 | 0 | 0 | 0 | 3 | 1 | 3 | 4 | 2 | 6 |

SD= Strongly Disagree, D= Disagree, N=Neither Agree nor Disagree, A= Agree, and SA=Strongly Agree

Results from the Likert scale surveys were corroborated by responses on the open-ended survey items that asked students to report what they learned. For the guided research group, student attitude scores show statistically significant changes between the pre and post scores in 21st century skills. This can also be supported by Table 5, where 21st century skills also show high frequency in learning outcomes for students. For the research internship group, the statistically significant change in attitude towards science can be seen in Table 2. Table 5 supports these findings by showing that students from this group most frequently reported learning about science related topics (content, lab techniques, data collection/analysis, etc.).

Open ended responses from the pre and post survey prompt, “List three things you learned from your experience in the program:” were analyzed using two open coding cycles. For all open-ended responses, frequency does not equate to sample size, since there were two cycles of coding and students could have mentioned more than one category in their responses. In Table 5, frequencies for each type of response are shown for both the guided research group and the research internship group separately. In the “What Did You Learn?” columns are the main themes for learning outcomes that were seen in the open-ended responses. The frequencies for each of these themes are shown.

**Table 5**

Students’ response to lessons learned from the program

| Guided Research | | Research Internship | |
|---|---|---|---|
| What Did You Learn? | Frequency | What Did You Learn? | Frequency |
| Collaboration | 7 | Science content | 6 |
| Social-Emotional Strategies | 7 | Science skills | 4 |
| Communication | 5 | Specialized lab techniques | 4 |
| Science/engineering content | 4 | Collaboration | 4 |
| Learned something about themselves | 4 | Research | 3 |
| Career opportunities in STEM | 3 | Time Management | 3 |
| Time management | 3 | SEL | 2 |
| College options | 2 | Creativity | 2 |
| Specialized lab techniques | 2 | Job/career opportunities | 2 |
| Trying new things | 1 | Professionalism | 2 |
| Working with professionals | 1 | Engineering skills | 1 |
| Project management | 1 | | |

Other open-ended response questions from the weekly feedback forms were also analyzed to develop a rich description of the summer program (See Methods). Table 6 summarizes takeaways from each prompt for the guided research group. Each prompt had a wide array of responses that varied in length and subject. Overall, many students once again emphasized their learning of 21$^{st}$ century skills. In the design challenge prompt, a majority of students said something about learning design techniques. In the rest of the prompts, the responses varied a lot more from one another, giving insight on what the students were learning from each of the activities.

**Table 6**

Guided Research – Weekly Feedback Form

| "What did you learn from the Windmill Design Challenge?" | Frequency of Responses |
|---|---|
| Design techniques | 5 |
| Science and engineering content | 4 |
| Improving designs | 3 |
| Usefulness of activity | 2 |
| Collaboration | 2 |
| Project management | 1 |
| **"What were your thoughts and feelings when doing the experiment?** | **Frequency of Responses** |
| Enjoyment of activity | 3 |
| Project management | 3 |
| Time management | 2 |
| Experimental design process | 2 |
| Creativity | 1 |
| Research procedures | 1 |
| Research does not always go to plan | 1 |
| **"What were your thoughts and feelings when preparing your slide presentation?"** | **Frequency of Responses** |
| Project management | 2 |
| Creating a finished product | 1 |
| Peer and teacher collaboration | 1 |
| Enjoyment of activity | 1 |
| Patience | 1 |
| Difficulty of research | 1 |
| Perseverance | 1 |
| Communicating research to others | 1 |
| **"What were your thoughts and feelings when presenting in front of other scientists and engineers?"** | **Frequency of Responses** |
| Enjoyment of activity | 2 |
| Confidence in abilities | 2 |
| Public speaking | 2 |
| Importance of feedback | 1 |
| Lack of confidence | 1 |

| | |
|---|---|
| Performance anxiety | 1 |
| Effectiveness of mentoring | 1 |
| Positive outlook on final product | 1 |
| Usefulness of activity | 1 |

The research internship program group also completed weekly feedback forms, but this form asked participants to summarize what they had done in the lab that week. This question was asked at the end of every week and gave students a chance to summarize their learning each time. In Table 7 below, frequency of student responses is shown for all weeks. These lab experiences mentioned can give insight on if what students did in the program had influence on their attitudes towards STEM areas of study or 21st century skills.

**Table 7**

Research internship – Summary of Students Responses on Weekly Feedback Form

| Lab Experiences | Frequency |
|---|---|
| Specialized lab techniques | 17 |
| Data collection | 12 |
| Data analysis | 11 |
| Final project prep | 10 |
| Experiment prep | 9 |
| Lab upkeep/cleaning | 9 |
| Science or engineering content | 7 |
| Reviewing existing data/research | 5 |
| Engineering design solutions | 4 |
| CAD modeling | 4 |
| Using lab equipment | 3 |
| Assembly of lab equipment | 2 |
| Mathematic calculations | 2 |
| Application to real world problems | 1 |
| Making prototypes | 1 |
| Making observations based on results | 1 |
| 3D printing | 1 |

**Limitations**

Each group within the program were small sample sizes, with 10 pre/post surveys analyzed for the guided research group and only 9 pre/post surveys analyzed for the research internship group. Because of this small sample size, the t-test results are not able to indicate very meaningful attitude changes. Students also tended to rate themselves highly on the pretest, making it harder to measure change between the two surveys.

**Discussion**

Results involving changes in student attitudes showed statistical significance in areas that aligned with the program's focuses on teachings of both S&E practices and $21^{st}$ century skills. However, the t-test alone is not very meaningful due to limitations. Even with present limitations, the results from the t-test do correlate with analysis of the open-ended response results. Student responses emphasized learning $21^{st}$ century skills in the guided research group and science in the research internship group. These trends in the qualitative data indicate a practical significance that program directors can use to show positive influences of the program. As a staff member who built relationships with each of the students, I have also seen an immense change in student attitude towards science and engineering through observation. Based on my own observations, students were visibly more confident when collaborating with others by the end of the program. It was also seen that students overall enjoyed their time in the program and were able to improve their $21^{st}$ century skills from when they first began the program. I recall that after students presented their research, they felt accomplished and seemed more confident in what they were able to create. My observations of student learning within the program match up with the results of this case study. Even with a small group of students in the program, the t-test coupled with the open-ended responses provide insight to two concepts. 1) Participation in a summer program can influence student attitude toward STEM, and 2) Students learned about essential 21st century skills and were provided with opportunities for authentic science experiences. These findings corroborate with prior findings of Kitchen, Sonnert, & Sadler (2017) when comparing each program's goals to student learning outcomes. Findings of this case study are also consistent of Cohen et al. (2019) when looking at students' benefits to teaching 21st century skills and exploring STEM careers in a summer program. Implications from this case study in support with prior research can provide program directors with information about learning outcomes for participants and understanding of parts of the program that were successful in their original goals.

**Conclusion**

The results of this case study imply changes in attitudes toward science and 21st century skills. Open-ended responses that were analyzed frequently noted student learning gains in these categories. A larger sample size with similar t-test results would provide more support for this statement and could potentially provide additional information about students' attitudes towards engineering as well. As the program continues, this data can help provide understanding for what parts of participation in a summer program can influence students' attitudes toward STEM. Additionally, this case study supports findings from similar studies in that it shows positive learning outcomes from both the teachings of 21st century skills and providing additional opportunities for authentic science experiences. Providing these experiences that have positive effects in student learning are crucial in the attempt to increase STEM self-efficacy.

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