

The Effects of Short-Term Science Engagement Activities on Student STEM Identity in  
Wyoming

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## **Introduction**

STEM identity has been shown to have a strong correlation with educational success and career goals, so discovering ways to improve interest in science and help foster STEM identity may lead to better educational outcomes for students (Singer et al, 2020). Additionally, jobs in STEM fields tend to have higher salaries than other jobs and qualified workers are in high demand (McDonald et al, 2019). Many studies look at the effects of long term or institutional factors such as teaching methods and exposure to positive role models in STEM, but few have looked if singular science activities can have a significant effect on the students interest in and identity related to STEM (Young et al, 2013; Hughes et al, 2013). Since such long-term and institutional changes will take time and effort to implement, it is important to look for ways to boost STEM interest in the meantime. In fact, getting more students interested in STEM now will help with achieving some of the broader changes previous studies have shown to be effective, such as more representation in STEM fields for women and minorities (Young et al, 2013; Singer et al, 2020). Additionally, most studies have only focused on whether certain interventions can help specific types of students whereas a broader lens might help to gain a better understanding of how STEM activities may increase identity and interest for students.

Studies that have looked at shorter experiences have shown promising results in increasing students' interest in STEM, which is one of the major components of a positive STEM identity. One study conducted by the Arizona Science Lab, found that a one day field trip was enough to change students' perceptions of science to be more positive in a group of students with declining interest in STEM (Innes et al, 2012). Using a five point agreement scale survey, 307 students grades 4-9 were surveyed before and after they participated in science and engineering specific workshops to gauge their perceptions and interests in STEM fields. Innes et al (2012) found that these workshops had a substantial positive effect on students' perceptions toward STEM fields. They attributed a large portion of this positive change to the hands-on nature of the workshops, which allowed students to work on and explore engineering concepts for themselves. They also found an increase in both interest in STEM fields and feelings of self-efficacy related to science and engineering. Their results support working to implement more supplemental out of the classroom activities to improve STEM interest in K-12 students (Innes et al 2012).

However, while studies have examined how to foster STEM identity with institutional changes and how to increase STEM interest with short term field trip experiences, there is not much research on whether field trip experiences can go beyond fostering STEM interest and actually foster a more positive STEM identity. This is important because while interest in STEM is a component of identity, it is not the only factor that makes STEM identity such a strong predictor of future success.

*Purpose of Study*

The purpose of this research project is to discover if a short three day field-based science outreach activity could substantially change students' interest in science and their STEM identity. The survey created for this study will gauge if short science activities outside of regular class have an impact on the students perception of science and whether they view themselves as capable of being scientists.

### *Hypotheses*

We hypothesized that the three day science outreach activity would increase students' STEM identity and positive perceptions about science.

### **Methods**

#### *Subjects*

The participants for this study included seventeen 5th grade students from a Wyoming school who engaged in a field-based three day research project in a local state park. This collaboration was initiated by the 5th grade teacher who reached out to the university outreach program to ask for assistance in helping the students understand, implement, and perform the scientific method. Prior to the research project, parents were given a consent form to complete to have their child enroll in the study. Out of 23 students, 17 students, 6 male and 11 female, enrolled as participants.

#### *Field-Based Research Project*

The students participated in a three day ecological study in a local state park where they were divided into four groups led by local university faculty and graduate student researchers. The four groups conducted studies investigating water quality, tree and soil density, bird diversity, and rock erosion. On the first day, the students and their research leaders went out into the field to make observations and the research leaders guided the students through questions they could ask related to their topic in the field. Each group then chose one or two research questions they wanted to answer and brainstormed what kind of equipment they might need to answer that question. On the second day, the students and research leaders went back into the field and actually collected data to answer their research question(s). The research leaders brought relevant equipment for the students to use to help them gather data and the students kept notes and numbers in their field journals. On the third and final day, the research leaders met the students at their school where they worked together to analyze, create, and present research posters of their findings and conclusions.

#### *STEM Identity Survey*

In order to determine if this research project had an effect on the students' STEM identity, interest in science, or their future goals, the students were given the same survey to complete immediately prior to the research project and immediately after the project (Appendix 1).

Students were asked for their verbal assent prior to completing the surveys and the surveys were completely anonymous.

The pre and post surveys consisted of 20 statements adapted from previous STEM identity surveys where students ranked their agreement to the statements on a scale of one to five, one being strongly disagree, five being strongly agree by circling the corresponding number on the paper (Young et al, 2013; Hughes et al, 2013; Singer et al, 2020). The survey included twelve positive statements and seven negative statements about science. Both surveys also include one open-ended response question about the experience to serve as a qualitative metric for the effect the experiences had on the students. The pre and post survey questions were identical except for the last statement and the free response question.

### *Analysis*

The survey responses to the Likert scale questions were compared using a two tailed t-test, comparing answers to questions on the pre survey to the answers to the same questions on the post survey using R Software. The qualitative questions were ranked for positive attitudes toward science by classifying verb and adjective choices as either positive, neutral, or negative. Additionally, validity will be assessed by invalidating survey responses where the respondent either agreed or disagreed on both the science positive and science negative statement for the same concept, such as indicating agreement with both the statements “I like science” and “I don’t like science”. All statistics were set using a p-value  $<0.5$  as this is an exploratory study with a small sample size.

### **Results**

Our quantitative results did show significant changes in 9 of the 18 comparable questions (Table 1). There was an increase in the post survey responses compared to the pre survey response in question 2 “I would take more science classes even if I didn’t have to”, question 9 “In general, I find working on science assignments very interesting”, question 11 “Science is a difficult subject”, question 13 “I have come to think of myself as a scientist”, and question 14 “Being a science student has very little to do with how I feel about myself”. There was a decrease in the post survey responses to question 4 “Overall, being a science student is important to my sense of what kind of person I am now”, question 5 “It is not important to me to be good at science”, question 8 “I do not like doing science”, and question 18 “If you do poorly in school, you will do poorly in life”. These results demonstrate that the experience did have an effect on the students interest and identity in STEM. Figure 2 and Figure 3 show the shifts in the responses to the pre survey compared to the post survey for all of the questions, divided by positive and negative questions. Of the positive questions, 3 increased and 1 decreased. Of the negative questions 3 of them decreased and 2 increased. Overall there was a significant increase in the overall response to the positive questions (Figure 4, Table 2).

From our qualitative analysis of the word choice and intent for the free response questions, most of the students were excited in participating in the event and found it to be fun (Figure 5). In their initial responses to the pre survey, the most common words used were “opportunity” and “exciting” (Figure 5). In the post survey, the most commonly used words were “activity” and “fun” (Figure 6). In the pre survey, 11 students were looking forward to the experience, 3 thought it was better than an alternative they would be doing in the classroom, and 1 student did not look forward to the outreach opportunity (Figure 7). In the post survey, 10 students said it was a good experience, 4 thought it was better than an alternative in the classroom, and there were no negative responses about the opportunity by students (Figure 7). All of the students who completed the question on the post survey said they would like to participate in another experience similar to the one they just finished (Figure 8). In the pre survey, 8 of the responses indicated the students’ were excited about the opportunity because it provided a different learning environment than the classroom, and 10 indicated that it was because they thought the experience looked fun (Figure 9). In the post survey, 4 said they would do the experience again because it was a different learning environment, and 9 said they would do it again because they found it fun and interesting (Figure 9).

## **Discussion**

STEM identity is a high predictor of increased educational success, such as earning a high school diploma and undergraduate degree. Further, it is positively correlated with greater earning potential and career achievements (Singer et al, 2020). Opportunities that can facilitate increased STEM identity prior to high school levels when students are poised for greater STEM performance, can have important long lasting impacts on future career pursuit and success (Vincent-Ruz & Schunn, 2021). We found that intensive outreach and engagement with 5th grade students can increase STEM identity over only a three day set of activities. Our findings support the value and potential for short outreach collaborations to positively contribute to larger institutional goals, such as increasing the diversity of individuals in STEM (Singer et al, 2020).

Based on our findings, our three-day outreach program positively influenced students’ STEM identity. We observed increases in agreement to STEM positive statements including question 2 “I would take more science classes even if I didn’t have to”, question 9 “In general, I find working on science assignments very interesting”, and question 13 “I have come to think of myself as a scientist”. Our results support the hypothesis that immersive STEM activities can positively influence student interest in science fields. We also observed decreases in questions with a negative STEM connotation, such as question 5 “It is not important to me to be good at science” and question 8 “I do not like doing science”. From these findings, we can infer that the students placed greater value and interest in science through this experience. Together, our results indicate that our immersive STEM outreach experience positively influenced student STEM identity and interest in science.

Interestingly, we also saw an increase in agreement to the statement “science is a difficult subject” (question 11). This demonstrates that although the students are now more interested in science, they also think it is harder than they did prior to participating in designing and conducting an experiment. These findings were congruent with the results of Innes et al (2012) who showed STEM interest increased after an out of the classroom experience but our study adds in additional detail that students do view science as a harder action than they did before. We believe this can be attributed to students' perception of challenge and adversity, and the realization that although something may be difficult, it can still be worth pursuing. Further, we believe perception of science shifted as a result of the increased experience and development of skills to work through the scientific process, which allowed students to acknowledge that though science can be challenging, it can also be enjoyable (e.g., question 9). From this experience the participants also saw themselves more as scientists (question 13) demonstrating that they felt more empowered to do science. Further, we believe increased STEM identity may positively influence student success in other subject areas by instilling the confidence to continue pursuit of scholastic achievement in light of adversity.

We also analyzed the student's answers to the pre and post survey free response questions to help gauge their feelings about the experience itself. On the pre survey, the words “opportunity” and “exciting” were used the most (Figure 5) and the words “activities” and “fun” were the two most used words on the post survey (Figure 6). These results demonstrate that the students enjoyed the experience. From the pre to the post survey, we also saw an increase in students who wanted to do the activity because they thought it sounded fun and interesting compared to those who wanted to do the activity because they didn't want to be in school (Figure 9). The increase in students who wanted to participate in the experience itself demonstrates that the experience caught the students attention and got them more interested in doing more actual field based research in the future. This trend in our qualitative data of the effect of the event on the students supports the findings from the quantitative analysis that this outreach experience had positive effects on the students STEM interest and STEM identity.

While our study does show promising results for effecting STEM identity in a short period of time, we were only able to study one class at one school. Therefore it is possible that the results are not applicable across the board and the changes were affected by the already existing learning environment and class at that one school. Additional studies that include a larger sample size than our exploratory study drawn from more classes and more schools would be very helpful in confirming our findings. Additionally, some students choose not to answer the final question on the survey, further decreasing the available data. Finally, based on our findings, there are several clear directions for future research into the connection between short science events and the fostering of a stronger STEM identity. How short can we still see changes? Many outreach events visit with students during one class period/visit. It would be interesting to see what the smallest duration of outreach can be to lead to changes in STEM identity. Since we took students out of the classroom for the experience, examining the effects of staying at the school and bringing in experts to see how this changes STEM interest and identity would also be helpful in figuring out how best to implement activities to foster STEM identity. Many students are excited to not be in the classroom so it is important to see if there are STEM identity and interest

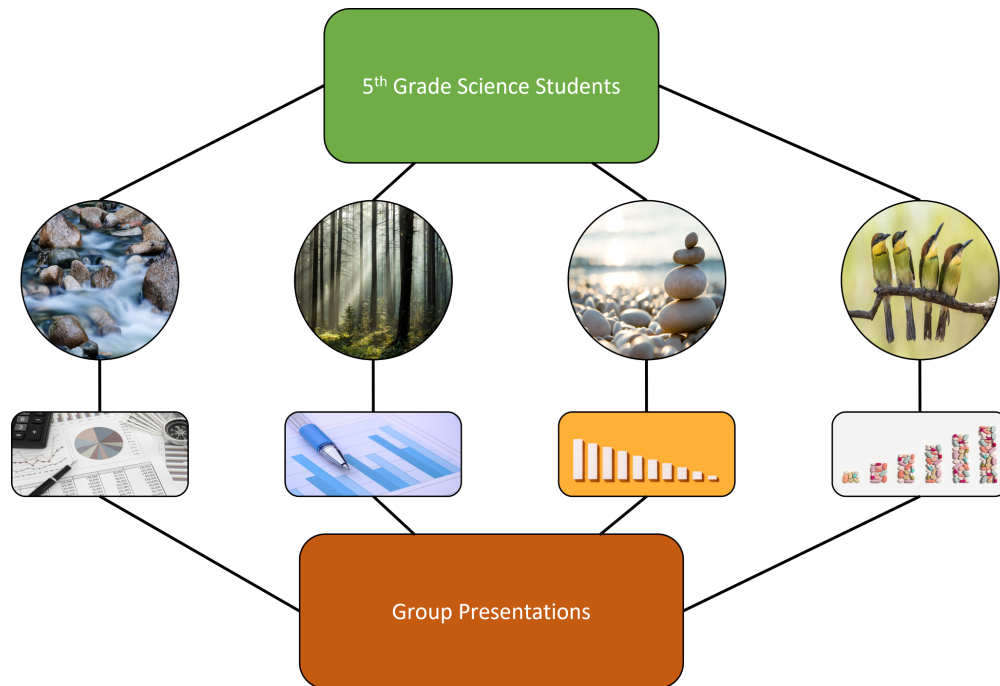
changes within the classroom as well. In the previous study by the Arizona Science Lab, increase in STEM interest can occur when students work in pairs. Our study demonstrated that a similar increase could be observed in students who worked in groups of 5, which leads to the question: is there an optimal number of students in a group and is there a point where there are too many students and the effects of the experience begin to diminish?

This study shows that short-term science activities can promote STEM identity and increase interest in science. These increases in identity and interest may also have long-term benefits for institutional change such as increasing the diversity of individuals in STEM and promoting more integration of hands-on, interactive STEM activities in K-12 classrooms throughout Wyoming and nationally. Implementing short-term, hands-on activities are a tangible programmatic change that can be readily applied through partnerships and programs already established in many universities across the United States. By implementing these short-term activities, K-12 students can benefit from the activities without having to wait for longer institutional changes which will come over time. In summary, short-term engagement activities can have profound impacts on K-12 student STEM identity and interest in science, which promotes an increase in student success when they enter into higher education and/or the workforce.

## **References**

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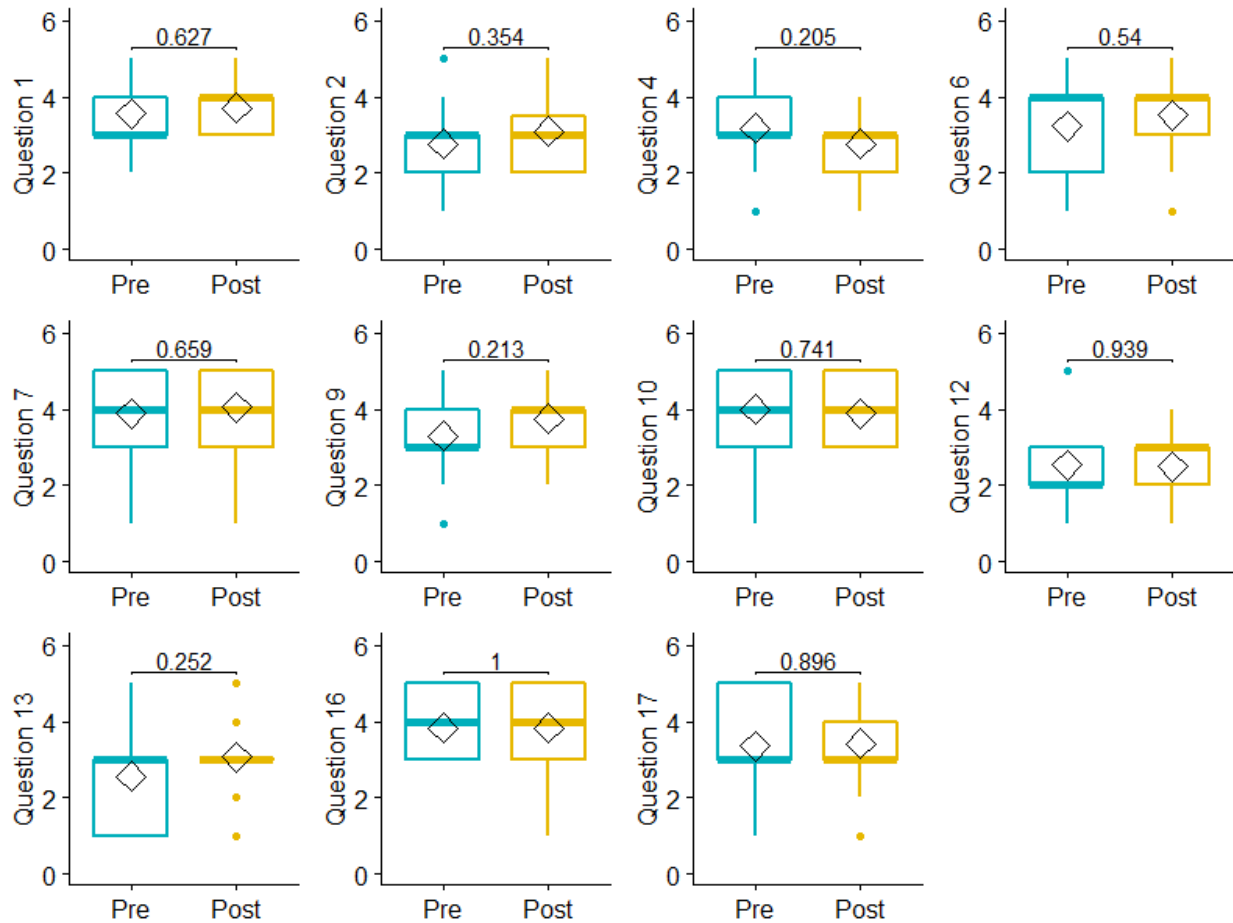
## Figures



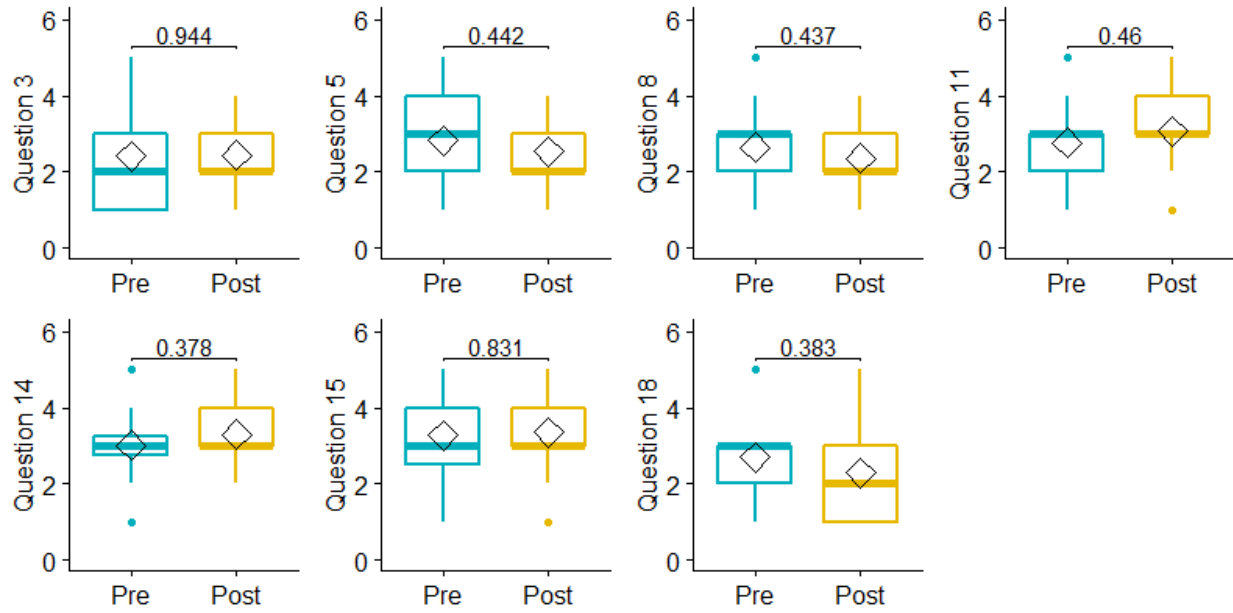
**Figure 1: Method Flow Chart.** Seventeen 5th grade students were separated into four research groups (second row). The research topics included: 1) water ecology 2) botany and soil science 3) geology 4) ornithology. Each group collected their data in the field and put together their own data and analysis (third row). The class then came back together and presented their research in front of their peers, parents, teachers, principal, and science leaders.

**Table 1.** Descriptive statistics of the scores for each statement on the Pre and Post Surveys and a comparison between the two.

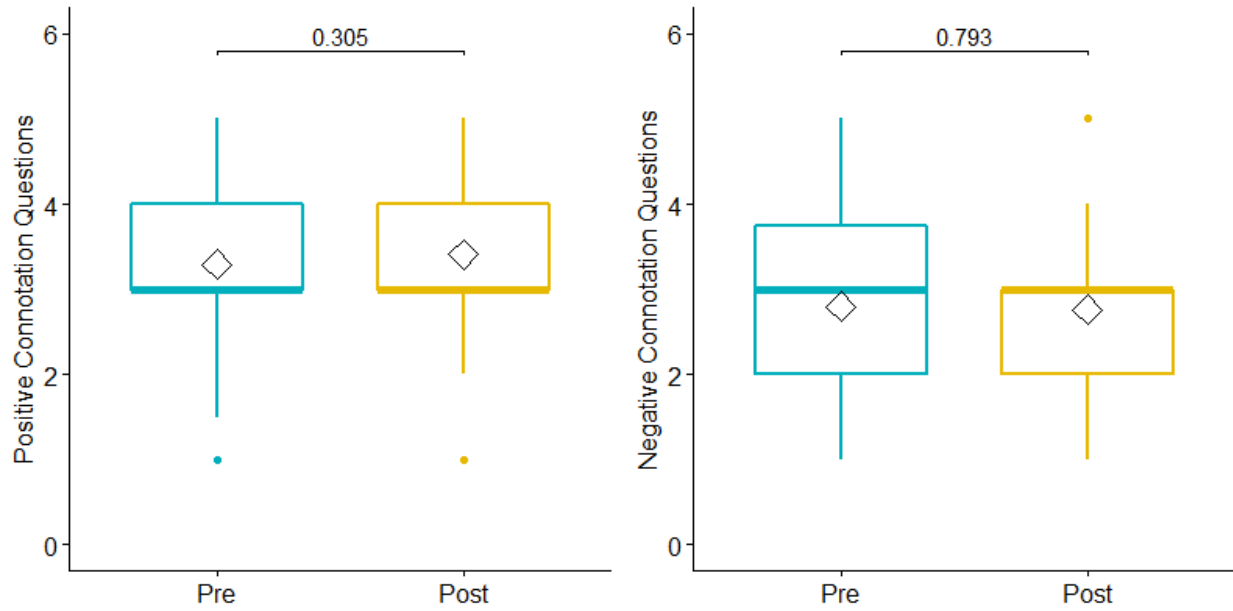
<b>Question</b>	<b>Pre-survey mean (SD)</b>	<b>Post-survey mean (SD)</b>	<b>Direction change</b>	<b><i>P</i> value</b>
1 I like doing science	3.56 (0.97)	3.71 (0.77)	Increase	0.63
2 I would take more science classes even if I didn't have to	2.76 (1.03)	3.09 (0.97)	Increase	0.35
3 Doing experiments in science class is frustrating	2.41 (1.37)	2.44 (1.03)	Increase	0.94
4 Overall, being a science student is important to my sense of what kind of person I am now	3.18 (1.01)	2.76 (0.83)	Decrease	0.21
5 It is not important to me to be good at science	2.82 (1.24)	2.53 (0.94)	Decrease	0.44
6 I would rather solve a problem by doing an experiment than to be told the answer	3.24 (1.52)	3.53 (1.23)	Increase	0.54
7 More time should be spent on hands-on projects in science or technology activities at school	3.88 (1.17)	4.06 (1.14)	Increase	0.66
8 I do not like doing science	2.65 (1.27)	2.35 (0.86)	Decrease	0.44
9 In general, I find working on science assignments very interesting	3.29 (1.16)	3.74 (0.83)	Increase	0.21
10 I like learning how things work	4.00 (1.17)	3.88 (0.86)	Decrease	0.74
11 Science is a difficult subject	2.76 (1.15)	3.06 (1.14)	Increase	0.46
12 Being a scientist is important to who I want to be	2.53 (1.18)	2.50 (1.03)	Decrease	0.94
13 I have come to think of myself as a scientist	2.56 (1.39)	3.06 (1.09)	Increase	0.25
14 Being a science student has very little to do with how I feel about myself	3.00 (0.97)	3.29 (0.92)	Increase	0.38
15 I spend time on science work because I have to	3.26 (1.28)	3.35 (1.11)	Increase	0.83
16 I like to get science games or science experiment kits as presents/gifts	3.82 (0.88)	3.82 (1.19)	Decrease	1.00
17 Being a scientist looks fun	3.35 (1.37)	3.41 (1.23)	Increase	0.90



**Figure 2: Pre and Post Box and Whisker Plots for all Positive Questions.** Blue boxes indicate the pre survey responses on a scale of 1-5 with the darker line indicating the median and the diamond representing the mean. Yellow boxes represent the post survey responses. Questions are written in table one. Data shows only questions that indicate a positive connotation related to science and STEM identity. Significance is set at  $p < 0.5$ .



**Figure 3: Pre and Post Box and Whisker Plots for all Negative Questions.** Blue boxes indicate the pre survey responses on a scale of 1-5 with the darker line indicating the median and the diamond representing the mean. Yellow boxes represent the post survey responses. Questions are written in table one. Data shows only questions that indicate a positive connotation related to science and STEM identity. Significance is set at  $p < 0.5$ .



**Figure 4: Comparison between Pre Survey and Post Survey responses for all positive and all negative connotation responses.** Blue boxes indicate the pre survey responses on a scale of 1-5 with the darker line indicating the median and the diamond representing the mean. Yellow boxes represent the post survey responses. Significance is set at  $p < 0.5$ .

**Table 2.** Descriptive statistics for all positive connotation statements combined and for all negative connotation statements combined.

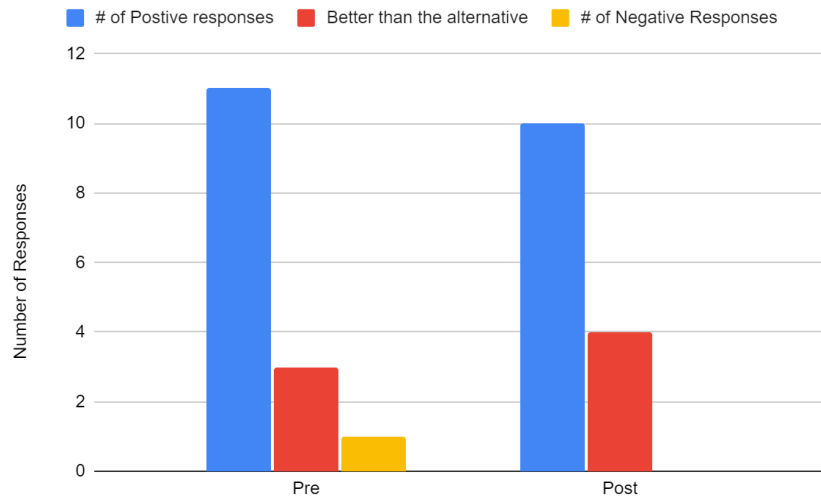
<b>Question Connotation</b>	<b>Pre-survey mean (SD)</b>	<b>Post-survey mean (SD)</b>	<b>Direction change</b>	<b><i>P</i> value</b>
Positive Connotation Questions	3.29 (1.25)	3.41 (1.11)	Increase	0.305
Negative Connotation Questions	2.80 (1.24)	2.76 (1.12)	Decrease	0.793



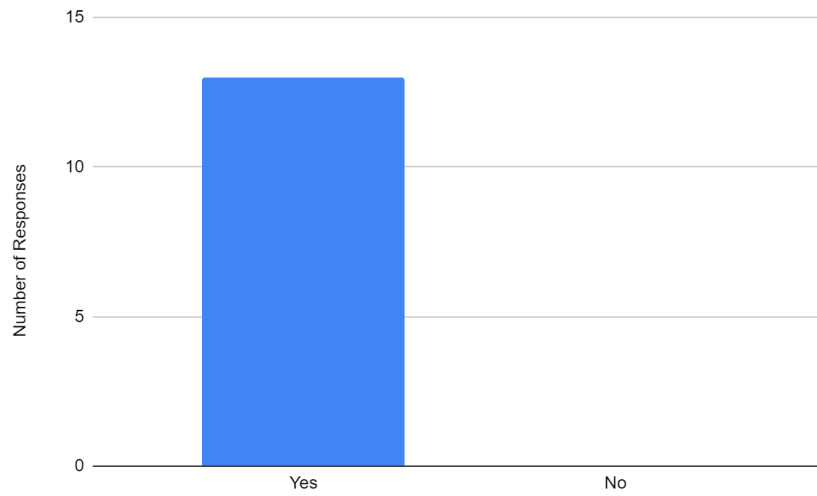
**Figure 5: Pre-Survey Word Cloud.** Word cloud of most commonly used words from the qualitative free response question on the pre-survey. The larger the word, the more times students' indicated that word in their responses.



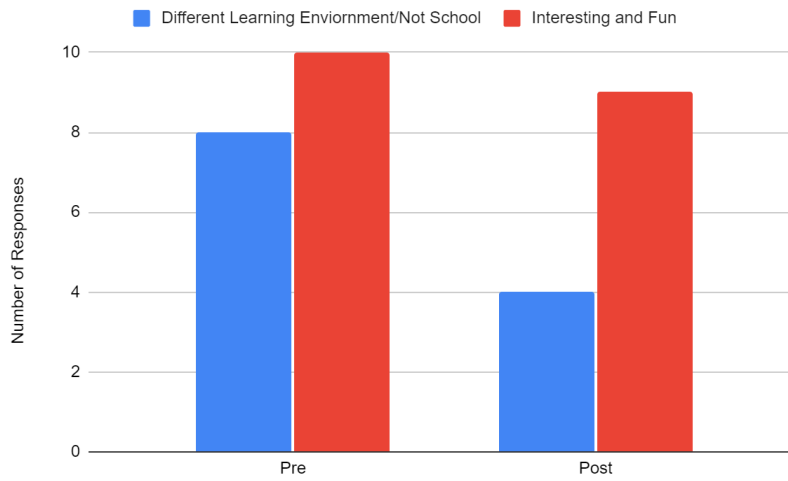
**Figure 6: Post-Survey Word Cloud.** Word cloud of most commonly used words from the qualitative free response question on the post-survey. The larger the word, the more times students' indicated that word in their responses.



**Figure 7: Number of Responses for Each Free Response Question.** Number of positive versus negatively coded responses on the free response question on the pre survey compared to the post survey based on word choice and overall intent.



**Figure 8: Number of Responses about Participation.** Number of responses on the post survey free response question that indicated the student would like to participate in another experience similar to the one they just finished.



**Figure 9: Number of Responses Related to Reason for Participation.** Comparison between the pre survey and post survey responses of the reason students were looking forward to or would like to do again this experience. Responses were counted more than once if they included both reasons.

Appendix

**University of Wyoming**

**Honors College and Science Initiative**

**Pre-STEM Survey**

**Directions:** This survey contains 20 questions. There are no right or wrong answers. Read each of the statements below and then circle the number that best shows how you feel. Please select only one number for each question. Feel free to ask questions if anything is confusing.

	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
1. I like doing science	1	2	3	4	5
2. I would take more science classes even if I didn't have to	1	2	3	4	5
3. Doing experiments in science class is frustrating	1	2	3	4	5

4. Overall, being a science student is important to my sense of what kind of person I am now	1	2	3	4	5
5. It is not important to me to be good at science	1	2	3	4	5
6. I would rather solve a problem by doing an experiment than to be told the answer	1	2	3	4	5
7. More time should be spent on hands-on projects in science or technology activities at school	1	2	3	4	5
8. I do not like doing science	1	2	3	4	5

9. In general, I find working on science assignments very interesting	1	2	3	4	5
10. I like learning how things work	1	2	3	4	5
11. Science is a difficult subject	1	2	3	4	5
12. Being a scientist is important to who I want to be	1	2	3	4	5
13. I have come to think of myself as a scientist	1	2	3	4	5

14. Being a science student has very little to do with how I feel about myself	1	2	3	4	5
15. I spend time on science work because I have to	1	2	3	4	5
16. I like to get science games or science experiment kits as presents/gifts	1	2	3	4	5
17. Being a scientist looks fun	1	2	3	4	5
18. If you do poorly in school, you will do poorly in life	1	2	3	4	5
	1	2	3	4	5

19. I am excited about this opportunity					
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20. Please write below why (or why not) this opportunity is exciting to you.

**University of Wyoming  
Honors College and Science Initiative  
Post-STEM Survey**

**Directions:** This survey contains 20 questions. There are no right or wrong answers. Read each of the statements below and then circle the number that best shows how you feel. Please select only one number for each question. Feel free to ask questions if anything is confusing.

	<b>Strongly Disagree</b>	<b>Disagree</b>	<b>Neutral</b>	<b>Agree</b>	<b>Strongly Agree</b>
1. I like doing science	1	2	3	4	5
2. I would take more science classes even if I didn't have to	1	2	3	4	5

3. Doing experiments in science class is frustrating	1	2	3	4	5
4. Overall, being a science student is important to my sense of what kind of person I am now	1	2	3	4	5
5. It is not important to me to be good at science	1	2	3	4	5
6. I would rather solve a problem by doing an experiment than to be told the answer	1	2	3	4	5
7. More time should be spent on hands-on projects in science or technology activities at school	1	2	3	4	5

8. I do not like doing science	1	2	3	4	5
9. In general, I find working on science assignments very interesting	1	2	3	4	5
10. I like learning how things work	1	2	3	4	5
11. Science is a difficult subject	1	2	3	4	5
12. Being a scientist is important to who I want to be	1	2	3	4	5

13. I have come to think of myself as a scientist	1	2	3	4	5
14. Being a science student has very little to do with how I feel about myself	1	2	3	4	5
15. I spend time on science work because I have to	1	2	3	4	5
16. I like to get science games or science experiment kits as presents/gifts	1	2	3	4	5
17. Being a scientist looks fun	1	2	3	4	5

18. If you do poorly in school, you will do poorly in life	1	2	3	4	5
19. I would do more activities like this if I had the opportunity	1	2	3	4	5

20. Please write below why (or why not) you would like to do more activities like this if you had the opportunity.

Survey Questions for both Pre and Post Adapted from:

1. Young DM et al (2013). The Influence of Female Role Models on Women’s Implicit Science Cognitions. *Psychology of Women Quarterly*.37(3):283-292. doi:[10.1177/0361684313482109](https://doi.org/10.1177/0361684313482109)
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3. Singer, A., et al., (2020) S. How to foster the formation of STEM identity: studying diversity in an authentic learning environment. *IJ STEM Ed* **7**, 57. <https://doi.org/10.1186/s40594-020-00254-z>